

2022

## The Effect of Flooding on Inequality in Developing Countries: A Qualitative Analysis

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THE EFFECT OF FLOODING ON INEQUALITY IN DEVELOPING  
COUNTRIES: A QUALITATIVE ANALYSIS

by

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A thesis submitted in partial fulfillment of the requirements  
for the Honors in the Major Program in Economics  
in the College of Business Administration  
and in the Burnett Honors College  
at the University of Central Florida  
Orlando, Florida

Fall Term, 2022

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## ABSTRACT

Global warming continues to have a negative effect on the environment and, by extension, the economy. Incidence of natural disasters are increasing because of climate change, with flooding being one of the most common and costly types of disaster. Studies on the effect of floods on the economy have revealed that flooding increases the amount of income inequality. However, there is not a unified, qualitative analysis of the reasons for the post-flood increase in inequality. This thesis examines multiple different flood events in several developing countries to answer how flooding affects inequality in developing countries. It produces a synthesized analysis on the underlying causes of flood induced income inequality. These causes were found to be the increased vulnerability of low-income households to flooding and their lower capacity to cope with flood damages, relative to middle- or high-income households. Vulnerability has spatial and structural dimensions, and capacity to cope is influenced by a household's asset portfolio and post-flood adaptation ability; it is also interconnected with coping capacity and contributes to a cycle of poverty escalation.

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## INTRODUCTION

As climate change continues, the number of costly natural disasters is expected to increase (Dotteri et al., 2018; Bui et al., 2014). In particular, the frequency of flooding, which is already one of the most common natural disasters (Dotteri et al., 2018), is expected to grow due to the rise in sea level and increase in extreme precipitation caused by climate change (Grasham et al., 2019; Prein et al., 2017). This is a cause for concern for economists, policy makers, and the general population alike because floods are among some of the costliest disasters. With over fifty-eight million people exposed to flooding each year, the risk of significant economic distress is high (Dotteri et al., 2018). In Vietnam, which ranks fourth in the world for number of people exposed to floods, natural disasters lowered per capita income by 6.9% and decreased expenditures by 7.1% from 2003 to 2008 (Bui et al., 2014). Additionally, the World Bank estimates that Pakistan lost as much as twenty-six percent of its GDP in 2010 because of severe flooding that occurred that year (Naqvi, & Rehm, 2014). Pakistan and Vietnam's status as developing countries partly explains why the economic impact of these floods was so significant. Naqvi and Rehm (2014) found that from 1980 to 2011, low-income countries lost four times as much of their GDP as high-income countries and suffered sixteen times more deaths as a result of natural disasters. This was despite the fact that the frequency of natural disasters at each income level is similar.

There is increasing evidence that the intensity of a particular hazard is not the only determinant of the amount of damage caused, but that the affected community's socio-economic

conditions play a large role as well (Jha et al., 2021). The literature reveals that extreme weather events, such as high precipitation levels, are much more likely to become a disaster when they affect low-income households (Jha et al., 2021). Low-income communities are unable to build flood mitigating infrastructure like flood barriers or resilient infrastructure that can withstand flooding due to budget constraints, which increases the damage of flooding. Because poor households face greater flood-induced damages than non-poor households, flooding often increases income inequality (Bui et al., 2014; Yamamura, 2015; Silva et al., 2022; Tovar Reaños, 2021). This thesis will explore how flooding affects income inequality in developing countries.

A focus on developing countries is appropriate because people living in developing countries are the most at risk for flood damage (Shaikh & Fankhauser, 2022). Inequality is known to limit a country's economic growth (Benabou, 1998; Galor & Zeira, 1993; Rodrik, 1999), therefore policymakers should take inequality into consideration as they work to improve their country's economy. As the incidence of flooding increases, its effect on inequality will also increase, making a thorough understanding of the socio-economic factors that cause this relationship even more important. While the literature includes explorations of the differential effect of flooding on the rich and poor, it is usually in the context of a specific flood or in a specific country. The literature lacks a broader, synthesized exploration of the relationship between flooding and inequality that uses evidence from multiple different events across different countries.

