

# Colombo

## Exposure, Vulnerability, and Ability to Respond to Floods

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## Abstract

This paper examines the exposure, vulnerability, and ability of households in Colombo, Sri Lanka, to respond to floods, and brings out significant policy implications. The study used detailed questionnaire-based surveys to obtain data on households, to understand the vulnerability and impacts of the severe floods of November 2010 and recurrent floods since then. Households that were selected for the surveys were located in and around flooding spots in the city. The study finds that the floods have imposed a significant burden on poor households. Poor and non-poor households have suffered damages to the structure of their houses, household assets and appliances, and vehicles. With recurrent floods, they continue to bear the cost of damages as well as short-term measures to cope with floods. For poor families, these costs are borne through

very limited resources and borrowing from informal sources, compared with the nonpoor who have more savings in financial form and greater access to formal sources of credit. Poor families tend to invest all their earnings in their home, furniture, and utensils, which suffer the most during floods. In addition, households suffer indirect impacts due to non-availability of transport, power, drinking water, food, and essential supplies. They also tend to lose workdays, which leads to loss of income and productivity. Many poor families have considered relocation to flood-free areas, but they lack the financial resources for the move. If the government offers such a scheme, many would be willing to take it up, if factors like job opportunities, clean surroundings, access to medical facilities, transportation, and good social networks are ensured in the new locations.

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# Colombo: Exposure, Vulnerability, and Ability to Respond to Floods

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## 1. Background

The world is urbanizing at a rapid pace and all future population growth is expected to occur in cities. It is estimated that almost 5 billion people will live in cities by 2030 and the majority of them will reside in cities of the developing world in Asia and Sub-Saharan Africa.<sup>1</sup> Urbanization plays a critical role in the economic development and social change of a nation. As cities and urban agglomerations develop and expand, they create dynamic centers of economic growth with increased job opportunities, better incomes and provision of essential services to their people. However, they also bring about problems of their own with pressures of exploding population, inadequate infrastructure, poverty, rapidly mushrooming informal settlements and rampant environmental degradation. Added to these pressures are the hazards associated with climate change and natural climate variability. The ability of cities to respond to the dual challenges of urbanization and climate change is going to determine the future economic growth, poverty alleviation, environmental sustainability and quality of life. The future of sustainable development will depend on the way cities adapt and respond to these challenges.

Many coastal cities across the globe, in particular in Asia, are hotspots of vulnerability due to climate change and natural climate variability and are at risk from extreme and recurrent events like heavy precipitation, flash floods, cyclones and sea level rise. Such events lead to massive damages to life and property, loss of value of the asset base and adverse effects on economic and social life. The adaptive capacity of such cities is often lower due to vulnerable location, large population residing in informal settlements and pressure on existing infrastructure, and this puts constraints on available physical, financial and human resources to cope with climate risks. Hence, extreme or recurrent weather events have adverse and long-term consequences for economic development and poverty alleviation and can alter the development trajectory of the city and surrounding areas. It is, therefore, critical to assess the exposure and vulnerability of cities in Asia to recurrent weather events, understand the impacts of such events on the population and their ability to respond.

This empirical study is carried out in Colombo, the largest city and commercial capital of Sri Lanka. Colombo is the most important financial center of Sri Lanka and the metro area alone generates almost half of the country's gross domestic product. The city, however, is acutely vulnerable to heavy rainfall, storm surges and other climate risks due to its coastal location. This study focuses on the exposure and vulnerability of Colombo residents to recurrent floods and their ability to respond. In particular, the poor households tend to have greater exposure and more vulnerability to such recurrent hazards and have limited ability to respond and adapt. The findings of this study are expected to help Colombo city administrators and policy makers in better targeting of adaptation interventions and would also have wider policy implications for similar cities.

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<sup>1</sup> UNFPA (2007), State of the world population: Unleashing the potential for urban growth, United Nations Population Fund.

This paper is structured as follows. The next section describes the city profile, rainfall pattern and recurrent floods. Methodology and data sources are outlined in Section 3, followed by the discussion on findings on exposure, vulnerability and ability to respond in Section 4. Section 5 brings out the policy implications of the study, followed by the summary and conclusion in Section 6.

## 2. Profile of Colombo city, rainfall and flooding

Colombo is the largest city and commercial capital of Sri Lanka and is located adjacent to the administrative capital Sir Jayewardenepura-Kotte. Colombo city has been developed along the low-lying river estuary overlooking the western seafront and occupies an area of 37 sq. km.<sup>2</sup> The city, with six administrative districts as shown in Figure 1, is under the jurisdiction of Colombo Municipal Council (CMC). CMC, with an annual budget of Lankan Rupees (LKR) 9 billion, is the largest local authority in Sri Lanka and one of the oldest in South Asia with operations since 1865. CMC has 15 departments with functional responsibility of public health, solid waste management, roads development, water, drainage, land, environmental development and social services. The role of CMC assumes great importance for the economy of the island nation, since Colombo metro area generates almost half of the country's GDP.<sup>3</sup>

Colombo district forms a major part of the Western province of Sri Lanka which is the most densely populated province in the whole country. The gross domestic product of this province was LKR 4,610,509 million (USD 24.78 billion<sup>4</sup>) at current prices in 2015, which is 41.2% of the national GDP.<sup>5</sup> The per capita GDP of the Western province was LKR 771,117 (USD 4246.38) in the same year.<sup>6</sup> Important statistics for Colombo are given in Table 1 below.

*Table 1: Important statistics for Colombo*

Total population of Colombo District	2.3 million <sup>7</sup>
Population in Colombo city	10,00,000 (approx.) <sup>8</sup>
Residential	555,031 as per Census 2012
Floating	400,000 (approx.)
Household monthly income (Colombo District)	LKR 77,723 in 2012-13 <sup>9</sup>
Per capita monthly income (Colombo District)	LKR 19,346 <sup>10</sup>
Official poverty line	LKR 4044 per person per month <sup>11</sup>

<sup>2</sup> <http://www.cmc.lk>.

<sup>3</sup> <http://www.worldbank.org/en/news/feature/2014/07/02/helping-colombo-hold-back-next-flood>.

