

Impact of Extreme Weather on Construction Projects in Koronadal City, Philippines

Lenon V. Namuag*, Joshua Marvin A. Noval, El-j A. Flores, Czeska Mae B. Pagay, Earl Ian T. Delgado
Civil Engineering Department, Mindanao State University – General Santos, General Santos City, Philippines

*Corresponding Author Email: lenon.namuag@msugensan.edu.ph

Date received: September 15, 2024

Date revised: December 9, 2024

Date accepted: December 23, 2024

Originality: 86%

Grammarly Score: 99%

Similarity: 14%

Recommended citation:

Namuag, L., Noval, J.M., Flores, E., Pagay, C.M., Delgado, E.I. (2024). Impact of extreme weather on construction projects in Koronadal City, Philippines. *Journal of Interdisciplinary Perspectives*, 3(1), 223-231.

<https://doi.org/10.69569/jip.2024.0530>

Abstract. This research investigated the impact of extreme weather on construction projects in Koronadal City. This study aimed to (1) identify the specific types of extreme weather events affecting construction projects; (2) measure the perceived level of impact of extreme weather on construction project timelines, budgetary allocations, labor productivity, equipment performance, and the overall project quality; (3) identify the potential health and safety hazards that might be encountered by individuals in the construction industry; and (4) measure the perceived level of effectiveness of the existing resilience measures employed by construction projects in Koronadal City to mitigate the adverse impact of extreme weather. Data were gathered using survey questionnaires from various respondents, including engineers and construction workers. A survey involving 177 respondents identified frequent weather-related challenges, with heat waves being the most prevalent, followed by heavy rainfall and less frequent occurrences of floods, tropical cyclones, and tornadoes. The study also explored the impact of extreme weather on the health and safety of construction personnel, highlighting issues such as physical strain, heat-related illnesses, and increased risks of accidents due to adverse weather. The findings indicate significant disruptions to project timelines and financial planning, with a considerable majority reporting that extreme weather necessitates project management and budgeting adjustments. Furthermore, the study reveals the effectiveness of current resilience measures, including providing adequate hydration and regular breaks in shaded areas and utilization of adequate rest breaks, rotating tasks, and employee wellness programs. This paper underscores the urgent need for enhanced adaptive measures and more efficient risk management strategies to ensure the safety and effectiveness of construction practices in regions vulnerable to extreme weather.

Keywords: Construction projects; Extreme weather; Health hazards; Resilience measures; Safety hazards.

1.0 Introduction

The construction industry is critical for infrastructure development and economic progress but is highly vulnerable to the adverse impact of extreme weather. Its reliance on outdoor, labor-intensive activities exposes it to significant risks, exacerbated by the increasing frequency and intensity of extreme weather due to climate change. Studies consistently emphasize the detrimental impact of extreme weather on construction productivity, worker safety, financial stability, and project quality (Alshebani & Wedawatta, 2014).

Heatwaves are among the most significant challenges faced by the construction industry. Prolonged exposure to high temperatures can cause heat stress, leading to health risks and decreased productivity for workers performing physically demanding tasks outdoors (Kiefer et al., 2016). Gubernot et al. (2013) documented a global rise in heat-related injuries from 2006 to 2017, highlighting the vulnerability of construction workers to extreme

heat. Similarly, Dunne et al. (2013) projected that environmental heat stress could reduce global labor productivity by 20% by 2050. Regionally, Al Alawi (2020) found that in Oman, extreme temperatures extend project timelines by up to 38% beyond planned schedules. Alaghbari et al. (2006) corroborated these findings, identifying heatwaves as a leading cause of construction delays. Karthick et al. (2022) further highlighted that outdoor workers face heightened risks of heat strokes, extreme fatigue, and accidents, including slips and falls, during periods of high temperatures. These findings underscore the urgent need for heat-mitigation measures in construction.

Economic implications are also significant. Schuldt et al. (2021) reported that 45% of construction projects globally are delayed by extreme weather, resulting in billions of dollars in revenue losses annually. Gandhi et al. (2014) also identified heatwaves as a critical factor affecting labor productivity, logistics, and financial planning. Their study emphasized the need for integrating weather-resilience strategies into construction planning to minimize these impacts. In the Philippines, the risks are amplified due to the country's tropical climate. Guadalupe (2018) predicted that Mindanao could experience year-long heatwaves by 2050 under worst-case scenarios. However, existing safety protocols are insufficient to mitigate these risks, leaving workers and projects highly vulnerable (Mills, 2003).