Answering "how does flooding affect inequality in developing countries" using qualitative thematic analysis will produce an outline that future researchers can apply to specific incidences they are studying, as well as a qualitative basis for quantitative studies on this topic. The evidence suggests that there is a causal relationship between flooding and increased income



inequality in developing countries. This thesis provides a qualitative guide that can be used as a basis for research using empirical methods to test this relationship. In other words, it outlines the apparent causes of post-flood rises in inequality so that researchers can examine quantitative data to test the relationship. A thorough exploration of flooding and inequality lays the foundation for an equitable, efficient climate change response.

This thesis will unfold as follows: First, it will review the relevant literature that discusses changes in income inequality. Then it synthesizes the findings of several papers that explore the reasons behind differential post-disaster outcomes at various income level in two sections: the first section will discuss the increased vulnerability of low-income households in developing countries to flooding with specific discussion on the unique challenges of rural and urban areas, and the second will explore the decreased ability of low-income households in developing countries to cope with disaster damages. Next, the thesis outlines the methods used to analyze the existing literature, and then the findings are synthesized in the analysis section to produce a direction for future empirical research. Finally, the conclusion summarizes the analysis of the literature.

## LITERATURE REVIEW

The literature review begins with a summary of the relevant evidence of inequality changing after a natural disaster to establish the veracity of the basis of the research question- that flooding changes inequality. Then, it reviews the existing research on the low-income population's higher vulnerability to flooding, as compared to middle- or high- income communities; in other words, why are low-income communities more likely to experience flooding, and when they do flood, why it is more likely to will cause significant damage. Vulnerability has geographical and structural dimensions, so the thesis distinguishes factors of vulnerability that are issues unique to rural or urban areas. Finally, the review ends with a discussion of the literature exploring low-income household's decreased capacity to cope with flood damage, in comparison to middle- or high-income households. Their vulnerability makes low-income households more likely to experience flood damage, and their low coping capacity means that they find it difficult to recover and rebuild after that damage is done.

There is a long history of flood management strategies that stretches across the globe (Nakamura & Oki, 2018). Ancient civilizations were aware of the risk of living near water ways and constructed embankments and other risk-mitigating structures to protect themselves (Nakamura & Oki, 2018). Today we continue to look for effective ways to control flooding, a task that is especially important considering the negative effect that flooding has. Several studies have demonstrated that natural disasters increase income inequality. Bui et al. (2014) found that in Vietnam, a country where thirty percent of households were affected by at least one natural

disaster between 2003 and 2008, natural disasters increased the Gini Coefficient<sup>1</sup> by 0.2%, the Theil L<sup>2</sup> index by 0.1%, and the Theil T index by 0.3%. Yamamura (2015) analyzed panel data from 1970 to 2004 from eighty-six different countries with a range of GDPs and found that a country's Gini Coefficient increases by an average of one percent as a result of natural disasters in the short run. However, after two years the effect of the natural disaster on the inequality measure is no longer seen. The author hypothesizes that inequality only changes in the short-term because governments redistribute wealth after disasters to help low-income communities recover, which pushes the Gini Coefficient back to its pre-disaster level. It should be noted that Yamamura (2015) does not focus specifically on developing countries, and the short-term nature of the change in the Gini Coefficient may not be true in developing countries where governments have fewer resources and are therefore less able to redistribute wealth to low-income households.

Anbarci, Escaleras, and Register (2005) examined the intersection of political economy and natural disaster; they argue that inequality can limit a country's ability to respond appropriately to natural disasters because it makes collective action more difficult. Policy aimed at reducing hazard risk works best when communities of different income levels can work together with the government, but the uneven distribution of incomes decreases the unity of a country and makes it more difficult for the population to agree on the appropriate way to distribute the costs of the

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<sup>1</sup> The Gini Coefficient refers to an index of the distribution of wealth in a group of people which is between zero and one calculated using the Lorenz Curve. The Lorenz Curve plots the share of people at each income level against their cumulative share of total income earned. The Gini Coefficient moves closer to one as more wealth is concentrated amongst a smaller population of high-income earners. This measures wealth inequality in a concise way.

