Poverty and Floods in Cap-Haïtien

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Executive summary

Nested in a bay, the Cap-Haïtien metropolitan area is home to a large river basin, is characterized by rapid and uncontrolled urbanization, and fears devastating floods during the rainy season. Frequent and severe natural disasters can potentially increase Cap-Haïtien households' vulnerability to falling into poverty traps. Several characteristics of poor households explain this phenomenon: among other characteristics, the risky nature of their livelihoods (mostly informal activities) and the fragility of their dwellings expose poor households to significant risk of natural disasters. Furthermore, when these disasters occur, poor households have limited assets and limited access to social protection and/or early-warning systems to effectively prepare for, cope with and recover from shocks. As a result, natural disasters often have a disproportionate effect on the well-being of poor households leaving them vulnerable to poverty traps.

Using data from a comprehensive survey, the Climate-related Risks and Poverty Survey (CRPS) collected between October and November 2018, the present report intends to describe the nature of floods in Cap-Haïtien and their association with poverty. This rich dataset allows us to examine this relationship through the lens of exposure – the extent to which poor households are affected by floods; vulnerability – the extent of the effect of floods on poor households; and resilience – the ability of poor households to effectively prepare for, cope with and recover from floods. By examining the exposure, vulnerability and resilience of poor households to floods, we provide insights into the poverty-vulnerability nexus in the context of natural disasters. In a country such as Haiti where natural disasters are frequent, such insights are useful for informing DRM and poverty reduction strategies.

In this analysis we find that floods create important disruptions in households' lives with interruptions in their children's school and destructions to roads and paths. Poor households and households living in high-risk areas appear to suffer more from floods than the average population of Cap-Haïtien. In addition, households affected by floods experience a decrease in consumption per capita by 12 percent although this effect is statistically insignificant. Households have very little resilience with nearly half of the households affected by a flood reporting not being able to restore their consumption to pre-flood levels. To cope with a flood, two out of three households use their savings while worryingly reductions in the consumption of food items is another common coping mechanism, particularly among poor households.

1 Introduction

Nested in a bay, the Cap-Haïtien, Haiti second largest city, is home to a large river basin characterized by rapid and uncontrolled urbanization and fears devastating floods during the rainy season. The Cap-Haïtien metropolitan area is crossed by the Haut du Cap-River and characterized by a wide hydrological system that gathers in the Bassin Rhodo, a large estuarine water basin. Since the 1980s, people have illegally settled along ecologically-sensitive river banks due to the general lack of housing opportunities in Cap-Haïtien. Residents settle in areas deemed unsafe, but within proximity to job opportunities in the city center, schools, the municipal market, and other services**.** Furthermore, high rates of sedimentation downstream in the drainage canals, a lack of solid waste management system, and uncontrolled settlements in or nearby ravines and low-lying areas, have reduced the retention capacity of watersheds in time of heavy rainfall increasing the vulnerability to floods.

In Haiti, frequent and severe adverse natural events affect negatively households, and even more the poorest. In 2012, nearly 75 percent of households and 95 percent of the extremely poor households were economically impacted by at least one shock in 2012 (World Bank & ONPES, 2014). Haiti's high vulnerability to natural disasters is perhaps best understood by comparing it with its neighbors. Between 1980 and 2010, Haiti experienced 74 disasters resulting in 233,919 causalities whereas the Dominican Republic with whom it shares the island of Hispaniola experienced 47 disasters which resulted in 1,486 casualties during the same period (World Bank & ONPES, 2014). Floods are the most common weather-related natural disaster in Haiti. Between 1980 and 2010, Haiti experienced more than twice as many floods than the Dominican Republic. This is largely attributable to severe deforestation that has weakened and impoverished the land, construction of dwellings on waterways among others. (World Bank & ONPES, 2014). In addition to the high risk of exposure to floods, most households in Haiti have low level of resilience- often relying on their savings to cope with shocks; exposing them to being vulnerable to poverty.

In Cap-Haïtien, high structural vulnerability of infrastructure and high exposure to floods, increasing households' vulnerability to falling into poverty traps. Built-up areas are particularly exposed; they are disproportionately concentrated in high seismic hazard zones (60 percent), and around half are at risk for flood events. Additionally, public infrastructure and housing are highly vulnerable from a structural point of view and have been highly affected by recent disasters. For Cap-

Haïtien in particular, analysis of satellite imagery[1] suggests that about 72 percent of Cap-Haïtien's buildings in 2015 had been constructed on flood prone land.[2] Of the buildings located in areas highly exposed to floods, 22 percent are located in neighborhoods that have been classified as irregular using semi-automated methods for satellite imagery classification.[3] The combination of high hazard exposure and high vulnerability of housing and other critical infrastructure puts the population at risk of natural disasters. The aftermath of these disasters is often marked by a significant loss of lives and destruction to property leaving households more vulnerable to poverty traps.

In this context, effective disaster risk management (DRM) policies are needed to lower vulnerability to poverty. While the overall poverty headcount in 2012 was at 58.5 percent of the population and the extreme poverty rate at 23.8 percent, more than eighty percent of the population is vulnerable to falling into poverty or staying into poverty. DMR policies and interventions can be designed to lower households' vulnerability to poverty through preparedness and early-warning systems (EWS) and through strengthening households' capacity to mitigate the impact of these disasters when they occur. The formation of these policies must be informed by evidence on the impacts of shocks as well as existing shock mitigating strategies used by households and their effectiveness.

The purpose of this report is to describe the nature of floods in Cap-Haïtien and its relationship with poverty. We examine this relationship through the lens of exposure, vulnerability and resilience of households (particularly the poor) to floods using recently collected household survey data. In terms of exposure, we describe the profile of households affected by floods and provide insights into the factors which influence their likelihood of being affected by floods. With respect to vulnerability, we estimate the impact of floods on household welfare – in particular household consumption levels. Finally, we examine the resilience of households to floods by assessing the strategies used by households to prepare for and/or cope with floods when they occur. By considering exposure, vulnerability and resilience of households to floods, we provide insights into the extent to which negative effects of floods (high vulnerability) is risk-induced (meaning high exposure to

[1] Haiti Urbanization Review, World Bank 2018.

[2] For this calculation the city of Cap-Haïtien consists of 4 sections: Bande du Nord, Haut du Cap, Petite Anse, and Basee Plaine.

[3] This 'irregular' label can be considered a proxy for relatively lower income neighborhoods and from a remote sensing/technical perspective means the area is characterized by small, un-organized buildings.

uninsured risk of facing floods by virtue of location, livelihoods of households, among others) or poverty-induced (meaning low resilience due to limited capacity/resources to invest in effective mitigating and/or coping strategies). This distinction is particularly important for identifying appropriate policies to lower households' vulnerability. For instance, to mitigate poverty-induced vulnerability, policies to encourage investments in physical and human capital such as cash transfers and provision of essential services are likely to be more effective. On the other hand, insurance schemes will be more appropriate for lowering risk-induced vulnerability (Skoufias, Kawasoe, Strobl, & Acosta, 2019).

The report uses recent data from a Climate Related Risks and Poverty Survey (CRPS) of households in Cap-Haïtien. The survey conducted from October to November 2018 was designed to collect comprehensive data on the risk and exposure of households in Cap-Haïtien to floods as well as strategies used to prepare for and/or cope with floods, households' access to EWS. Poverty estimates for households were computed using the Survey of Wellbeing via Instant and Frequent Tracking (SWIFT) methodology and other household characteristics such as type of dwelling, demographics, economic activities and ownership of assets were also collected. It is important to highlight that since the data is a single cross-section and since the incidence of floods was self-reported, causal inference on the effect floods cannot be established. The results in our analysis are interpreted as correlations to highlight the association between floods and poverty in Cap-Haïtien.

Natural disasters particularly floods are a major source of vulnerability to poverty for households in Cap-Haïtien. Affected households experience interruptions in basic services (such as water, electricity and schools) and business/work, as well as destruction of infrastructure and assets. It is estimated that households affected by floods experience a 12 percent decrease in per capita consumption. However, this effect is statistically insignificant. In high-risk areas where households face a significant risk of exposure to frequent floods, the effect of floods on household welfare is similar in both magnitude and statistical significance. The negative effects of floods on the welfare of these households appears to be largely driven by their high risk of exposure to frequent floods and low capacity to adequately prepare for or effectively cope with floods when they occur. Most households resort to using their savings which is often insufficient to mitigate the effects of floods thereby exposing them to the risk of being trapped in poverty.

The report is structured as follows, we begin with a brief literature review of the nexus between exposure, vulnerability and resilience to natural disasters, and poverty. In section 3, we describe the

data beginning with the socio-economic characteristics of households in Cap-Haïtien including their demographics, nature of their dwellings, economic activities. In section 4, we examine the exposure of households to floods by describing the profiles of affected households. Section 5 examines the vulnerability of households to floods by using simple regressions to estimate the effects of floods on household welfare and the heterogeneity of the impact across households. In section 6, we examine households' resilience to floods by describing the strategies used to prepare for and cope with floods. The concluding section focuses on implications of the results.