Heavy rainfall presents another formidable challenge for the construction industry. El-Rayes and Moselhi (2001) identified its profound impact on road-building projects, including erosion, sedimentation, and flooding. Pathiranage and Halwatura (2010) noted that these issues often halt operations, leading to delays and increased costs. In addition, Akomah and Jackson (2016) highlighted that heavy downpours can damage exposed structures, cause excavation collapses, and render roads impassable. In the Philippines, the frequency and severity of tropical cyclones have risen in recent decades, causing catastrophic flooding and severe disruptions in construction projects. On average, 20 tropical cyclones enter Philippine waters annually, with eight or nine making landfall (Yang, 2012). These events frequently surpass the threshold of 100 mm of rainfall in 24 hours, leading to widespread destruction and delays.

Despite the evident challenges posed by extreme weather, regulatory measures in the Philippines remain inadequate. Seposo et al. (2017) highlighted the lack of comprehensive heat-health action plans, while Gubernot et al. (2013) noted that existing regulations are too general to address the specific risks posed by extreme weather. Moreover, much of the available literature focuses on global trends or developed countries with advanced infrastructure and safety protocols. Studies such as those by Mora et al. (2017) and Zander et al. (2018) provide valuable insights but are often not directly applicable to the Philippine context due to differences in infrastructure and socio-economic conditions. This gap underscores the need for localized research that examines the unique vulnerabilities of the Philippine construction industry, particularly in smaller urban areas like Koronadal City.

Localized research is imperative to address the specific vulnerabilities of the construction sector in regions like South Cotabato, where outdoor, labor-intensive activities are highly susceptible to extreme weather. This study systematically investigated the impact of extreme weather on construction projects in Koronadal City. The objectives included identifying the prevalent types of extreme weather affecting construction activities, quantifying their perceived impact on project timelines, budgetary allocations, labor productivity, equipment performance, and overall project quality, and evaluating the health and safety hazards faced by workers. Furthermore, the research assessed the perceived effectiveness of existing resilience measures employed to mitigate these impacts.

Despite the growing body of literature on the consequences of climate change and extreme weather on construction globally, the focus predominantly remains on developed regions with advanced infrastructure and adaptive measures. Developing regions like South Cotabato remain underexplored. This study bridges the identified research gap by offering a comprehensive analysis of how extreme weather influence the construction sector in Koronadal City. The findings provide actionable recommendations to enhance safety protocols, fortify resilience strategies, and mitigate risks, thus contributing to the adaptive capacity of the local construction industry in the face of escalating climate challenges.

2.0 Methodology

2.1 Research Design

The purpose of this research is to evaluate the impact of extreme weather on construction projects in Koronadal City. This study employs a descriptive quantitative research design. By measuring variables such as the frequency of extreme weather, the level of impact these events have on construction projects, and the effectiveness of resilience strategies, this approach enables precise and objective analysis through statistical measures of central tendency.

2.2 Research Locale

This research was conducted in Koronadal City, situated in Region XII, Philippines. The coverage of this study is the jurisdiction of the City Engineers Office of Koronadal City for the implementation of their civil work projects. Koronadal City, also known as Marbel, is a city located in South Cotabato, Philippines. The city is divided into 27 districts and is a small cultural center, where three dominant cultures (Christian, Muslim and local) are mixed up in a unique manner. The issuance of Executive Order No. 304, issued by former President Gloria Macapagal Arroyo, designating the City of Koronadal as the Regional Center and seat of SOCCSKSARGEN Region, further boosted the development of Koronadal City. It is the capital of the province of South Cotabato, regional administrative center of SOCCSKSARGEN, and the second most populous city after General Santos City.

2.3 Research Participants

The researchers obtained a total of 325 workers from the reply letter of the Koronadal City Engineers' Office. Upon obtaining the names from the City Engineers Office of Koronadal City, the researchers used the stratified random sampling technique, specifically, proportionate sampling. To have a 95% confidence level, the researchers needed to have a sample size of 177 workers to ensure a real value within $\pm 5\%$ of the surveyed value. Using the proportionate stratified random sampling technique, the total workers required for the technical, skilled, and unskilled workers are 17, 66, and 94 workers, respectively. The researchers divided the total population of respondents into three strata: technical, skilled, and unskilled workers. The workers included in the technical worker's stratum are the civil engineers, project managers, foremen, quality control aide, leadmen, contractors, electrical engineers, electricians, and surveyors. For the skilled workers, the equipment operators, steelmen, painters, masons, carpenters, ceiling installers, welders, and scaffolders were involved. Lastly, for the unskilled workers, only the general laborers were included.

2.4 Research Instrument

This research employed a survey questionnaire which is adapted and modified from previous research entitled "Evaluation of the Impacts of Extreme Weather Events on the Infrastructure Development of the Construction Industry in Ontario" by Rizwan. Modifications were made to the survey questions such as excluding the occurrence of weather events like the frost and snowfall since these are not applicable where the study is conducted. The demographics part of this study was modified to the present organizational structure of construction industry. Most of the questions in this material are in the form of a Likert Scale, which were useful in addressing the research objectives.