<sup>2</sup> The Theil index is a decomposable measure of income inequality. It measures inequality by measuring how far a population is from a perfectly equal society where everyone receives the same income. A Theil index score of zero is achieved by a perfectly egalitarian society, and a score of one is achieved by a perfectly unequal society. The Theil L index is the mean logarithmic deviation measure of the Theil index and is more affected by differences in the distribution of income at relatively low-income levels. Conversely, the Theil T index is more affected by distribution differences at relatively high-income levels.

hazard-reducing programs and policies (Anbarci et al., 2005). This reveals that the pre-existing inequality in a country can cause inequality to deepen because it limits that country's ability to respond to disaster shocks (Anbarci et al., 2005).

Interestingly, Warr and Aung (2019) found that Cyclone Nargis decreased inequality in Myanmar when it occurred in 2008 because it primarily affected regions where household income was higher than the national average. When a natural disaster destroys the assets of people that are wealthier, it reduces their income and diminishes the gap between the rich and poor (Tovar Reaños, 2021; Warr and Aung, 2019). However, it is less common for non-poor households to suffer greater damage from natural disasters than poor households because poor households are forced to accept much higher hazard risk due to their budgetary constraints and socio-economic status (Hoeven et al., 2015; Jha et al., 2021; Warr & Aung, 2019).

### Vulnerability

This thesis will rely on Jha et al.'s (2021) definition of vulnerability, which is “the existing structural system that makes communities prone to damage as a result of external events”, for the context of this thesis because it combines the social scientist's view of vulnerability as a static state of being and the climate scientist's view of vulnerability as the probability that an extreme weather event will affect a person or community. Vulnerability has been used in the literature to describe the likelihood that a person or community will be exposed to flooding (Patankar, 2017), as well as the likelihood that flooding will cause significant damage to a household or community. Economic vulnerability to natural disasters is positively associated with the World Bank's Poverty Headcount Index, demonstrating that poverty increases vulnerability to flooding (Bui et al., 2014).

Low-income people are more likely to be affected by flooding: in a study of flooding in the Itapocu River Basin in Brazil, Silva Araújo, Ohara, Miyamoto, and Takeuchi (2022) find that households that are below the poverty line or just above it had a higher level of water in their house as a result of flooding than non-poor households. This results in a larger amount of damage proportional to their income. Income-based spatial segregation is partially to blame for the vulnerability to flooding of poor communities in places like the Itapocu River Basin. The budget constraints low-income households face force them to take on additional flood risk by living in hazardous areas where property prices are cheaper, therefore increasing their vulnerability in comparison to households with higher income (Silva Araújo et al., 2022).

The rise in inequality caused by low-income community's increased exposure to flooding because of spatial segregation is exacerbated by these household's inability to invest in prevention methods (Silva Araújo et al., 2022). One of the most important ways to boost the resilience of low-income communities is renovating structures so that they can withstand flooding and other extreme climatic events (National Academies of Sciences, Engineering, and Medicine, 2022; Silva Araújo et al., 2022). The National Academies of Sciences, Engineering and Medicine (2022) recommends building partnerships with people living in at-risk communities to jointly adapt existing infrastructure so that it is up to code and encourage "a systemic change toward resilient and equitable infrastructure investment". Policy makers must also consider the cost of resilient infrastructure. While stricter building codes can reduce flood damage, they increase the price of infrastructure (Bartram, 2019; Henry, 2001) which makes it more difficult for low-income people to purchase housing and other structures. For infrastructure investment to be effective, the government and other concerned parties must

consider options for financing these projects so that the costs can be absorbed rather than passed down to people living in poverty (National Academies of Sciences, Engineering, and Medicine, 2022). Rather than safe infrastructure being reserved for a select few, equitable infrastructure development and the widespread adoption of strict building codes will make low-income communities less vulnerable to flood losses, which consequently shrinks the vulnerability gap between high- and low-income groups.

The unstable infrastructure found in low-income communities leads to a higher likelihood of injury or death caused by natural disasters for people living in poverty than others (Yamamura, 2015). A disparity in the effectiveness and existence of early warning systems in communities of different income levels can also explain the differential injury incidence and fatality rates. A survey conducted by Patankar (2017) concerning the differential effects of 2010's severe flooding in Sri Lanka's capital Colombo found that just eight percent of households living below the poverty line received early warning of the impending flood. In comparison, thirty seven percent of non-poor households were warned. Radio and TV were the source of the early warning for fifty percent of the non-poor families; with many people living below the poverty line unable to afford these appliances it is no surprise they are less likely to be aware of flood risk (Patankar, 2017). Impoverished communities in Colombo were also unaware of where to go in case of a flood, with only six percent of people living below the poverty line knowing where the closest shelter was (Patankar, 2017). In contrast, eighty percent of non-poor households knew the location of nearby shelters (Patankar, 2017). As a result, poor people were less likely to escape dangerous areas before the flooding occurred, which led to serious health issues, injury, and death for many living in these communities.

