

GCRF-OSIRIS

Social, Environmental & Economic Impact Assessment

*Optimal Investment Strategies to Minimize Flood Impact
on Road Infrastructure in Vietnam*

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1. INTRODUCTION

1.1. Overview

Vietnam is ranked globally as the country with fourth highest exposure to flooding. According to the Vietnam Meteorological and Hydrological Administration, between 1985 and 2015, more than 95 major floods affected Vietnam. The national Institute of Meteorology, Hydrology and Environment (IMHEN) recorded over 5,000 people killed and 25 million impacted by floods during the last 50 years (IMHEN-UNDP 2015). Rapid urbanization, aging drainage systems and climate change impacts exacerbate the problem of floods on transport infrastructure in cities, and increase damage and costs at household level.

The OSIRIS project seeks to support efficient investment strategies which address these issues, with the following objectives.

1. Identify gaps and inefficiencies in current infrastructure investment and maintenance programmes, especially in relation to climate change and flooding issues that affect transport.
2. Build a set of future flood scenarios affecting the urban area under study with their associated probability of occurrence based on rainfall predictions, historical data and climate change projections.
3. Develop qualitative approaches to evaluate the impact of floods on local communities and the social benefit of avoiding flood damage to road infrastructure. Identify feasible flood-control measures and evaluate their cost and benefits.
4. Develop a multi-period optimisation model for strategic, long-term planning of mitigation actions which minimizes the impact of floods on urban road networks over different flood scenarios. Propose a set of economic and sustainable strategies for investing in flood avoidance and damage mitigation that are robust to climate change and rapid urbanization.
5. Apply the developed methodology to the city of Hanoi. Integrate the research results into future planning and interventions.

The social, environmental and economic impact assessment aims to provide a realistic view of the effects of flooding on the urban community of Hanoi, which can be used for the research model. The assessment considers social, environmental and economic impacts experienced by two broad groups of people:

- **Residents** of the assessment areas, many of whom are also local business people, trading from their homes, or from shops attached to their homes
- **Visitors** to the assessment areas, who work as street vendors, motorcycle-taxi or car-taxi drivers, most of whom come into the area to sell their goods and services early in the day, and leave the area at the end of the day, or when their produce has been sold. Street vendors in this category are usually coming into the urban area from outlying districts of the city, bringing food or vegetables, or ready-made snacks, often by bicycle or motorcycle.

The assessment gives special attention to the different impacts experienced by women and men.

1.2. Location and Timeframe

Hanoi is the political, cultural and scientific center in the north of Vietnam, and the national capital, bordering Thai Nguyen and Vinh Phuc provinces to the north, Ha Nam and Hoa Binh to the south, Bac Giang, Bac Ninh and Hung Yen to the east, and Hoa Binh and Phu Tho provinces to the west. The city has twelve urban districts, one district-level town, and 17 rural districts. The area identified for survey was a group of four urban districts: Dong Da, Nam Tu Liem, Hoang Mai and Ha Dong which are among the areas

most severely impacted by floods during the wet season. Dong Da and Hoang Mai are older districts, while Nam Tu Liem and Ha Dong are relatively newly established.

Figure 1: Hanoi



and its Central Districts



Key criteria for selection of the districts were: a) their vulnerability to flooding; b) inclusion of both old and new districts in the study area; and c) the level and types of investment programmes, which have been funded and planned by the government to address flooding issues. Old districts are less affected by floods compared to newly established districts, because: a) Hanoi has expanded to the sites in the west, where ground elevation does not comply with standards; b) drainage systems in these new urban areas have not received sufficient investment, and still depend on older agricultural drainage systems; c) new areas are over-urbanised, with inadequate planning or controls relating to flood risk.

The assessment took place over 11 days, between July and August 2018.

1.3. Data Collection

Quantitative data collection was used with the two main stakeholder categories (residents and visitors). Qualitative methods were used to confirm (or otherwise) data findings, mainly through focus group discussions, separating women and men, and in-depth interviews. Additional qualitative methods were consultations with local government, business and community-based organisations, and observation. Local literature (local government reports and damage assessments) were also consulted.

Initial sets of indicators for social, environmental and economic impact were developed into survey questions. Two survey forms were designed for the two target groups – residents and visitors. Data collectors and supervisors were recruited – students from Hanoi Construction University and Hanoi Architecture University, who had previously carried out similar work. The data collectors and supervisors were trained, and then carried out a simple piloting of the survey materials. Following minor adjustments to the materials, the full data collection process was carried out, data was entered, synthesized and analyzed.

The survey took place in the midst of Hanoi's stormy season, during a time of regular torrential downpours. This could be considered as an advantage for the research, as local people were able to reflect quickly on their situation and to propose appropriate measures for dealing with floods. Despite

the sometimes extreme weather, the data collection team was able to drive their own motorbikes to reach the most affected households and street vendors for interviews.

1.4. The Sample

Cochran’s formula was used to estimate the sample size for both target groups. The sample size for unknown population is determined based on the following formula (1):

$$n_0 = \frac{(t)^2 * (p)(q)}{(d)^2}$$

Where:

n_0 = Desired sample size

t = value for selected alpha level (the standard 95% confidence interval will have alpha level of .025 in each tail, $t = 1.96$. (The alpha level of .05 indicates the level of risk the researcher is willing to take that true margin of error may exceed the acceptable margin of error).

p = Proportion in the target population estimated to have a particular characteristic

$q = 1.0 - p$

d = Marginal of error (with budget constraint, 7% error is acceptable)

When sample size $n_0 > 5\%$ of the population, the following formula (2) is used to correct the final sample size (n_1):

$$n_1 = \frac{n_0}{(1 + n_0 / \text{Population})}$$

The aim was to have a sample size with a 95% confidence interval and a 5% marginal of error. The survey of residents was conducted separately from the survey of visitors. With the total population of estimated 500,000, the sample size for target interviewees computed using the two formulas (1) and (2) was 385.

A cluster sampling method was used to select interviewees for the survey. To correct the potential loss of sampling efficiency, a design effect (D) was added in the equation to correct the sample size (Magnani, 1997). A design effect of 1.5 is commonly accepted. Therefore, the designed sample size for survey of target respondents is 577 (= 1.5 x 385). This was adjusted to 300 residents 200 visitors.

The cluster sampling method was multi-stage. The clusters were the selected districts. Magnani (1997) mentions there is no general rule on the number of clusters selected. With the given budget and timeframe, four clusters were suitable.

Of the 500 people interviewed, 497 were eventually used, (the remaining three not giving reasonable or sufficient answers to interview questions). These interviewees were as follows:

Table 1: Respondents included in the sample

Respondents	Resident households		Visitors			Total
	Households doing trade	Households not trading	Street vendors	Motorcycle taxi drivers	Car taxi drivers	
Male	47	65	15	86	7	220
Female	117	67	88	4	1	277
Total	296		201			497

Excel 2016 and SPSS 20 (Statistical Package for Social Sciences) were used for data processing. The data was coded, punched, cleaned and validated before being subjected to analysis.

2. RESULTS OF RESIDENTS

The resident interviewees were 43.4% from Ha Dong, 18.1% from Nam Tu Liem, 27% from Hoang Mai, 11.1% from Dong Da, and 0.4% claiming to be from other surrounding regions. Among these households, 164 out of 296 are primarily engaged in business, accounting for 55.4% of the total. These businesses consist mainly of small food stores, grocery stores, coffee shops and iced tea stalls on pavements or by the roadside. The remaining 44.6% of households are primarily employees, in governmental or private agencies, or retired. The gender of the respondents, 62.2% female and 37.8% male, is given below:

Table 2: Gender of respondents

Gender/District	Dong Da	Ha Dong	Hoang Mai	Nam Tu Liem
Male	20	50	24	18
Female	14	79	54	37
Total	34	129	78	55

Interviews were carried out in locations which are regularly flooded: My Dinh, Me Tri, Co Nhue, Nhan My (Nam Tu Liem District); Kham Thien, Luong Dinh Cua, Kim Lien (Dong Da District); Van Quan, Duong Noi, Xa La, Yen Nghia, Phu Luong, Trieu Khuc, Kien Hung (Ha Dong District); Giap Bat, Tan Mai, Hoang Van Thu, Tinh Lien (Hoang Mai District).

2.1. Perceived Duration of Floods

Most often, floods are perceived to last less than one day, (see Figure 2, below). Ha Dong District however, experiences longer periods of flooding, with about 46% of respondents saying that floods generally last from one to three days.

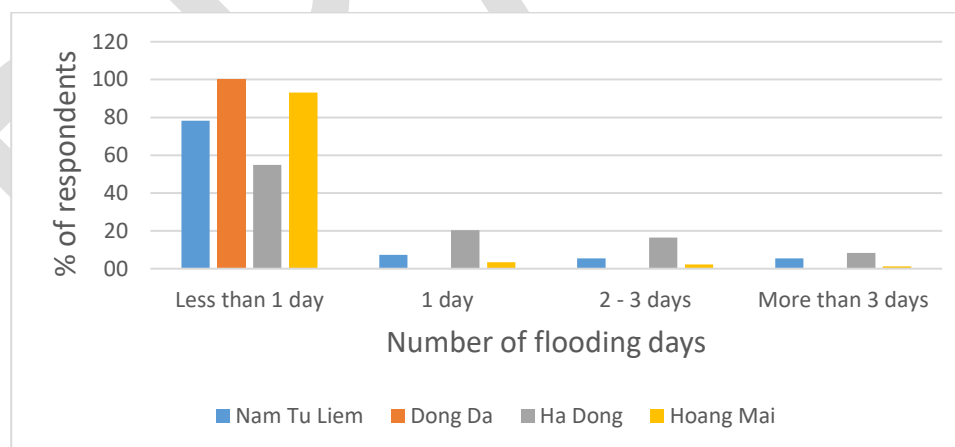


Figure 2. Perceived duration of floods in four districts from 2015 to 2018

2.2. Perceived Flood Characteristics

Generally, flood depths in all four interview locations was perceived to range from 0.2 to 0.5 metres (Figure 2). Nam Tu Liem and Co Nhue specifically, has some areas where flood depth rose above one metre. Dong Da and Hoang Mai experienced lower flood levels, fluctuating from 0.2 to 0.5 metres. Nam Tu Liem and Ha Dong saw higher average flood levels, ranging from 0.5 to 1.0 metre. The survey also

showed that flooding is perceived to have worsened in Hanoi, between 2015 and 2018, in comparison to previous periods (Figure 4).

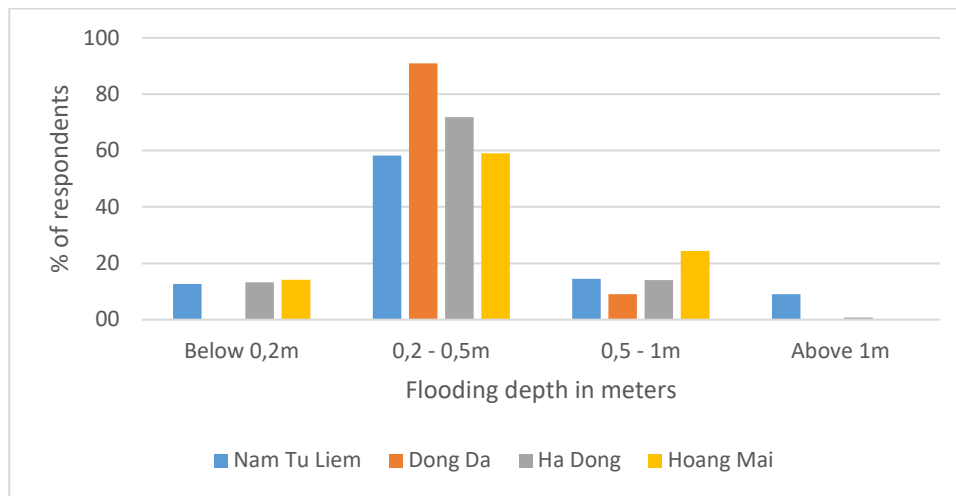


Figure 3. Perceived average flood depth from 2015 to 2018

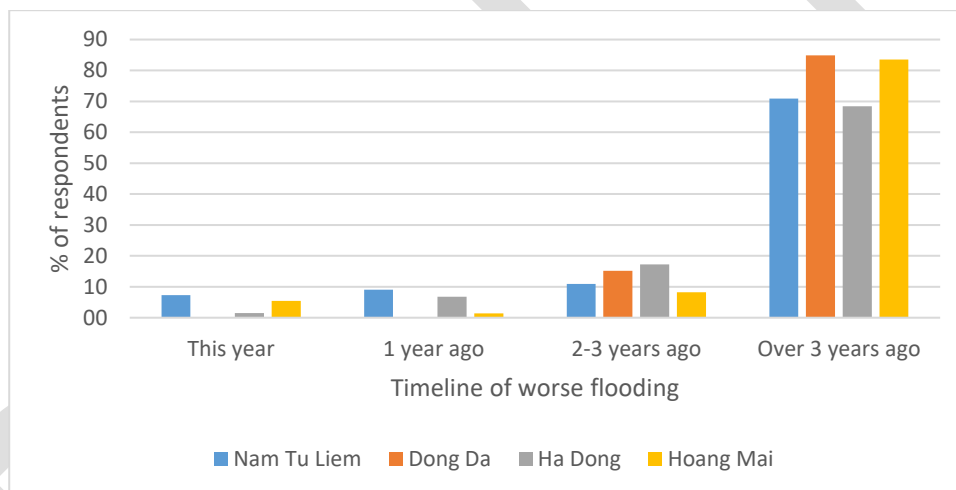


Figure 4. Perceived change in severity of floods

Main reasons for flooding are perceived as the aged drainage system (44.4% of respondents) and the prolonged, heavy rain (36.1% of respondents). A smaller number of residents answered that low-lying residence, over urbanization and higher road surfaces to residential housing may aggravate urban floods at metropolitan regions.

