Assessing Stormwater Infrastructure Challenges in the Philippines
(Technical Topic)

Flooding and Community Impacts: Understanding Community Responses to Flooding in the Philippines
(STS Topic)

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By

Jeremiah Castillo

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Technical Team Members: Scout Bale, Emma Coutts, Esther Park, Greg Zeckman

On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

ADVISORS

Dr. Caitlin Wylie, Department of Engineering and Society

Somayeh Asadi, Development of Civil and Environment Engineering

Introduction:

As climate change intensifies and urban areas expand, the Philippines faces growing stormwater management challenges. Inadequate infrastructure, urban runoff, and frequent typhoons exacerbate flooding, impacting communities across the country. Following Typhoon Ondoy in 2009, the deficiencies in Metro Manila's flood management system became evident, underscoring the need for improved drainage, flood forecasting, and integrated community-based strategies (Gilbuena et al., 2013). These issues are further compounded around Laguna Lake, where rapid urbanization and pollution overwhelm stormwater infrastructure, jeopardizing both the environment and flood mitigation efforts (Reyes et al., 2018). The rising pollutant levels from urban runoff, wastewater, and industrial discharge not only increase flood risks but also pose significant public health concerns, as evidenced by frequent exceedances of water quality limits for ammonia and phosphorus (Reyes et al., 2018). At the same time, community responses to flooding play a crucial role in managing its impact. In flood-prone areas such as Cagayan de Oro and Zamboanga City, local communities have adopted self-organized solutions like rainwater harvesting and relied on social networks to cope with inadequate government support (Paguigan, 2023; Zabala, 2023). These community-driven initiatives, shaped by socio-economic conditions, local knowledge, and available resources, illustrate the intersection of social systems and technological interventions in influencing decisions to stay or evacuate during floods.

This prospectus will explore both stormwater infrastructure challenges and community responses to flooding in flood-prone regions. The technical aspect will focus on assessing stormwater infrastructure challenges in the Philippines, while the STS aspect will

examine how communities in these areas respond to flooding, providing insights into the complex relationship between technology, governance, and social systems.

Technical Topic: Assessing Stormwater Infrastructure Challenges in the Philippines

The Philippines faces ongoing challenges in stormwater infrastructure, particularly in managing the impacts of heavy rainfall and typhoons on urban areas like those surrounding Laguna Lake. Laguna Lake is described as the largest inland freshwater body in the Philippines (Reyes et al., 2018, pg. 1), serving essential functions such as "aquaculture, natural detention basin for flood control, and a source of water for domestic, commercial, and industrial water supply, among others" (Reyes et al., 2018, pg. 2). However, these functions are increasingly compromised by pollution from urban runoff, domestic wastewater, and industrial discharge which have significantly degraded water quality (Reyes et al., 2018). Compounding these issues, rapid population growth and urbanization, industrialization, and deforestation have led to a substantial increase in pollutant levels, making effective stormwater management essential for both ecological and human health (Reyes et al., 2018, pg. 2).

The lake's watershed, which receives runoff from "densely populated urban zones," is heavily affected by "increased pollutant loads from domestic, industrial, and commercial sources" (Reyes et al., 2018). These pollutants not only elevate flood risks but also create severe public health concerns, as evidenced by frequent exceedances of water quality limits for ammonia and phosphorus. This environmental stress emphasizes the need for integrated watershed management strategies that can address both flood control and water quality in a sustainable manner (Reyes et al., 2018).

In addressing these stormwater challenges, rainwater gardens present a viable green infrastructure solution, as demonstrated in studies using the Storm Water Management Model (SWMM) for simulations. In a study focused on Manila's flood-prone España Boulevard, SWMM simulations indicated that rainwater gardens can reduce flood depths by up to 19.42% for a 25-year return period and 14.78% for a 50-year return period (Yano et al., 2022). This reduction in flood depths provides "residents and first responders more time during flood events," which is critical for densely populated urban areas facing frequent extreme weather events (Yano et al., 2022). Rainwater gardens also contribute to environmental quality improvements by capturing and filtering stormwater. They are particularly effective in "removing nutrient-based pollutants such as nitrogen and phosphorus," which are prevalent in urban runoff and contribute to eutrophication and other ecological issues in bodies of water like Laguna Lake (Yano et al., 2022). Furthermore, rainwater gardens provide additional ecological benefits, such as "improving air quality and conserving water," aligning with sustainability goals essential for the Philippines' long-term environmental resilience (Yano et al., 2022).