Differences in the geographical, structural, and social features of urban and rural communities create a distinct group of issues that low-income people must face. While vulnerability of low-income households is common across all regions, rural and urban areas each have their own set of unique challenges that contribute to this vulnerability. (Naqvi, & Rehm, M. 2014).

### *Rural Household Vulnerability.*

The majority of poor, rural households make their livelihoods from agriculture, which is particularly vulnerable to flood damage (Naqvi, & Rehm, M. 2014). Pakistan's 2010 floods decreased agricultural output in these vulnerable rural regions by up to seventy percent, which took a devastating toll on the local people's income and food supply (Naqvi, & Rehm, M. 2014). Because agriculture relies on a clean and consistent water supply, farms are often located near rivers. This is particularly true in developing countries where plumbing to connect rural farms to distant water sources may not be available. The same waterways that allow these farms to function can also destroy them if they flood: flooding can displace soil, wash away crops, and contaminate water bodies, subsequently damaging crops and poisoning livestock (Shaikh & Fankhauser, 2022; Yamamura, 2015). In addition, flooding can destroy the carefully built irrigation systems and other farming infrastructure that allows crops to grow (Shaikh & Fankhauser, 2022). Rural farmland is at risk for flooding because of its strategic location near waterways, and low-income farmers' reliance on agriculture for survival means that flooding causes significant damage and ensures that floods become disasters for the local economy.

### *Urban Household Vulnerability*

The rate of urbanization is expected to rise until 2050, and around ninety percent of this growth is expected to take place in Asia and Africa (UN DESA, 2019) which are both particularly vulnerable to climate change and flooding (Dottori et al., 2018). Urbanization brings an increase in informal settlements, colloquially known as slums, with it. The number of people living in informal settlements is expected to reach two billion in the coming decades (World Health Organization & UN Habitat, 2016). This trend is important in risk management discussions because urban wage earners are at high risk of poverty caused by an extreme weather; in fact, Ahmed, Diffenbaugh and Hertel (2009) found that urban workers were even more vulnerable than rural workers who are dependent on agriculture.

The process of urbanization can create problems in risk management. For example, as the city of Colombo expanded, so did its flood risk: the changing land use caused clogged drains and canal systems and the new construction activity increased runoff, all of which contributed to the severity of the damage of the 2010 flooding there (Patankar, 2017). Unlike the traditional construction taking place in Colombo, much of the urban growth in the developing world takes the form of informal settlements. Slums are often located on flood prone land next to a body of water with soil that has a low infiltration capacity (Silva Araújo et al., 2022). These settlements do not follow the proper building codes, which leads to overcrowding, poor drainage, and weak buildings (Grasham, 2019; Silva Araújo et al., 2022). Together this creates a perfect storm of vulnerability: encampments are more likely to be flooded and more likely to experience significant damage from that flooding than the formal communities where better-resourced people live.



Inappropriate government behavior towards slums often increases flood vulnerability even further (Moulds et al., 2021). Some governments choose to ignore informal settlements, which guarantees that the infrastructure there will never be improved enough to increase the resilience of these communities (Moulds et al., 2021). A lack of government presence also leads to underreporting of flooding, which can cause people to miscalculate the risk of living there and stop them from making efforts to adapt their living space to be more flood resilient (Moulds et al., 2021). Conversely, if the government chooses not to ignore informal settlements, they often forcibly remove the people living there and destroy the slum. This does not encourage impoverished people to move to safer areas as the policymakers might hope, but rather forces them to move to areas that are even more hazardous (Moulds et al., 2021). Mass evictions do not address the underlying issues of poverty, affordable housing shortages, and income inequality that lead to the formation of slums, which makes this policy counterproductive (Moulds et al., 2021). To reduce the vulnerability of urban slums, Moulds et al. (2012) recommends that the government works together with residents to upgrade the settlements to have better drainage and stronger structures, and that proactive measures are taken to ensure that in the future city expansions take place on safer land.

