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The Superficial Impacts of Underground Mining on Its Neighboring Areas Amid a Typhoon: A Narrative Review

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Abstract**—***Underground mining is crucial for extracting valuable minerals but presents significant environmental and safety risks, especially in regions prone to typhoons. This study examines the superficial impacts of underground mining on neighboring areas, focusing on issues such as land subsidence, soil degradation, groundwater contamination, infrastructure damage, biodiversity loss, and challenges in land reclamation. These impacts are compounded when severe weather events like typhoons exacerbate mining-related disruptions. The sad landslide in Masara, Maco, Davao del Sur, where a mix of mining-caused subsidence and typhoon-related heavy rains resulted in a devastating conclusion, is highlighted in the study. This event exemplifies the amplified risks associated with underground mining amid typhoons and underscores the need for comprehensive risk management strategies. The findings suggest that underground mining can weaken infrastructure, leading to increased instability during typhoons, and can contribute to groundwater contamination and soil erosion, posing significant health and environmental risks. Additionally, the combination of underground mining and typhoons can have a devastating effect on biodiversity and ecosystem health. Several knowledge gaps are identified, including the specific mechanisms by which typhoons affect land subsidence patterns, the spread of contaminants in groundwater during heavy rainfall, and the combined impact of mining subsidence and typhoons on infrastructure. Further research is needed to develop sustainable mining practices, effective land reclamation strategies, and robust risk assessment measures. Given the severity of the risks, this study recommends stricter regulations, prioritized environmental protection, and ongoing research to mitigate the adverse effects of underground mining in typhoon-prone regions. By addressing these knowledge gaps, stakeholders can work toward ensuring the safety and well-being of communities living in mining-affected areas.*

Keywords**—** *Biodiversity loss; Environmental risk; Groundwater contamination; Infrastructure damage; Land reclamation; Land subsidence; Soil degradation; Typhoons; Underground mining.*

I. INTRODUCTION

Mining is a labor-intensive industry crucial for extracting valuable minerals from the earth, contributing significantly to government revenues and economic growth (Rehman et al., 2021 as cited by Stephen et al., 2019). In the Philippines, underground mining is a major type of modern mining, particularly suitable for extracting minerals like lead, silver, and gold from below the earth's surface (Cummins, n.d.). This method involves burrowing tunnels into the rock to access ore deposits, with the potential risk of accidents leading to miners being trapped underground (National Geographic Education, n.d.).

As a result, in their quest for profit, mining companies take advantage of our natural resources by removing these minerals. Due to its greed, the extractive industries (mining and mineral processing) have long been blamed for a variety of global environmental and sociocultural issues (Salman et al., 2022). There is no denying that there have always been ecological and environmental issues related to mining operations, from the building of mining infrastructure to the extraction and processing of minerals. Local peoples' livelihoods are destroyed in areas where mining operations are carried out because some of them have been threatened, uprooted, or even killed for trying to oppose mining operations in their community.

Unfortunately, it's a bummer that mining companies care more about money than the planet and people, which causes all kinds of problems around the world. Mining areas are often plagued by ecological and environmental issues that harm the people who live there and sometimes cause disasters like the recent landslide in a Philippine gold mining village at Masara, Maco, Davao del Sur, where many people died and people want the mining company to take responsibility (Mongabay, 2024).

This study aims to understand how underground mining affects nearby areas, especially in places where typhoons often happen. Underground mining is vital for extracting minerals but can cause serious problems like land subsidence, soil damage, groundwater contamination, and loss of biodiversity. These problems become worse when typhoons hit, sometimes leading to disasters, like the recent landslide in Masara, Maco, Davao del Sur.

The study looks into how underground mining can cause environmental and infrastructure damage and how typhoons make these issues worse. It also emphasizes the need for better risk management and more responsible mining practices. The focus on the Masara landslide shows why mining companies need to take safety seriously and be held accountable.

This study aims to examine the superficial impacts of underground mining on neighboring areas, with a focus on several key issues, including land subsidence, soil degradation, groundwater contamination, infrastructure damage, biodiversity loss, and challenges in land reclamation. The research also seeks to explore how these impacts are compounded by severe weather events like typhoons. By reviewing existing studies, the paper aims to identify knowledge gaps and propose areas for further research.