<sup>4</sup> 1 USD = 132.8 LKR is the exchange rate used throughout this paper. This was the average exchange rate in 2015 when the study was carried out in Colombo.

<sup>5</sup> Central Bank of Sri Lanka (2016), Sri Lanka Socio-Economic Data 2016, Vol. XXXIX, June 2016.

<sup>6</sup> *Ibid.*

<sup>7</sup> Central Bank of Sri Lanka (2016), Economic and Social Statistics of Sri Lanka 2016, Vol. XXXVIII, June 2016.

<sup>8</sup> City Profile available on Colombo Municipal Council website <http://www.cmc.lk>.

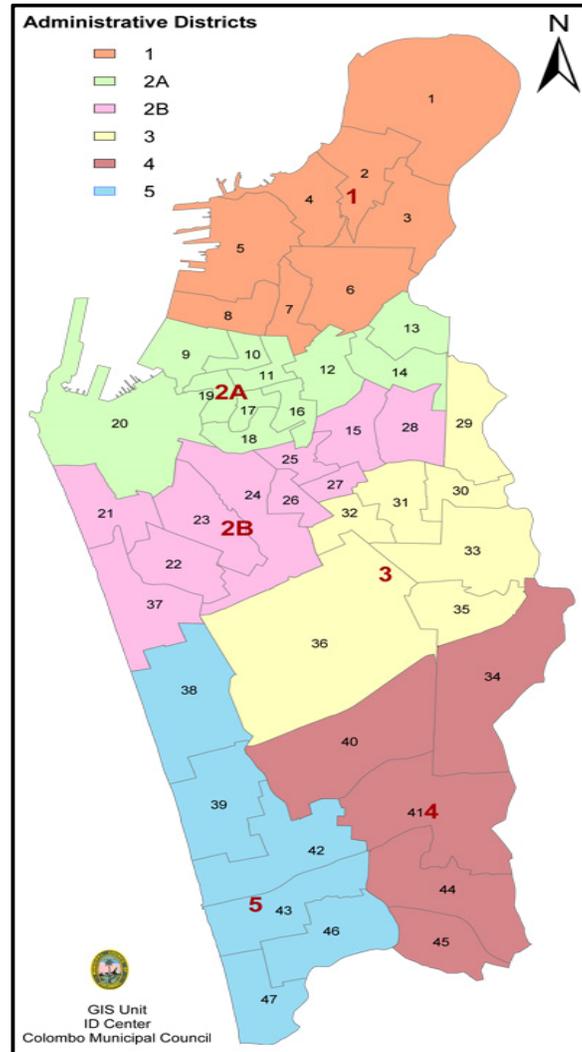
<sup>9</sup> Govt. of Sri Lanka (2015), Household Income and Expenditure Survey – 2012/13, Department of Census and Statistics, Ministry of Policy Planning Economic Affairs, Child Youth and Cultural Affairs.

<sup>10</sup> *Ibid.*

<sup>11</sup> [http://www.statistics.gov.lk/poverty/monthly\\_poverty/](http://www.statistics.gov.lk/poverty/monthly_poverty/).

Percentage of households below poverty line	1.1 <sup>12</sup>
Average size of the household	3.9 <sup>13</sup>
Housing units	103,408 <sup>14</sup>
Slums and others	13,928 <sup>15</sup>

Figure 1: Colombo city administrative districts<sup>16</sup>



Source: <http://www.cmc.lk>

As regards topography, climate and natural hazards affecting Sri Lanka, they are mainly hydrological and geological in nature, such as, floods, landslides, cyclones, tidal surges and tsunamis. Being on the

<sup>12</sup> *Ibid.*

<sup>13</sup> Central Bank of Sri Lanka (2016), Sri Lanka Socio-Economic Data 2016, Vol. XXXIX, June 2016.

<sup>14</sup> City Profile available on Colombo Municipal Council website <http://www.cmc.lk>.

<sup>15</sup> *Ibid.*

<sup>16</sup> Colombo City Map available at <http://www.cmc.lk>.

west coast and falling in the wet zone, Colombo city also faces hazards of high precipitation and floods regularly. Colombo district gets inundated during the south-west monsoon due to heavy rainfall and run-off of large volumes of water from the river catchment areas and canals.<sup>17</sup> Colombo is a harbor on the western coast of Sri Lanka and faces a warm and humid tropical climate with average temperature of 27.8°C and humidity ranging from 74% during the day and 85% during the nights as per data for the period of 1996-2012.<sup>18,19</sup> The city and surrounding areas fall under the Wet Zone in the south-western quadrant which receives rainfall throughout the year. Colombo district falls under the Kelani River basin which starts from the Sri Pada Mountains in central hills and flows down until it reaches the river mouth in Colombo city. This river basin gets a high amount of rainfall each year with the annual average of 3,000 millimeters (mm) and the river flow variations are between 800 m<sup>3</sup>/s and 1,500 m<sup>3</sup>/s.<sup>20</sup> The topography combined with high rainfall during monsoon causes frequent disastrous floods in the middle and lower reaches of the river. Flooding is particularly severe in the lower reaches starting from Hanwella to most downstream, i.e., Colombo city.<sup>21</sup>

Besides the heavy rains in the river basin, the average annual rainfall over Colombo city has also been quite high at 2,273.52 mm over the period of 2001-2014 as per data obtained from the Department of Meteorology in Sri Lanka. However, there have been significant variations from year to year with the lowest average of 1,774.2 mm in 2011 and highest average rainfall of 3,674.12 mm in 2012. The annual rainfall recorded between 2001 and 2014 at the weather station in Colombo is shown in Figure 2 below. The annual rainfall was also quite high at 3,369.9 mm in 2010 when Colombo city experienced disastrous flooding.

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<sup>17</sup> NBRO (2010), Status of Disaster Management, National Building Research Organisation, Ministry of Disaster Management, Sri Lanka.

<sup>18</sup> Central Bank of Sri Lanka (2006), Economic and Social Statistics of Sri Lanka 2006, Vol. XXVIII, November 2006.