2 Exposure, vulnerability and resilience to floods and poverty

Earlier empirical evidence indicates that the occurrence of natural disasters such as floods, droughts, and other extreme weather events is a major constraint to households' ability to escape poverty. For instance, droughts and rainfall shortages in Nicaragua increased households' probability of remaining in the bottom of the income distribution by 10 percent (Premand & Vakis, 2010). Similarly, in Peru, exposure to natural disasters is associated with a 2.3 to 4.8 likelihood of remaining in poverty (López-Calva & Ortiz-Juárez, 2009); and one standard deviation increase in the number of natural disasters increases poverty rates by 1 percent (Glave, Fort, & Rosemberg, 2008). Similar results were also found in El Salvador (Baez & Santos, 2008); in Honduras (Morris, et al., 2002); in Guatemala (Tesliuc & Lindert, 2002) among others. These studies illustrate the extent to which shocks (including natural disasters) may widen inequality gaps by trapping poor households in poverty; or pulling back into poverty households who have managed to escape. Therefore, the inability of poor households to effectively deal with natural disasters leaving them vulnerable to large negative effects on their welfare is often a central feature of their poverty status.

Poor households are often disproportionately more exposed, highly vulnerable and less resilient to natural disasters. Exposure, vulnerability and resilience are common themes in the literature on natural disasters. By exposure, studies identify and/or profile households who are likely to be affected by natural disasters. The analysis of the vulnerability of households typically involves measuring the effect of disasters on household welfare[4]. Resilience, especially socio-economic

[4] Gallardo (2018), Skoufias, Kawasoe, Strobl, & Acosta (2019) among other studies have discussed at length ex-ante versus ex-poste measures of well-being vis-à-vis natural disasters. To illustrate this distinction, ex-poste analysis of natural disasters such as using poverty as an outcome reports the extent to which disasters has affected household welfare by decreasing consumption or per capita expenditure to 'below-poverty-line' levels resulting in the household being poor. An

resilience, examines the ability of households to adequately cope with and recover from disasters (Hallegatte, Vogt-Schilb, Bangalore, & Rozenberg, 2016). Several studies highlight the overexposure, high vulnerability and low resilience of poor households to natural disasters and provide several explanations for this phenomenon. Poor households' livelihoods (which in rural areas is mostly agriculture-related) and the state of their insurance and credit markets (which is often missing/incomplete), expose them to significant uninsured disaster risks (Dercon, 2004). Additionally, in terms of geographic location, poor households are also more likely to settle in areas where despite the attractions of economic opportunities, public services, and social services, the risk of natural hazards is high (Hallegatte, 2012; Loayza, Olaberria, Rigolini, & Christiaensen, 2012; Patankar, 2015). Furthermore, given their low capacity (stock of assets and human capital) and low-quality assets (such as fragile dwellings), these households are often unable to effectively cope with and/or recover from the negative effects of natural disasters (Akter & Mallick, 2013; Jalan & Ravallion, 1999). Empirical evidence on the vulnerability of households to natural disasters report large negative effects of such events on the welfare (consumption, income, assets, health, human capital) of affected households-majority of whom are often the poorest households (Jacoby & Skoufias, 1997; Dercon & Krishnan, 2000; Skoufias & Quisumbing, 2005).

In line with this research, recent research has described high vulnerability depending if it is risk-induced or poverty-induced. Risk-induced vulnerability implies that households face a high uninsured risk of exposure to natural disasters and as such may remain or fall back into poverty in the future (Skoufias, Kawasoe, Strobl, & Acosta, 2019). Similarly, poverty-induced vulnerability occurs when households lack the capacity to cope with the negative effects of natural disasters and hence remain poor when affected by disasters (Skoufias, Kawasoe, Strobl, & Acosta, 2019). Understanding this distinction with respect to household vulnerability is useful for designing appropriate policies. For instance, for households facing risk-induced vulnerability, providing insurance may be a more effective policy whereas cash transfers and other programs which promote investments in productive assets and/or human capital will be more effective to lower poverty-induced vulnerability (Skoufias, Kawasoe, Strobl, & Acosta, 2019).

ex-ante analysis of vulnerability to poverty on the other hand consists of defining the expected level of well-being and the risk of falling into poverty due to a deviation from their current level of well-being caused by the occurrence of a natural disaster. (Gallardo, 2018) provides a recent and detailed survey of various techniques used in the literature to identify vulnerability.

The negative effects of natural disasters on household welfare often linger on into the future making households vulnerable to falling deeper or slipping back into poverty. Limitations in their capacity to adequately prepare for and/or cope with the effect of shocks imply that poor households take longer to recover or restore their welfare to pre-shock levels. Furthermore, the types of strategies adopted by these households such as depleting their assets, savings, or stock of human capital to mitigate the impacts of shocks also have significant implications on their future welfare. Access to social protection programs and/or DRM strategies including EWS is often limited and biased against poor households (Gentle, Thwaites, Race, & Alexander, 2014; Akter & Mallick, 2013; Hallegatte, Vogt-Schilb, Bangalore, & Rozenberg, 2016). As a result, affected households (particularly the poor) often resort to using negative coping strategies and/or reactive adaptation measures (such as evacuation) rather than proactive adaptation measures (such as building dykes) which are generally more effective (Francisco, Predo, Manasboonphempool, Tran, & Jarungrattanapong, 2011). Empirical studies on the effect of the use of these coping strategies such as selling productive assets (Deaton, 1992; Dercon, 2002); using savings (Paxson, 1992); investing in low-risk, low-return crop choices and asset portfolios (Rosenzweig & Binswanger, 1993); and increasing labor supply by removing their children from school (Jacoby & Skoufias, 1997; Kochar, 1999; Morduch, 1995) indicate that they are not only insufficient but also increase the likelihood of poverty traps in the medium and long terms (Dasgupta, 1993; Dercon, 1996; Dercon, 2004).

With little empirical evidence on the extent of exposure, vulnerability and resilience of households to floods in Haiti, this report aims explore the relationship between floods and household welfare in Cap-Haïtien through the lens of exposure, vulnerability and resilience. Despite limitations in the data, we attempt to provide insights into the extent to which exposure, vulnerability and resilience to floods are driven by uninsured risk (using data from risk maps) and/or poverty.

3 Description of the data and of households in Cap-Haïtien

3.1 Climate-related Risks and Poverty Survey (CRPS)

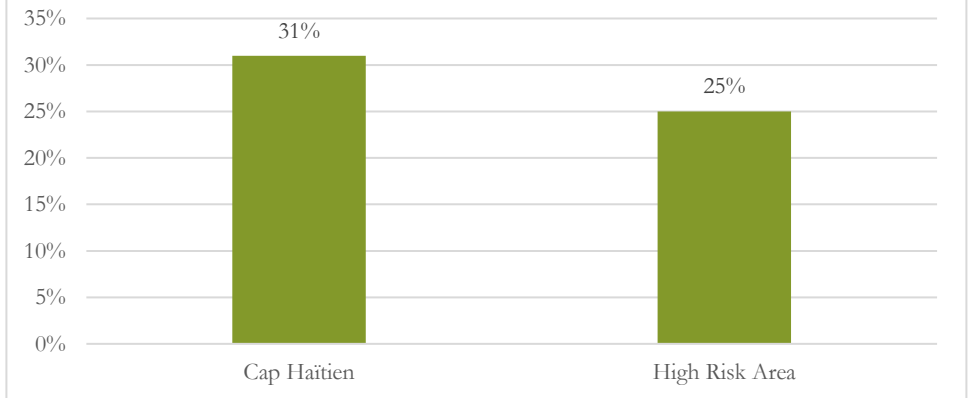
Data used in this report was obtained from the Climate-related Risks and Poverty Survey (CRPS) in the metropolitan area of Cap-Haïtien survey. The survey was designed to collect information on socioeconomic conditions of households (family composition, education, dwellings), climate-related risks (mostly floods), and cell phone uses. A representative sample of households in the Cap-Haïtien metropolitan area was selected for the survey. Other domains of inference considered

in developing the sampling frame include: project area and high-risk areas. The project areas in Cap-Haïtien refer to the areas benefiting from the Municipal Development and Urban Resilience (MDUR, P155201) project while the high-risk areas are identified based on hazard maps and refer to areas with 'moderate to high/strong' and 'strong to very strong' risks of floods.[5] The survey combined SWIFT modules computed by the Poverty Global Practice of the World Bank with a module on frequent climate-related risks created by Global Facility for Disaster Reduction and Recovery (GFDRR). This questionnaire covered extensive details on EWS with questions on knowledge of and access to the different forms of EWS, level of awareness, means of accessing or source and effectiveness of early-warning systems. Other details about floods including household level preparedness strategies, impact, coping strategies and recovery are also extensively covered in the questionnaire.

3.2 Households in Cap-Haïtien

Poverty affects 3 out of 10 individuals in Cap-Haïtien with poor households being larger in size, have a higher dependency ratio and more likely to be female headed. Using the resulting per capita consumption aggregate and the national poverty line from 2012, one can estimate poverty in Cap-Haïtien in 2018[6]. Poverty in Cap-Haïtien is estimated at 31 percent with a slightly lower rate in high-risk area at 25 percent (Figure 1). The average household size of poor households in Cap-Haïtien is 6 members which is significantly greater than the size of non-poor households. Poor households also have significantly higher dependency ratios – 0.89 compared to 0.43 in non-poor households. Furthermore, half of poor households are female headed.