2.5 Data Gathering Procedure

The researchers handed out the questionnaires to the respondents in person. The data gathering took place from March 21 to 23, 2024, in Koronadal City.

2.6 Data Analysis

This study used the Weighted Mean to analyze the data gathered for the assessment of the impact of extreme weather on construction projects in Koronadal City. The Weighted Mean was used to calculate the average scores assigned to various aspects through questionnaires. Table 1 shows the Likert Scale used in the study.

Table 1. Five-point likert scale, mean ranges, and descriptions used in the study

Weight Scale	Mean Range	Descriptions
5	4.20 – 5.00	Always / Highly Significant Impact / Highly Effective
4	3.40 – 4.19	Often / Considerable Impact/ Considerably Effective
3	2.60 – 3.39	Sometimes / Moderate Impact / Moderately Effective
2	1.80 – 2.59	Seldom / Slight Impact / Slightly Effective

2.7 Ethical Considerations

This research was conducted in strict adherence to ethical guidelines, ensuring the protection of the rights and well-being of all participants. Informed consent was obtained from all respondents prior to their participation, and their responses were kept confidential throughout the study. The data collected will be used solely for research purposes and will not be disclosed or used in any manner that could harm or be used against the respondents.

3.0 Results and Discussion

3.1 Frequency of Occurrence of Extreme Weather Events

Table 2 highlights the frequency of various extreme weather impacting construction projects. The findings reveal that heat waves pose a significant challenge for construction workers, with a high weighted mean of 4.74, indicating that this condition is almost constant, occurring "always" or more than five times a week. These results align with Guadalupe (2018), who reported that the Philippines has ranked as the fifth most affected country by extreme weather events over the past two decades. Furthermore, projections suggest that Mindanao could face year-long heat waves by 2050.

Table 2. Frequency of occurrence of extreme weather events

Weather Events	Weighted Mean	Description
Heat Waves	4.74	Always
Heavy Rainfall	3.07	Sometimes
Floods	1.78	Almost Never
Tropical Cyclones	1.77	Almost Never
Others (Earthquake)	1.20	Almost Never
Tornadoes	1.19	Almost Never

The frequent occurrence of heat waves corroborates the findings of Mora et al. (2017), who identified a threshold where high temperatures and relative humidity can become life-threatening. Their research suggests that 30% of the global population is exposed to these dangerous conditions for at least 20 days annually, a percentage that is projected to rise. The data indicate that heavy rainfall occurs relatively frequently, with a weighted mean of 3.07, categorizing it as "sometimes," and typically experienced up to three times a week. In contrast, tropical cyclones and floods are much less common, with weighted means of 1.77 and 1.78, respectively, placing them in the "almost never" category, indicating occurrences of no more than once every two weeks.

However, these patterns are expected to change significantly as global temperatures rise. Projections suggest an increase in the intensity of extreme rainfall events, estimating a 4.3% rise in rainfall intensity for each degree Celsius increase in global mean temperature (Villafuerte et al., 2015). Additionally, by 2100, the 20-year return value of annual maximum daily precipitation will increase by 8.5-17% across various climate scenarios. Regional assessments indicate that northwestern and eastern coastal areas will likely experience more pronounced increases in heavy rainfall (Hong et al., 2022).

This anticipated shift in weather patterns raises significant concerns for construction projects, as heightened rainfall intensity can lead to substantial delays, equipment malfunctions, and safety hazards. Consequently, the construction industry must implement targeted adaptation strategies to mitigate the adverse impact of these changing weather conditions effectively. Tornadoes were similarly infrequent, with a weighted mean of 1.19, reflecting their rarity in the area, as they typically occur less than once every two weeks. Earthquakes were also rare, with a mean of 1.20, showing they occur at similar intervals. A comparable study by Gandhi et al. (2014) reported similar trends in India, identifying high temperatures (4.517), rainfall (4.312), and drought or water restrictions (4.116) as the most frequent extreme weather events. This consistency across studies highlights the commonality of heat waves and rainfall as significant challenges for construction sectors.

3.2 Level of Impact of Extreme Weather on Construction Firms

Table 3 indicates a widespread concern among respondents regarding the significant impact of extreme weather on construction project timelines. With a weighted mean of 3.93, it is clear that extreme weather considerably influences project schedules.

Table 3. Level of impact of extreme weather on construction firms

Situations	Weighted Mean	Description
Project Timelines	3.93	Considerable Impact
Labor Productivity	3.73	Considerable Impact
Budgetary Allocations	3.40	Considerable Impact
Overall Quality and Durability of Construction Projects	3.36	Moderate Impact
Performance or Overall Quality of Construction Equipment	3.32	Moderate Impact

Heat stress represents a significant threat to workers' health, impairing their well-being and productivity, and can lead to substantial economic losses (Zander et al., 2018). The effects of hot and humid weather are particularly pronounced in the construction sector. Research conducted by Al Alawi (2020) in Oman illustrates that extreme temperatures can severely impact labor productivity and extend project timelines. The study found that adverse weather conditions, especially during periods of intense heat, can cause project delays ranging from 3% to 38% beyond the initially planned schedule. Additionally, Alaghbari et al. (2006) confirmed that heat waves significantly contribute to construction delays.