Table 3. Perceived main reason for flooding

<i>Reason for Floods</i>	<i>Percentage</i>
Torrential rain	36.1%
Aged drainage system	44.4%
Over-urbanization/ mushrooming of new buildings and skyscrapers	4.4%
Low-lying residence	10.1%
Construction of higher roads	3.7%
Covering the reservoirs for other construction	0.9%
Other	0.4%

2.3. Economic Impacts

Economic impacts were assessed based on perceived damage to road and sewage systems, damage to property, decreases in income, temporary rising prices, and broken vehicles (mainly motorcycles with flooded engines).

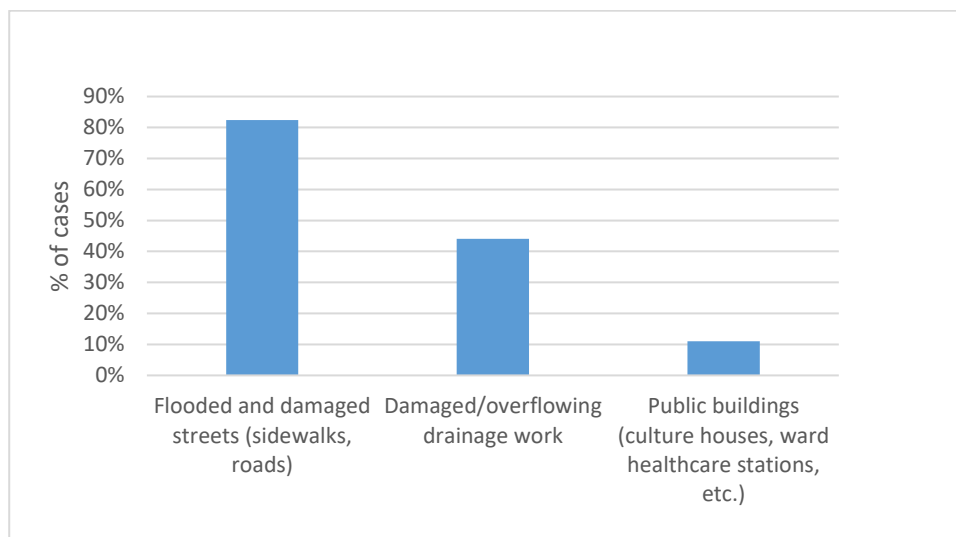


Figure 5. Perceived % of streets, drainage systems and public buildings impacted by floods

Regarding damage to property, more than half (57.8%) of households normally experience flood waters entering their houses/stores/place of business during the flood season. The perception of flood depths is that they are normally less than 0.5 metres from road level (see Figure 6).

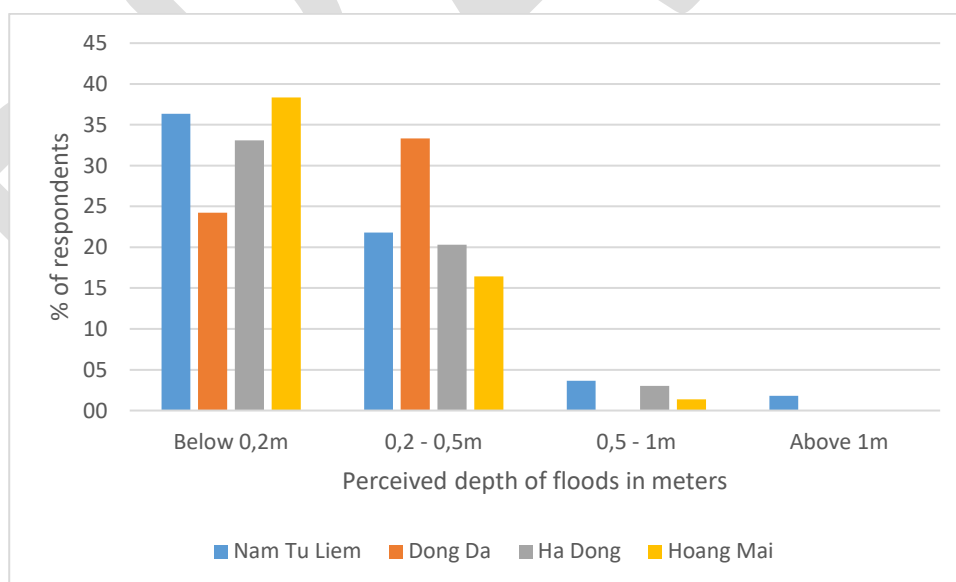


Figure 6. Perceived depth of floods, from road level, in homes, stores and businesses

Small business households, such as coffee shops, grocery stores, food and beverage stalls along streets or pavements, were perceived as more vulnerable to downpours and floods, than non-trading households, due to their greater expenses for renting space, hiring staff, and their vulnerable stocks of goods. Those with greater turnover were also those perceived as having greater losses during floods.

Women were perceived as being more impacted than men, as women are more often working or trading from home. Perceived disproportional impacts on women include having to prepare meals in flooded kitchens, and running shops/restaurants/cafes in flooded conditions. Men on the other hand are more likely to work away from home, for example in construction or as employees.

Observations by the survey team in the middle of the flood season included damp (mold and peeling paintwork inside houses) and subsidence, which householders attribute to sustained water levels at street level. Business for trading households was also severely disrupted.

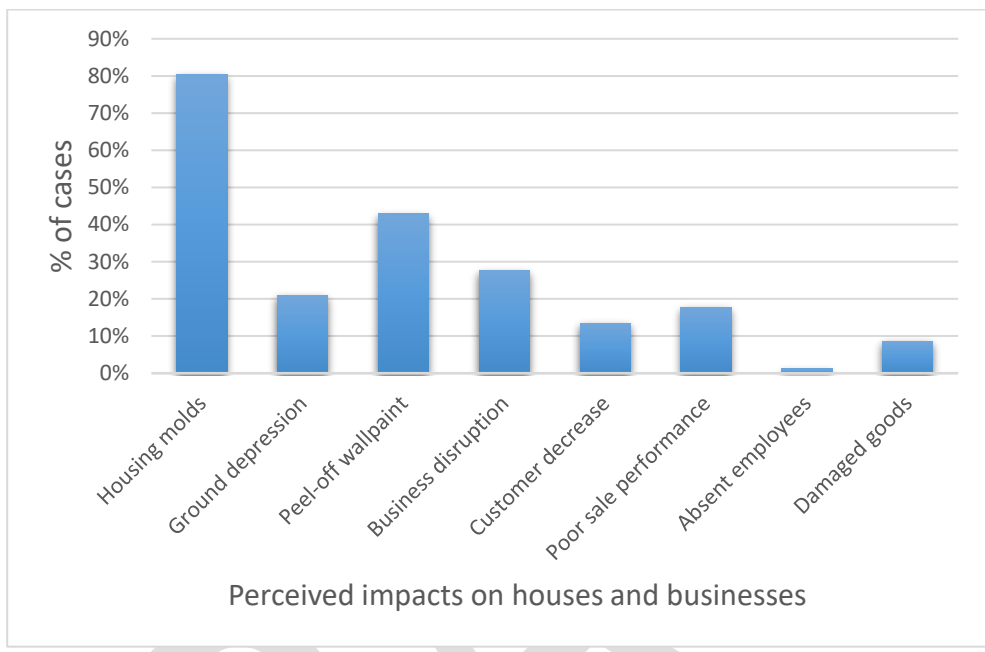


Figure 7: Perceived economic impacts on houses and businesses

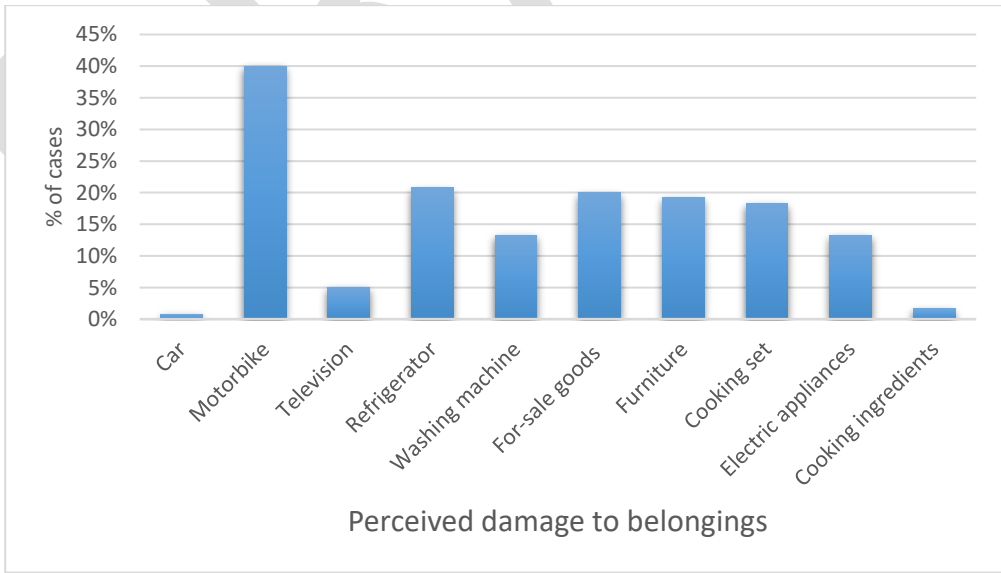


Figure 8: Perceived damages by floods, to household belongings

As shown in Figure 8, the greatest perceived damage to household belongings, is to motorcycles. A motorcycle is the often a household’s most expensive item, and vulnerable to floods, as households often still try to use them when water levels are not too high. But engines are easily flooded when travelling through deeper water, and are expensive to repair or replace. Despite these property losses, only 12.2%

of residents had insurance for their belongings. Families living in apartments (35 such households were interviewed) can have damaged cars and motorcycles when underground parking lots are flooded (17%). Residents in apartments are sometimes isolated when nearby areas are flooded (11%). Electricity cuts, which occur frequently during flooding, have greater impact on residents of apartments, interfering with utilities such as water pumps and elevators. According to interviews with householders, such situations generally create more additional work for women than for men.

During floods, trading households often face increased prices for cooking ingredients, increased prices from the wholesalers, and obstacles in transportation of supplies. Details are shown in the chart below.



Figure 9. Difficulties facing trading households during floods

Focus group discussions showed that increased prices of cooking ingredients, and scarcity of goods and raw ingredients during flooding, led especially to women needing to spend more time searching for food in more markets and more distant markets, resulting in higher levels of stress. Only 10% of trading households responded that they increased prices of their goods or services, to make up for difficulties during the flood season.

Overall, a majority of women in trading and non-trading resident households said that floods directly affected their work and income, through either having a shortage of products or inputs for production (such as cooking ingredients) or being unable to sell goods, or being unable travel to work. Incomes lost during each flood period depended partly on the number of days of lost work or business. Most losses were in the range VND 0 to VND 500,000.

Table 4. Range of perceived cash incomes lost by resident households, during a short-term flood event

Lost Income (VND) ¹	Male	Female
< 200,000	30.4%	49.0%
200,000 - 500,000	5.1%	7.8%
500,000 - 1,000,000	2.4%	3.7%
1,000,000 - 3,000,000	0.0%	0.7%
> 3,000,000	0.0%	1.0%
Total	37.8%	62.2%

¹ VND = Vietnamese Dong. VND 30,000 = approximately £1.

Flooding also has an economic impact on residents due to rising prices of staples such as rice, fresh vegetables, meat, fish, dry and instant food, with the price of fresh vegetables having the greatest impact. Fifty two percent of respondents (134 women and 81 men) perceived a minor rise in prices while 27% of respondents (50 women and 31 men) perceived a significant increase. The increased price of food was perceived to impact women more than men, as women are usually the purchasers of household food. Increased prices reduce the money which women have available, and obliges them to look for cheaper food in markets further from home as prices increase.

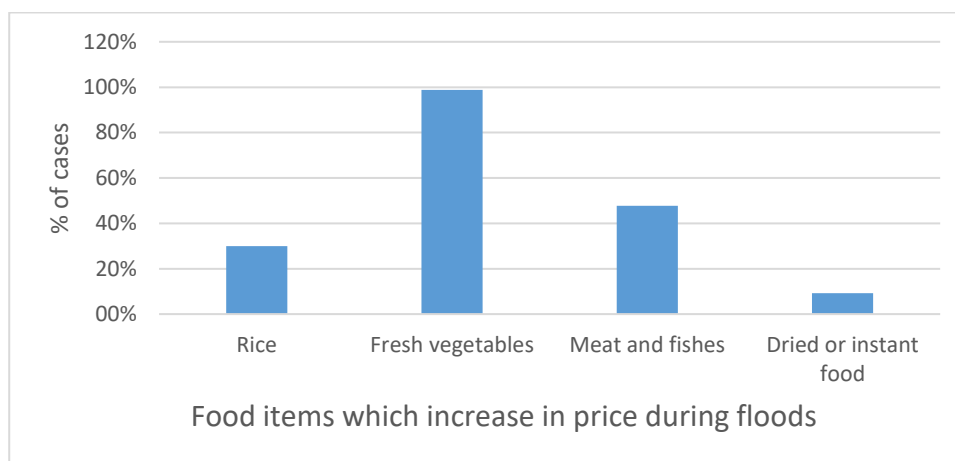


Figure 101: Temporary increased prices of food during floods

Overall among economic impacts, “Damages to road and drainage systems” was selected by respondents as having the greatest economic impact of flooding, for households in the urban area. The second greatest impact was broken vehicles (mostly motorbikes), then “temporary food rising prices”, “income losses” and “damage/loss to housing, belongings and goods”. Details of the ranking are shown in the table below.