Figure 1: Poverty Rate in Cap-Haïtien



[5] Details about the survey including the sampling technique and household selection for the survey are provided in the Appendix 9.1.

[6] Details about the SWIFT methodology used to estimate poverty are presented in Appendix 9.2

Source: authors' estimates with CRPS 2018

Table 1: Description of household composition

	Cap-Haïtien	High-risk areas	Poor households
Female household head (percent)	46 (0.50)	46 (0.50)	50 (0.50)
Household Size	3.81 (1.98)	3.87 (2.02)	5.81 (1.54)
Number of children (less than 5 years old)	0.28 (0.52)	0.25 (0.52)	0.54 (0.68)
Number of adults (more than 18 years old)	2.52 (1.31)	2.56 (1.33)	3.10 (1.28)
Average age of household members	29.43 (12.56)	30.58 (13.51)	23.00(7.68)
Age of household head	40 (13.8)	42 (14.5)	42 (15. 75)
Dependency Ratio (%)	52% (0.73)	53% (0.79)	89% (1)

Notes: Dependency ratio is calculated as (number of household members less than 15 years of age + number of household members over 64 years of age)/ number of household members between 15 and 64 years. Standard deviations in parenthesis.
Source: Authors' calculation using CRPS 2018

Majority of household heads in Cap-Haïtien (particularly the poor) work in small businesses. In Cap-Haïtien, over 70 percent of household heads work in businesses, including small family businesses (Table 2). Only about 4 percent of household heads work in public enterprises, less than 10 percent work in private enterprises and about 6 percent work in public-private enterprises. Given that small business appears to be the main source of livelihoods for households in Cap-Haïtien- particularly the poor, exposure to natural disasters such as floods is likely to affect their welfare. The occurrence of floods for instance may halt of business activities and/or damage goods and businesses. The immediate and aftermath effects of such events on the welfare of affected households are likely to be large and negative – particularly when they have low capacity of coping with shocks.

Table 2: Activities of household head (in percent)

	Cap-Haïtien	High-risk areas	Poor households
Public enterprise/administration	3.58 (0.19)	4.40 (0.21)	-
Parapublic enterprise	5.55 (0.23)	4.71 (0.21)	12.5 (0.33)
Private enterprise	9.52 (0.29)	12.21 (0.33)	3.54 (0.18)
Business/family business	72.93 (0.44)	70.25 (0.46)	73.37 (0.44)
Associative enterprise/cooperatives	2.3 (0.15)	1.84 (0.13)	-
Household chores	1.2 (0.11)	2.17 (0.15)	-

Notes: Standard deviations in parenthesis. Weights applied.
Source: Authors' calculation using CRPS 2018

Most households in Cap-Haïtien live in single-level buildings with a floor made of cement/concrete/marble. Nearly 72 percent of households in Cap-Haïtien live in single level buildings, 25 percent live in multi-level buildings; and 2 percent live in houses made of debris (slum-type houses). About 17 percent of households live in houses built on waste- majority of which (33 percent) are slum-type dwellings (Table 3). More poor households live in single-level buildings (86 percent), on compacted waste (27 percent) and in slums (3 percent). Their houses are less likely to

have roofs made of cement/concrete; or floors made of cement/ceramic/marble. These attributes of the dwellings of households in Cap-Haïtien indicate that the quality of houses (particularly the poor) are likely to be low and fragile. Single-level buildings and houses built on compacted waste are more likely to be inundated in the event of a flooding. Furthermore, these buildings (particularly those without cemented floors and/or roofs) are likely to be more fragile and less likely to withstand the impact of floods.

Table 3: Dwelling characteristics

Variable	Cap-Haïtien	High-risk areas	Poor households
Number of bedrooms	2.16 (1.68)	2.27 (2.04)	1.75 (0.77)
Floor in cement/ceramic/marble	93% (0.25)	90% (0.3)	83% (0.37)
Roof in cement/Concrete	48% (0.5)	55% (0.5)	29% (0.45)
Slum-type Building	2% (0.15)	3% (0.17)	3% (0.17)
Single-Level Building	72% (0.45)	60% (0.49)	86% (0.34)
Multi-level Building	25% (0.43)	34% (0.48)	9% (0.28)
Building built on compacted waste	17% (0.37)	18% (0.39)	27% (0.45)

Notes: Standard deviations in parenthesis. Weights applied
Source: Authors' calculation using CRPS 2018

Households mainly own small assets and half of them have savings. More than half of households in Cap-Haïtien (53 percent) have savings of some kind. Less than half (49 percent) of poor households have savings. Most households own small assets such as charcoal stove/cooker, cell phone and radio. Poor households own fewer and less valuable assets. The use of assets and/or savings to cope with shocks is widely documented in the empirical literature as highlighted in the previous section. For households in Cap-Haïtien (particularly among the poor), the composition of their asset portfolios as shown in Table 4 below imply that such strategies are less likely to be effective exposing households to poverty-induced vulnerability.

Table 4: Description of household composition (in percent)

Variable	Cap-Haïtien	High-risk areas	Poor households
HH Has Savings	53 (0.5)	55 (0.5)	49 (0.5)
Cooking Related Assets			
Electric/Gas Oven	7 (0.25)	8 (0.28)	-
Gas Stove	12 (0.33)	15 (0.36)	2 (0.14)
Charcoal Stove/Cooker	98 (0.15)	97 (0.17)	97 (0.17)
Electric Stove	6 (0.23)	7 (0.25)	-
Communication Related Assets			
Radio	65 (0.48)	63 (0.48)	36 (0.48)
Stereo	15 (0.36)	22 (0.41)	4 (0.19)
Cellular Phone	91 (0.29)	87 (0.33)	78 (0.41)

Television	57 (0.5)	61 (0.49)	29 (0.45)
Computer	11 (0.32)	12 (0.32)	-
Internet Access	4 (0.2)	5 (0.21)	-
Transport Related Assets			
Bicycle	11 (0.32)	12 (0.33)	6 (0.24)
Motorcycle	20 (0.4)	17 (0.38)	30 (0.46)
Car	5 (0.22)	6 (0.25)	-
Energy Related Assets			
Generator	9 (0.29)	11 (0.31)	-
Inverter/Accumulator/batterie	7 (0.26)	10 (0.29)	1 (0.08)
Solar Panel	17 (0.38)	15 (0.36)	15 (0.36)
Sewing machine	8 (0.28)	9 (0.29)	1 (0.07)
Fan	38 (0.48)	36 (0.48)	7 (0.26)
refrigerator/freezer	29 (0.45)	30 (0.46)	6 (0.23)
Other	1 (0.08)	1 (0.1)	-

Notes: Standard deviations in parenthesis. Weights applied
Source: Authors' calculation using CRPS 2018

4 Exposure to floods in Cap-Haïtien

In this section we examine the exposure of households in Cap-Haïtien to floods by describing the attributes of households who were affected by floods (including the number of times they were affected) between 2015 and 2018. We consider attributes such as households' risk of exposure to floods, the quality and characteristics of their dwellings, poverty, etc. to highlight the extent to which exposure to floods is risk-induced and/or poverty-induced. Based on these attributes, we provide insights into the nature of floods in Cap-Haïtien and describe households who are likely to be affected.

Most households, particularly the poor and those in high-risk areas, were affected by a flood in the last 3 years, mainly the 2017 one. Half of the households were affected by a flood with as many as 77 percent of households who live closer to the Bassin Rhodo being affected (Table 5). Furthermore, 65 percent of poor households were affected by floods and experienced an average of 4.5 floods between 2015 and 2018. High-risk areas faced similar rates of exposure to floods during the period. Households affected by floods report an average of four incidences of floods during this period. Between 2015 and 2018, the highest incidence of floods occurred in 2017 when 68 percent of households were affected by floods at least once. While disentangling the extent to which such high exposure is risk- or poverty-induced may be complex it can be observed that floods are slightly more common among poor households and among households living in high-risk areas, both in terms of the percentage of affected households and frequency, than the city average. One interpretation of this

observation is that poor households are more likely to live in low quality single-level dwellings which are fragile and more likely to be damaged in the event of a flood.

Table 5: Affected by a flood and most recent floods

	Cap-Haïtien	High-risk areas	Poor households
Household affected by a flood (in percent)	58 (0.49)	63 (0.48)	65 (0.48)
Most recent flood was in 2015	1 (0.11)	2 (0.14)	-
Most recent flood was in 2016	13 (0.33)	10 (0.31)	6 (0.23)
Most recent flood was in 2017	68 (0.47)	71 (0.46)	74 (0.44)
Most recent flood was in 2018	18 (0.38)	17 (0.38)	20 (0.40)
Numbers of floods	3.57 (2.73)	3.90 (3.05)	4.46 (3.12)

Notes: The most recent flood is only for households who were affected by a flood. Standard deviations in parenthesis. Weights applied.
Source: Authors' calculation using CRPS 2018

More female-headed households have been affected by at least one flood even, but male-headed households experience floods more frequently. In 2018, on average 61 percent of female-headed households in Cap-Haïtien experienced floods at least once between 2015 and 2018 compared to 54 percent of male-headed households (Table 6). However, male-headed households experienced more flood events on average than female-headed households, nearly 4 flood events compared to 3 flood events with the difference being statistically significant.