This research will utilize Geographic Information Systems (GIS) data to look into high-risk flood areas around Laguna Lake, offering crucial spatial insights to pinpoint zones most suitable for green infrastructure interventions. Geographic Information Systems (GIS) is a computer-based tool that works to store, analyze, and display data about the Earth's surfaces. It uses geographic data and connects it to a map to identify the location of features. By integrating GIS mapping with SWMM modeling, the study will create a framework to evaluate the effectiveness of rainwater gardens and similar infrastructure solutions in real-world conditions. The combination of GIS's "capabilities for analyzing and

displaying digital spatial data" with SWMM's ability to simulate flood scenarios provides a robust approach to improving stormwater management in the Philippines (Reyes et al., 2018). This integrated approach aims to offer actionable insights for strengthening stormwater infrastructure to reduce flood risks and improve water quality across flood-prone regions in the Philippines.

STS Topic: Flooding and Community Impacts: Understanding Community Responses to Flooding in the Philippines

Flooding remains a persistent and complex challenge in the Philippines, exacerbated by climate change, rapid urbanization, and inadequate infrastructure. In densely populated urban centers like Metro Manila, flooding causes severe disruption to daily life, resulting in significant economic losses and widespread displacement. Due to severe flooding, many families were forced to evacuate because their houses were destroyed or rendered uninhabitable. Those affected often had to rely on government-proposed strategies and supplies, while others, due to a lack of resources, had no choice but to stay in the same area, facing heightened vulnerability. This problem is further exacerbated by the increasing frequency and intensity of floods due to climate change (Gilbuena et al., 2009). Poor drainage systems, overcrowded informal settlements, and limited infrastructure contribute significantly to flood risks in urban areas. Meanwhile, communities in regions like Cagayan de Oro have turned to self-organized solutions, such as rainwater harvesting, to address the challenges posed by insufficient government intervention (Paguigan, 2023). These responses vary, influenced by socio-economic conditions, local knowledge, and resource availability, creating a complex socio-technical problem. Understanding how communities

in flood-prone areas of the Philippines respond to flooding, and the factors that influence their decision to either stay or relocate during and after floods.

There are several case studies in the Philippines that show how communities respond to flooding. One case would be situated in Zamboanga City. In Tumaga River, Zamboanga City, families face constant flooding, but many rely on community-based early warning systems and social networks for support during flooding events. In a research study conducted by Zabala (2023), it was found that these families rely heavily on community-based early warning systems, which allow them to prepare ahead of flooding events. These networks provide resources for evacuation and recovery, particularly in areas with limited infrastructure. Higher-income families tend to have better access to flood-resistant housing, which lower-income families depend more on community support (Zabala, 2023). Another case would be about the Typhoon Ondoy in 2009. In Metro Manila, Typhoon Ondoy revealed the inadequacies of the city's flood management infrastructure, including poor drainage systems. According to Gilbuena et al. (2009), although evacuation centers were set up, many residents, especially those in informal settlements, could not reach them due to poor transportation and inadequate infrastructure. This situation highlighted the importance of community-driven solutions in flood management. Socio-economic factors also played a role, with wealthier residents having better access to safer areas and flood-resistant infrastructure. In Cagayan de Oro, residents' decisions to stay or evacuate during floods are influenced by the availability of transportation and proximity to evacuation centers. A study by Gamboa et al. (2021) on disaster response routes emphasized the need for better evacuation routes and facilities, stating that the city faces "inadequacies in the city's flood management system, particularly the lack of well-

maintained evacuation routes and facilities." Inadequate transportation and evacuation options often delay evacuations, increasing exposure to flood risks. The research stresses the role of local governance in improving these routes and the importance of community networks for assisting those unable to evacuate.