Level of importance		Ranking importance level						% of highest rank, out of the total
		No rank	5	4	3	2	1	
Options	Temporary food rising prices	76	36	49	55	52	28	25%
	Income decrease	85	35	34	39	42	61	29%
	Broken vehicles (cars, motorbikes)	70	51	28	40	60	47	27%
	Damages to road and drainage systems	53	26	25	46	57	89	37%
	Housing, belongings or goods losses/ damages	75	26	31	41	57	66	30%

(Ranking from 1 to 5 – 1 is “the most important” and 5 is “the least important”)

Table 5: Response for ranking importance of economic impacts

2.4. Environmental Impacts

Among 296 responding households, 23% stated they suffered from impacts of dirty water or water pollution, and 9.8% said they were affected by cut-off water supplies, during flooding events (see Figure 11). Reasons for water pollution were given as:

- Dirty water flowing into household water tanks
- Water tank belonging to a whole apartment block being flooded or contaminated
- The water source at a residential water factory being contaminated by floods.

These impacts again were perceived as greater for women than for men, as women have more responsibility for water-related household work such as washing, bathing children, and cooking. In response to flood-related water pollution, measures taken by households were mainly:

- Water filtering
- Discharging dirty/contaminated water and seeking fresh water from other local sources. This can include buying bottled water to drink
- Do nothing but wait for fresh water supply

Trading households, however, were more impacted by water issues, with 10% of food and beverage stores finding difficulty in cooking or serving food and drinks.

Environmental pollution is a significant impact of flooding in Hanoi, as floodwaters carry and mix with other waste water and materials, such as domestic waste water coming from families' sinks, showers, and toilets, including sewage; and waste from commercial, industrial, and agricultural activities including metals, solvents, and toxic materials. Floodwater runoff carries these wastes into waterways, leading to water pollution. Respondents perceived the sources of environmental pollution as in the chart below, (animal carcasses coming from restaurants).

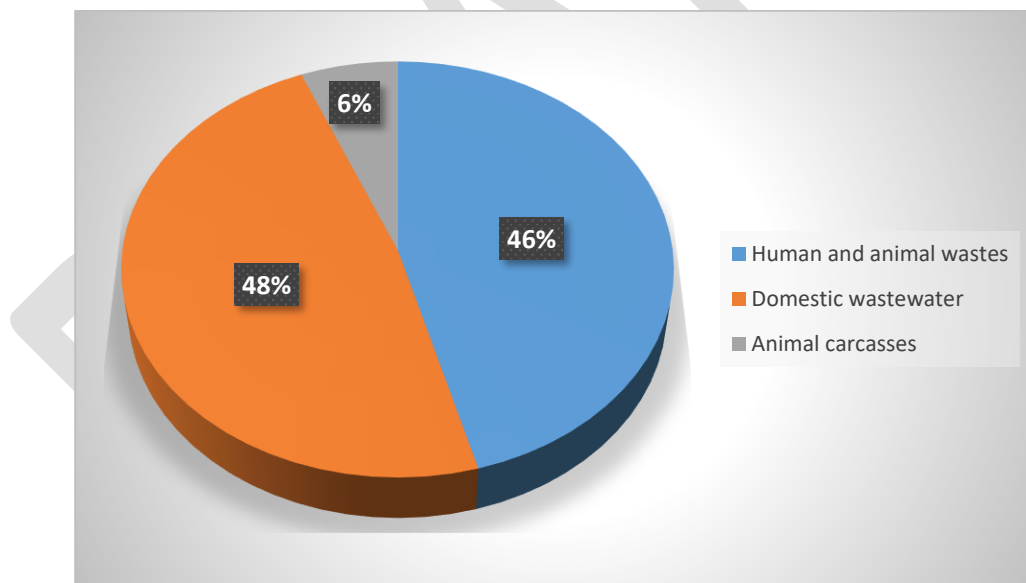


Figure 2: Perceived factors contributing to environmental pollution during flooding events

Unpleasant smells during flood events were reported by 92.2% of respondents, as a sign of environmental pollution. The smells were reported to come from rivers, lakes, water ducts, and near markets and near hospitals. Environmental pollution is therefore expected to increase risks of disease or epidemic, and increase costs of health care, as well as damaging green/planted areas. Respondents reported their perceptions of environmental impacts as in the chart below.

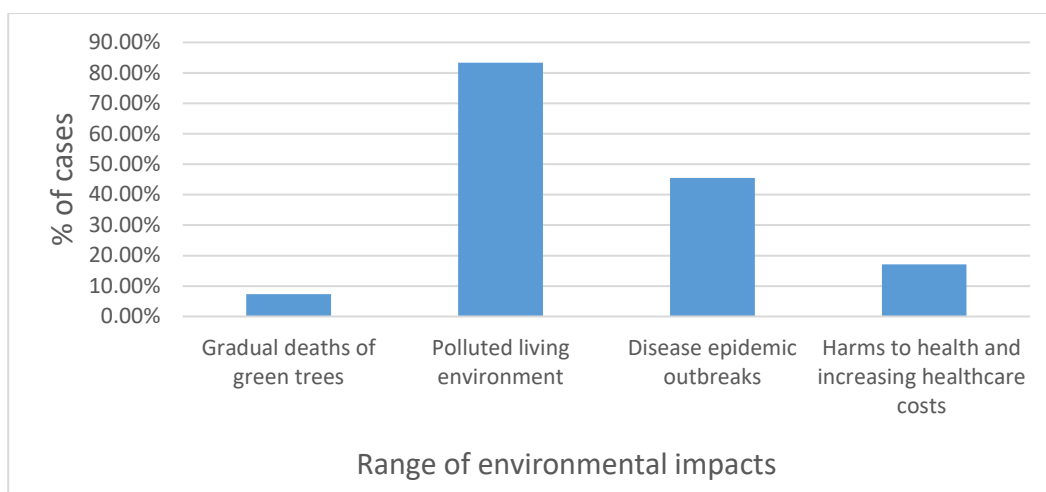


Figure 3: Perceived environmental impacts of flooding on local communities

Respondents gave further details of disease and health issues caused by the environmental impacts of flooding. These include skin rashes, ‘pinkeye’, diarrhea, respiratory diseases, and dengue fever spread by mosquitos. Skin rashes and dengue fever were the health issues most reported by respondents, affecting mostly children and elderly household members. These household members were usually reported as cared for by women, increasing women’s workload. Costs of medicine and treatments also increased stress on the household, especially women, who normally take responsibility for buying medications.

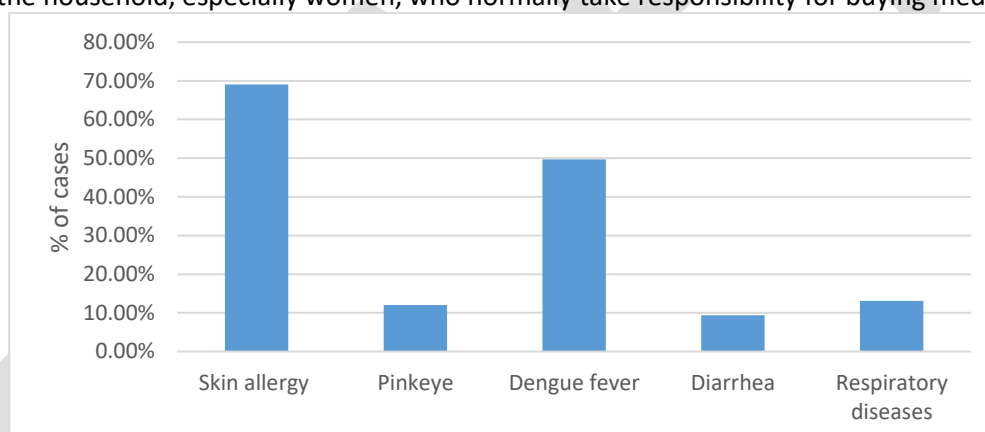


Figure 4: Common health problems and diseases during flooding events

Flooding also raises risks of serious accidents from submerged hazards such as potholes, fallen trees, and damaged electricity wires and electric shocks.

Overall, environmental impacts of flooding in the four project Districts were ranked in order of severity according to the following table.

Table 6. Perceived importance of environmental impacts of flooding for residents

Level of importance		Ranking (4=least, 1=most)					% of highest rank, out of the total
		No rank	4	3	2	1	
Options	Negative impact on water quality	97	63	60	33	43	32%
	Environmental pollution	27	12	36	69	152	57%
	Outbreak of disease or epidemic	74	26	56	88	52	40%
	Other risks: Submerged potholes, fallen trees, damaged electric lines	75	81	38	50	52	37%

The ranking showed that environmental pollution is perceived as the most significant environmental impact of flooding in the study areas, while outbreaks of disease and/or epidemics, other risks (submerged under floodwaters), and negative impact on water quality, are less concerning to respondents.

Whilst the value of economic impacts can often be measured with quantitative methods, environmental impacts are more difficult to quantify. However, the relative significance of environmental impacts as perceived by local communities, as documented here, could be considered as a true reflection of their relative values.

2.5. Social Impacts

When asked how floods impact a family’s daily travel, approximately 90% of respondents highlighted the difficulties created by flooded roads – how traffic congestion vastly increases the time needed to travel, and the risks involved in travelling on flooded roads. Perceived transport difficulties are illustrated below.

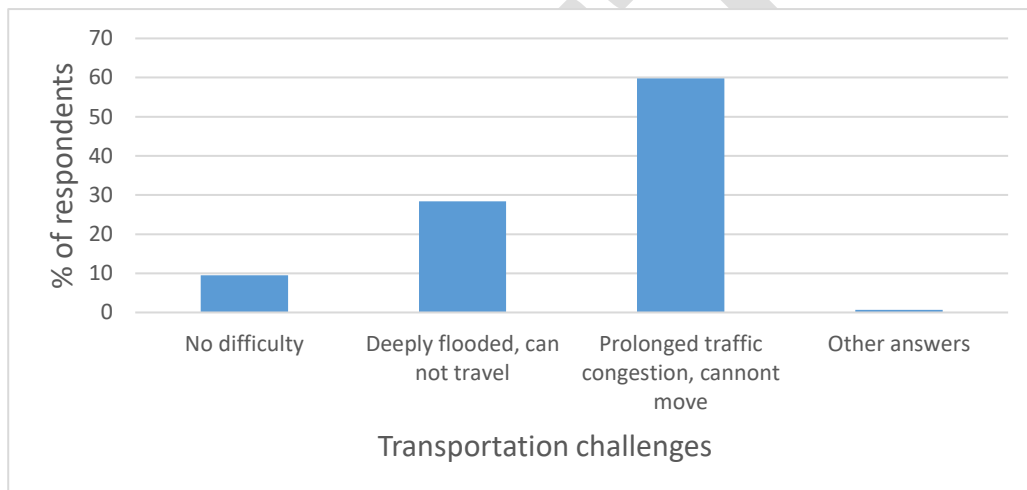


Figure 57: Transport challenges during flooding, as perceived by resident households

For households with children, 50% of children are absent from school during storms and flooding. Such absence from school normally lasts one to two days. When children do not go to school, a family member at home needs to take care of them most of the time, especially when roads are flooded. According to the survey, 75% of these carers are mothers and grandmothers, while 25% are fathers, grandfathers or other relatives or friends.

Many households avoid attempting to reach healthcare providers during the flood season, unless medical attention is urgent. Traffic congestion is a discouraging factor. However, 10.8% of respondents reported difficulty in accessing medical services when they needed them, during floods.

Of respondents who answered the question “Are there any difficulties in approaching public services in your residence during flood times?” 59% reported difficulties in approaching administrative services, 35% faced challenges in participating in cultural activities, and 6% experienced challenges in accessing postal services. However, many respondents were reluctant to answer, as they did not wish to criticize local public service providers.

The table below, shows the perceived ranking of social impacts of flooding, among residents.

Table 7. Perceived importance of social impacts of flooding for residents

Level of importance		Ranking importance level						% of highest rank, out of the total	
		No rank	5	4	4	3	2		1
Options	Weaker community cohesion	137	51	37	22	24	2	23	32%
	Difficulty in access to public services (admin procedures, security, postal services)	147	24	18	57	31	3	16	38%
	Difficulty in access to healthcare services	151	14	5	19	46	12	49	34%
	Prolonged traffic congestion at severely flooded hotspots	19	1	4	3	5	243	21	88%
	Children's absence from schools	143	9	16	17	30	16	65	42%

(Ranking from 1 to 5 – 1 is “the most important” and 5 is “the least important”)

Among the social impacts of flooding, residents assessed that “prolonged traffic congestion at severely flooded hotspots” was the most significant negative impact. “Children’s absence from schools” was the second priority, as family members have to stay at home to take care of them. “Difficulty in access to healthcare services” and “weaker community cohesion” were considered as less important.

2.6. Knowledge and Attitude of Residents Regarding Floods

83.4% of residents had been informed and were aware of torrential rains, with potential to cause floods, before each downpour. Most residents were informed through news from public media such as television or newspapers.