Table 6: Floods by Gender of household head

Variable	Male Headed	Female Headed
Household affected by floods	54% (0.50)	62% (0.49)
Number of floods in previous 3 years	3.83 (2.87)	3.32 (2.55)

Notes: Standard deviations in parenthesis. Weights applied
Source: Authors' calculation using CRPS 2018

Box 4-1 Risk-induced vs. poverty-induced exposure to floods in the case of gender of household heads and location of dwelling.

The high prevalence of floods among female-headed households appears to be more poverty than risk-induced. By comparing the extent to which households are exposed to risk of floods (based on whether they live in high-risk areas or not) and their likelihood of living in fragile dwellings (based on their poverty rates), we can draw some insights into the extent to which exposure to floods is risk-induced or poverty driven. For instance, compared to male-headed households female-headed households have a higher poverty rate (24 percent compared to 13 percent) although female-headed households are less likely to live in high-risk areas (54 percent versus 58 percent) (see table below). We have seen previously that poor households are more likely to live in single-level buildings with fragile materials which are unable to withstand heavy downpours. As such, the high exposure of female-headed households to floods is likely driven by their poverty and less likely by their exposure to risk of floods.

Households who live on compacted waste on the other hand face both risk and poverty induced exposure to floods. Households living on compacted waste on the other hand have both higher rates of poverty and face higher risk of exposure to floods. Sixty percent of households who live in dwellings built on compacted waste are also classified as living in high-risk areas. Furthermore, 33 percent of these households are poor and thus likely to live in dwellings less suited for the high risk of floods they face. Therefore, the exposure of these households to floods is likely to be induced by both the high risk they face as well as their poverty.

	HH Head Gender		Dwelling Built on Compacted Waste	
	Male	Female	Yes	No
Poor	13%	24%	33%	20%
High Risk Area	58%	54%	60%	50%

Source: Authors' calculation using CRPS 2018

Floods are more frequent among households living in slum-type houses and houses built on compacted waste. Although overall, the prevalence of floods is higher among households living in single-level buildings, the frequency of floods among these households is lower relative to households living in other building types, particularly slum-type dwellings (Table 7). However, on average, households living in slum-type dwellings experienced floods 8 times compared to 3 times for households in single-level buildings and 4 times for households in multi-level buildings. Households living in slum-type dwellings appear to have moved into their current dwellings recently (4 years ago on average). Similarly, 78 percent of households living on compacted waste experienced floods and have experienced an average of 4 floods between 2015 and 2018. Differences in the incidence of floods across households based on dwelling characteristics (particularly floor materials) illustrate the risk of exposure to floods faced by households with fragile dwellings. Households whose floors are

made of modern materials such as cement or marbles are more likely to be able to withstand heavy rainfall without being inundated than households whose floors are made of clay and other materials. The high prevalence and frequency of floods among households living in slum-type dwelling built on compacted waste is a cause for concern since they are likely to be less resilient to floods with the frequency of floods further weakening their capacity to cope and/or mitigate the impact of floods.

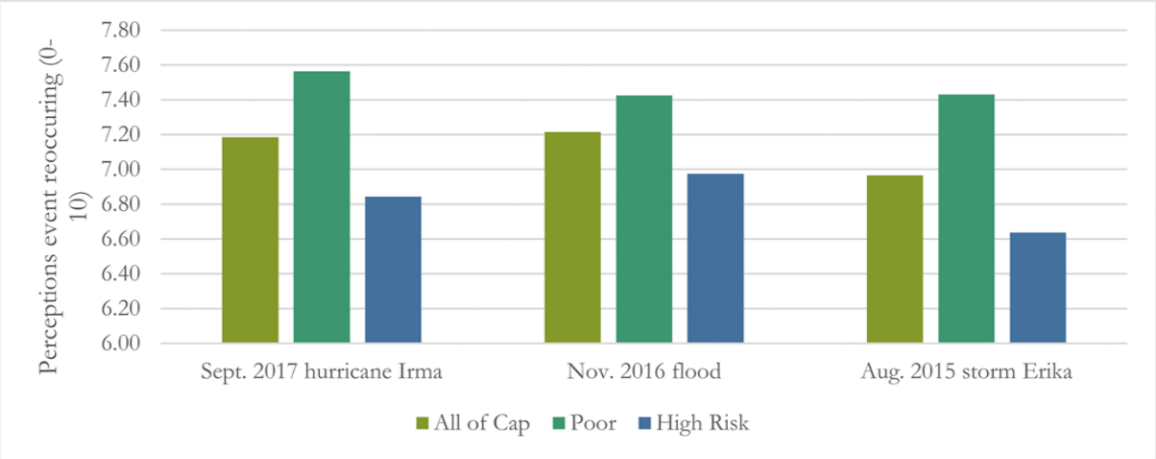
Table 7: Percent of households facing floods and number of floods, by dwelling types

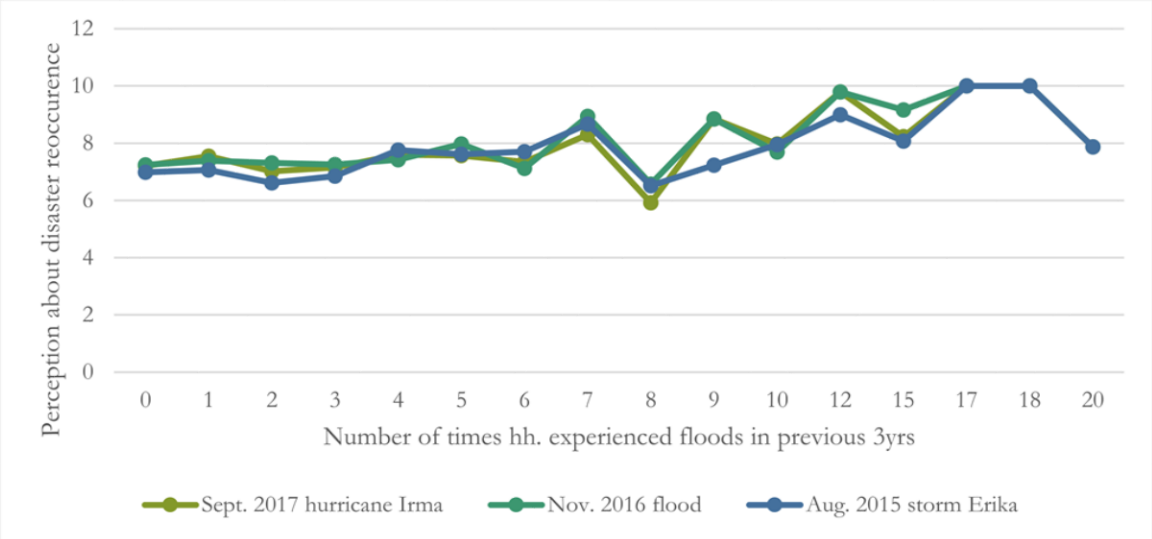
	Incidence of Floods (%)	Frequency of Floods
Building Type		
Slum-type houses	50 (0.50)	8 (7.73)
Single-level building	60 (0.49)	3 (2.28)
Multi-level building	51 (0.50)	4 (2.71)
Dwelling Built on Compacted Waste		
Yes	79 (0.41)	4 (2.76)
No	44 (0.50)	3 (2.82)
Dwelling Floor Material		
Modern materials (cement, marble, etc)	56 (0.50)	3 (2.40)
Non-cement materials	84 (0.37)	4 (4.71)
Roof Material		
Cement/Concrete Roofs	58 (0.49)	4 (2.97)
Non-cement roofs	57 (0.50)	3 (2.44)

Notes: Standard deviations in parenthesis. Weights applied
Source: Authors' calculation using CRPS 2018

Box 4-2 Perception about reoccurrence of floods

Perceptions about the reoccurrence of recent natural disasters are high- particularly among households repeatedly affected by floods and poor households. Based on a ranking between 0 and 10 (where 0 implies it is impossible for a natural disaster to reoccur and 10 implies it is possible for a given disaster to reoccur) the average households' perception about the reoccurrence of each of the three most recent natural disasters is 7. Across the three disasters which occurred between 2015 and 2017, the 2016 floods and 2017 hurricane Irma had slightly higher perception of reoccurrence. Some degree of heterogeneity in perceptions about floods can also be observed across households. For instance, poor households have higher perceptions that natural disasters (particularly the 2017 hurricane Irma) may reoccur. Households living in high-risk areas on the other hand have slightly lower perceptions about the reoccurrence of natural disasters.





Source: Authors' calculation using CRPS 2018

Box 4-3 Floods and migration of households

Exposure to floods is highest among households who migrated from other departments- particularly those from rural areas. Majority of households who migrated from other departments in rural Haiti experienced at least one flood and an average of nine flood events over the three-year period. Similarly, nearly 70 percent of households who migrated from other departments in urban Haiti were also affected by floods albeit less frequently- an average of four flood events. Majority of these households, migrating from rural and urban areas live in high-risk areas.