Other studies (Akomah & Jackson, 2016; El-Rayes & Moselhi, 2001; Ronalds, 2023; Pathiranage & Halwatura, 2010) have similarly highlighted the profound impact of extreme weather, particularly heavy rainfall, on road-building projects. Such adverse conditions can lead to delays due to safety concerns, worker discomfort, equipment malfunctions, and interruptions in critical construction activities. This underscores the necessity for the construction industry to factor in potential disruptions from extreme weather in its planning and risk management strategies.

In a similar study by Gandhi et al. (2014), logistics and supply chain disruptions were the most affected, making logistics the most critical concern. Delayed deliveries and transportation issues were crucial challenges, underscoring the widespread impact of weather on the logistics of construction projects. Moreover, this study revealed the impact of extreme weather on budgetary allocations for construction projects. Garnering a mean score of 3.40, placing it within the considerable impact category, it can be concluded that extreme weather substantially influences financial planning within the construction sector in Koronadal City. The results of the study of Gandhi et al. (2014) showed that the financial implications were also significant, particularly in increased marginal cost and revenue losses, highlighting similar concerns about the financial burden imposed by extreme weather.

The findings from this study align closely with the observations made by Alshebani and Wedawatta (2014) regarding the impact of extreme weather on labor productivity. In Koronadal City, the average score of 3.73 highlights that extreme weather considerably hinder labor efficiency among construction workers, echoing the findings of Gandhi et al. (2014), which emphasized severe effects on worker health, productivity, and attendance. According to the Dunne et al. (2013) study, environmental heat stress leads to a 10% reduction in labor productivity, which is projected to decrease to 80% by 2050. The studies of Alshebani and Wedawatta (2014), Gandhi et al. (2014), and Dunne et al. (2013) underscore the challenges faced by workers, including difficulties in reaching construction sites due to adverse weather conditions. These disruptions reduce productivity and reflect a broader trend where high temperatures and humidity levels negatively influence labor outcomes, resulting in decreased productivity and potential economic implications for the construction industry.

The result showed a mean value of 3.32 regarding the impact of extreme weather on construction equipment performance, indicating a moderate impact. Furthermore, the surveyed data illustrated a weighted mean of 3.36 for the impact of extreme weather on the overall quality and durability of construction projects. These projects experience moderate impact from extreme weather, highlighting the need to integrate weather adaptability into both the planning and execution phases of projects. According to Schuldt et al. (2021), weather conditions significantly impact construction materials, including concrete, asphalt, brick, and steel. Both extreme cold and heat can affect the strength and placement of concrete. At the same time, precipitation can impede asphalt application and masonry work—additionally, wind, temperature fluctuations, and rainfall challenge steelwork, particularly in vertical construction. Earthwork operations are also vulnerable; rainfall can lead to soil flooding while freezing temperatures complicate excavation efforts. These weather-related factors ultimately influence the overall quality and durability of construction projects.

Mill (2003) also highlights the effects of undertaking construction projects during extremely hot weather. Hot weather affects construction equipment functionality, concreting processes, workers' conditions, labor productivity, adherence to safety procedures, and financial considerations. Furthermore, extreme weather significantly affect construction projects, causing delays, safety risks, and equipment malfunctions (Pathirana & Halwatura, 2010). These disruptions can damage worksites, obstruct progress, and affect project timelines. This supports the findings of this study, which highlight the impact of weather on construction sites.

3.3 Potential Health and Safety Hazards that the Workers Encountered in the Construction Industry due to Extreme Weather in Koronadal City

The survey results on health and safety hazards related to extreme weather among construction workers reveal significant concerns (see Figure 1). Physical strain and fatigue were the most reported issues, affecting 90.40% of respondents, which highlights the substantial impact of extreme weather on worker endurance and efficiency. Similarly, heat-related illnesses were noted by 88.14% of participants, with 156 workers emphasizing this concern. These findings are consistent with the broader literature, such as Karthick et al. (2022), which points to outdoor workers being particularly vulnerable to heat strokes and extreme fatigue due to their physically demanding activities in high temperatures. Kiefer et al. (2016) also emphasize that prolonged exposure to high temperatures presents a significant health risk for construction workers engaged in strenuous tasks. Furthermore, high temperatures reduce worker productivity, and prolonged exposure to heat leads to heat-related illnesses (Schuldt et al., 2021).