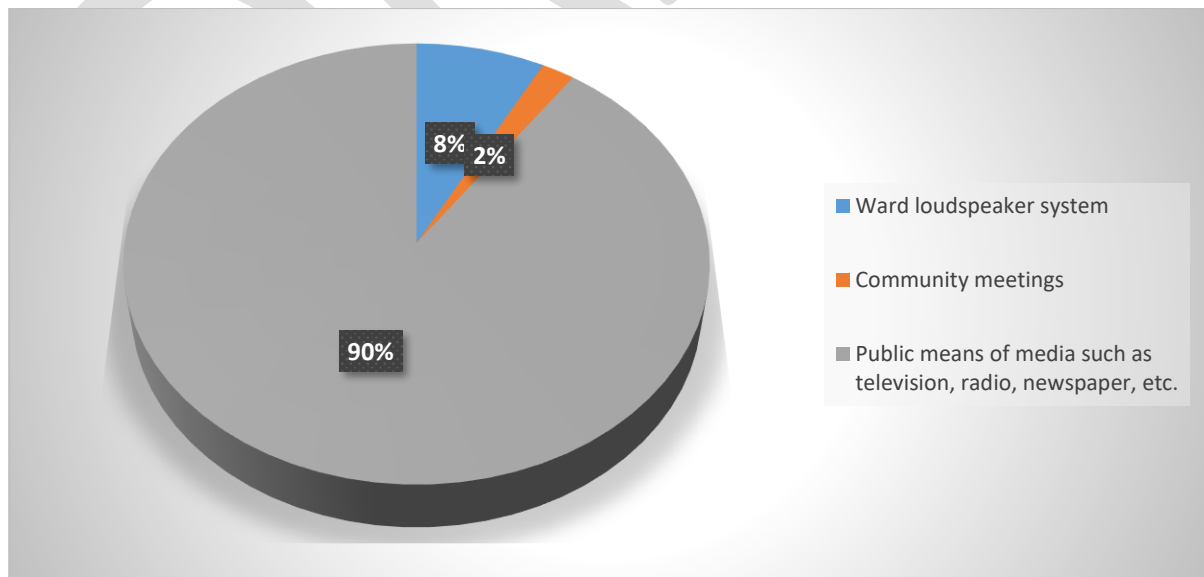


Figure 68: Sources of news about weather forecasts

Respondents’ beliefs or perceptions of the main causes of urban flooding are illustrated in the chart below.

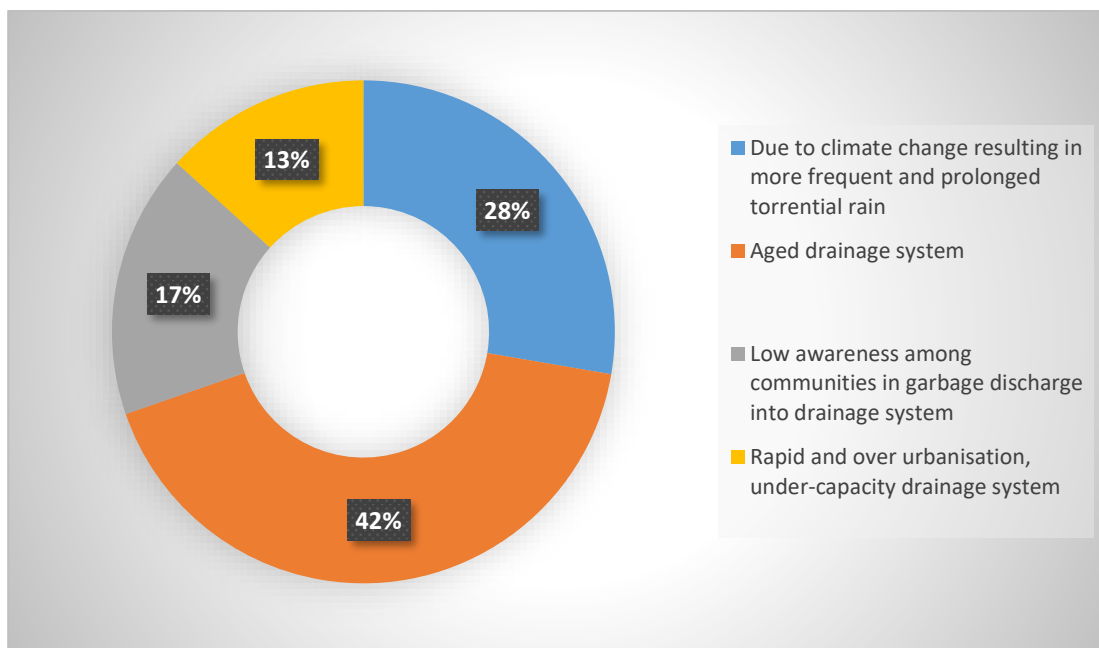


Figure 197: Perceived main causes of urban flooding, by residents

The aging drainage system was considered to be the main cause of flooding, followed by climate change and its impacts on rainfall. Poor waste discharge, and rapid urbanization, were also considered as significant, but lesser causes.

67.2% respondents were aware of the issue of climate change. Of these, 100% believed that climate change has adverse effects on precipitation. Residents' views on the specific impacts of climate change on precipitation are charted below.

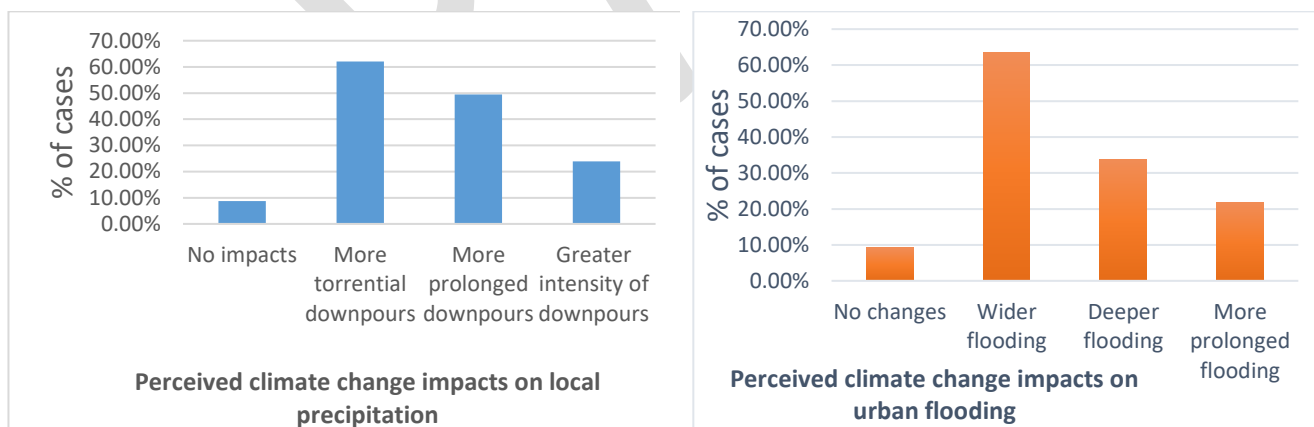


Figure 8: Perceived climate change impacts on precipitation and flooding

Table 8: Perceived climate change impacts on local precipitation, responses by gender

Options	Gender	
	Female	Male
More torrential downpours	26.2%	40.1%
More prolonged downpours	20.9%	32.0%
Greater intensity of downpours	11.0%	14.5%
Total	38.4%	61.6%

Table 9: Perceived climate change impacts on urban flooding, responses by gender

Options	Gender	
	Female	Male
Deeper floods	26.2%	26.4%
More prolonged flooding	14.5%	20.9%
No change	7.6%	6.6%
Wider spread of flooding	51.7%	46.2%
Total	61.4%	38.6%

2.7. Gender Dimensions

Surveys and focus group discussions have shown that flooded roads in Hanoi impact women disproportionately, through economic loss and decreased incomes, increased stress, increased workloads and family duties, reducing time for relaxation, and increasingly difficult decisions relating to flood mitigation measures both in the short term and long term. Roles of men and women in the family are different, pre-flood, post-flood, and during floods. Before floods occur, women and men in a family tend to undertake specific tasks separately. Women normally make many preparations prior to floods, including preparation of food reserves, tidying the house, and moving goods to higher places. Meanwhile, most men carry out heavier tasks such as flood-proofing the house to the extent possible, moving heavy furniture, raising the height of doorsteps to prevent water entering the house, raising floods, and clearing drainage systems (Figure 20).

Women and men tend to share tasks when floods strike and after flood recede (Figure 21 and figure 22). Both women and men can participate in discharging water from the house, moving things, and tidying. Further dredging of drainage systems is often done by men during floods. After floods, women have more work to do, with tidying and cleaning up.