The share of households living in high-risk areas is higher among households who have lived in their current houses for over 20 years than those who have lived in their house for less than five years, yet the incidence of floods is higher among the latter. More than 60 percent of households who have lived in their current dwellings for more than 20 years live in high-risk areas. However, only 46 percent of these households experienced floods in the previous three years- albeit more frequently- an average of four flood events. On the other hand, more than half of households who have moved into their current houses within the previous five years do not live in high-risk areas, yet they faced a higher incidence of floods. Within the previous three years, floods affected 63 percent of these households. Ordinarily, the observation that living in high-risk areas is less common among households who have recently moved into their houses may ease efforts to reduce the vulnerability to of households to future floods. However, since floods appear to be less common among households who have lived in high-risk areas for as long as 20 years and more common among recent dwellers, it is worth examining possible changes in the riskiness of these areas overtime.

5 Vulnerability of households to floods

In this section, we discuss the vulnerability of households to floods by examining the effect of floods on household welfare. We do this in two ways: we begin by describing the effects of floods on households including damages to their assets and livelihoods based on self-reported responses. In the second part, we estimate the effect of floods on household welfare using household consumption per capita. In both parts, we identify vulnerable households based on the extent of the effects of floods on households' assets, livelihood and welfare.

5.1 Examining the effects of floods

Interruption of schools and destruction to roads and paths are the most common negative effects from floods reported by households. Floods affect almost all aspects of the daily life of the inhabitants of Cap-Haïtien. Floods cause interruptions in schools and economic activities, damage roads, homes and assets, and affect supply of basic services-water, electricity and food. The effects on schools and roads are most common: respectively, 62 percent and 57 percent of households affected

by floods in Cap-Haïtien indicate interruptions in their kids' school and destructions to roads and paths as the main impact of floods (Table 8). Interruptions in business/work are also common; 49 percent of households who experienced floods also experienced interruptions in their work or business. Nearly 35 percent of households affected by floods also report damage to their home and assets and more than 25 percent report loss of important documents. Interruptions in basic services are also experienced by affected households with 37 percent of households having trouble accessing water after a flood and 40 percent facing constraints in accessing electricity. Given than most households rely on their businesses as a source of livelihood, damage to roads and paths is likely to significantly affect business activity thereby affecting the welfare of households.

Table 8: Impacts on floods (percent of households)

	Cap-Haïtien	High-risk areas	Poor HH
Damage to Home	37 (0.48)	35 (0.48)	43 (0.50)
Lost Assets	35 (0.48)	43 (0.50)	39 (0.49)
Trouble Accessing food	23 (0.42)	26 (0.44)	31 (0.46)
Trouble Accessing Kerosene/charcoal	23 (0.42)	25 (0.44)	33 (0.47)
Lost important documents	23 (0.42)	26 (0.44)	19 (0.39)
Interruptions in Water Service	37 (0.48)	44 (0.50)	46 (0.50)
Damaged Sanitation services	21 (0.40)	21 (0.41)	20 (0.40)
Lost electricity	40 (0.49)	48 (0.50)	32 (0.47)
Business/work affected	49 (0.50)	50 (0.50)	52 (0.50)
HH member became sick	36 (0.48)	41 (0.49)	50 (0.50)
Interruptions in kids' school	62 (0.48)	66 (0.47)	78 (0.41)
Roads/paths destroyed	57 (0.49)	50 (0.50)	63 (0.48)

Notes: Standard deviations in parenthesis. Weights applied.
Source: Authors' calculation using CRPS 2018

Overall, the effect of floods on poor households and households living in high-risk areas appears to be more severe making them most vulnerable. Compared to non-poor households, poor households lose more because of floods. Apart from loss of important documents, access to electricity and sanitation services, all other effects of floods are more common among poor households. More poor households report damage to their homes and assets, and interruptions in their business/work and schools of their children than non-poor households. Similarly, the effects of floods also appear to be quite severe among households in high-risk areas. Effects of floods such as loss of assets, damaged sanitation services, and interruptions in schools, electricity and water supply are most common among households in high-risk areas. The fact that these effects of floods are most common among poor and high-risk households (who are more likely to live in slum-type dwellings

and on dwellings built on compacted waste; and whose main livelihood is business) has significant implications on poverty eradication and highlight the need for effective social protection policies.

Home destruction and loss of assets due to floods are most common among households living in slum-type dwellings. The occurrence of floods resulted in the destruction of their houses for 72 percent of affected households living in slums. Comparatively, less than 40 percent of affected households in single-level and multi-level buildings reported destruction to their homes. Similarly, 67 percent of households affected by floods who live in slum-type dwellings lost assets compared to 33 percent of affected households who live in single-level buildings and 38 percent of those who live in multi-level buildings. Other effects of floods which are more common among households living in slum-type dwellings include: difficulty accessing kerosene/charcoal, loss of important documents, damaged sanitation services and sickness of household member. Interruptions in water services, electricity, business/work, schools and destruction of roads or paths are more common among households living in single and multi-level buildings. These differences in the effects of floods on households further illustrate the vulnerability of poor households (most of whom live in slum-type dwellings) to natural disasters. The fragile nature of their dwellings makes them more vulnerable to large negative effects of floods- including damage to their dwellings and assets. Their exposure to floods and its effects such as destruction to their houses and assets further lower their capacity to mitigate the impact of such shocks and their ability to escape poverty.

5.2 Estimating the impact of floods on household welfare

Floods have multidimensional effects on households' welfare. As shown in Table 8, floods have an effect on household dwellings, assets, work/business, health, access to basic services and other goods affecting the lives and livelihood of households in Cap-Haïtien. To estimate the impact of floods on the welfare of households in Cap-Haïtien, we examine the extent to which the incidence of floods affects household consumption per capita as follows:

$$\ln(y_i) = X_i\beta + \alpha S_i + \varepsilon_i$$

where y_i is an indicator of household welfare measured using household consumption per capita of household i; X_i is the vector of household characteristics such as demographics, assets, education level and employment of household head; S_i is an indicator of the incidence of floods - i.e a binary variable which takes a value of one for households affected by floods in the previous three years and zero otherwise; and ε_i is the error term. Our main parameter of interest in this specification is α. The

extent to which shocks affect the welfare of households in Cap-Haïtien can be examined by assessing whether α is significantly different from zero.

Table 9: Estimating the impact of floods on household consumption

VARIABLES	Basic model (1)	Model for high-risk areas (2)
Incidence of Flood (=1)	-0.124 (0.0893)	-0.128 (0.0952)
Number of floods in previous 3yrs	0.0133 (0.0118)	0.00563 (0.0147)
High risk Area (=1)	-0.0274 (0.0608)	-
Project Area (=1)	0.0815 (0.0524)	0.102* (0.0563)
Household received aid following flood	-0.208* (0.121)	0.00264 (0.107)
HH coping strategies (base category= No strategy)		
Household level strategies	0.0703 (0.0662)	0.0899 (0.0787)
External support- family/friends/govt	0.0670 (0.134)	-0.134 (0.148)
HH Level characteristics		
Household size	-0.179*** (0.0168)	-0.163*** (0.0150)
Household dependency ratio	-0.0775** (0.0344)	-0.0211 (0.0347)
Female Headed HH	0.0713 (0.0685)	-0.0147 (0.0549)
Age of Household head	0.0262* (0.0140)	0.0239* (0.0130)
Squared of age of HH head	-0.000226 (0.000157)	-0.000227 (0.000146)
HH Head Level of education (Base category= None)		
Incomplete Primary	0.149 (0.262)	0.394 (0.244)
Complete Primary and Incomplete Secondary 1	0.190 (0.260)	0.409* (0.245)
Complete Secondary1 and incomplete Secondary 2	0.328 (0.256)	0.447* (0.240)
Complete Secondary2 and Tertiary	0.509** (0.255)	0.635*** (0.245)
HH Head Activities (base category= Unemployed)		
Public enterprise/administration	0.220 (0.197)	0.00397 (0.233)
Parastatal enterprise	-0.145 (0.108)	-0.236* (0.126)
Private enterprise	0.0856 (0.111)	-0.134 (0.0963)
Business/family business	0.0354 (0.0731)	-0.108* (0.0637)
Associative enterprise/Cooperatives etc.	-0.340** (0.145)	-0.483** (0.200)
Household work	-0.0567 (0.165)	-0.223** (0.111)
Household has savings (=1)	0.00459 (0.0606)	0.0837 (0.0569)
Assets		
Cooking assets	0.172 (0.182)	-0.236 (0.180)
Communication assets	0.461*** (0.0925)	0.447*** (0.122)
Transport assets	0.263*** (0.0701)	0.285*** (0.0648)
Energy-related assets	0.211*** (0.0589)	0.225*** (0.0585)
Other assets	-0.00125 (0.0948)	-0.0573 (0.0981)
Duration in dwelling (base category= Less than 5yrs)		
5 to 10 years	-0.0732 (0.0749)	-0.0543 (0.0742)
11 to 20 years	0.0403 (0.0891)	-0.00620 (0.0715)
More than 20 years	0.0547 (0.0974)	0.137 (0.0855)
Building Type (base category= Slum)		
Single-level	-0.351** (0.147)	-0.146 (0.234)
Multi-level	-0.285* (0.166)	-0.0973 (0.242)
Others	-0.407** (0.185)	-0.0545 (0.278)
Source of electricity (=1 if connected to the grid)	0.129** (0.0613)	0.0338 (0.0584)
Source of water (=1 if DINEPA/Public Fountain)	0.0447 (0.0657)	0.0105 (0.0528)
Household built on compacted waste (=1)	-0.149** (0.0723)	-0.101 (0.0628)

Household floor made of cement/marble	0.122 (0.0924)	0.0957 (0.0985)
Household roof made of cement/concrete	0.0791 (0.0765)	0.143** (0.0643)
Constant	9.943*** (0.438)	10.07*** (0.435)
Observations	417	346
R-squared	0.657	0.576
Adj. R-squared	0.621	0.523

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Although a lower consumption per capita is associated with households affected households in Cap-Haïtien, the effect is statistically insignificant. On average, consumption per capita of households affected by floods in Cap-Haïtien decreases by 12 percent. In high-risk areas, a similar effect (in both magnitude and statistical significance) is observed. A few caveats in the data may offer some explanation for the statistically insignificant negative effect of floods on the welfare of households in Cap-Haïtien.