## Capacity to Cope

It is impossible to completely eliminate the risk of flood, but systems can be put in place that make it easier for people to recover after an extreme climatic event. Rodrik (1999) found that inequality can limit a country's ability to respond to external shocks, and there is an expansive literature that finds that inequality has a negative impact on economic performance and growth including works by Galor and Zeira (1993); Alesina and Rodrik (1994); and Benabou (1996). Existing income inequality is entrenched when disaster strikes as poverty-stricken communities lack the resources to recover from the shock, pushing them deeper into poverty (Bui et al., 2014; Silva Araújo, 2022; Patankar, 2017). Bui et al. (2014) quantifies this trend and calculates that 21.6% of Vietnamese households that were exposed to a natural disaster live below the poverty line, but if these same households had not been exposed only 18.92% would be below the poverty line.

Poor households find it much more difficult to hedge against income disruptions like flooding compared to non-poor households (Naqvi, & Rehm, M. (2014). Whereas middle- or upper-income families can afford to have a diverse asset portfolio including financial assets like stocks and bonds, low-income families' asset portfolio typically only includes tangible assets such as their home or farm because their budget restrict them from investing (Patankar, 2017; Shaikh & Fankhauser, 2022). When these physical assets are damaged by floods, low-income people lose any assets they could have used to recover financially from the extreme weather event; in contrast, if higher income people loose physical assets they can turn to financial assets that may still be intact (Patankar, 2017). Low-income people are also less likely to have savings to draw on in an emergency, and even if they do those savings are more likely to be depleted as a result

of flooding; in Pakistan rural families affected by flooding were unable to save any money for almost a year as they tried to recuperate their asset losses (Naqvi & Rehm, 2014). During this time these farmers' coping capacity was reduced to almost nothing because of their lack of assets, and another flood would have completely and perhaps irrevocably devastated their communities. Rural areas often have few sources of income available for the people living there; despite the loss of agricultural assets, rural Pakistani farmers found it difficult to find alternative sources of income to help them rebuild (Shaikh & Fankhauser, 2022). Instead of finding alternative ways to earn money they were forced to increase the time spent farming, but with their now limited resources the farmers' income did not increase despite dedicating more time to the job (Shaikh & Fankhauser, 2022). Food prices also increased due to the damage that crops and livestock sustained, further depleting what little income people in this area had (Naqvi, & Rehm,2014).

Households below the poverty line or just above it also have less access to financing such as insurance schemes, social safety nets (Shaikh and Fankhauser, 2022), formal loans from banks, and informal loans from friends and family (Patankar, 2017) to use to rebuild after a flood. A lack of access to these kinds of funds is a particularly difficult challenge for low-income people who have to miss work because of injuries they sustained or diseases they caught as a result of flooding (Yamamura, 2015).

The lack of emergency funding for low-income people affected by flood can partially be attributed to an inequitable and/or inefficient government crisis response. Pakistan received roughly \$1.52 billion in foreign aid to help the country recover from the 2010 floods (UN-OCHA, 2014), but because of a lack of coordination and a lack of knowledge about how to

properly handle disaster shocks, the government did not use this relief money effectively and many low-income households struggled to recover (Naqvi, & Rehm ,2014). Moulds et al. (2021) developed a simulation model to test the effectiveness of government outreach in the event of disaster under high/low efficiency and high/low equity conditions. “Efficiency” refers to the extent to which reconstruction efforts focus on protecting high-value assets, increasing land values, and building sustainable economic development. “Equity” refers to the extent to which reconstruction efforts are equitably distributed between the socio-economic classes. As would be expected, the high efficiency, high equity scenario produces sustained economic growth post-disaster at all income levels (Moulds et al., 2021). The two low equity scenarios produce a period of long-term economic decline in low-income communities, particularly urban informal settlements (Moulds et al., 2021). However, an equitable government response is not enough in and of itself and must be accompanied by an efficient use of resources in order to see sustainable growth.