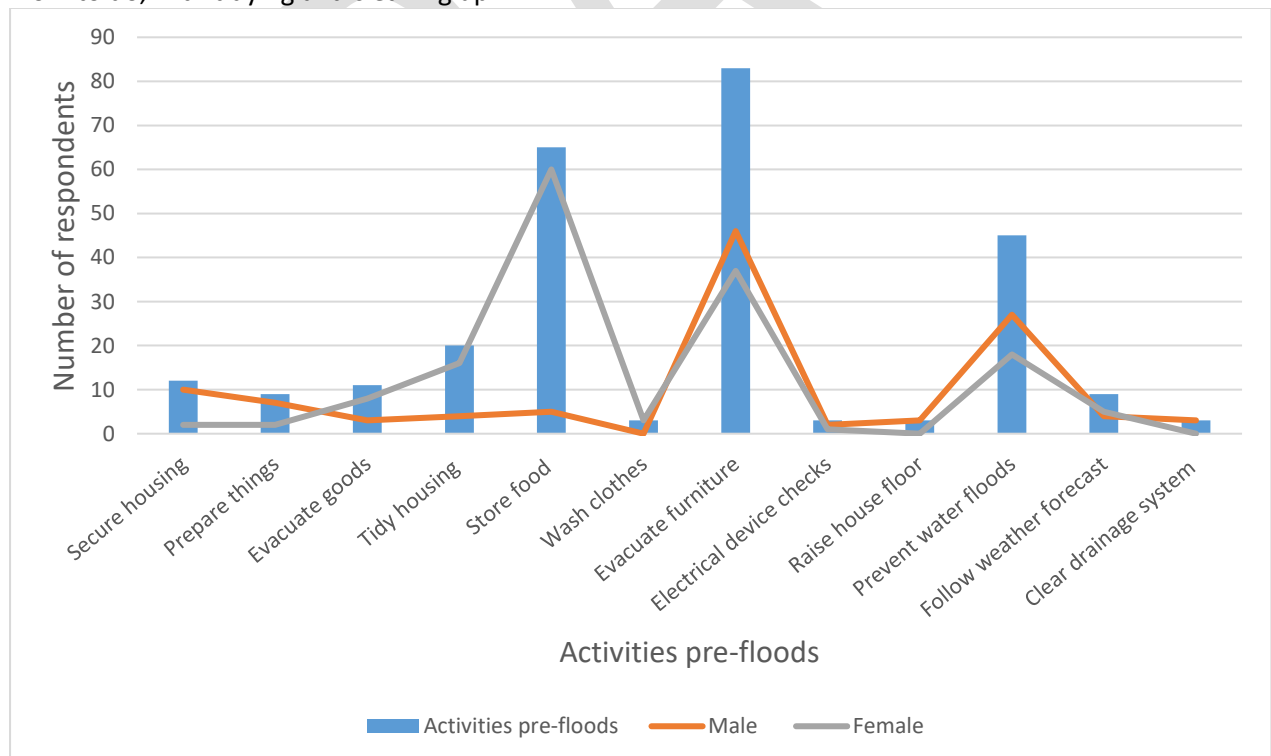


Figure 21: Pre-Flood Activities, reported by women and by men

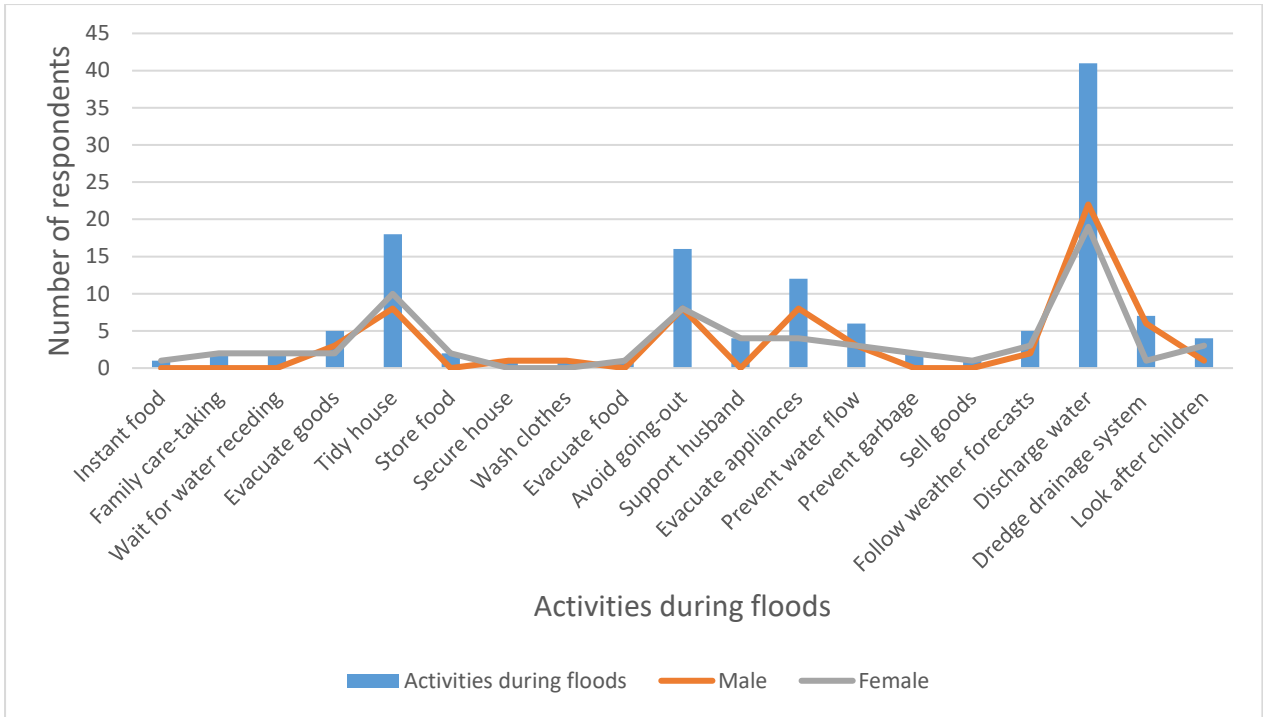


Figure 9: During Flood activities, reported by women and by men

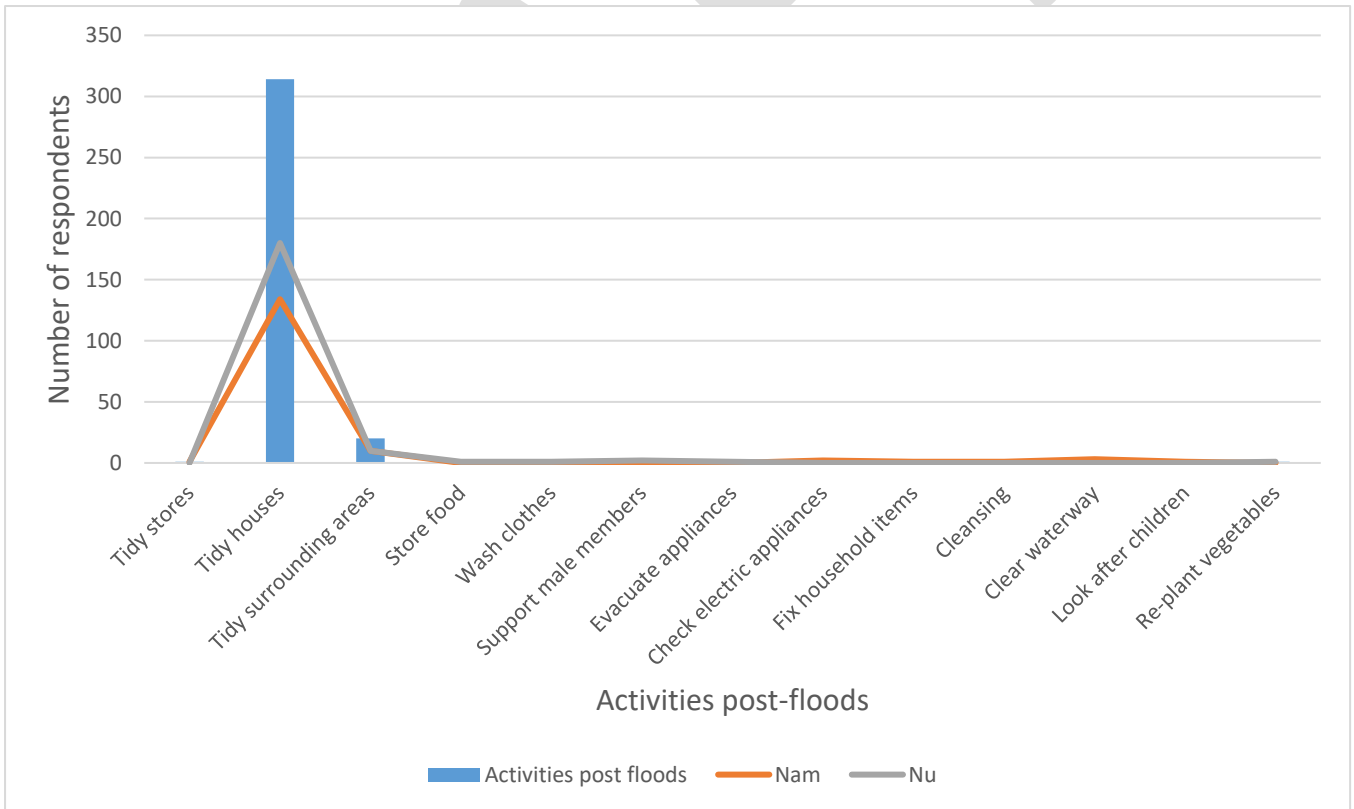


Figure 103: After-Flood Activities, reported by women and by men

When asked whether women or men had a greater burden of work before, during and after floods, 60.5% of respondents said that women had a greater burden of work. This was balanced between both female and male respondents. Especially, women were identified as having to spend more time tidying houses, cleaning living spaces, and washing more dirty clothes, in addition to other normal daily tasks.

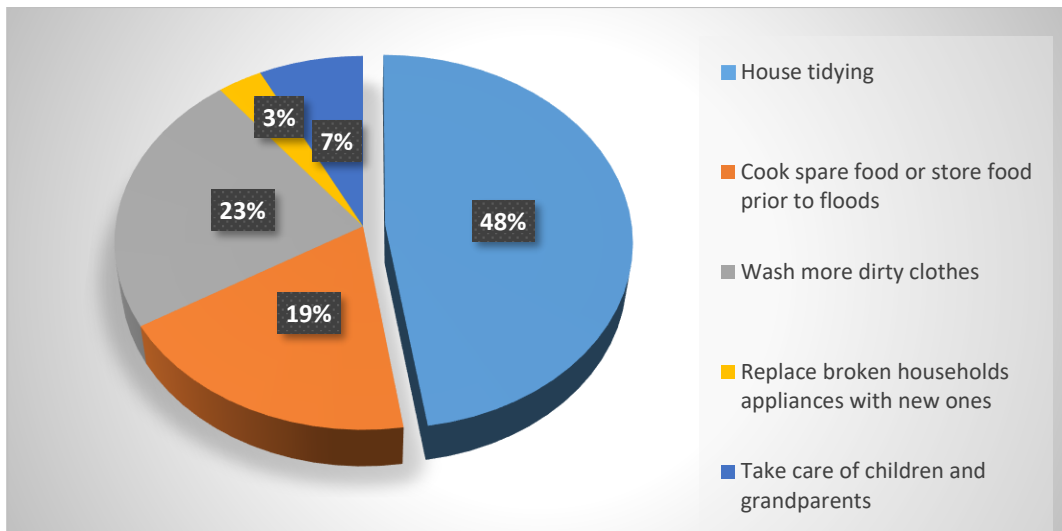


Figure 114: Additional tasks identified as carried out by women residents, before/during/after floods

When respondents were asked about solutions to better respond to flooding, they suggested improved storage of food, updated weather forecasts, raising floors and doorsteps, and other measures, but very few people suggested that housework should be more evenly shared, or that women should have a stronger role. See Figure 25, below.

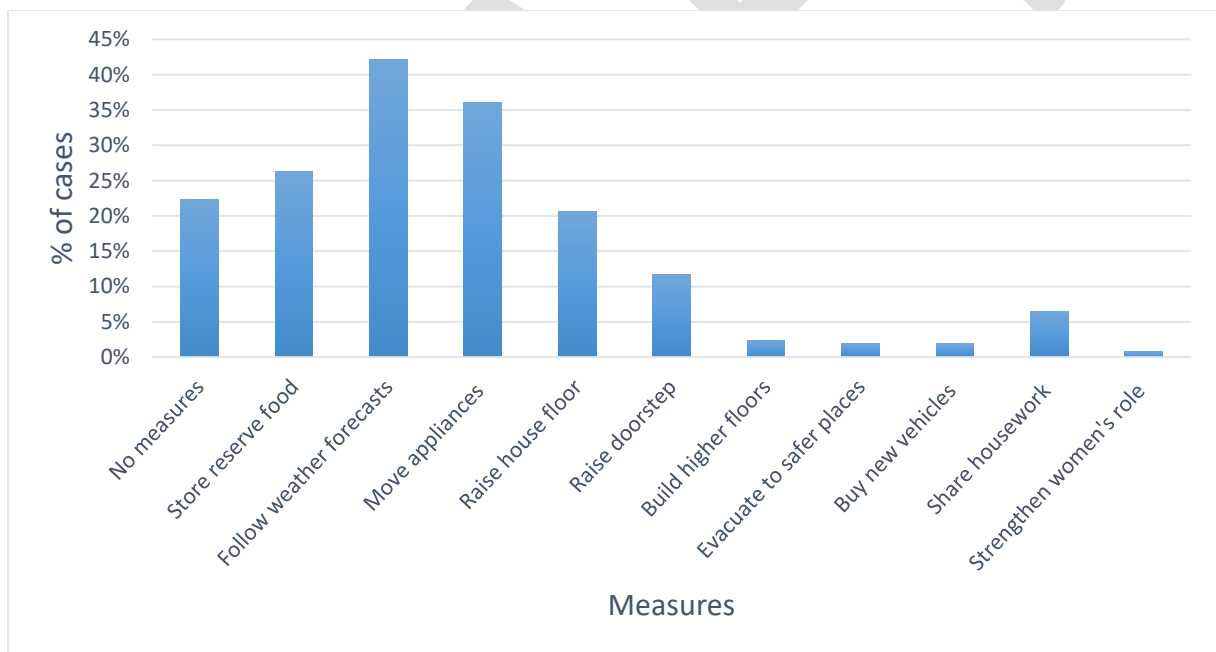


Figure 25: Measures suggested by residents, to mitigate flood damages

3. RESULTS OF VISITORS/STREET VENDORS

3.1. Visitors/Street Vendors profiles

The assessment also considered the impact of floods on those visiting the target districts on a daily basis, for work purposes. These include street vendors, motorcycle-taxi drivers (“xe om”), and car taxi drivers, whose livelihoods are closely related to natural hazards in urban areas, and who are particularly exposed

to floods. Of the respondents in this group, 51.2% were street vendors, 44.8% were motorcycle-taxi drivers and 4% were car-taxi drivers. Of these, 46.3% were female and 53.7% were male.

Table 10. Visitor respondents, numbers

Respondents gender	Street vendors	Motor taxi driver	Car taxi driver	Total
Male	15	86	7	108
Female	88	4	1	93
Total	103	90	8	201

Gender was also considered as an important dimension of the survey work, however in this situation, gender was already closely related to the nature of the work, as can be seen in the table above: men often work as motor/car-taxi drivers while women are more likely to choose street vending to earn their livelihood. 80.1% of respondents said that this street vending and taxi driving were their main jobs, while nearly 20% responded that they worked seasonally or part-time. During flooding, when children could not go to school, the women street vendors had significant difficulty maintaining their livelihoods, because they were expected to care for children, while the male taxi drivers had no difficulty in maintain their livelihoods. In this case therefore, the economic impacts of flooding are clearly gender-differentiated. Greater pressure and responsibility on the women vendors was also reported as leading to greater stress, affecting their health.

Among the four survey sites, street vendors tend to work more in Nam Tu Liem and Hoang Mai districts, less in Dong Da and Ha Dong. 86.6% of respondents said they had experienced significant flooding in their place of work. Perceived average depth of floods in four target districts was between 0.2 to 0.5 metres (see Figure 25), with most floods lasting less than one day.

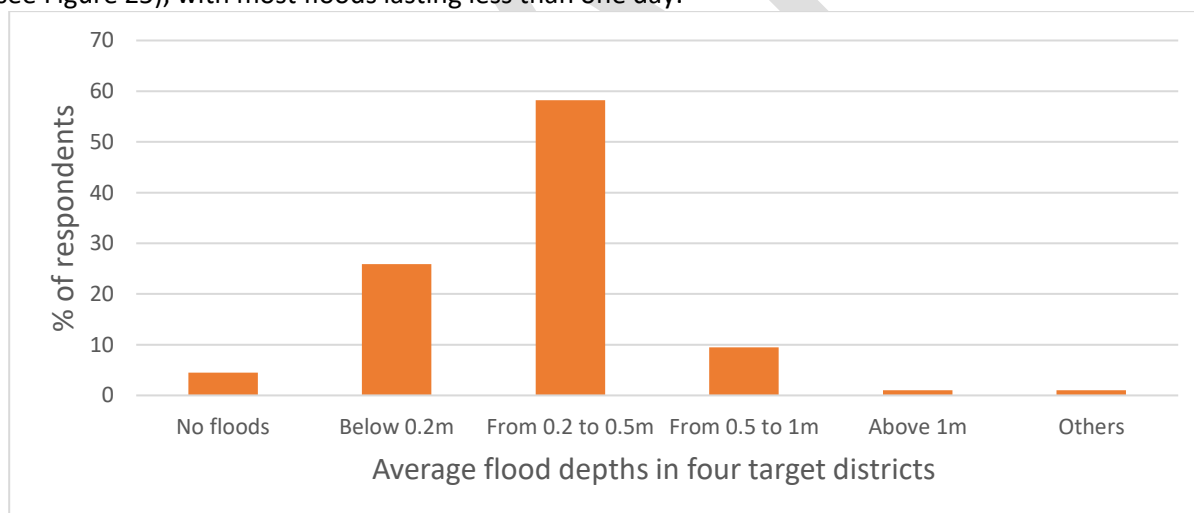


Figure 126: Perceived average flood depths, by visitors, in four target districts

94.5% of the visitors reported that their areas of work had been struck by floods and storms more frequently between 2015 and 2018, than in previous years. Specifically, areas regularly affected by floods, were reported to be:

- In Nam Tu Liem District: My Dinh bus station; Keang Nam Landmark; Pham Hung street, Nhan My, Phu My, Phu Do and Dinh Thon villages; My Dinh stadium; My Dinh 2 ward; Resco new urban area; Nhon urban area; Thang Long new urban area
- In Dong Da District: Kham Thien street; Hoang Tich Tri street; Thai Thinh ward; Thanh Cong ward; Thai Ha street; Kim Lien areas; Pham Ngoc Thach street; Truong Chinh street; Doan Thi Diem street
- In Hoang Mai District (Giap Bat area): Truong Dinh ward; Tan Mai ward; Giap Bat bus station; Giap Bat market; Nuoc ngam bus station; Dinh Cong new urban area; Nguyen Duc Canh street; Nguyen Chinh

street; Kim Dong street; Linh Nam street; Vinh Tuy bridge area; Minh Khai street; Dai Loc new urban area

- In Ha Dong District: Xuan Phuong new urban area; Xa La new urban area; To Huu street; Street 70; Yen Nghia bus station; Hospital 103; K – Tan Trieu hospital; Phung Khoang market; Vu Trong Phung street; Nguyen Xien street; Vuong Thua Vu street; Nguyen Trai street; Yen Xa area; Beltway no.3

Visitors perceived that most of these areas suffered from floods which lasted less than one day, and a few experienced longer floods lasting from one to three days. Perceptions were that these areas are flooded from 0.2 to 0.5 meters. Visitors attributed causes for the floods, with aged drainage systems as the most common reason given, and torrential rain as the second cause (see Figure 27 below).