Firstly, there is a gap of over a year between the timing of the occurrence of floods and the implementation of the survey to collect data for welfare estimation. Most of the floods reported by households occurred in 2017 (see Table 5), yet welfare was estimated based on data collected over a year later- between October and November of 2018. Therefore, the observed statistically insignificant effect of floods on household welfare may in part be because welfare levels of affected households have improved at the time of the survey- perhaps because of post-disaster support. Furthermore, Table 8 shows (albeit descriptively), that the effects of floods in Cap-Haïtien span beyond typical measures of welfare but also include interruptions in basic services- water, road network, schools etc.

Secondly, given that half of the population is affected by floods (Table 5), there is little variation in consumption fluctuations due to floods to capture a statistically significant negative effect. This means that even though consumption per capita decreases following a flood, but because many households are affected by the floods and hence experience a fall in their consumption levels, there is little variation in welfare of households across the city and hence a negative but statistically insignificant effect is observed. Based on these factors, it is important not to lose sight of the level of vulnerability faced by households in Cap-Haïtien to floods. In the absence of adequate social protection and/or effective early warning systems, these households may be a flood or two away from being falling deeper or being pushed back into poverty.

6 Resilience to floods

In this section, we describe households' resilience to floods in two ways: first, we discuss the duration it takes for households to recover from the effects of floods; and second, we explain observed speed of recovery from the types of preparatory and coping strategies used ex-ante and/or ex-post by households.

The resilience of households in Cap-Haïtien is low with nearly half of households affected by floods being unable to restore their consumption to pre-flood levels. For a quarter of households affected by floods it takes months and for another quarter weeks to restore their consumption levels following the floods. In addition, more than half of these households were also unable to re-establish their savings after being affected by floods. Among households who are unable to re-establish savings, 54 percent could not restore consumption levels to pre-flood levels. Although poor households and those living in high-risk areas are most vulnerable to floods and have lower capacity to cope with the impact of floods, their levels of resilience appear to be like non-poor households and those living in low/medium risk areas. This is likely driven by the fact that these households, by their exposure and low capacity are more likely to receive assistance (particularly post-disaster relief) as discussed earlier.

Female-headed households appear to be less resilient to the impact of floods in Cap-Haïtien. More female-headed households who were affected by floods were unable to restore consumption levels and savings to pre-flood level than male-headed households. Furthermore, for female-headed households who were able to restore consumption levels, it takes them longer indicating their low resilience; only 24 (29) percent of female-headed households restored consumption levels within weeks (months) compared to 28 (19) percent of male-headed households. A similar trend is observed in restoring savings.

Box 6-1 Early Warning Systems and preparedness

Early Warning Systems exist in Cap-Haïtien, but awareness remains low. Overall, only 40 percent of households in Cap-Haïtien know about EWS. Among poor households and those living in high-risk areas, awareness of EWS is slightly higher than the city average- 41 percent of poor households and 44 percent of households living in high-risk areas are aware of EWS. Of these households who are aware of EWS, 85 percent received flood alerts and 59 percent received alerts in advance of a flood event- often days in advance. Among poor households, receipt of floods alerts is higher: 87 percent of poor households who are aware of EWS received flood alerts and 73 percent received alerts before a flood- mostly weeks in advance. Most households (65 percent) who received alerts received it from other sources- mostly radios, televisions, etc. To improve the targeting of alerts from EWS and strengthen resilience, other sources of flood alerts such as Municipal Civil Protection Committees (CCPC), Associations and NGOs can be reinforced- particularly among poor and high-risk households.

Most households in Cap-Haïtien respond to flood alerts by stocking food/water and protecting important documents. Less than 30 percent of households who received flood alerts chose to evacuate. Among poor households and those living in high-risk areas, it is much lower- 14 percent and 23 percent respectively. Even though EWS alerts appear to be credible- all households who received a flood alert experienced floods; most households- more than 90 percent; responded to flood alerts by protecting their important documents and up to 48 percent choose to stock up food or water after receiving a flood alert. Similar trends are also observed in high-risk areas- where 64 percent of households who received flood alerts chose to stock water/food and 86 percent chose to protect important documents. Therefore, EWS reforms must raise awareness, increase the accessibility of alerts and educate households about better response/preparedness strategies.

	Cap-Haïtien	High Risk	Poor
Knowledge of EWS	40.45	43.87	41.07
Reception of EWS*	84.81	84.82	87.42
Receive EWS before floods*	59.01	55.97	72.69
From who did they receive the alert			
Communal Committee	20.6	28.32	18.83
Police	1.88	1.8	0
Associations/NGOs	12.84	11.52	3.43
Other	64.62	50.72	69.91
How far in advance did you receive alert			
Hours	12.91	8.44	28.51
Days	41.26	46.46	26.01
Weeks	22.92	22.4	35.76
Don't Know/Not Sure	22.91	22.7	9.72
Response to Alert			
Evacuate	28.79	23.27	13.61
Stored Food/water	48.07	64.18	21.64
Reinforced Structure	9.69	13.97	8.67
Cleaned up outside of house	21.47	27.67	3.37
Protected Important documents	90.78	86.92	92.03
Other	12.46	17.17	26.81

Note: Means calculated as the percent of people who know about EWS. Weights applied.
Source: authors' estimates using CRPS 2018.

Table 10: Household resilience and capacity to restore consumption/savings (percent of households)

	Cap-Haïtien	Poor	High Risk
Duration it takes to restore consumption			
Weeks	26 (0.44)	22 (0.41)	29 (0.45)
Months	24 (0.43)	29 (0.45)	26 (0.44)
Years	0.4 (0.06)	0.4 (0.06)	0.6 (0.08)
Did not recover	48 (0.50)	49 (0.50)	42 (0.49)
Ability to Re-establish Savings			
Yes	31 (0.46)	28 (0.45)	33 (0.47)
No	54 (0.50)	59 (0.49)	51 (0.50)
Didn't have savings	15 (0.36)	13 (0.33)	16 (0.36)

Notes: Weights applied.
Source: Authors' calculation using CRPS 2018

Resilience meaning households' ability to recover from non-monetary losses of floods still paints the same picture: the poor households in Cap-Haïtien are less resilient. In addition to consumption and savings, households in Cap-Haïtien (particularly the poor) are less resilient to the effect of floods on other aspects of their welfare such as their documents, work/business, health and their dwelling (Table 11). Nearly all poor households affected by floods reported never being able to recover their documents lost in the floods compared to a city-wide average of 83 percent. Similarly, 23 percent of affected poor households reported never being able to return to work or their business due to floods compared to a city average of 10 percent. Repairs to homes also take longer among poor households. For 69 percent of poor households, it takes weeks (compared to 26 percent of all households) and for 12 percent it takes years compared to 8 percent of all households.

Low resilience of households in Cap-Haïtien to negative effect of floods is also in part driven by institutional deficiencies. Interruptions in basic services such as water and sanitation, electricity, school, and roads due to floods often take (in some instances) months to be restored and in other instances never restored. Poor households in particular often face longer duration to get services restored. For instance, for most of the poor households, restoring water and sanitation services in the aftermath of a flood took months. Interruptions in schools and electricity as well as destruction to roads due to floods still took weeks to restore- particularly among poor households.

Table 11: Household resilience and capacity to recover from losses (percent of households)

Never recovered/restored	Cap-Haïtien	High Risk	Poor
Lost documents	83 (0.4)	77 (0.4)	100 (0)
Work/business	10 (0.3)	10 (0.3)	23 (0.4)
Health	7 (0.3)	5 (0.2)	14 (0.4)
Water services	3 (0.2)	4 (0.2)	
Sanitation service	23 (0.4)	33 (0.5)	40 (0.5)

Electricity	38 (0.5)	39 (0.5)	40 (0.5)
Roads/paths	35 (0.5)	41 (0.5)	31 (0.5)

Notes: Standard deviations in parenthesis. Weights applied
Source: Authors' calculation using CRPS 2018

Households affected by floods in Cap-Haïtien mostly rely on their own coping strategies- mainly by using their savings. Overall, 66 percent of households affected by floods used own-coping strategies (mainly their savings) to mitigate the impact of floods. More than 30 percent of affected households did not use any strategy. The availability of external support- from government, family and friends is low overall with only four percent of households affected by floods receiving external support. However, about 74 percent of affected households receive some form of aid/assistance after a flood event. Although poor households appear to have lower capacity to deal with floods, they are the highest receivers of external support to cope with floods: about 11 percent of these households received support from government family or friends; and nearly all of them received aid/assistance after a flood event. For households living in high-risk areas, 40 percent of them who are affected by floods received aid/assistance during a flood event and nearly all of them received aid/assistance after a flood event. Although households appear to generally have a low capacity of dealing with floods, the provision of aid/assistance- particularly for the most vulnerable- the poor and those living in high-risk areas is important for building/strengthening their resilience.