1. *Superficial Impacts of Underground Mining Underground mining is a significant contributor to surface-*

level disruptions and degradation. This literature review consolidates research on the impacts of underground mining on various aspects of surface environments, examining issues like subsidence, soil degradation, groundwater contamination, erosion, infrastructure damage, biodiversity loss, and challenges in land reclamation (Liu, Xu, & Zhang, 2023).

1.1 Subsidence and Surface Deformation

Mining subsidence can lead to the leaching of surface soil water and nutrients, thereby reducing the soil quality (Sengupta, 2018). The mining subsidence causes the loss of soil water and nutrients, which is the direct cause of the decrease in soil fertility and degradation, especially in arid and semi-arid areas (Ma et al., 2019).

From this, it can be said that the environmental impact of mining subsidence on soil quality is an important part of it. One of the most dangerous geological risks is terrain subsidence, which has an impact on slopes and engineering structures (Ma et al., 2019). This hazard not only brings disaster to the mountains but also the urban area, this shows that the surface deformation caused by underground mining has a broad and far-reaching impact.

Of course, the problems and hazards brought by surface deformation are far more than that. Ma, Shuyue, et al. (2022) researched the multi-hazard effect of underground coal mining and put forward the opinion that surface deformation is a comprehensive disaster, and it also highlights the connection between surface deformation and its various hazards. The results of this study indirectly illustrate the problem of the relationship between the effects of subsidence and surface deformation and the complex state. Yang, Xuelin, et al. (2019) explored the evolution of ground subsidence and surface cracks of shallow-buried close-distance multi-seam mining. Therefore, the research of multifactor interaction in this paper provides a referential and comparative basis for further research and emphasizes the importance of an in-depth study of subsidence and surface deformation. The analysis of the results is valuable, so it is also necessary for this paper to carry out more in-depth research and comparison on this basis, especially on the question of whether the type of surface deformation affects the hazard caused by the difference.

1.2 Soil Degradation

Underground mining activities, particularly coal extraction, have been identified as a significant contributor to soil degradation, leading to the subsidence of agricultural land and loss of productivity (Emmanuel, Jerry, & Dzigbodi, 2018). The impact of underground longwall mining on prime agricultural land has been a particular area of concern, prompting research and policy discussions on how to mitigate these effects (Lechner, Baumgartl, Matthew, & Glenn, 2016). This issue is not unique to a specific geographic location, as studies have shown that land subsidence due to coal mining can lead to reduced soil fertility and soil degradation in arid and semi-arid regions (Ma, Zhang, Ruan, Guo, & Chai, 2019).

The adverse impacts of underground mining on soil degradation have also been identified in the context of ecological restoration following land degradation by mining activities. Liang et al. (2020) found that novel phosphate-solubilizing bacteria play a crucial role in enhancing soil phosphorus cycling, thereby contributing to the restoration of soil health and quality. This highlights the potential for bio-remediation strategies to mitigate the negative effects of mining on soil degradation.

In addition to coal extraction, bauxite mining activities have also been associated with soil degradation. The possibility of soil formation is indicated by the growth of alkaline electrochemical properties in bauxite residue that is undergoing natural rehabilitation, as shown by Kong et al. (2018). This suggests that natural rehabilitation processes can potentially counteract soil degradation resulting from mining activities.

While the literature has provided valuable insights into the factors contributing to soil degradation in the superficial impacts of underground mining, there are notable knowledge gaps that warrant further investigation. For instance, Mazaira and Konicek (2015) highlighted the intense rock burst impacts in deep underground construction and the importance of prevention strategies. The extension of such studies to the superficial impacts of underground mining, particularly in the context of soil degradation, would provide valuable insights into the comprehensive understanding of this issue.

1.3 Groundwater Contamination and Surface Erosion

Concerns about the possible health effects and environmental damage linked to heavy metal contamination and changed soil and groundwater hydrology have made underground mining's effects on groundwater contamination and surface erosion increasingly pressing.

The serious problem of heavy metal pollution from mining operations, which may endanger locals' health, was brought to light by Mazaira and Konicek (2015). Water samples taken from rural areas close to mines showed concentrations of arsenic (As), cadmium (Cd), and chromium (Cr) higher than the World Health Organization's (WHO) recommended levels for drinking water. The urgency of developing practical solutions to reduce heavy metal pollution and safeguard the public's health is highlighted by this.