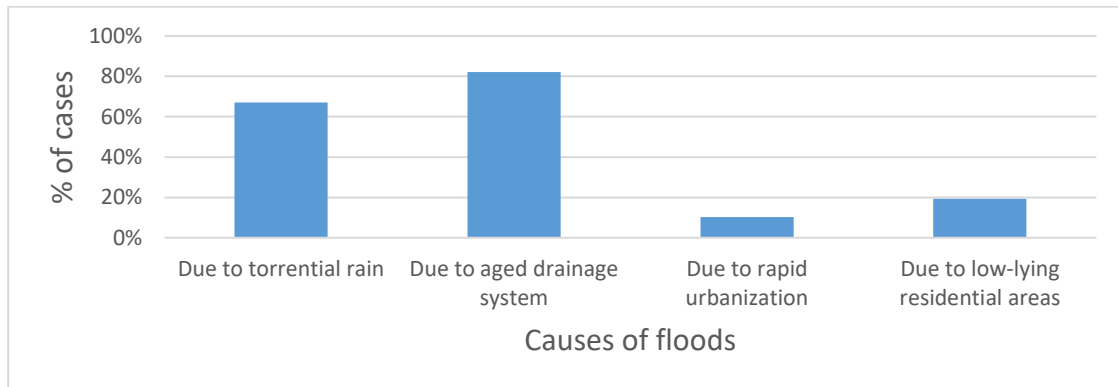


Figure 27: Perceived causes of floods in Hanoi, by visitors

3.2. Economic Impacts

60.2% of street vendors responded that they travel by motorbike, while about 20% travel on foot or by bus. All forms of transport are susceptible to flood impacts. If there is a flood, approximately half of street vendors and taxi drivers continue with their work, while the others decide to remain at home, or find other temporary work.

Average incomes for street vendors and other visitors are shown in the Figure 28, below. This shows the economic impact, when visitors lose a day or more work, due to flooding. The survey found that 84% of respondents who stop work during flooding, do not find other paid work during that time, and therefore have no income.

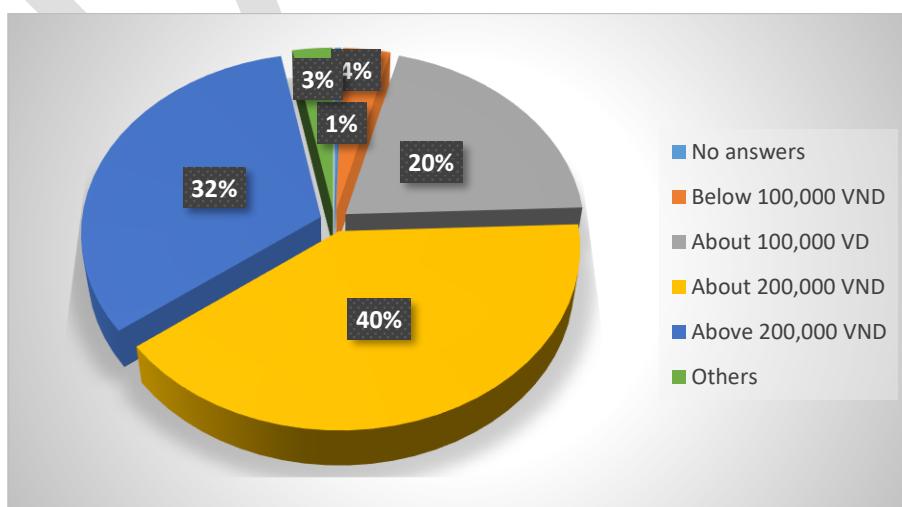


Figure 28: Daily income of street vendors and motorcycle/car taxi drivers

As street vending is the only economic activity for most visitors, they depend on this income, and disruptions due to floods can impact food security for themselves and their families. The chart below shows that most do not have replacement jobs in times of flooding.

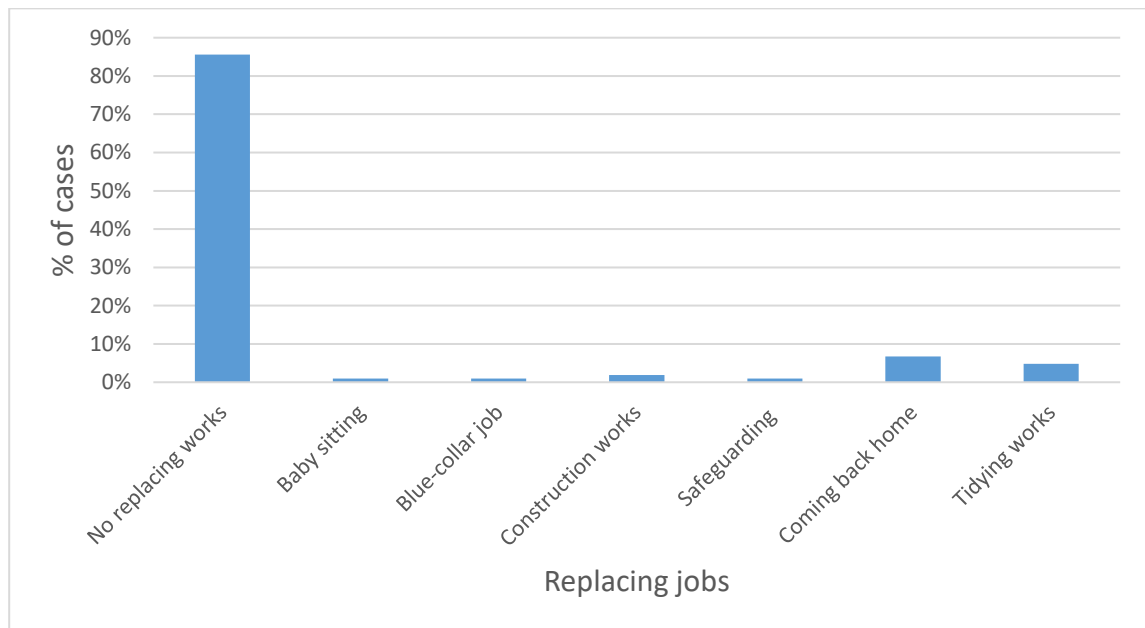


Figure 29: Temporary replacement jobs for visitors, during days off work from flood location

Flooding also impacts those who choose to carry on working. For taxis, traffic congestion during floods mean that each journey takes a long time over short distances, resulting in lower fares and income. Taxis also risk damage to their motorcycle and car engines if water is too high. The chart below shows the impact of floods on those visitors who choose to continue working.

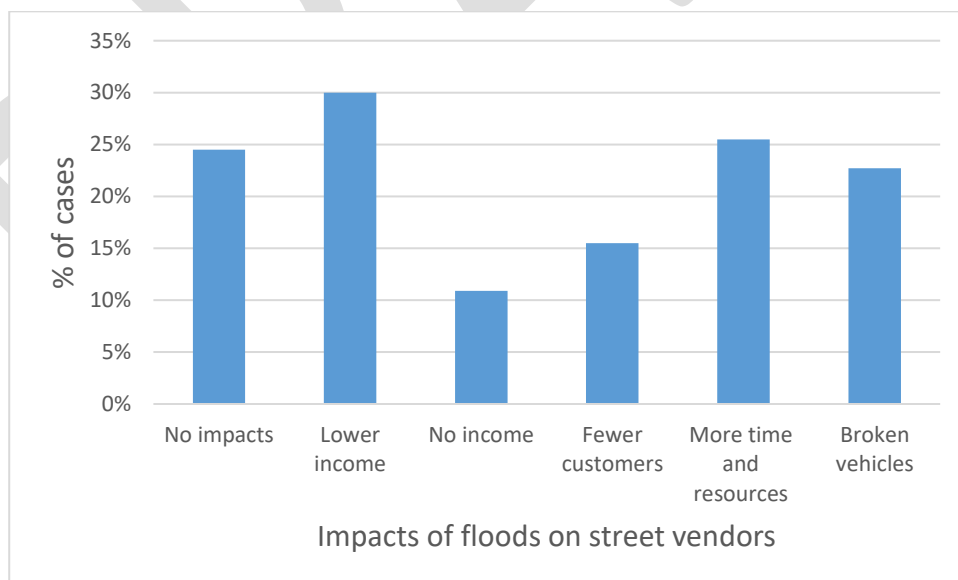


Figure 30: Impacts of floods on visiting taxi drivers and street vendors

Temporary income losses have further consequences for poor households. Parents look for other ways to make money, which may not be legal, or which may be dangerous. Lack of money can lead to family conflicts. The survey found the following as 'main consequences' for visiting taxis and street vendors, when floods impact their usual incomes, illustrated in Figures 31 and 32, below.

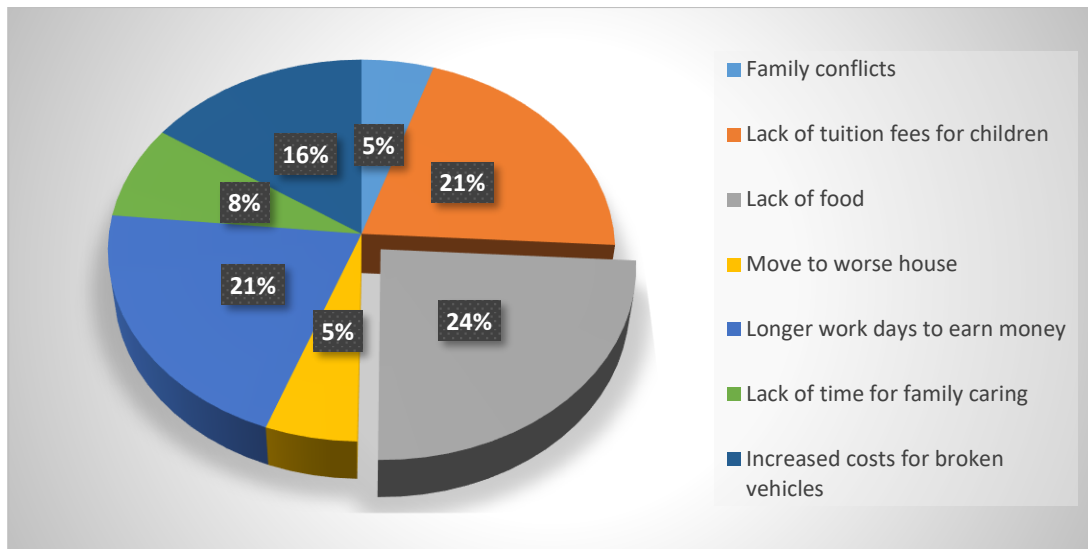


Figure 31: Main consequences of flood impacts for visitors/taxi-drivers/street vendors

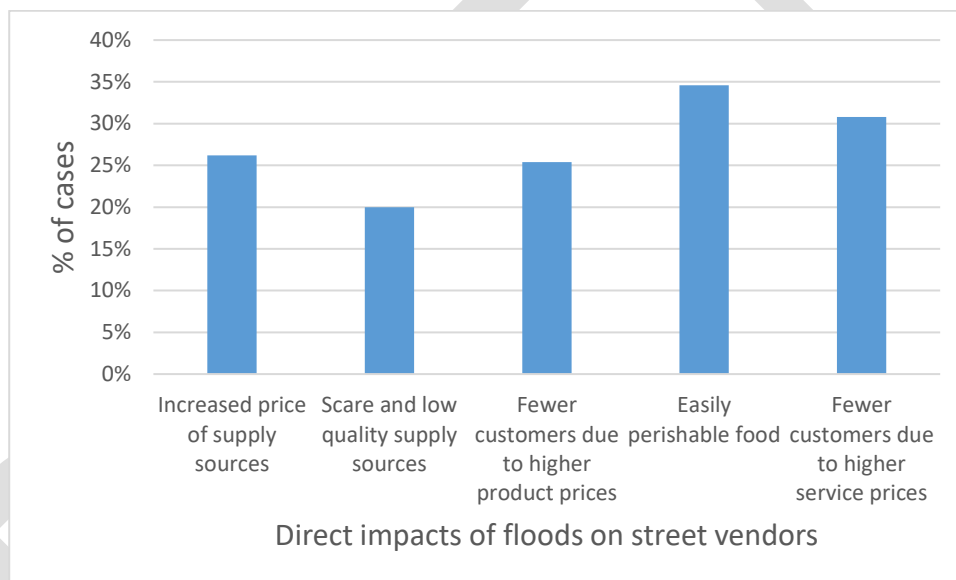


Figure 13: Direct effects of floods on street vendors

3.3. Social and Environmental Impacts

Street vendors and motorcycle taxi drivers work in open-air conditions and are susceptible to flooding. Uncovered manholes or large potholes in flooded water causes accidents. Flooding often follows storms, which cause falling branches and trees, which in turn sometimes bring down electricity lines. Therefore, submerged branches on roads, or fallen electric cables, are very serious environmental risks to vendors and taxi drivers trying to continue work during times of flooding. The following chart shows the main risks during flooding, identified by visiting workers.