Table 12: Coping strategies and assistance (percent of households)

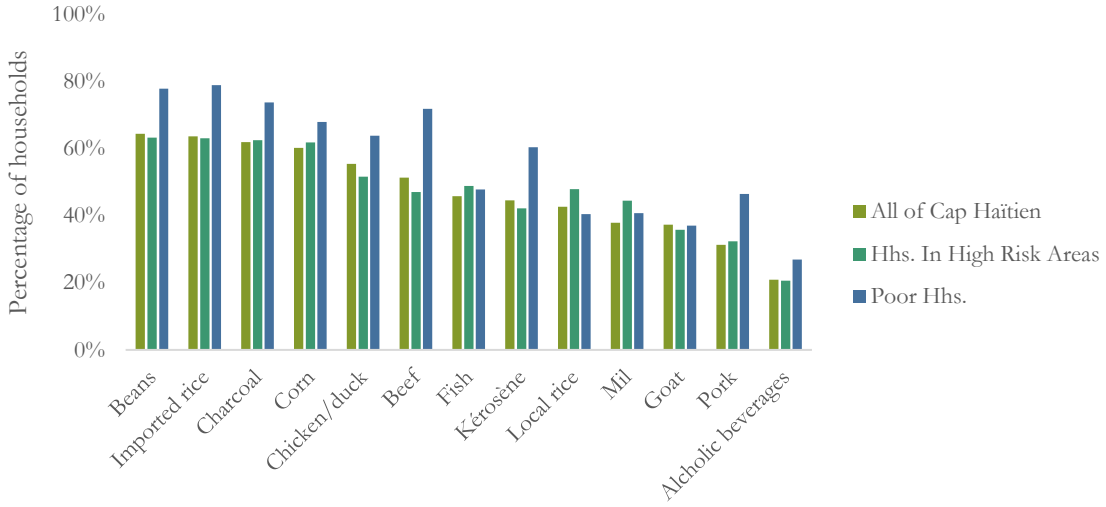
	Cap-Haïtien	Poor	High Risk
Coping Strategies			
Household level strategies	66 (0.47)	59 (0.49)	70 (0.46)
External support- family/friends/govt	4 (0.20)	11 (0.31)	3 (0.18)
Did Nothing	30 (0.46)	31 (0.46)	27 (0.44)
Assistance Received			
Received any assistance	4 (0.19)	7 (0.26)	4 (0.19)
Received assistance during Flood	26 (0.44)	0	41 (0.49)
Received assistance After Flood	74 (0.44)	100 (0)	59 (0.49)

Notes: Weights applied. Although we did not have any questions on preparatory strategies, households use these categories when replying to coping strategies.
Source: Authors' calculation using CRPS 2018

In addition to using savings, reductions in the consumption of food items is another common coping mechanism, particularly among poor households. More than 50 percent of households affected by floods resort to decreasing their consumption of several food items such as beans, imported rice, corn, chicken/duck and beef. Similar pattern is also observed among households who live in high-risk areas. These strategies are particularly more common among poor households. More than 70 percent of poor households affected by floods decrease their consumption of imported rice,

beans and beef. Reduction in the consumption of these food items as coping mechanisms of households affected by floods is likely to result in poor nutritional and dietary outcomes.

Figure 2: Reduced consumption of food items (% of households)



Note: Weights applied.
Source: Authors' calculation using CRPS 2018

Most households rely on their savings to cope with floods. Forty-two percent of households affected by floods used their savings to mitigate the impact of the floods. The use of savings is less common among poor households; only 25 percent of poor households affected by floods relied on their savings to cope with the impact of the floods compared to 46 percent of non-poor households. Similarly, households in high-risk areas also rely significantly on savings and 45 percent of affected households in high-risk areas relied on their savings to cope with shocks. Reduction in quantity of food or number of meals to cope with the impact of floods is also common among poor households- 16 percent of poor households used this strategy compared to 4 percent of non-poor households (used by 4 percent). Other coping strategies used by households in Cap-Haïtien include: migration by household members (particularly among the non-poor households). It is important to highlight that 8 percent of affected households in Cap-Haïtien and 10 percent of those living in high-risk areas did not use any coping strategy to mitigate the impact of floods.

7 Conclusion

Several factors may explain the high exposure and vulnerability of poor households to natural disasters. First, these households often face significant risk of disasters. Secondly, they also have low capacity to adequately prepare ex-ante or effectively cope ex-poste with natural disasters. As a result,

the occurrence of natural disasters such as floods often pushes these households deeper into poverty. Similarly, households who are marginally above the poverty line may also be a flood or two away from sliding back into poverty.

In Cap-Haïtien, floods are frequent and widespread. Between 2015 and 2018, more than 50 percent of households were affected by floods at least once. Low capacity to cope with frequent floods increases the vulnerability of these households to poverty traps. It is estimated that households affected by floods experience a 12 percent decrease in per capita consumption. However, this effect is statistically insignificant. In high-risk areas where households face a significant risk of exposure to frequent floods, the effect of floods on household welfare is similar in both magnitude and statistical significance. However, interruptions in basic services (such as water, electricity and schools) and business/work; as well as destruction to infrastructure and assets are common effects of floods in Cap-Haïtien. The high rate of poverty and low capacity, assets and savings to mitigate the impact of floods on household welfare, imply that most of these households remain at risk of falling deeper or sliding back into poverty. Most households rely on their own-coping strategies (which often involve using their savings) which is often insufficient thereby increasing their vulnerability to poverty traps. Reforms such as effective and shock-responsive social protection programs and DRM strategies such as EWS are crucial for lowering vulnerability and building resilience of households in Cap-Haïtien. While EWS exist in Cap-Haïtien, they appear to be less effective- most households who received alerts of floods resorted to protecting their documents, stacking food, reinforcing their dwellings, etc. rather than evacuating. Better sensitization of households about EWS to raise awareness about flood alerts from various authorities and promote evacuation can significantly contribute to lowering the negative effects of floods.

8 References

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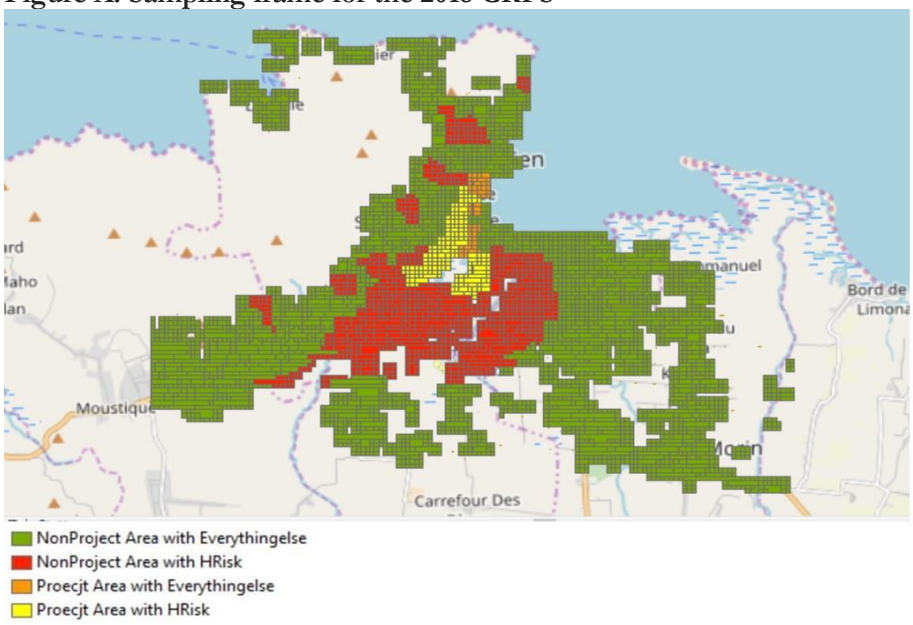
9 Appendix

9.1 Climate-related Risks and Poverty Survey (CRPS) data

An original two-stage sampling strategy was designed to ensure the representativeness of the survey results. The sampling frame was constructed using the consumption aggregates from the 2012 *Enquête sur les Conditions de Vie des Ménages après le Séisme* (ECVMAS) collected by the *Institut Haïtien de Statistique et d'Informatique* (IHSI). The team designed a two-stage sampling framework- beginning with the identification of all applicable Primary Sampling Units (PSUs) in the first stage; and selection of households within selected PSUs in the second stage.

Explicit stratification is done first for Cap-Haïtien and the project area, with an additional stratum on high-risk area. Using the domains of inference (Cap-Haïtien, project area, and high-risk areas), we construct four strata: project areas with high/moderate risk of floods; project areas with low/no risk of floods; non-project areas with high/moderate risk of floods; and non-project Areas with low/no risk of floods.[7] The 'High Risk' strata consist of areas with 'moderate to high/strong' and 'strong to very strong' risk areas as defined in the Cap-Haïtien flood risk report conducted by Signalert for the Government of Haiti "*Caractérisation et cartographie du risque inundation et de submersion marine sur l'agglomeration du Cap-Haïtien, 2015.*

Figure A: Sampling frame for the 2018 CRPS



Source: UDA consulting Company, 2017.