One program that developing countries could consider as an effective, equitable disaster response is cash and food transfer programs. Naqvi and Rehm (2014) develop a model, SHELscape, which analyzes how environmental shocks affect other parts of the economic system. SHELscape was used to predict how a hypothetical food and cash transfer program would have affected low-income workers impacted by flooding (Naqvi and Rehm, 2014). The model predicts that the cash transfer program raises the affected workers’ income more than the food transfer, but the food transfer has a greater effect on overall wellbeing when it was able to reduce prices that had risen because of the limited supply of food where agriculture had been destroyed by floods

## METHODOLOGY

This thesis' objective is to examine the pre-existing literature on the impacts of flooding in developing countries to synthesize what is known about the degree of vulnerability of low-income households and their lower coping capacity, and how flooding affects inequality. (Peterson et al., 2001). The literature was reviewed using a deductive approach with the expectation that themes of high vulnerability and low coping capacity will be discovered within the data. Evidence of these themes was coded into the following categories: location, infrastructure, assets, and adaptation ability. . Coded evidence was separated into the appropriate theme, vulnerability or coping capacity. Table 1, which describes what is meant by each code, and what theme each code fell under, is found on the following page.

**Table 1***Codes Used in Deductive Literature Review*

Code	Explanation	Anticipated Theme
Location	Evidence of a community's geographical location affecting the likelihood of flooding	Vulnerability
Infrastructure	Evidence of the characteristics of infrastructure affecting the likelihood of flood damage	Vulnerability
Assets	Evidence of the availability of assets and the makeup of asset portfolios affecting recovery outcomes	Capacity to Cope
Adaptation Ability	Evidence of a household's ability to adapt to facilitate recovery	Capacity to Cope

*Table 1*

## ANALYSIS

A deductive literature review using thematic analysis produces a clear outline for researchers to use to both predict the effects of flooding on inequality ex-ante and analyze the effects ex-poste. Low-income households take on more flood risk as they make decisions about what locations to live in and the quality of the buildings they reside and work in, which makes them more vulnerable to flooding. Income based spatial segregation forces people living at or below the poverty line to live in flood prone locations like urban informal settlements and rural areas that border rivers; as a result they are more likely to experience flooding (Patankar, 2017; Moulds et al., 2021; Silva Araújo et al., 2022). These segregated poor areas have subpar infrastructure because low-income people cannot afford to invest in renovating buildings to be up to code and flood resilient (National Academies of Sciences, Engineering, and Medicine, 2022; Silva Araújo et al., 2022). Drainage infrastructure, early warning systems, and other flood prevention infrastructure such as flood walls are also often lacking in these low-income areas, which increases the vulnerability of the population that lives there (Francesco et al., 2018; Patankar, 2017; Shaikh & Fankhauser, 2022; Silva Araújo et al., 2022).

The budget constraints that force low-income households into vulnerability also lower their coping capacity. Low-income people do not have significant savings to draw upon in an emergency like a flood, and their asset portfolios are often homogenous and made mostly of tangible assets that can be destroyed by flooding (Naqui & Rehm, 2014; Patankar, 2017; Shaikh & Fankhauser, 2022). This means that poor households do not have adequate assets to help them rebuild after flooding, making them unable to cope when faced with disaster. Full recovery from disasters requires adaptation to new circumstances, but poor households often lack the necessary

adaptation ability. People living in vulnerable, low-income areas often have less job opportunities and are unable to diversify their income to include new sources of income that are not disrupted by flooding (Shaikh & Fankhauser, 2022). They also face difficulty obtaining loans from both formal and informal sources (Patankar 2017), and they can fall victim to an inequitable government disaster response that leaves them without sufficient aid (Moulds et al., 2021). Together these things make recovering from flood damage difficult and adapting to become disaster resilient almost impossible.

Vulnerability and coping capacity are also intertwined; the relationships between each code within the themes are summarized in Table 2.