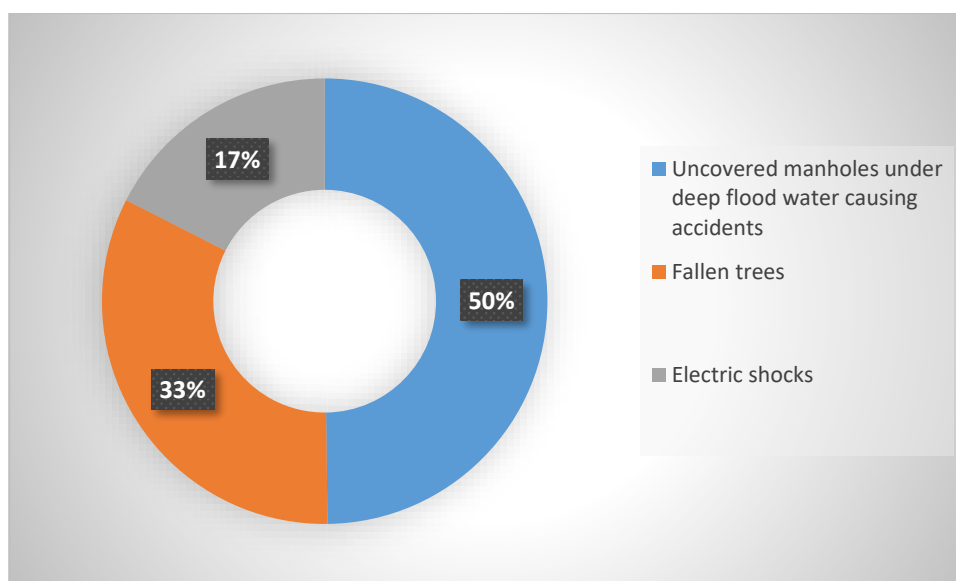


Figure 33: Main risks of flooding on street vendors during flood season

Bad odors from flood waters are also reported by 90% of the visitors interviewed, as a sign of environmental pollution. The perceived causes of the odors were human and animal wastes, and overflows of polluted water from industrial into residential areas.

Visitors ranked the environmental impacts of flooding, according to how important/severe were the impacts, as follows.

Level of importance		Ranking importance level					% of highest rank, out of the total
		No rank	1	2	3	4	
Options	Reduced water quality	52	34	24	40	51	34%
	Environmental pollution	18	86	47	32	18	47%
	Diseases and epidemics	52	44	48	34	23	32%
	Potential risks (uncovered manholes, electric shocks etc)	40	51	33	32	45	32%

(Ranking from 1 to 4 – 1 is “the most important” and 4 is “the least important”)

Table 11: Response for ranking importance of environmental impacts

Table 11 above has the same ranking method as previous ranking of the residents’ interviews. Specifically, respondents rank the importance level of economic impacts from 1 to 4 with number 1 associated with “the most important” and number 4 with “the least important”. In this case, the table shows that “environmental pollution” is assessed as the most important environmental issue caused by flooding, followed by “water quality” and “disease epidemics”, and “potential risks” as the least important element.

Street vendors report that they also like to receive the weather forecast from public media (87.6%) such as television, radio, newspapers and the Zalo Network (a popular online network for Vietnamese users), see Figure 34, below.

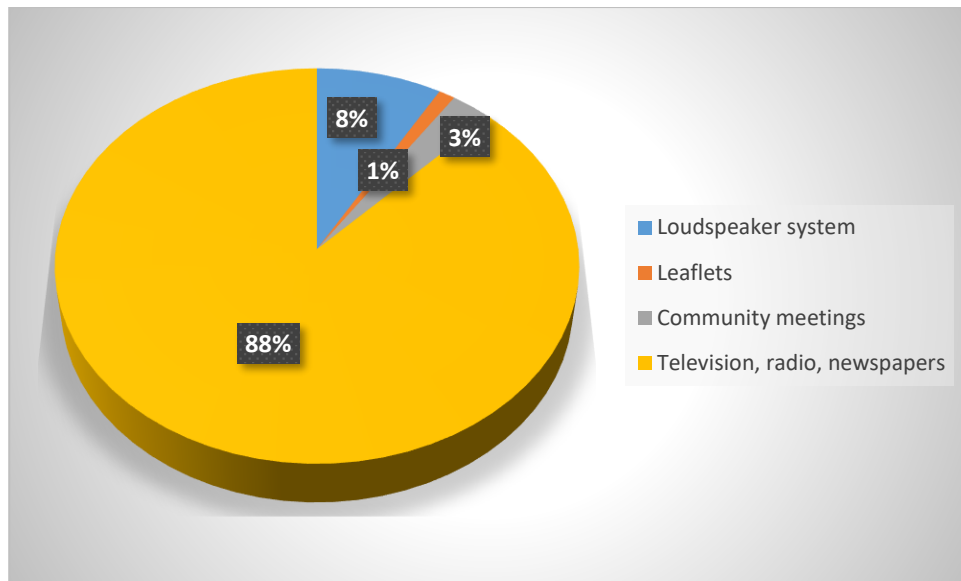


Figure 34: Media used by street vendors to receive weather forecast news

The survey result shows a surprise fact that up there were up to 76.6% respondents, 63.2% of which are women, having heard of “urban flooding” definition and surprisingly the similar percent to be aware of climate change. Majority of them think degraded drainage system as the primary cause for the flooding situation of the metropolitan. Some others are climate change resulting in prolonged torrential rain, low awareness of local communities on garbage discharge and rapid over-urbanization not corresponding with sewage system (Figure 35). Besides, several other reasons were mentioned, specifically destroying green trees, covering natural lakes and reservoirs, low-lying residence, ineffectiveness of local authorities in coping with urban flooding.

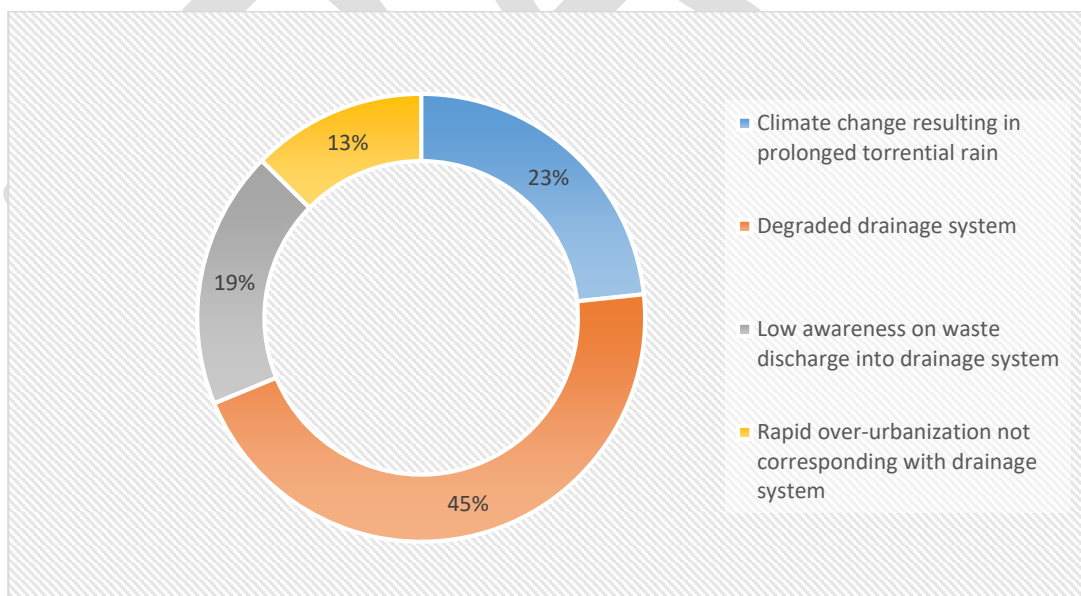


Figure 35: Response for causes for urban flooding

Many interviewees understand that climate change poses various impacts on precipitation such as triggering more prolonged and larger rainfall as well as longer flooding time for urban communities. For urban flooding, street vendors and motor/car taxi drivers understand that climate change can cause worse situation such as deeper, wider and even more lasting flooding and consequently affects their livelihoods.

Street vendors, motorbike/car taxi drivers whose earn-living works sticks are susceptible to floods and rainfall propose several measures to cope with issue. The most common selected solutions are clearing water ways, upgrading or re-constructing drainage system, raising awareness for communities or building reservoirs. Some other popular answers include raising floors and expanding road system, conducting simultaneous planning, following weather forecasts and suitably dividing water ways (Figure 36).

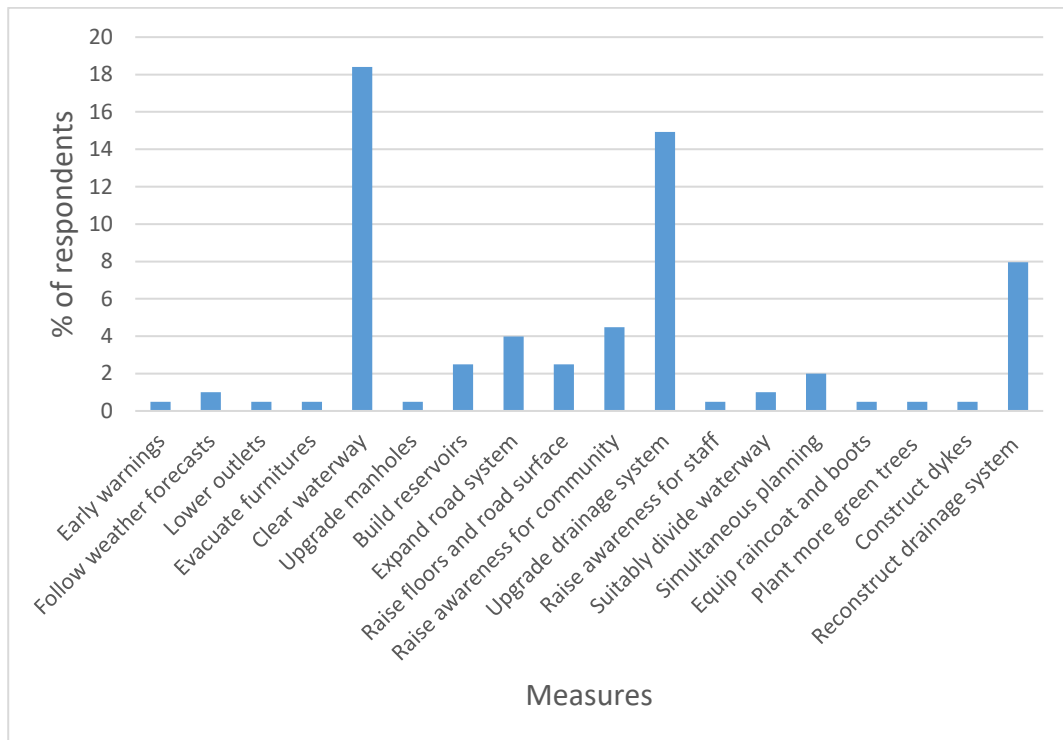


Figure 36: Proposed measures for urban flooding

4. DISCUSSION AND RECOMMENDATIONS

4.1. Discussion

The assessment shows that, in the opinion of residents, women and men, the impacts of urban flooding in Hanoi are felt most acutely, and have the greatest economic and social impacts, *along roads*. The main social impacts of flooding for residents of the four Districts, were “prolonged traffic congestion at severely crowded hotspots”, and the main economic impact was “damage to road and drainage systems”. Maintaining the efficiency of roads during the frequent periods of flooding in Hanoi, is therefore a priority for local and national government. The GCRF-OSIRIS project is well placed to engage with local and national government agencies to stimulate research for improved solutions.

Regarding economic impacts, the survey results showed that both households/small traders and street vendors/motor or car taxi drivers are affected. Flooding causes damage to public works and private belongings, and has a direct impact on incomes including those of poor households who visit the target areas for daily work as vendors and motorcycle/car taxi drivers. The majority of street vendors are women, many of whom take on additional responsibilities for children who cannot go to school during flooding, and so lose their income. Focus group discussions showed that women vendors working in flooded streets have additional stress to ensure their valuable produce is kept dry during travel to and from flooded areas. Overall, the economic impacts of flooding in Hanoi are gender-differentiated, with greater impact on women, and consequential impacts on their levels of stress and their health. Ranking

the levels of importance of the impacts of flooding, the most critical impact for residents and for visiting traders was decreased income, affecting individuals, households and communities.

Regarding environmental impacts, resident trading and non-trading households were assessed to be most vulnerable and exposed to pollution exacerbated by floods along roads. Households are impacted by garbage carried by floodwaters, and by overflows of wastewater from canals and streams, and by foul smells from these sources of pollution. Some households have their water supply cut off, or water supply becomes contaminated and dirty, disrupting daily cleaning/washing activities. There is threat of outbreaks of disease whenever there are floods. Visitors to the area, working in the streets, are at different risks. These street vendors and motorbike/car taxi drivers are at risk from submerged potholes, fallen trees and possible electric shocks. From the range of environmental impacts, environmental pollution was ranked the most critical from respondents. Environmental impacts were also perceived to be gender-differentiate, with women most responsible to care for children and elderly relatives who became sick due to environmental pollution. Women were also more obliged to clean houses, kitchens and streets from garbage after floods subsided.

The assessment considered social impacts on resident households, not on street vendors or taxi drivers. Main impacts of flooding along roads were the prolonged traffic congestion, causing difficulty to travel to work, difficulty to take children to school, difficulty to access healthcare services and other public administrative services, and lowering of trust in the capacity or commitment of local authorities. Children's absence from school was ranked as the most critical impact, affecting families socially and economically.