In addition to the Philippines, other countries have experienced various types of responses to flooding. In Bangladesh, community-based flood mitigation strategies have proven to be highly effective, especially in rural and peri-urban areas. Shaw (2006) points out that local institutions, both formal and informal, are vital to sustaining flood management efforts. One of the key successes in Bangladesh has been the creation of community-driven flood mitigation programs. These programs engage local communities in building small-scale flood infrastructures, such as embankments and raised platforms for homes, which helps residents adapt to rising floodwater. Shaw (2006) emphasizes that these local initiatives, supported by government policies, have proven more sustainable than top-down interventions, as they are better suited to the specific needs of the communities. Similarly, in Vietnam, community-based flood mitigation strategies have been central to managing flood risks, particularly in rural areas. Shaw (2006) notes that local knowledge and community engagement are essential to these strategies. Communities engage in practices such as elevating homes and constructing flood barriers, ensuring that flood management measures are adapted to local conditions. The integration of community efforts with government policies has led to a more sustainable and comprehensive flood management system. Shaw (2006) argues that the success of these strategies in Vietnam lies in the strong partnership between local communities and the government, which enables effective flood risk management. Comparing these international examples with the

Philippines' experiences offers valuable insights. While communities in Bangladesh and Vietnam have successfully integrated local knowledge with government policies, leading to sustainable flood management strategies, similar community-driven approaches are critical in the Philippines. In both Metro Manila and Cagayan de Oro, where governmental flood management strategies have often fallen short, local communities have had to rely on social networks and informal support systems to cope with flood risks. The lessons from Bangladesh and Vietnam underscore the importance of combining community-based measures with government initiatives to enhance flood resilience in the Philippines.

For this research, Community-Based Disaster Risk Management (CBDRM) will serve as the socio-technical framework to analyze community responses to flooding in the Philippines. CBDRM is a "process in which at-risk communities are actively engaged in decision making", and it "contributes to addressing the root causes of vulnerabilities and transforming the structure that generate inequality and underdevelopment." (Kafle et al., 2006). CBDRM emphasizes the active participation of local communities in all stages of disaster risk management, from preparedness to recovery. It focuses on building local resilience through community-driven solutions (Shaw, 2006). This approach integrates both hard (infrastructure-based) and soft (community-based) measures to manage flood risks effectively. It recognizes that local knowledge, social networks, and community cohesion play pivotal roles in reducing vulnerability to floods. According to the Community-Based Disaster Risk Reduction guide (2008), CBDRM is grounded in the belief that communities are the first responders during a disaster and that empowering these communities to take charge of their own safety and resilience is key to reducing disaster risk. CBDRM will be used to analyze how communities in flood-prone areas like Metro

Manila and Cagayan de Oro respond to flooding and decide whether to evacuate or stay. By examining local governance, community networks, and flood management technologies, this framework will offer a clear understanding of the social and technical aspects of flood management. In addition to that, CBDRM will assess the effectiveness of community-based initiatives, like early warning systems and localized flood measures, in boosting resilience. This approach aligns with the research question by focusing on the intersection of social systems, governance, and technology in shaping community responses to flooding. It aims to identify strategies for improving flood resilience through integrated, community-driven solutions.

Conclusion

The Philippines is confronting significant challenges in managing stormwater due to the combined impacts of climate change, urban expansion, and inadequate infrastructure. This is particularly evident in urban centers like Metro Manila and areas around Laguna Lake, where poor drainage systems and urban runoff exacerbate flooding risks. The aftermath of Typhoon Ondoy in 2009 exposed the vulnerabilities of the country's flood management systems, highlighting the urgent need for improvements in drainage, flood forecasting, and the integration of community-based strategies. In addition to these technical challenges, communities in flood-prone regions have adopted self-organized responses, such as rainwater harvesting and reliance on local social networks to cope with insufficient government intervention. By examining both the technical infrastructure issues and the community responses to flooding, this research aims to offer comprehensive

solutions that combine engineering and local participation to enhance flood resilience in the Philippines.

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