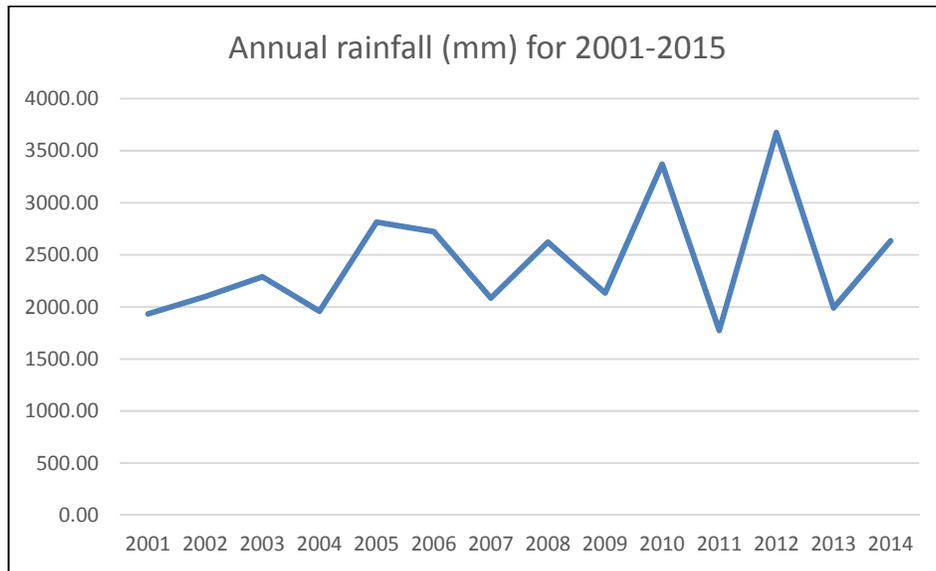
<sup>19</sup> Central Bank of Sri Lanka (2013), Economic and Social Statistics of Sri Lanka 2013, Vol. XXXV, April 2013.

<sup>20</sup> Sugeeswara S. and Jayawardena A., (2010), Development of a flood forecasting model for Kalu river and Kelani river basins in Sri Lanka using radial basis function neural networks. Available at

[www.icharm.pwri.go.jp/training/master/pubilication/pdf/2010/sugeeswara.pdf](http://www.icharm.pwri.go.jp/training/master/pubilication/pdf/2010/sugeeswara.pdf)

<sup>21</sup> *Ibid.*

Figure 1: Annual rainfall in Colombo (2001-2014)



Source: Department of Meteorology, Sri Lanka, [www.meteo.gov.lk](http://www.meteo.gov.lk)

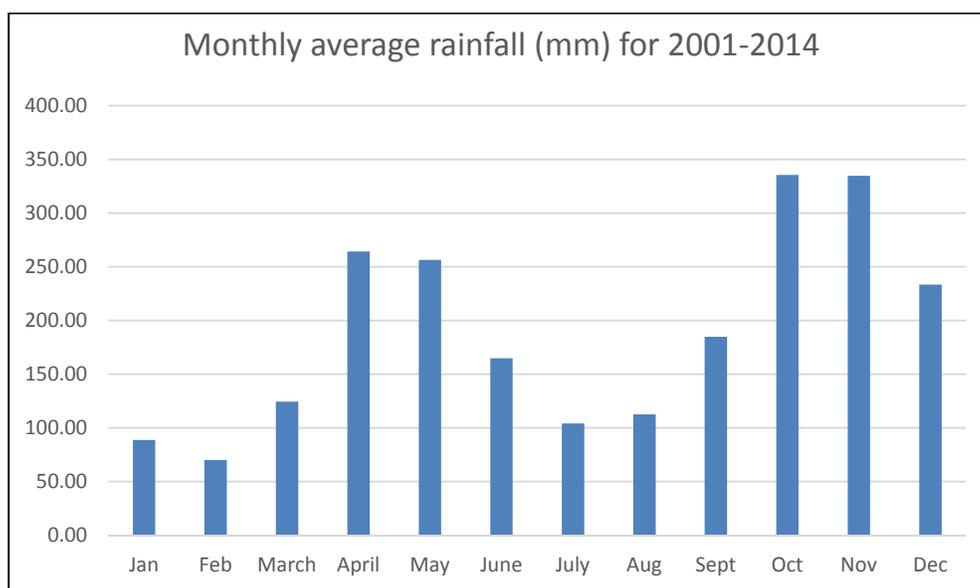
Further, monthly average rainfall distribution over Colombo for 30 years covering 1981 and 2010 shows that May, October and November are the wettest months with monthly rainfall above 300 mm.<sup>22</sup> Heavy rainfall is known to occur in the southwest monsoon period between May and September and also between inter-monsoon periods of March-April and October-November.<sup>23</sup>

Figure 3 shows monthly average rainfall over Colombo between 2001 and 2014. Further, there have been 19 days during 2006 and 2014 when the daily rainfall exceeded 100 mm and led to flooding in the city. On average, there have been about two such days every year. In the year 2010, rainfall exceeding 100 mm occurred for 7 days. There have been occasions, in November 2005 and November 2009, when the city faced 270 mm and 207 mm daily rainfall respectively. In November 2010, the city recorded 440.2 mm which is the heaviest daily rainfall recorded over this entire period.

<sup>22</sup> World Bank (2013), Report on the Development and Application of the Urban Drainage Model, Selection No. 1043824/Sri Lanka: Update/Upgrade of the Hydrologic-Hydraulic Model and New Urban Micro-Drainage System Model for Greater Colombo Basin.