**Table 2**

*Summary of the Relationship Between Vulnerability and Coping Capacity*

		<b>Vulnerability</b>	
		<i>Location</i>	<i>Infrastructure</i>
<b>Coping Capacity</b>	<i>Assets</i>	The makeup of asset portfolios is affected by a household’s geographical location, and a person’s assets determine where they live and work	An absence of flood prone infrastructure leaves physical assets at risk. Asset portfolios determine the quality of infrastructure a person can afford
	<i>Adaptation Ability</i>	Where a person lives and works affects their ability to diversify their income	Weak and damaged infrastructure limits a person’s ability to implement flood-resistant adaptations

*Table 2*



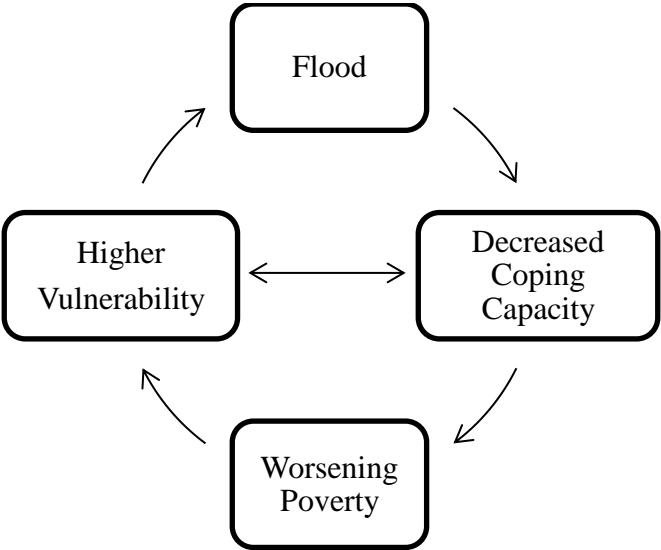
The relationship between location, assets, and adaptation ability is clearly demonstrated by the effects of flooding in Pakistan. Pakistani farmers must live in vulnerable, flood-prone areas because they need to be near water ways for irrigation. These rural areas have few opportunities outside of agriculture, and thus the average Pakistani farmer's asset portfolio is mostly, if not totally, comprised of tangible assets related to farming (such as their farming equipment, crops, and livestock) or their home (Shaikh & Fankhauser, 2022). The location where these low-income farmers live makes them vulnerable to flooding, but it also limits asset portfolio diversification. The lack of portfolio diversification lowers their coping capacity because they can not hedge against disaster-related income disruptions. The rural area where these low-income communities are located also limits their adaptation ability: these isolated areas have few opportunities outside of agriculture, which means that once farmland is destroyed by flooding farmers cannot adapt and find other sources of income.

Furthermore, the value of assets a person has determines where they can afford to live and work. In the flood-prone areas of Columbo, Patanker (2017) found that people wanted to move out of these vulnerable locations, but they did not have the means to do so. Low-income households experience decreased coping capacity because of their lack of assets, and that same lack of assets pushes them to take on more vulnerability by living in cheap but dangerous locations.

Low-income communities are often unable to afford infrastructure that would protect them from flood damage because of the small size of their asset portfolios, causing them to be more vulnerable to floods and less able to cope with the disaster's damages. The size of the asset portfolio is not the only thing that matters, the makeup of the portfolio also connects

vulnerability and coping capacity through infrastructure. The reliance on physical assets that is common amongst people living in poverty is particularly risky considering the poorly built and poorly maintained infrastructure that low-income communities feature, because these assets are more likely to be destroyed when they are not physically protected by infrastructure (Patankar, 2017). The small amount of assets held by poor people prevent them from building flood-resilient infrastructure, which puts their tangible assets at risk and makes it more difficult to cope with flood damage. Inability to adapt also prevents low-income communities from renovating or building new, safe infrastructure. If households are unable to adapt their sources of income in the wake of flooding, they may have difficulty recovering from flood damage and will not have the resources to restore their infrastructure.

The literature points towards a cyclical relationship between vulnerability, coping capacity, flooding, and poverty; this relationship is illustrated in Figure 1.



**Figure 1**  
*Poverty Escalation Cycle*

Households living at or below the poverty line are more likely to experience flooding because they live in flood prone areas with little flood resilience. Then when they experience flooding their assets are destroyed and they have little savings to draw on to recover from flood damage. This pushes low-income households deeper into poverty, which forces them into even more dangerous living situations, which increases the likelihood that they will experience a flood, which decreases their already depleted capacity to cope, which causes them to fall deeper into poverty, and so on. As people fall deeper into poverty the gap between upper-income households and lower-income households widens and income inequality increases.