Shams et al. (2020) further supported this concern by assessing the exposure to heavy metals and the associated carcinogenic and non-carcinogenic human health risks in the groundwater around mines in Joghatai, Iran. Their findings underscored the urgent need for comprehensive risk assessment and management strategies to safeguard human health in areas affected by underground mining activities.

The impact of underground coal extraction techniques, such as longwall mining, on surface erosion and soil hydrology alterations was explored by Lechner et al. (2016). They highlighted that longwall mining causes agricultural land to subside, which changes the soil and groundwater hydrology, changes the topography, and raises the possibility of increased erosion or waterlogging. Additionally, zones of compaction or cracking cause significant changes in soil physical and chemical properties. These findings underscore the complex interplay between underground mining activities and surface erosion, indicating the need for a holistic approach to effectively manage environmental impacts.

1.4 Environmental Disruption and Biodiversity Loss

Environmental disruption and biodiversity loss as a result of mining activities have been of increasing concern. The impact of underground mining on ecosystems, biodiversity, and human well-being is a topic of intense research and debate. Anthropogenic environmental changes have been found to affect ecosystem stability via biodiversity (Hautier et al., 2015). This suggests that the environmental disruptions caused by mining activities, especially in underground mining, can lead to significant loss of biodiversity. Furthermore, Sonter et al. (2018) highlight the key issues and research needs in conservation science related to mining and biodiversity, emphasizing the urgency of understanding and mitigating the impacts of mining on biodiversity.

Isbell et al. (2013) discuss the consequences of nutrient enrichment and biodiversity loss on declines in ecosystem productivity. This finding highlights the interconnectedness of environmental disruption and biodiversity loss, indicating that activities such as underground mining can lead to nutrient enrichment and subsequent declines in ecosystem productivity.

A review of the worldwide effects of climate change, adaptation strategies, and long-term mitigation strategies is presented by Abbass et al. (2022). While not specific to underground mining, this research underscores the broader environmental impact of human activities and the urgent need for sustainable mitigation measures to address these challenges.

Baan et al. (2013) and Marques et al. (2019) investigate the impacts of land use on biodiversity, highlighting the increasing impacts driven by population and economic growth. These findings are relevant to the discussion of mining activities, as they contribute to land use changes that can have detrimental effects on biodiversity.

Leip et al. (2015) and Reynolds et al. (2015) investigate the impacts of livestock production and food crop production on nitrogen, sulfur, and phosphorus emissions, and environmental constraints associated with agricultural activities. While not directly related to mining, these studies provide insights into the broader environmental impacts of human activities and the potential parallels with the impacts of mining on biodiversity.

The environmental consequences of big oil palm businesses, which Lee et al. (2014) claims are worse than those of Indonesian smallholders, are discussed. While not specific to mining, this research highlights the significant environmental disruptions caused by large-scale industrial activities, which may parallel the impacts of underground mining on biodiversity.

The severe effects of rock bursts in deep underground construction and the preventative strategies are discussed by Mazaira and Konicek (2015). While specific to construction activities, these findings are relevant to underground mining, as they underscore the potential for significant environmental disruptions in underground environments and the need for preventive measures to mitigate these impacts.

Cooper and Gutowski (2017) review the environmental impacts of reuse, emphasizing the importance of considering the environmental consequences of human activities. While not specific to mining, this research underscores the need for a holistic understanding of environmental impacts across various human activities, including mining.

1.5 Infrastructure Damage

Understanding and mitigating these impacts is crucial for ensuring the safety and stability of underground constructions. Mazaira and Konicek (2015) discuss intense rockburst impacts in deep underground construction and methods for their prevention. They highlight the need for effective rockburst prevention strategies to minimize infrastructure damage in underground mining activities. The authors emphasize the importance of understanding the mechanisms and characteristics of rock bursts to develop effective prevention measures.

Backers and Stephansson (2012) present the ISRM Suggested Method for the Determination of Mode II Fracture Toughness, which is relevant to understanding the behavior of rock masses under mining-induced stress. This research finding is important for assessing the potential for infrastructure damage in superficial impacts of underground mining, as it provides insights into the fracture behavior of rock formations.

Przyłucka et al. (2015) discuss the combination of conventional and advanced DInSAR (Differential Synthetic Aperture Radar Interferometry) techniques to monitor very fast mining subsidence. This research finding is relevant to understanding the extent and magnitude of subsidence events in mining areas, which directly impact the stability of surface infrastructure. By monitoring subsidence, it is possible to assess the risk of infrastructure damage and implement mitigation measures accordingly.