<sup>23</sup> *Ibid.*

Figure 3: Monthly average rainfall in Colombo (2001-2014)



Source: Department of Meteorology, Sri Lanka, [www.meteo.gov.lk](http://www.meteo.gov.lk)

Flooding is common in Colombo city and many other parts of Sri Lanka. The UN Office for the Coordination of Humanitarian Affairs (OCHA) has recorded the impacts of floods in Colombo and other surrounding districts from 1984 onwards. From 2008 onwards, floods have regularly been recorded in Colombo and nearby districts with disastrous consequences for the people. For instance, in June 2008, Colombo and nearby areas were affected by flash floods and over 400,000 people were rendered homeless.<sup>24</sup> Once again, in October 2008, Gampaha and Colombo city experienced flash floods.<sup>25</sup>

On November 10, 2010, Colombo district experienced torrential rainfall of more than 440 mm, inundating most parts of Colombo city and the surrounding areas. Flash floods were reported in Colombo city, Colombo districts and the surrounding districts of Gampaha, Kalutara and Kegalle. The flash floods were largely due to the obstruction of the flow of rainwater in the draining ditches and canals by unauthorized construction on the sides of the canals and improper bridges and culverts.<sup>26</sup> Rapid assessment done by the Disaster Management Centre of Sri Lanka placed the total number affected people at 213,292 (50,235 families) of which 193,261 (43,799 families) were in Colombo district alone.<sup>27</sup> The floods caused significant damage in terms of impact on infrastructure including housing, unavailability of food, adverse effects on livelihoods and disruption of essential services like electricity and transportation. The primary survey undertaken in this study has focused mainly on

<sup>24</sup> <http://reliefweb.int/disaster/fl-2008-000079-lka>.

<sup>25</sup> <http://reliefweb.int/disaster/ff-2008-000199-lka>.

<sup>26</sup> *Ibid.*

<sup>27</sup> OCHA (2010), Sri Lanka Floods Situation Report #1, 13 November 2010, United Nations Office for the Coordination of Humanitarian Affairs.

these flash floods and subsequent recurrent floods while assessing impacts on households and their ability to respond.

### 3. Methodology and data sources

The aim of the present study is to examine the exposure and vulnerability of the households in Colombo city (the metro Colombo area under the jurisdiction of the CMC) to heavy precipitation and resultant floods. The study particularly focuses on vulnerability and impacts of the November 2010 flood event and subsequent recurrent floods and the ability of households to respond. There is specific emphasis on poor households, their vulnerability and ability to respond vis-à-vis non-poor households. Table 2 gives details of the methodology and sources of primary and secondary data to understand distinct aspects focused upon in this study – hazard, exposure, vulnerability and impacts and ability to respond. This framework is similar to the one used in the World Bank report on building the resilience of the poor in the face of natural disasters.<sup>28</sup> The framework looks at monetary losses from damages to assets due to floods and other disasters but goes beyond this to measure well-being losses for people in the face of disasters. Risk assessment is done by understanding hazard, exposure, vulnerability and socioeconomic resilience. Similar methodology is used in this study to analyze the exposure, vulnerability and impacts of floods on Colombo residents and their ability to respond based on socioeconomic factors that determine resilience.

In order to understand the flood hazard that households are exposed to, information has been obtained from the CMC on the location of flooding spots in the metro Colombo area. CMC has identified 43 flooding spots (given as Annex 1 to this paper) on the basis of the extent of flooding experienced during the November 2010 floods. These flood-prone locations have further been combined into 15 intervention areas where CMC has planned specific flood control measures. Maps have been created as a part of this study to identify the flooding spots to understand the extent of flooding across the metro Colombo area. To assess the exposure of households to recurrent floods, locations selected for the primary survey have also been identified based on the flooding spots.

*Table 2: Methodology and data sources for the study*

	Methodology	Data Sources
<b>Hazard</b>	<ul style="list-style-type: none"> <li>Examine the flood-prone locations within Colombo city</li> </ul>	<ul style="list-style-type: none"> <li>Data obtained from Colombo Municipal Council on location of flooding spots identified after the November 2010 floods</li> </ul>

<sup>28</sup> Hallegatte et. al. (2017), Unbreakable: Building the resilience of the poor in the face of natural disasters, Climate Change and Development Series, Washington DC, World Bank, doi:10.1596/978-1-4648-1003-9.

<b>Exposure</b>	<ul style="list-style-type: none"> <li>• Examine the location of surveyed households in relation to the flood-prone locations</li> </ul>	<ul style="list-style-type: none"> <li>• GIS based maps created to identify the location of surveyed households vis-à-vis the flooding spots</li> </ul>
<b>Vulnerability and Impacts</b>	<ul style="list-style-type: none"> <li>• Stratified random sampling of households in flood-prone locations and possible interventions areas for flood control</li> <li>• Administering questionnaires to sample households to capture vulnerability and impacts</li> </ul>	<ul style="list-style-type: none"> <li>• Sampling frame determined using the flood-prone locations and important intervention sites identified by the CMC engineers</li> </ul>
	<ul style="list-style-type: none"> <li>• Examine the impacts on poor and non-poor households separately</li> <li>• Examine welfare impacts such as health, productivity and savings in assets that get exposed to floods easily</li> </ul>	<ul style="list-style-type: none"> <li>• Primary data collected from 250 households in selected areas in Colombo city</li> </ul>
<b>Ability to respond</b>	<ul style="list-style-type: none"> <li>• Identify household adaptation options, their costs, source of finance and decision-making process</li> <li>• Examine the option of relocation, influencing factors and willingness to relocate</li> </ul>	<ul style="list-style-type: none"> <li>• Primary data collected from 250 households in selected areas in Colombo city</li> </ul>

The vulnerability and impacts of floods on households and their ability to respond in Colombo city have been captured through the primary survey carried out in the flood-prone areas, in particular, near the 15 intervention sites, which were further combined into 11 Micro Drainage Intervention Catchments - P1 to P11 – depending on the value of the financial package. The details of these catchment locations are also given as Annex 2 to this paper. Stratified random sampling has been used to select households across these 15 sites. The survey locations have been chosen after assessment of information available with CMC on flood prone locations and consultations with CMC officials. The CMC engineers categorized the catchment areas into high, medium and low population/density zones and the sample has been distributed accordingly. A detailed primary survey of 250 households has been carried out in the identified areas, the details of which are given in Table 3 below.