[7] More information on sampling design is available upon request.

The lack of recent population data is overcome with the use of population estimates from remote sensing. Since there are no census maps for all PSUs in Cap-Haïtien, a grid-segment design, or area-probability approach was used. In this approach, uniform grids are layered over the city segmented into 100 x 100 meters[8] which is close to the standard measure of a city block. Grid-segments were assigned a population density based on georeferenced population data obtained from WorldPop.[9]

The two-stage selection of households provides for the calculation of the probability of selection of households. Applying the total number of households to the sample frame of PSUs facilitates the use of probability proportional to size selection and give lower, but not zero, probability to sparsely populated areas. In the second stage, a listing of all households within a given PSU is conducted to determine the probability of household selection. By design, 120 PSUs were surveyed and 5 households per PSU were to be selected. Then the probability of selecting any given household for inclusion in the sample is the product of the probability of the grid-segment (PSU) being selected and the probability of the household within being selected.

All data were collected between October and November 2018 using a Computer Assisted Personal Interview (CAPI) form by a private Haitian research institution INURED. The survey was completed for 591 households as nine households preferred not to answer to the survey and no replacement households were identified. Of these 591 households, one household did not respond to any of the survey questions and another two households had several missing responses. These households were dropped leaving us with 588 useable observations.

Weight are applied to ensure that the estimates obtained from the survey data are representative of the population of interest. These weights are the result of the recorded probabilities of selection at each stage of selection defined below:

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[8] We have also compared this with 50 x 50-meter grids and 250 x 250-meter grids. However, in the former, there were lots of sparsely populated grids- of the 10, 221 grids with at least one household, 9,178 grids had less than 15 households. This increases the likelihood of selecting grids with less households thereby affecting our sample. The 250 x 250 meter grids were found to be too large and possibly difficult to implement. With an average of 31 households per grid, the 100 x 100 meter grids appear to be reasonably easy to implement.

[9] An alternative measure of population density based on satellite imagery of landcover was also used in addition to data from WorldPop. This data identifies roof-tops (distinguished into residential and non-residential buildings) and hence number of dwellings. By multiplying the number of residential buildings in each grid with the average household size, a approximate population density is obtained which for the purposes of sensitivity analysis, is compared with the data from WorldPop.

$$p_{hij} = P_1 P_2 = \frac{k_j n_{ij}}{N_j} \frac{m_{ij}}{n'_{ij}}$$

Where:

p_{hij} is the probability of selecting household h in grid i and stratum j;
P_1 is the probability of selecting a given PSU in stage 1 of the sampling strategy;
P_2 is the probability of selecting a given household in stage 2 of the sampling strategy;
k_j is the number of PSUs selected in stratum j;
n_{ij} is the size of grid i in stratum j;
N_j is the size of stratum j;
m_{ij} is the number of households selected in grid i of stratum j;
n'_{ij} is the number of households listed in grid i of stratum j.

The household selection weights (refer to this as w_{sel}) is the inverse of the probability of selection defined above. The selection weight was further adjusted for non-response by taking a ratio of the number of households selected for interview and the number of households interviewed. This value equals to 1 if 5 households which were (by design) selected for interviewed were interviewed; to less than 1 if more than 5 households were interviewed; and to more than 1 if less than 5 households were interviewed. The final weight becomes:

$$\mathrm{w_{final}} = \mathrm{w_{sel}} \times \mathrm{w_{nr}}$$

Where:

$\mathrm{w_{sel}}$ is the inverse probability of selection in the sample design;

$\mathrm{w_{nr}}$ is the adjustment to account for non-response rates.

There are some outliers in the weights- mostly for grids with very low 1st stage probability. To trim the weights, we winsorized these outliers by replacing any value above the 99th percentile with the highest value from the 98th percentile of the final weights defined above.

9.2 SWIFT Methodology

Typically, data on household consumption, expenditure or income is collected and used to construct poverty lines and analyze poverty profiles of households in most surveys. However, the CRPS survey did not include data on household consumption, expenditure or income. To fill this gap, we use the Survey of Wellbeing via Instant and Frequent Tracking (SWIFT)methodology along with the 2012 *Enquête sur les Conditions de Vie des Ménages après le Séisme* (ECVMAS) to compute household poverty.

SWIFT is a data collection method developed to provide timely, quick, and accurate data on poverty through a small set of country-specific questions. Developed by the World Bank to estimate poverty incidence between consecutive comprehensive household surveys (Ahmed et al., 2014; Yoshida et al., 2015), SWIFT methodology complements traditional household surveys which are collected on average every five years by providing more frequent poverty measurements to monitor poverty changes. Although the model can use either consumption or income as the welfare measure, the country preference takes precedence to maintain comparability. SWIFT develops country-specific models.

SWIFT model assumes a linear relationship between household total consumption/income (y_h) and its correlates (x_h) with a projection error (u_h). The inclusion of this error term differentiates this model from other predictive tools

$$lny_h = x_h{}'\beta + u_h \quad (1)$$

SWIFT estimates the log transformation of the dependent variable to smooth asymmetries and normalize the distribution of the variable, making it easier to estimate. SWIFT controls for issues linked to over-fitting – when a model performs well within the sample but poorly outside the dataset – by cross-validating the model (Kuhn and Johnson, 2013). The purpose of cross-validation in SWIFT is to identify the optimal level of significance- or p-value- in the model, which would balance the number of determinants and the goodness of fit across the sample. Cross-validation consists of two steps: (a) splitting the sample in n-folds and running the model in n-1 folds and testing it on the nth fold [10] and (b) running multiple models per fold, testing various thresholds of significance for model variables. This process of 'stepwise' selection entails adding variables to the Ordinary Least Square (OLS) model sequentially if they bring enough information, and simultaneously removing them if they do not. Each fold has a chance to be the testing data and this process is repeated n times by changing the nth fold each time. The optimal p-value performs best in terms of mean-squared errors[11] between actual and projected welfare, and the absolute value of the difference between the actual and projected poverty (or forest-dependence) rates. This concludes the cross-validation process and the

[10] We pick ten folds, but it could be any number of folds.

[11] The average of the sum of squared differences between y_h and $\hat{y}_h = x_h' * \hat{\beta}$

stepwise OLS regression is run a final time on the full sample of data using the selected p-value. The resulting regression is the SWIFT poverty model.

To ensure the quality and robustness of the models, SWIFT carries out two tests (if data are available): backward imputation and validity test. The former applies the final model to a previous round of data to check the stability of the model over time. The latter tests whether the error term follows a normal distribution using a simulation method developed by Elbers, Lanjouw and Lanjouw (2002, 2003).

The result is a small set of questions. The resulting questionnaire from SWIFT considerably simplifies data collection and encourages teams to collect data quicker and more frequently than traditional lengthy household surveys. The questions The SWIFT data are collected through CAPI (Computer Assisted Personal Interviews) to ensure quick analysis and results. The data collected include ownership of various types of assets, source of energy and water, characteristics of household's dwelling- materials used for floor and roof, number of rooms; household demographics including household size, age and education level of household head; as well as location of the household-administrative unit.

The final stage consists of predicting per capita consumption. In this final prediction phase, SWIFT utilizes multiple imputation estimations to apply the coefficients from the model to the variables in the new dataset. Random error is simultaneously introduced by adding 1000 imputations with error per household estimate.

A poverty dummy can be created using predicted consumption per capita from the model. This is done by repeatedly projecting predicted consumption per capita for all households. Although several applications of the SWIFT methodology run twenty simulations for each household, we choose to run 100 simulations for each household to ensure that the results are stable. In each simulation, households' likelihood of being poor is obtained by comparing the simulated household consumption with a poverty line. The average poverty rate of the 100 simulations is used as to estimate the poverty rate. This rate is often expressed as a percentage and hence does not enable us identify poor versus non-poor households. To construct a binary indicator of poverty at household level, we identify a threshold beyond which a household is classified as being poor. To do this, we choose the

poorest 31 percent of the households where 31 comes with the multiple imputation (or SWIFT imputation) of the 100 simulations.

9.3 Coping Strategies

Table 13: Coping Strategies used

	Cap-Haïtien	High-risk areas	Poor HH
Use savings	41.57	44.88	25.1
Food assistances from parents/friends	1.2	1.94	1.96
Government/State food assistance	0.13	0.22	0
Monetary aid from parents/friends	1.82	0.11	7.4
Reduction in quantity of food/number of meals	6.56	3.66	16.02
Reduction in quality of food	1.7	2.74	2.03
Food for Work	0.25	0.41	1.07
Migration of one or more HH members	14.53	16.6	11.25
Reduction in non-food related spending	0.2	0.33	0.85
Took loans from lenders/business people	0.29	0.47	1.23
Sold HH goods (equipment, etc.)	0.3	0.48	1.25
Cut wood/Made charcoal	0.18	0.29	0
Sent children to other homes	1.06	0.99	1.33
Engaged in spiritual activities (e.g., p	0.51	0.49	0
Others	17.17	13.99	19.48
Did nothing	8.22	9.84	4.59
Don't know/Not sure	4.31	2.58	6.43

Source: Authors' calculation