1.6 Challenges in Land Reclamation

Subterranean mining has been linked to several difficulties in the process of reclaiming land, especially concerning the surface effects on the land. Key problems associated with underground longwall mining operations include altered soil and groundwater hydrology, topographical modification, and increased erosion or waterlogging risk (Lechner, Baumgartl, Matthew, & Glenn, 2016). These actions may also result in the development of compaction or cracking zones, which can alter the physical and chemical composition of the soil. These results draw attention to the intricate relationships that exist between mining operations and the environment, relationships that can provide substantial obstacles to land reclamation initiatives.

This means that the challenge with the impacts of underground mining on the surface is that mining deep below ground can cause changes to the land above in ways that are difficult to fix. When miners remove large amounts of material from underground, the ground above can sink or shift, a process known as subsidence. This can create dips, cracks, or uneven surfaces, leading to changes in the landscape. These shifts can also affect how water moves through the soil and underground. If water pathways are blocked or altered, it can lead to waterlogging or it can drain water away, causing dry patches. When the ground moves or cracks, it can cause erosion, where wind or water washes away soil. This can make the land less stable and harder to reclaim.

It has been discovered that underground mining operations not only physically alter the land but also cause the loss of water and nutrients in the surface soil, which eventually degrades the

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quality of the soil (Ma, Zhang, Ruan, Guo, & Chai, 2019). The difficulties involved in land reclamation in mining areas are further compounded by the loss of soil fertility and the deterioration of the soil in arid and semi-arid regions. The enduring consequences of these discoveries emphasize the necessity of all-encompassing approaches to tackle the effects of subterranean mining on soil fertility and quality, especially in areas with restricted water supplies. In short, underground mining can also change the soil itself, making it compacted or creating cracks. This can harm the soil's structure, affecting plant growth and making it less fertile. Because of all these changes, the soil might lose important nutrients, which are crucial for plants and other life. This makes it harder to grow things on the land later.

And lastly, the combined effects of land shifting, water changes, erosion, and soil damage can disrupt local ecosystems, affecting plant and animal life. When it comes to reclaiming land after underground mining, all these factors make it tough. You can't just fill in the holes and expect things to return to normal. You have to fix the structure of the land, manage the water, and restore nutrients to the soil, which takes a lot of work and careful planning.

2. *Underground Mining Impacts in its Neighboring Areas Amid Typhoon*

Everything from water quality to land stability is impacted by underground mining's severe effects on the environment. Typhoon-induced severe weather conditions can intensify these effects, thereby increasing the risks to human safety and the environment.

2.1 Land Stability and Subsidence

Underground mining can lead to ground subsidence, causing surface cracks and land instability, exacerbated during typhoons (Yang et al., 2019). As a terrible example of the increased danger, Mongabay (2024) reported that a fatal landslide occurred in a Philippine mining community after a typhoon. Subsidence increases the danger of landslides and erosion, posing a threat to infrastructure and raising larger environmental and safety issues.

Typhoons, with their heavy rains and strong winds, can make this instability even worse. The intense rain can fill those underground spaces, making the ground heavier and more likely to collapse. The powerful winds can push against already weakened areas, causing further cracks and movement. These issues create broader safety and environmental concerns. Communities near mining areas might be at greater risk of accidents and damage to their homes and infrastructure. Land stability problems also disrupt the natural environment, harming plant and animal habitats.

Overall, the combination of underground mining and typhoons can create severe risks to both people and the environment, requiring careful planning and safety measures to protect against these dangers.

2.2 Groundwater Contamination

Mining activities often release harmful substances into the environment, which can seep into groundwater (Mazaira & Konicek, 2015). Shams et al. (2020) noted that heavy metals from mining can contaminate groundwater, posing health risks to local communities. Typhoons, with their intense rainfall and flooding, can exacerbate the spread of these contaminants, leading to widespread environmental and public health concerns.

Because of this, when you have both underground mining and typhoons, there's a greater chance of groundwater contamination. This not only creates environmental concerns but also raises public health issues. Communities near mining areas may find their water sources unsafe to use, leading to a need for clean water solutions and more intense environmental clean-up efforts. The impact can be widespread, affecting people's health, wildlife, and the overall quality of the environment.