*Table 3: Details of surveyed areas*

Flooding Locations	Areas surveyed	No. of households
<b>District -01</b>		

Bloemandhal road Arther De Silva Mawatha Junction	Kotahena East,	51
Madampitiya Road at Kimbula Ela	Mahawaththa	
Nagalagam Street at Garden 175 and 211	Mahawaththa	
Kadirana Wattta, Mattakkuliya	Mattakkuliya	
Oxygion Flat Paramananda Mawatha	Bloemendhal	
<b>District -2A</b>		
Opposite Muslim Burial Ground –SRI Saddarma Mawatha (100’-0” Road)	Grandpass, Grandpass South	20
<b>District -2B</b>		
School lane, (Dematagoda)	Dematagoda	30
Sri Saddarma Mawatha (Opposite CGR Land)	Maligawaththe	
<b>District -03</b>		
Sri Dhamma Mawatha (261 Housing scheme to Camble Place)	Kuppiyawaththa	70
<b>District -04</b>		
Devi Balika Roundabout (Castle Street Buddhaloka Mawatha Junction)	Narahenpita	46
Model Farm Road	Narahenpita	
Kirulapone Junction up to Police Station (Off High Level Road)	Kirulapona	
Poorwarama Road, Kirulapone	Kirulapona	
Torrington Avenue , Near Canal Torrington South canal	Thimbirigasaya	
Robert Gunawardhena Mawatha	Pamankada	
Sulaiman Terrace	Thimbirigasaya	
<b>District -05</b>		
Buddhaloka Mawatha Sambuddathwajayanthi Mawatha Junction (Thunmulla Junction)	Milagiriya	33
40th Lane, Dr. E. A. Cooray Mawatha and Vivekananda Mawatha	Wellawatta	
I. B. C. Road, Fernando Road, Vevaset Place	Wellawatta	
Gover Street, Police park avenue	Milagiriya	
Marine Drive- Nelson Place junction	Wellawatta	
Marine Drive –Milagiriya Avenue	Milagiriya	
Boswell Road and Lilly Avenue	Wellawatta	
<b>Total</b>		<b>250</b>

The questionnaire administered to the households focuses on different aspects, such as, (a) socio-economic profile of households including their education, occupation, income and assets ownership, (b) physical characteristics of houses, (c) physical, economic and health impacts of floods, (d)

preparation for and ability to respond to floods and (e) relocation as an option. The vulnerability, impacts and ability to respond have further been examined separately for poor and non-poor households

## 4. Results and discussion

This section analyzes the primary and secondary data to understand more about the exposure of households in Colombo city to recurrent floods, vulnerability and impacts of floods on families and their assets and their ability to respond given the technical, economic and social constraints.

### 4.1 Exposure to floods

As discussed earlier, the coastal location of Colombo city makes it more prone to flood hazards. In the Greater Colombo basin, of which Colombo city is a part, floods occur regularly during the monsoon season. The significant reasons for frequent floods are changing land use and new construction on the old drainage system, clogging on the drainage and canal system in and around Colombo city and increasing the overland flow run-off coefficient as a result of urbanization. After the major flood events in 2010, the administration has recognized and is trying to address some of the reasons for poor flood management. In the Greater Colombo basin, maintenance of drains, canals, outfalls and gates is the joint responsibility of the Colombo Municipal Council (CMC), Sri Lanka Land Reclamation and Development Corporation (SLLRDC) and Urban Development Authority (UDA). The larger natural drainage canals, termed as the Macro Drainage System, around Colombo city are maintained by the SLLRDC. The man-made channels and conduits forming part of Micro Drainage System are the responsibility of the CMC.