#### Further Testing

Further empirical testing of the proposed poverty escalation cycle will provide insight into the accuracy of the suggested relationship between flooding, coping capacity, poverty, and vulnerability. A longitudinal study of a low-income particular community, over a period of time that includes multiple floods, that measures changes in coping capacity and vulnerability related variables, will provide data that can be used to analyze the cycle. Measures of vulnerability should consider location and infrastructure. A flood hazard map, such as the one produced by Dewan (2013), could be used in combination with household income data to measure the number of low-income people living in flood prone areas. An infrastructure quality index (Owusu-Manu et al., 2019) and an infrastructure resilience index, such as the Critical Infrastructure Resilience Index (Perera & Arachchi, 2022) could be used to measure the overall quality of infrastructure in low-income communities. Together these measures of geographical and infrastructural risk can create a vulnerability composite indicator.

Coping capacity can be measured by examining the size of a household's asset portfolio, because their assets determine how difficult it will be for them to recover from flood damages. Researchers could test the poverty escalation cycle by first measuring the changes in low-income household's asset portfolios after a flooding event, then any changes in the number of people living at or below the poverty line in the flood-affected area. Collecting quantitative data about income levels is also vital, so that researchers can measure how many people are living in poverty and how deeply impoverished those people are.

It should be noted that because of the interconnected nature of vulnerability and coping capacity, researchers find it difficult to empirically measure these qualities separately. Further research is needed to determine the ideal way to measure vulnerability and coping capacity so that each measure is distinct from the other and there is no interference between variables.

Changes in the average size of low-income household's asset portfolios, the number of people living at or below the poverty line, and the vulnerability composite indicator should be measured after a flooding event and compared to pre-flood data. Correlation analysis will allow researchers to test the relationship between each of these stages of the poverty escalation cycle and thus evaluate the validity of the proposed cycle.

## CONCLUSION

Continuing anthropogenic warming is expected to raise the incidence of floods in the coming decades, and changes like increasing urbanization and population growth mean this flooding could cause major economic turmoil, especially in developing countries. Low-income households are disproportionately affected by floods, which worsens income inequality in the affected countries. A thorough review of the relevant literature has revealed the key underpinnings of the relationship between flooding and income inequality in developing countries, which provides to the direction future empirical research should take. This qualitative thematic analysis produced broad categories of socio-economics factors that have made low-income households more susceptible to flood damage: vulnerability and low coping capacity. After comparing studies done about different flooding events and looking for similarities, flooding is shown to increase income inequality in developing countries because people living in poverty are more vulnerable to experiencing flooding and have a lower coping capacity to recover from them than middle- and high-income households. Low-income households are more vulnerable because they are forced to live in flood-prone locations with little flood-resilient infrastructure due to their budget constraints. They have a lower capacity to cope with flood damages because they have fewer and less diverse assets to draw from in an emergency and are less able to adapt to adopt strategies such as income diversification that would both help them recover from already inflicted flood damage and mitigate flood damage in the future. Thematic analysis also reveals a cycle of poverty escalation whereby poor households are forced to live in vulnerable areas, which makes them more likely to experience flooding, then they are not able to

recover from the disaster damages and sink lower into poverty, which in turn makes them reside in increasingly vulnerable areas and homes, and so on.

This qualitative analysis produces a key research question for the study of inequality and flooding: how do vulnerability and coping capacity affect the increase in income inequality that is typically experienced after a flood? There are multiple layers to this question that require further empirical research. First, research is needed to measure the extent of the relationship between vulnerability and coping capacity and worsening inequality. This empirical research should take into account that vulnerability and coping capacity are intertwined. Therefore, the challenge of decomposing overall changes in inequality due to flooding into changes caused by increased vulnerability and changes caused by lower coping capacity requires special attention. Quantitative analysis is also needed to analyze the poverty escalation cycle proposed in this thesis. Similarly, researchers face the issue of interconnected variables when measuring this cycle.

A thorough exploration of this research question using empirical methods will provide the foundation for an equitable response to flooding in developing countries. These findings can also be used to develop a broader response to climate change that provides sufficient aid to people living in poverty that will offset the negative effects of climate disaster on income inequality, thereby advancing the fight against extreme poverty globally.

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