2.3 Infrastructure Damage

Underground mining can weaken infrastructure, with subsidence causing roads, buildings, and other structures to become unstable (Przyłucka et al., 2015). Typhoons can cause further damage with strong winds and heavy rain, increasing the risk of collapse or significant structural damage. This is especially concerning in regions where mining-induced subsidence has already compromised stability.

Imagine when a typhoon hit this area. Typhoons bring super-strong winds and heavy rain. These extreme weather conditions can put extra stress on already unstable structures. If a road has cracked because of subsidence, the heavy rain from a typhoon can make the crack bigger or even wash parts of the road away. Buildings with unstable foundations are at risk of collapsing because the ground is no longer solid beneath them.

Overall, when underground mining and typhoons combine, the impact on infrastructure can be severe. Roads may become unsafe, buildings could collapse, and essential services like water and electricity could be disrupted. This makes it challenging for communities to stay safe and recover after a typhoon, especially in areas where mining has already caused significant damage to the ground and the structures built on it.

2.4 Biodiversity Loss and Ecosystem Disruption

Underground mining and typhoons both impact biodiversity and ecosystems. Sonter et al. (2018) found that mining activities contribute to habitat destruction, leading to biodiversity loss. Typhoons can further disrupt ecosystems, reducing stability and hindering recovery (Hautier et al., 2015). The combined stress from mining and typhoons can have long-lasting effects on ecosystem health and biodiversity.

In short, the combination of the effects of underground mining with those of a typhoon can destroy biodiversity and ecosystems. For example, if the mining is already taking its toll on habitats and forcing wildlife out, then a typhoon can further deteriorate the situation due to too much stress. However, the impacts may continue to influence the health of the ecosystem. It may take years for nature to heal, and in some places, certain plants and animals may never return.

2.5 Soil Degradation

Underground mining can cause soil degradation due to subsidence and reduced soil fertility (Emmanuel, Jerry, & Dzigbodi, 2018). When typhoons bring heavy rains, they can further erode soil, leading to increased degradation. Lechner et al. (2016) discussed the impact of underground mining on soil structure, which can be worsened by the heavy rainfall associated with typhoons.

Furthermore, when typhoon is usually associated with a lot of heavy rain and strong winds. It may additionally exacerbate the damage of mining since a large amount of water can wash away the topsoil that is the richest, eroding it. The water losses soil from the area, which is accompanied by cracking and other irregularities, makes the lan even less stable. Soil that has less stable structures, as industrial soil usually does, may slide down as a landslide when the storm water is not absorbed but flows in all directions. The nasty thing is that it takes away the soil as well. Moreover, when enough rain happens, it floods areas, creating standing water. The standing water aside from damaging the soil will make it almost impossible to plant anything.

As Lechner et al. reported underground mining destroys the soil structure by breaking it into pieces and makes it easy for the soil to erode. These concerns can be compounding why larger amounts of water and winds carrying the legacies of a typhoon will make soil degradation even less accessible and much more needed to reclaim and restore land.

2.6 Challenges in Land Reclamation

Land reclamation in areas affected by underground mining is challenging due to subsidence and soil degradation (Lechner et al., 2016). Typhoons can exacerbate these issues by causing further erosion and altering topography. Successful reclamation efforts must consider the combined impacts of mining and extreme weather events to ensure sustainable restoration and minimize long-term damage.

For instance, when there is a typhoon, the situation only gets worse. Due to the deluge and gusts of wind brought by each typhoon, even more, erosion may occur – many layers of soil may be taken away, more dips and cracks may form, and sometimes, the ground may simply slide. Dirt and debris may spin and get into the air or water current – as a result, the topography changes. As for its reclamation, that is, an attempt to restore and adjust a land for use, it will be more challenging to solve this issue than to fill in subsidence brought by underground mining. It means the consequences of extreme weather will have to be fixed, or it will be required to take into account the damage that typhoons may cause.

1. Mechanisms of Land Subsidence During Typhoons Research has shown that subsidence of the land surface can be caused by underground mining, which can result in great harm to the surface structures and ecosystems. Nevertheless, we know little about how these patterns change during typhoons and specifically how such factors as heavy rains and strong winds worsen the problems associated with subsidence. Comprehensive research is required to define these relationships so as to predict hazard-prone areas under extreme weather conditions better.
2. Groundwater Contamination Patterns in Typhoon- Prone Regions

Although studies such as Mazaira and Konicek (2015) and Shams et al. (2020) have recognized the possibility of heavy metal pollution associated with mining; however, we do not know how typhoons contribute to the spread of contaminants in groundwater. Thus, there is a need for more studies to evaluate the movement of pollutants during typhoon events and their consequential effects on local water quality over time. Soil erosion and leaching of mine waste materials into groundwater when it rains heavily are some of the important things that should be taken care of.