Figure 4: Colombo city map with districts and wards

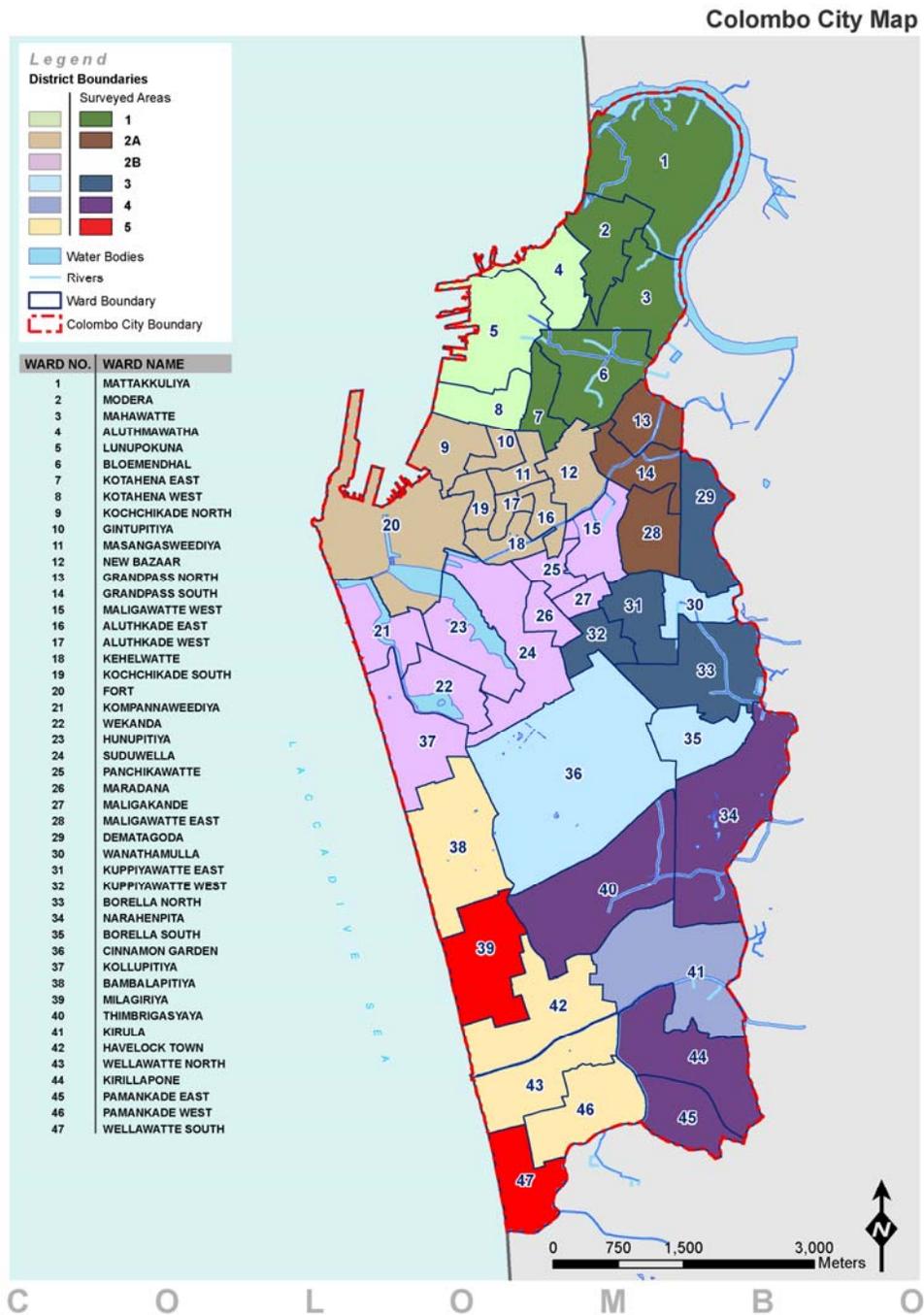
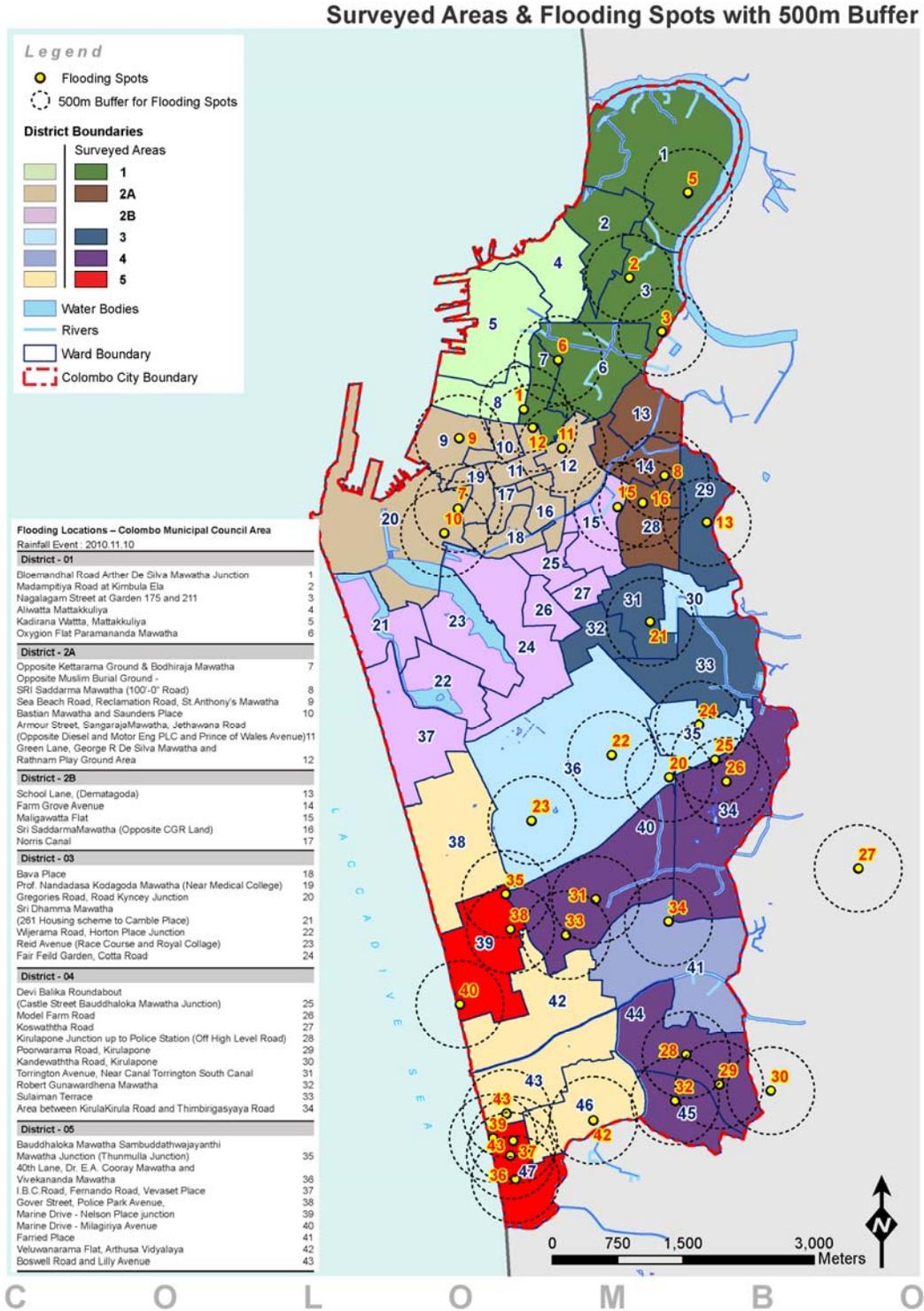


Figure 5: Flooding spots in Colombo city



Colombo city districts are shown in Figure 4 above. After the November 2010 floods, CMC has identified 43 flooding spots in these districts as shown in Figure 5. The study carried out detailed questionnaire-based surveys of 250 households located near the flooding spots. The survey has covered five districts of Colombo city and detailed maps for each survey area are given as Annex 3 to this paper. The survey has tried to capture vulnerability and impacts on households located in and around the major flooding spots. However, CMC does not have detailed land use maps available for different areas within the city. Hence, this study has not been able to analyze the details of the total number of residential and commercial establishments exposed to floods, approximate number of residents facing recurrent floods and the total wealth exposure.