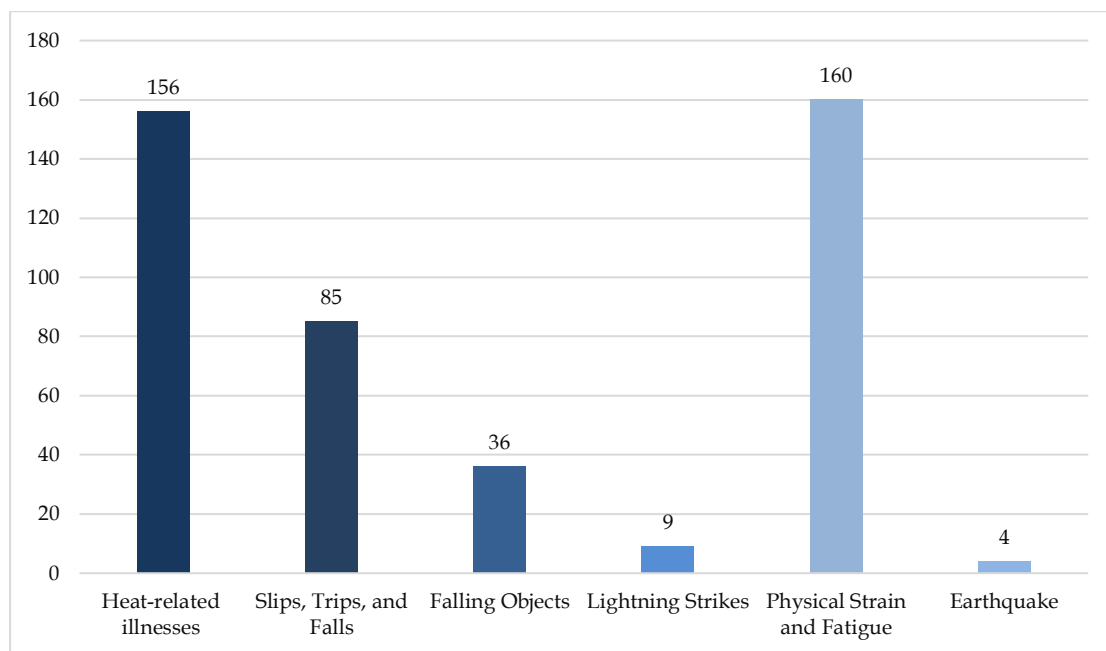


Figure 1. Potential health and safety hazards that the workers encountered in the construction industry due to extreme weather in Koronadal City

Furthermore, Gariazzo et al. (2023) demonstrated a significant correlation between elevated temperatures and increased occupational injuries in the construction industry. This highlights the heightened risks posed by extreme heat, confirmed by the survey's participants, who reported frequent heatwaves and hazards associated with hot weather at their workplaces. The frequent occurrence of heat waves compounds these health risks, as reflected in the high prevalence of heat-related illnesses reported in the survey. These findings underline the pressing need for effective health and safety strategies to mitigate the impact of extreme weather.

Additionally, 48.02% of respondents reported experiencing slips, trips, and falls, exacerbated by adverse weather conditions affecting surface stability and worker balance. In connection, Karthick et al. (2022) revealed that

extreme weather poses accidents, slips, and falls. Also, according to Schuldt et al. (2021), precipitation and wind impact workers' safety, slow productivity, and increase the risk of accidents. Falling objects (20.34%) and lightning strikes (5.08%) were less frequently reported but remained significant hazards, primarily during stormy or windy weather. Lastly, only 2.26% of respondents mentioned earthquakes as a safety concern.

In conclusion, the findings emphasize the significant impact of extreme weather on worker safety and project efficiency. As noted by most respondents, physical strain, fatigue, and heat-related illnesses point to the prevalence of heat waves, consistent with previous studies (Kiefer et al., 2016; Gubernot et al., 2013). Other hazards, such as slips, trips, falls, and falling objects, further underline the need for improved safety measures during adverse weather conditions (Karthuck et al., 2022; Schuldt et al., 2021). While earthquakes were mentioned less frequently, they suggest the need for broader safety preparedness in construction projects, especially in areas with regular seismic activity.

3.4 Perceived Level of Effectiveness of Resilience Measures Implemented on Construction Sites

This study also measured the perceived level of effectiveness of resilience measures currently implemented on the construction firms to mitigate the impact of extreme weather. Table 4 shows the level of effectiveness of resilience as perceived by the respondents.