3. Infrastructure Damage Linked to Mining Subsidence and Typhoons

The research has shown that underground mining-related subsidence weakens infrastructure and leads to unstable roads, buildings, and other structures. Nevertheless, there is limited information on how these undermined infrastructures are affected by typhoons. Such studies in areas with high mining activities will help in devising mitigation measures by examining the ways through which building structures are damaged during typhoons.

4. Biodiversity Loss and Ecosystem Disruption During Typhoons

When mining, habitat is destroyed and biodiversity is lost. Moreover, typhoons can exacerbate ecosystem disturbances that have cumulative consequences on biodiversity. Mining-impacted ecosystems during severe weather events are studied to understand the devastation caused by typhoons and long-term effects on biodiversity. For example, future studies should focus on the resilience of ecosystems within mining areas as regards extreme weather patterns like typhoons and their potential for ecological restoration.

5. Comprehensive Assessment of Soil Degradation Due to Underground Mining and Typhoons

Studies have shown that soil degradation is a result of underground mining, but we haven't really looked into how typhoons affect soil fertility and structure. It's important to research the long-term impact of mining-related subsidence on soil quality and understand how typhoons contribute to erosion and soil loss. Finding new ways to reclaim and restore soil through innovative techniques could be the key to tackling these challenges.

6. Challenges in Land Reclamation and Sustainable Restoration Amid Typhoons

Land reclamation plays a crucial role in areas affected by mining, but dealing with typhoons can make things even more complicated. These powerful storms can cause erosion and change the shape of the land, making it challenging to restore. Surprisingly, there hasn't been much research on sustainable land reclamation strategies that consider both underground mining and typhoons. It would be really helpful to explore innovative techniques that can withstand extreme weather events. This way, we can ensure effective land reclamation and ecological restoration.

7. Combined Effects of Underground Mining and Typhoons on Local Communities

The impact of underground mining on local communities is a well-known concern, but there hasn't been much research on how typhoons worsen these effects. It would be beneficial for future studies to explore how the combined impact of underground mining and typhoons affects the social, economic, and health dynamics in neighboring areas. It's important to understand these impacts so that we can develop comprehensive risk management strategies and ensure the resilience of the community.

II. Conclusion

Underground mining leads to several environmental and infrastructural issues, including land subsidence, soil degradation, and groundwater contamination. Typhoons intensify these impacts, causing greater surface instability, structural damage, and broader environmental disruption. The review emphasizes that typhoon-induced subsidence and erosion can trigger catastrophic events, as seen in Masara, where the combination of mining-induced subsidence and typhoon-related heavy rains contributed to a devastating landslide.

A recent review highlights the connection between typhoon-induced subsidence and erosion, and the occurrence of catastrophic events. An example of this can be seen in Masara, where a devastating landslide was triggered by a combination of mining-induced subsidence and heavy rains brought on by a typhoon.

The combined effects of mining and typhoons pose significant risks to local communities, ecosystems, and infrastructure. This raises urgent concerns about public health, safety, and biodiversity. The contamination of groundwater from mining activities, which is further exacerbated by typhoons, calls for robust risk assessment and management strategies to protect the well-being of affected communities. Similarly, the impact on biodiversity due to habitat destruction is a critical issue that requires immediate attention and innovative conservation strategies.

The review also identifies several areas where further research is needed. These include understanding the specific mechanisms by which typhoons influence land subsidence, studying the impact of heavy rainfall on the dispersion of contaminants, and investigating the combined effect of subsidence and typhoons on infrastructure damage. Additionally, comprehensive studies are required to assess the social, economic, and health impacts of mining and typhoons on neighboring communities.

Moving forward, it is crucial to focus on developing environmentally friendly mining techniques that can withstand severe weather conditions. This involves creating efficient land reclamation plans, monitoring subsidence patterns, and exploring cutting-edge restoration methods. By addressing these gaps, policymakers and business executives can ensure the safety and resilience of areas affected by mining, and implement more effective risk mitigation strategies.

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