## 4.2 Vulnerability and impacts of floods

In order to understand the vulnerability and impacts of floods, a survey of 250 households was carried out. As reported by the survey enumerators, there is a mix of poor and middle income households around most flooding spots. However, exact information on the location of relatively poorer people vis-à-vis all the flooding spots in the city is not available in the absence of detailed land use maps. Total sample size of 250 households is not a very large sample but representative enough to understand the vulnerability of households to flood hazard. The sample is drawn from 15 intervention sites across Colombo city using stratified random sampling. Hence, results drawn from this sample would give reasonably good insights into vulnerability of households to flood hazard. This section analyzes the socio-economic profile of the surveyed households to understand vulnerability and impacts of recurrent floods.

### 4.2.1 Socio-economic profile

The household survey across five districts of Colombo city reveals distinct characteristics of families that help us to understand more about their socio-economic status and extent of vulnerability to floods. Most families have been living in the same area for around 30 years with about 17.6% migrating from rural areas in the past two decades. This corresponds with the urban-rural and migration statistics in Sri Lanka. Unlike cities in other developing countries, Colombo does not experience influx of migrant population from rural areas in big numbers.

The average family size among surveyed households is 4-5 persons and there is generally only one earning member in each family. The heads of the households are mostly not qualified beyond higher secondary or grade 8 and are either engaged in private service or are self-employed. For instance, 56% of heads of household have studied only up to higher secondary and 30.4% have studied up to Grade 8. 23% are engaged in private service, 15% in own business and 20% are self-employed professionals. 12% are skilled workers and 10% are unskilled. Remaining are in government service or retired.

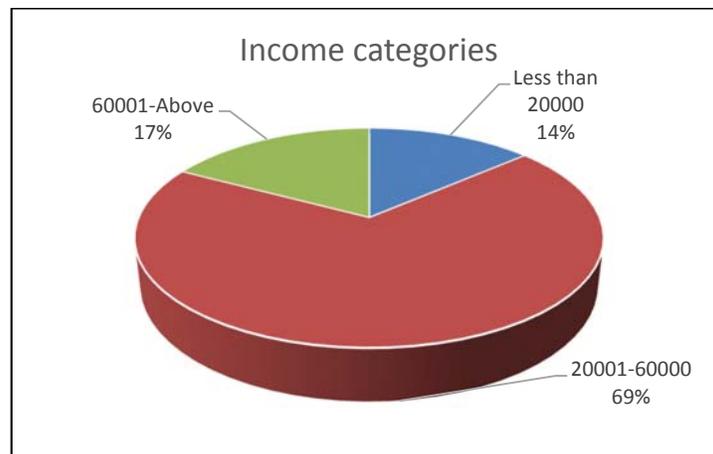
The most crucial indicator of the socio-economic status of households is their family income. The surveyed households have been classified on the basis of their monthly income as seen in Figure 6. The District Official Poverty Line estimated using the spatial price index values calculated at the district level by the Household Income and Expenditure Survey (HIES) 2012-13 data indicates the

poverty line of LKR 4,044 for the month of June 2015 for Colombo district.<sup>29</sup> For the average family of 4-5 persons, this works out to approximately LKR 20,000 as the monthly income of households below the poverty line. Thus, 13% of the surveyed households in this study are below the poverty line (BPL).

Further, the mean household income in Colombo district was LKR 77,723 and median household income was LKR 50,071 as per HIES 2012-13.<sup>30</sup> Based on this, we classify households into the following categories. Families with monthly income of LKR 20,001-60,000 are classified as poor households, who are above the poverty line and above median household income level but below the mean household incomes in Colombo district. Families with incomes of LKR 60,001 and above are classified as middle income or non-poor households with their incomes above or equivalent to the mean household income in Colombo district.

This study, thus, uses three income categories of surveyed households for further analysis. The main assumption is that the monthly incomes are a good proxy for the socio-economic status of the households. The three categories used for analysis are – **Below Poverty Line (BPL)** households with income of LKR 20,000 or less, **Poor households** with income of LKR 20,001-60,000 and **Non-poor households** with income of LKR 60,001 and above. Accordingly, 34 surveyed households (14% of total) are below poverty line, 173 (69%) are poor households above poverty line and 43 (17%) are middle-income households.

*Figure 6: Monthly income of surveyed households*



Monthly expenditure patterns across the families corroborate the monthly income categories. 46 families (18.4% of total) have monthly expenditure below LKR 20,000. 166 (66.4%) spend between LKR 20,001 and 60,000 and 38 families (15.2%) spend above LKR 60,001. On average, 47% of the monthly expenditure of households is on groceries followed by 3-4% each on education, transportation, medical and electricity bills. Further, families spend about LKR 1,000 per month on

<sup>29</sup> [http://www.statistics.gov.lk/poverty/monthly\\_poverty/](http://www.statistics.gov.lk/poverty/monthly_poverty/).

<sup>30</sup> Govt. of Sri Lanka (2015), Household Income and Expenditure Survey – 2012/13, Department of Census and Statistics, Ministry of Policy Planning Economic Affairs, Child Youth and Cultural Affairs.

repairs and maintenance. The average savings for households are about 10.4% of their total monthly income and 50% of the total savings are kept in the bank account. However, from 34 households in BPL category, 20 families (60%) are not able to save anything from monthly incomes. From the remaining 14 families, only 6 have reported keeping savings in bank accounts and that amount is about 20% of total savings. This is an important finding and highlights how vulnerable the income-expenditure portfolio of the poor people is and how flood impacts would adversely affect this portfolio. A recent World Bank report,<sup>31</sup> using the global database, shows how poor people have no savings in financial form such as bank deposits than their better-off counterparts. The case study of Colombo shows, in actual numbers, how families in the BPL category are more vulnerable to natural hazards on account of extremely limited financial assets.

Besides monthly income and expenditure, information on the ownership of different appliances, assets and vehicles has been obtained to understand more about the socioeconomic profile of these households. Percentage of ownership among different categories of households along with average cost of appliances and vehicles is given in Table 4 below. The ownership pattern differs significantly across three categories. Majority BPL families have cellphones, LPG, television and electric fan. But their ownership of high-end consumer durables like refrigerators, washing machines and air conditioners is almost negligible. Even for the poor families, ownership of such appliances is considerably lower compared to families in the non-poor category. Even in the case of vehicle ownership, BPL households do not own a car. Car ownership is 5.8% and 27.9% of households among poor and non-poor families, respectively. 24.4% of families among the poor own an auto rickshaw that provides their livelihood.