Table 4. Perceived level of effectiveness of resilience measures implemented on construction sites

Resilience Measures	Weighted Mean	Description
1. Providing adequate hydration and regular breaks in shaded area.	4.33	Highly Effective
2. Utilization of adequate rest breaks, rotating tasks, and employee wellness programs.	4.24	Highly Effective
3. Development and communication of clear emergency response and evacuation plans	3.81	Considerably Effective
4. Incorporating resilient design features and reinforcing structures	3.81	Considerably Effective
5. Securing appropriate insurance coverage and implementing risk management strategies.	3.80	Considerably Effective
6. Diversifying the supply chain to reduce vulnerability to disruptions	3.77	Considerably Effective
7. Implementation of effective water management and drainage systems.	3.71	Considerably Effective
8. Regular monitoring of weather.	3.62	Considerably Effective

The respondents rated Adequate hydration and breaks highly effective, with a mean score of 4.33. This indicates that companies or agencies are proactively managing the risks associated with extreme weather by ensuring worker safety. Similarly, strategies such as rest breaks, task rotation, and wellness programs received a high mean score of 4.24, with 47.24 percent of respondents deeming them highly effective. This is also suggested in the study of Karthik et al. (2022), which suggests that employers should provide cool-down areas, encourage breaks, and offer cool water and electrolyte drinks. Lee et al. (2023) also recommended implementing flexible work hours to avoid peak heat periods. These studies confirm the effectiveness of these measures, as the respondents rated them as highly effective.

Employers should identify hazards, assess worker vulnerability, and develop control strategies. This may involve changes to work schedules, building safety, and communication plans (Levy & Roelofs, 2019). The study of Levy & Roelofs (2019) aligns with the survey's result that respondents considered the following measures effective: development and communication of clear emergency response and evacuation plans and incorporating resilient design features and reinforcing structures, with both having a weighted mean of 3.81. The study respondents also identified the following measures with their respective weighted mean as effective: securing appropriate insurance coverage and implementing risk management strategies (3.80), diversifying the supply chain to reduce vulnerability to disruptions (3.77), implementing effective water management and drainage systems (3.71), and regular monitoring of weather (3.62).

The findings of this study align with previous research emphasizing the importance of preparedness and risk management in mitigating the impacts of extreme weather (Fatima et al., 2023; Levy & Roelofs, 2019). The high ratings for weather forecasting, emergency planning, and resilient design underscore the significance of proactive measures in ensuring project resilience and worker safety. Collectively, these results highlight how important it is to put worker safety and well-being first in construction projects, especially when it comes to minimizing the impact of extreme weather. This shows that Koronadal City has a considerably high level of risk awareness and is implementing risk management strategies.

4.0 Conclusion

This study has demonstrated that construction projects in Koronadal City are subject to a variety of extreme weather, with heat waves and heavy rainfall occurring most frequently. These environmental challenges pose significant risks to both the efficiency and safety of construction activities. The recurrent nature of these conditions underscores the critical necessity for implementing effective strategies to mitigate their adverse impacts. It is imperative that construction companies and policymakers in Koronadal City prioritize the development and adoption of effective mitigation measures. Extreme weather in Koronadal City notably disrupt construction project timelines, budget allocations, labor productivity, construction equipment quality, and the overall quality of the projects. The data shows most construction workers report considerable impacts due to weather-related challenges, emphasizing the need for enhanced project management strategies that include weather adaptability and risk management plans.

The construction sector in Koronadal City faces significant health and safety risks due to extreme weather. Most notably, physical strain and fatigue, heat-related illnesses, slips, trips, and falls are prevalent among workers. These findings highlight the need for comprehensive health and safety protocols and worker training programs to mitigate these risks. The study reveals that extreme weather not only affects the health and safety aspects but also imposes significant economic and operational burdens on construction projects. Increased costs due to delays and damage, as well as the need for budget reallocation, are common, impacting the overall economic viability and efficiency of construction projects. The data gathered indicates that resilient construction practices, including provision of adequate hydration and regular breaks along with the utilization of flexible work schedule, are considered highly effective. Meanwhile, measures such as development and communication of clear emergency response and evacuation plans, incorporating resilient design features and reinforcing structures, securing appropriate insurance coverage and implementing risk management strategies, diversifying the supply chain to reduce vulnerability to disruptions, implementation of effective water management and drainage systems, and regular monitoring of weather are among the considerably effective measures on resilience. These shows that construction projects in Koronadal City implements effective resilience measures to mitigate the adverse impact of extreme weather.

Future research should focus on the impact of extreme weather on construction projects in Koronadal City compared to other regions, identifying challenges and resilience measures that can be adapted across diverse settings. Emphasis should be placed on developing innovative health and safety protocols, conducting cost-benefit analyses of resilience strategies, and evaluating policies to better manage weather risks. Expanding the study scope to include geological hazards and both public and private sector projects will provide a more comprehensive understanding of these challenges. Policymakers may consider amending existing laws to allow for weather-related suspensions in construction activities, while training programs and seminars for workers should be implemented to enhance preparedness and safety.

5.0 Contributions of Authors

The specific contributions of these authors are as follows:

Lenon V. Namuag: Conceptualization of study, Supervision, Writing and Editing, Checking, Validation
Joshua Marvin A. Noval: Conceptualization of Data Analysis, Writing and Editing, Checking, Validation
El-J A. Flores, Earl Ian T. Delgado, & Czeska Mae B. Pagay : Writing and Encoding, Data Gathering

6.0 Funding

This study was conducted without any financial support or funding.