Regarding knowledge and practices during urban flooding, both residents and visitors were aware of the concepts of urban flooding and climate change, either moderately or completely. The perceived causes of flooding and its impacts along the roads were: the aged drainage systems, low awareness among communities about proper garbage disposal, rapid over-urbanization without corresponding improvements in drainage capacity, and more frequent and prolonged rains as a result of climate change. Both residents and visitors believed that climate change was a significant cause of floods being generally wider, deeper, and more prolonged year-by-year.

Gender was an important dimension in the responses to the survey questions. Women were perceived to work longer hours, and to take on more additional tasks both in households and at work, especially those working as street vendors. Women are busier making preparing before floods, taking care of families during floods, and tidying up after floods. The most highlighted impacts on women were economic. These impacts included reduced daily income, higher cost of living as prices of food and daily expenses rose during flood periods, and damage to stock or produce for traders and vendors. Women also suffered greater impacts to their health and greater stress, and more direct exposure to pollution and flood-related risks. Focus group discussions showed that while decision-making power of women in Hanoi is greater than decision-making power of women coming from rural areas, this difference narrowed during flooding, as men took more decisions about mitigation measures. This also led to increasing conflicts between wives and husbands, often exacerbated by financial constraints.

Measures to address these issues, proposed by residents and visitors, included: clearing garbage and construction materials from waterways; further upgrade or reconstruction of drainage systems; better storage plans for reserve food supplies; closer attention to weather forecasts; and better household planning for moving furnishings and valuables to higher places. Most people interviewed showed satisfactory awareness of urban flooding and climate change. But there was less awareness about proper waste disposal, and the role of garbage and construction materials in blocking drainage systems.

4.2. Recommendations

The assessment showed that roads are focal points of impact of urban flooding, not only because they are routes to be travelled on, but also because they are places where people live and work. As such, they can be focal points of disaster preparedness. Regarding the social, economic and environmental impacts of floods at community level along roads in some of Hanoi's central districts, the project recommends that the Hanoi People Committee, Hanoi City Floods and Storms Steering Committee, the City Water Drainage Company of Hanoi, media stations and NGOs should invest in the following areas, to enhance other ongoing flood risk mitigation measures.

1. Promote further communication and awareness-raising about urban flood risk, and especially about its gender-differentiated impacts, targeting a range of populations, before, during and after floods. Gender-related measures – such as discussions between women and men to share their workload, reducing working times for women during floods, and joint decision-making between women and men regarding measures before, during and after floods – should be highlighted, because they may be among the most cost-effective measures to reduce the impacts of flooding at household level.
2. Raise awareness among households and street businesses to reduce discharge of waste into the city's drainage system
3. Facilitate preparations for households and for businesses, prior to the flood season, including harnessing the potential of community-based organisations to promote gender-based measures for flood risk management
4. Government agencies responsible for flood mitigation should clear waterways prior to the rainy season, and continue to improve effective communication of weather forecasts
5. Government agencies should budget for socio-economic-environmental impacts assessments in relation to floods, and allocate budgets for mitigation measures at local levels (local government, businesses and households)
6. Flood mitigation measures should include complementary soft and hard components for integration into the city's socio-economic development planning, and for investment.

Annex: Questionnaire Survey used for Residents

Research Project: Optimal investment strategies to minimise flood impact on road infrastructure in Vietnam Questionnaires for households			
Instruction to surveyors: - Make sure to introduce the research project "Optimal investment strategies to minimise the flood impact on road structure in Vietnam", explain the length of questionnaire. Interviewees are always allowed to stop the interview at their convenience.			
CODING			
GENERAL INFORMATION			
NO.	QUESTIONS	ANSWER CHOICES	Answer code
1	Does your current residence suffer from floods during rain season?	No Yes	0 1
2	How long does each flood last on average?	Less than 1 day 1 day 2 - 3 days More than 3 days Other, specify:	A B C D Z
3	What is average depth of flood water?	Below 0.2 m 0.2 - 0.5 m 0.5 - 1 m Higher than 1 m Other, specify:	A B C D Z
4	What are the causes of flood in your living residence?	Torrential rain Aged drainage system Over-urbanisation Low-lying residence Other, specify:	A B C D Z
5	Since when have your living residence experienced worse flooding?	This year 1 year ago 2-3 recent years More than 3 years ago Other, specify:	A B C D Z
ASSESSMENT OF ECONOMIC IMPACTS			
6	What are the urban flooding impacts on public works in your living residence? (Multiple choices possible)	Street (sidewalk, road) Drainage work Public buildings (Culture house, ward healthcare station, etc.) Other, specify:	A B C Z
7	You are living in:	Private house (Detached house) Private house (Apartment) Rental house (Detached house) Rental house (Apartment)	A B C D
8	Is your house flooded?	No Yes	0 1
9	If yes, how deep is your house flooded in water?	Below 0.2 m From 0.3 to 0.5 m From 0.5 to 1 m Above 1 m Other, specify:	A B C D Z
10	How does flood impact your house? (Multiple choices possible)	The house has mold The foundation is spoiled The wall-paint is peeling off Other, specify:	A B C Z
11	Which household assets in your house are seriously impacted by flooding over last year? (Multiple choices possible)	Car Motorbike Television Fridge Washing-machine Business goods (clothes, shoes, food and beverage, grocery items, etc.) Other, specify:	A B C D E F Z

12	How much is the estimated cost of property damages after last year floods?	VND	
13	Does your family purchase property insurance?	No Yes	0 1
14	If yes, which kind of property does your family buy insurance for? (Multiple choices possible)	Motorbike Car House Other, specify:	A B C Z
15	If broken, does your car/motorbike get compensation from the owner of building or insurance agency?	No Yes	0 1
16	If yes, how much is the compensation? (Please specify the case)	VND	
17	(Interview the apartment residents only) How does the flooding impact on your apartment? (Multiple choices possible)	The underground parking lot is flooded, cars and motorbikes are broken Being isolated, cannot go out for work or buying food Other, specify:	A B Z
18	Does your residence experience power cut-off due to the flooding?	No Yes	0 1
19	If yes, how long a power outage would be during flooding time?	Less than 1 day 1 day 2-3 days 4 - 7 days More than 1 week Other, specify:	A B C D E Z
20	If yes, how does the power cut impact on your family' life and production? (Multiple choices possible)	Production is interrupted, resulting in economic losses The elevator does not work No water pump No electricity for lighting No electricity for running fan, air-conditioner, etc. Other, specify:	A B C D E Z
21	How does the flood impact on your family's income? (Multiple choices possible)	Cannot go to work, lost man-day(s) Cannot sell goods, decrease turnover Cannot produce goods, decrease turnover Other, specify:	A B C Z
22	If you cannot go to work, how many days do you have to be off from work?	days	
23	How much income do you lost corresponding to your days-off?	VND	
24	If goods cannot be sold, how much does the turnover lose?	VND	
25	If goods cannot be produced, how much does the turnover lose?	VND	
26	Have your living expenses increased during the flood season?	No Yes	0 1
27	If yes, which specific items experience a temporary price increase? (Multiple choices possible)	Rice Fresh vegetables Fish and meat Dried foods, instant foods (dried bamboo shoot, dried shrimp, instant noodles, etc.) Other, specify:	A B C D Z
28	What is the regular price increase level?	A slight increase A considerable increase A significant increase (1.5 times or higher) Other, specify:	A B C Z
ASSESSMENT OF THE ENVIRONMENTAL IMPACTS			
29	How is your family's daily-used water affected?	Unaffected Being contaminated (specify: dirty, bad smell) Loss of water Other, specify:	A B C Z

30	If water is contaminated, what are the major reasons in your opinion? (Multiple choices possible)	The dirty flood water flows over the household water tank	A
		The water tank of the whole apartment is flooded and contaminated	B
		The water resource of residential water factory is contaminated	C
		Other, specify:	Z
31	In case of temporary water loss in flooding season, how long does it often last?	Less than 1 day	A
		1 day	B
		2-3 days	C
		4 - 7 days	D
		Over 1 week	E
	Other, specify:	Z	
32	If your water is contaminated, how can you handle this problem?	No processing	A
		Filtering water	B
		Discharging dirty water, filling the household water tank with fresh water	C
		Other, specify:	Z
33	During the temporary water cut time, which source of water does your family often use?	No water reserve	A
		Use reserved water	B
		Buy bottled water for use	C
		Buy fresh water elsewhere	D
		Other, specify:	Z
34	When flooding occurs, what are the factors that cause pollution in your residence?	Solid wastes	A
		Waste water	B
		Carcases	C
		Other, specify:	Z
35	What are the impacts of environmental pollution?	Resulting in the gradual death for green trees	A
		Impacting on the living environment of local residents	B
		Facilitating the outbreak of various epidemics	C
		Other, specify:	Z
36	Which are the common diseases during the flooding period (during and after)?	Skin diseases (athlete's foot, scabies, impetigo, etc.)	A
		Pinkeye	B
		Dengue	C
		Diarrhoea	D
		Respiratory diseases (sore throat, flu , bronchitis, etc.)	E
	Other, specify:	Z	
37	What are the potential flooding risks posing your residence?	Uncovered manhole is flooded under deep water resulting in unexpected accident	A
		Fallen trees	B
		Electric shocks	C
		Other, specify:	Z
ASSESSMENT OF SOCIAL IMPACTS			
38	How does flood impact on your family's transportation?	No obstructions	A
		Deep flooding water impeding the transportation	B
		Difficult transportation, traffic jam in many hours	C
		Other, specify:	Z
39	Can your children go to school?	No	0
		Yes	1
40	If no, during each flood season, how many days do children have to be absent on average?	1 day	A
		2 days	B
		3 - 5 days	C
		1 week	D
		Over 1 week	E
	Other, specify:	Z	
41	If students are absent from school, who will take care of them?	Grandfather	A
		Grandmother	B
		Father	C
		Mother	D
		Elder Brother	E
		Elder Sister	F
		Babysitter	G
Other, specify:	Z		

42	Does your family experience any difficulties in approaching the healthcare stations during the flooding time?	No	0
		Yes	1
43	If yes (specify):		
44	Are there any difficulties in approaching public services in your residence? (Multiple choices possible)	Ward/district administrative procedures	A
		Postal services	B
		Cultural services	C
		Other, specify:	Z
Assessment of Knowledge - Attitude - Practice			
45	Are you and your family informed of prolonged torrential rain possibly causing flood prior each heavy rainfall?	No	0
		Yes	1
46	If yes, where do you often receive warning of flooding potential during torrential rainfall?	Loudspeaker system at wards	A
		Leaflets	B
		Ward residential meetings	C
		Other, specify:	Z
47	Have your ever heard of urban flooding?	No	0
		Yes	1
48	What are the major causes of urban flooding?	As a result of climate change, prolonged heavy rain with high frequency	A
		Degraded drainage system	B
		The direct disposal of garbage into the drainage system due to the public unconsciousness	C
		Rapid over-urbanisation, inadequate drainage system resulting in flooding	D
	Other, specify:	Z	
49	Have you ever heard of climate change?	No	0
		Yes	1
50	In your opinion, how does climate change affect the precipitation? (Multiple choices possible)	Does not cause any adverse effects	A
		Result in heavier rain	B
		Result in more prolonged rain	C
		Result in higher frequency of precipitation in a short period	D
	Other, specify:	Z	
51	From your viewpoint, how does climate change impact on urban flooding?	Does not cause any adverse effects	A
		Result in wider flooding area	B
		Result in deeper flooding	C
		Result in more prolonged flooding	D
	Other, specify:	Z	
52	What is your family's solutions to deal with the consequence of floods? (Multiple choice available)	Do not have any solutions	A
		Raise the floor	B
		Raise the door steps to prevent water entering the house	C
		Update weather forecasts for flooding prevention and control	D
		Evacuate to a safer place	E
		Transfer properties to a higher place to mitigate flooding impacts	F
	Other, specify:	Z	
53	Does your family have any plans to cope with flooding in the upcoming period? (Multiple choices possible)	Does not have any plan	A
		Relocate to another place	B
		Temporarily move to a safe shelter	C
		Hold on for a while and tolerate flooding situation in a time	D
		Tolerate and pray because there is no place to go	E
		Raise the floor	F
		Build a completely new house	G
		Raise the door steps to prevent water entering the house	H
		Connect with neighbours, communities	I
	Other, specify:	Z	

54	Do your local authorities implement any measures of before/during/after flooding?	No Yes	0 1
55	Which solutions are recommended for the flood mitigation?	Construct, repair traffic roads prior to rainy season Construct, repair, expand drainage / sewage system, detention basin Dredge drains / drainage channels prior to the rainy season Adjust land use planning Conduct trainings, foster communication activities about measures to prevent and mitigate urban floods Raise the residential awareness of not discharging garbage into culverts and drainage system to prevent drainage system blockage Warn of heavy rain and flooding risks before rainy season Organise the relocation for inhabitants in seriously affected areas Organise campaigns on the prevention of flood-prone diseases (dengue, diarrhea, allergies, etc.) Other, specify:	A B C D E F G H I Z
56	How do you evaluate your trust in future urban flood mitigation and mitigation measures of your local authorities?	Do not trust Relatively trust Trust Completely trust Do not know	A B C D E
57	Can you recommend some measures on flood prevention, control and response?	1 2 3 ...	A B C D
Interviewer (Name, signature)		Interviewee (Name, signature)	
Name of interviewer:		Date: _____ (date/month/year)	
PERSONAL INFORMATION			
A1	City:	Current living address of interviewee	
A2	District:		
A3	Ward:		
A4	Area/ street:		
A7	Name of interviewee:		
A8	Gender:	1. Male	2. Female
A9	Phone number:		
<p>Before leaving this household, verify the entire questionnaire and fill the missing ones.</p> <p>Say thanks to those who participated in the interview.</p>			