7.0 Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this study.

8.0 Acknowledgment

The researchers would like to express their deepest gratitude to all who contributed to the completion of this research work. To the Divine Creator, the giver of life and wisdom, the authors offer this humble work with deep gratitude. They acknowledge His boundless mercy and providence, which have sustained them through challenges and inspired the research team to persevere in the pursuit of knowledge. The researchers would also like to extend their sincere appreciation to their families for their unwavering support, invaluable insights, and continuous encouragement throughout this academic journey. To the officials and employees of the Koronadal City Engineering Office, who extend their assistance in determining the research respondents that paved the way for the conduct of this study. The researchers are also thankful for the valuable inputs from their colleagues in the Civil Engineering Department of Mindanao State University – General Santos.

9.0 References

- Akomah, B. B., & Jackson, E. N. (2016). Contractors' perception of factors contributing to road project delay. *International Journal of Construction Engineering and Management*, 5(3), 79-85. <https://doi.org/10.5923/ijcem.20160503.02>
- Al Alawi, M. K. (2020). Modeling, Investigating, and Quantification of the Hot Weather Effects on Construction Projects in Oman. *The Journal of Engineering Research*, 17(2), 89-99. <https://journals.squ.edu.om/index.php/tjer/article/view/3696>
- Alaghabari, W. E., Razali A. Kadir, M., Salim, A., & Ernawati. (2007). The significant factors causing delay of building construction projects in Malaysia. *Engineering, construction and architectural management*, 14(2), 192-206. <https://doi.org/10.1108/09699980710731308>
- Alshehri, M. N., & Wedawatta, G. (2014). Making the construction industry resilient to extreme weather: Lessons from construction in hot weather conditions. In *Proceedings of the 4th International Conference on Building Resilience* (pp. 1-10). Salford Quays, United Kingdom. [https://doi.org/10.1016/S2212-5671\(14\)00985-X](https://doi.org/10.1016/S2212-5671(14)00985-X)
- Dunne, J. P., Stouffer, R. J., & John, J. G. (2013). Reductions in labour capacity from heat stress under climate warming. *Nature Climate Change*, 3(6), 563-566. <https://doi.org/10.1038/nclimate1827>
- El-Rayes, K., & Moselhi, O. (2001). Impact of rainfall on the productivity of highway construction. *Journal of Construction Engineering and Management*, 127(2), 125-131. [https://doi.org/10.1061/\(ASCE\)0733-9364\(2001\)127:2\(125\)](https://doi.org/10.1061/(ASCE)0733-9364(2001)127:2(125))
- Fatima, S. H., Rothmore, P., Giles, L. C., & Bi, P. (2023). Impacts of hot climatic conditions on work, health, and safety in Australia: A case study of policies in practice in the construction industry. *Safety Science*, 165, 106197. <https://doi.org/10.1016/j.ssci.2023.106197>
- Gandhi, S., Gupta, A., & Sethi, S. (2014). Extreme weather events and climate change impact on construction small medium enterprises (SME's): Imbibing indigenous responses for sustainability of SME's. *Journal of Earth Science & Climatic Change*, 5(1), 173. <https://doi.org/10.4172/2157-7617.1000173>
- Gariazzo, C., Taiano, L., Bonafede, M., Leva, A., Morabito, M., de' Donato, F., & Marinaccio, A. (2023). Association between extreme temperature exposure and occupational injuries among construction workers in Italy: An analysis of risk factors. *Environment International*, 171, 107677. <https://doi.org/10.1016/j.envint.2022.107677>
- Guadalupe, A., Ozaki, A., & Tanimoto, T. (2018). Smarter solutions for hotter times: what the Philippines can do. *The Lancet Planetary Health*, 2(2), e56-e57. [https://doi.org/10.1016/s2542-5196\(18\)30003-2](https://doi.org/10.1016/s2542-5196(18)30003-2)
- Gubernot, D. M., Anderson, G. B., & Hunting, K. L. (2014). The epidemiology of occupational heat exposure in the United States: a review of the literature and assessment of research needs in a changing climate. *International journal of biometeorology*, 58, 1779-1788. <https://doi.org/10.1007/s00484-013-0752-x>
- Heng, P. P., Mohd Yusoff, H., & Hod, R. (2024). Individual evaluation of fatigue at work to enhance the safety performance in the construction industry: A systematic review. *PLoS one*, 19(2), e0287892. <https://doi.org/10.1371/journal.pone.0287892>
- Hong, J., Agustin, W., Yoon, S., & Park, J. S. (2022). Changes of extreme precipitation in the Philippines, projected from the CMIP6 multi-model ensemble. *Weather and Climate Extremes*, 37, 100480. <https://doi.org/10.1016/j.wace.2022.100480>
- Karthick, S., Kermanshachi, S., Pamidimukkala, A., & Namian, M. (2022). A review of construction workforce health challenges and strategies in extreme weather conditions. *International Journal of Occupational Safety and Ergonomics*. <https://doi.org/10.1080/10803548.2022.2082138>
- Karthick, S., Kermanshachi, S., & Namian, M. (2022). Physical, Mental, and Emotional Health of Construction Field Laborers Working in Extreme Weather Conditions: Challenges and Overcoming Strategies. In F. Jazizadeh, T. Shealy, & M. J. Garvin (Eds.), *Construction Research Congress 2022: Health and Safety, Workforce, and Education - Selected Papers from Construction Research Congress 2022* (pp. 726-736).
- Kiefer, M., Rodríguez-Guzmán, J., Watson, J., van Wendel de Joode, B., Mergler, D., & da Silva, A. S. (2016). Worker health and safety and climate change in the Americas: issues and research needs. *Revista Panamericana de Salud Pública*, 40, 192-197. <https://pmc.ncbi.nlm.nih.gov/articles/PMC5176103/>
- Lee, D., Kim, H., Cho, H., Youn, J., & Jeong, K. (2023). A Study of Measures to Improve Construction Site Safety Management in Preparation of Heat Waves Caused By Climate Change. *International Journal of Applied Engineering and Technology*, 5(4), 89-96. <https://tinyurl.com/523f6ejz>
- Levy, B. S., & Roelofs, C. (2019). Impacts of climate change on workers' health and safety. In B. S. Levy & C. Roelofs, *Oxford Research Encyclopedia of Global Public Health*. Oxford University Press. <https://doi.org/10.1093/acrefore/9780190632366.013.39>
- Mills, E. (2003). Climate change, insurance and the buildings sector: technological synergisms between adaptation and mitigation. *Building Research & Information*, 31(3-4), 257-277. <https://doi.org/10.1080/0961321032000097674>
- Mora, C., Dousset, B., Caldwell, I. R., Powell, F. E., Geronimo, R. C., Bielecki, C. R., Counsell, C. W. W., Dietrich, B. S., Johnston, E. T., Louis, L. V., Lucas, M. P., McKenzie, M. M., Shea, A. G., Tseng, H., Giambelluca, T. W., Leon, L. R., Hawkins, E., & Trauernicht, C. (2017). Global risk of deadly heat. *Nature Climate Change*, 7(7), 501-506. <https://doi.org/10.1038/nclimate3322>
- Pathiranage, Y. L., & Halwatura, R. U. (2010). Factors influencing the duration of road construction projects in sri lanka. *Engineer: Journal of the Institution of Engineers, Sri Lanka*, 43(4), 17. <https://doi.org/10.4038/engineer.v43i4.6997>
- Raftery, A. E., Zimmer, A., Frierson, D. M. W., Startz, R., & Liu, P. (2017). Less than 2 °C warming by 2100 unlikely. *Nature Climate Change*, 7(9), 637-641. <https://doi.org/10.1038/nclimate3352>
- Rizwan, M. (2020). Evaluating the Impacts of Extreme Weather Events on the Infrastructure Development or Construction Industry In Ontario (Thesis). McMaster University
- Ronalds, R. (2023). Not again! A case study of heavy and recurring rainfall during a construction project. Retrieved from <https://tinyurl.com/523rxv35>
- Seposo, X. T., Dang, T. N., & Honda, Y. (2017). Exploring the effects of high temperature on mortality in four cities in the Philippines using various heat wave definitions in different mortality subgroups. *Global Health Action*, 10(1), 1368969. <https://doi.org/10.1080/16549716.2017.1368969>
- Schuldt, S. J., Nicholson, M. R., Adams, Y. A., & Delorit, J. D. (2021). Weather-related construction delays in a changing climate: a systematic state-of-the-art review. *Sustainability*, 13(5), 2861. <https://doi.org/10.3390/su13052861>
- Villafuerte, M. Q., Matsumoto, J., & Kubota, H. (2015). Changes in extreme rainfall in the Philippines (1911-2010) linked to global mean temperature and ENSO. *Int. J. Climatol*, 35(8), 2033-2044. <https://doi.org/10.1002/joc.4105>
- Yildirim, K., Koyuncu, C., & Koyuncu, J. (2009). Does temperature affect labor productivity: Cross-country evidence. *Applied Econometrics and International Development*, 9(1), 29-39. <https://tinyurl.com/3am3ca29>
- Zander, K. K., Cadag, J. R., Escarcha, J., & Garnett, S. T. (2018). Perceived heat stress increases with population density in urban Philippines. *Environmental research letters*, 13(8), 084009. <https://doi.org/10.1088/1748-9326/aad2c5>