*Table 4: Ownership and average cost of household appliances and vehicles*

Appliance	% of ownership			Average cost of appliance (LKR)
	BPL	Poor	Non-poor	
LPG	73.5	82.7	97.7	4,500
Electric fan	67.6	94.2	100.0	6,000
Television	73.5	92.5	97.7	25,000
DVD	17.6	51.4	76.7	2,000
Music system	44.1	31.2	18.6	11,600
Refrigerator	17.6	58.4	93.0	15,000
Washing machine	5.9	20.2	76.7	36,300
Air conditioner	0.0	2.3	9.3	72,000

<sup>31</sup> Hallegatte et. al. (2017), Unbreakable: Building the resilience of the poor in the face of natural disasters, Climate Change and Development Series, Washington DC, World Bank, doi:10.1596/978-1-4648-1003-9.

Computer	2.9	18.5	72.1	70,000
Cellphone	85.3	93.6	100.0	10,000
Motorcycle	0.0	11.6	48.8	170,000
Auto rickshaw	11.8	24.4	14.0	380,000
Car	0.0	5.8	27.9	189,000

While living in Colombo city for many years and facing the challenges of urban life, there are a number of factors that cause stress to households. Stress levels are ranked by them on a scale of 0 to 10, from least to the highest stress levels. As seen in Table 5, majority households (more than 60%) have ranked congestion in the area and floods as the major stressors followed by hectic life, monetary issues, poor housing conditions and other factors. There are interesting insights when these factors are examined across different socio-economic categories. For instance, more than 73% of BPL households are stressed due to floods and congestion in the area followed by poor housing conditions and monetary issues. This is important as floods are causing greater stress than even monetary issues that a BPL household is expected to face. In the case of poor households also, floods and congestion are pre-eminent factors causing stress for majority of them. Other factors are monetary issues, hectic life and poor social networks. For the non-poor, hectic life is the most important stressor. However, more than 50% also find floods as an important stressor followed by congestion and air pollution. This clearly shows that for the non-poor households, factors that affect the quality of life are causing greater stress than for other households for whom monetary issues are more important. Thus, differences across three categories reinforce our understanding of their socio-economic status.

*Table 5: Factors causing stress for households*

	% of Total HHs	BPL	Poor	Non-poor
Hectic life	54.0	38.2	50.3	81.4
Housing conditions not good	46.4	67.6	48.6	20.9
Lack of opportunities	24.4	26.5	25.4	18.6
Congestion in the area	62.8	75.8	68.8	51.2
Transport related issues	17.2	8.8	21.4	30.2
Floods	62.0	73.5	67.6	53.5
Air pollution	23.2	21.2	22.0	51.2
Social networks not good	42.0	41.2	50.3	32.6
Family issues	35.2	41.2	42.2	25.6
Monetary issues	50.4	58.8	58.4	34.9

As for the housing characteristics, 24% of respondent families have been living in buildings constructed before 1991 and 19.6% live in buildings that were constructed between 1991 and 2000.

32% do not know when their buildings were constructed. 83.2% families live in houses owned by them. This is a significant finding which suggests that for most families, their house is their main asset given that they do not have enough savings in financial form. As these houses are highly vulnerable to floods, the main asset of the families comes under threat due to flood hazard.

The types of houses differ from slums and shanties to multi-story buildings and skyscrapers. Slums are informal settlements created to accommodate the influx of labor force into the city. These are often small units constructed with durable material like bricks but inadequately maintained and lack basic facilities like water and sanitation. Most of them do not have land ownership where they are located.<sup>32</sup> Shanties are small single units constructed with non-durable material and have no regular electricity, water or sanitation.<sup>33</sup> They are found on vacant government or private land and face the threat of eviction any time. Majority of them in Colombo are built on land that is subject to frequent flooding.<sup>34</sup> Temporary huts are structures made from non-durable material and used for temporary shelters. These households shift out eventually to slums or shanties.

There are significant differences in the types of houses depending on the category of households as seen in Table 6. The BPL households either live in shanties, slums or single-story buildings. Among poor households, majority live in single-story buildings followed by slums and multi-story buildings. The same applies to non-poor households, but the percentage living in buildings is far higher. Since 60% of non-poor households live in single-story buildings, they are also directly impacted by flood waters.

*Table 6: Category-wise types of houses*

Type of house	BPL	Poor	Non-poor
Slum	14.7	21.4	2.3
Shanty	44.1	12.1	7.0
Temporary Hut	5.9	7.5	-
Single storey building	26.5	46.8	60.4
Multi storey building	5.9	11.6	27.9
Skyscraper	-	0.6	2.3

<sup>32</sup> Sevanatha Urban Resources Centre (2003), Partnerships to improve access and quality of public transport – A case report: Colombo, Sri Lanka, Water, Engineering and Development Centre, Loughborough University.

<sup>33</sup> *Ibid.*

<sup>34</sup> *Ibid.*

Further, among the respondents, 34% undertake annual maintenance followed by 38.4% households undertaking maintenance once in 2-3 years. A variety of construction materials have been used, including reinforced concrete, brick, wood and metal sheets.

More than half the families have reported living and working in the same area. Buses are the most favored mode of transportation, followed by three wheelers and two wheelers. Almost all families can access education facilities and stores/markets for household goods and services nearby. Similarly, medical facilities of different types, such as, general practitioners, specialists, hospitals and municipal health clinics, are available to all. 40% find the quality of water and sanitation 'fair' but 24% have reported it as 'poor'. Electricity connections are good and almost all the households get power supply for more than 21 hours per day. Proximity to work places and other facilities seems to be an important reason for families to continue living in flood-prone areas.

#### 4.2.2 Impacts of recurrent floods

Colombo city residents experience floods almost every year. All the surveyed households have reported getting directly and/or indirectly affected by flood waters. 95% families have reported that their area gets flooded every year. 88% of households experience that their building compound gets flooded every year on average 4 times during monsoon. 61% families have to cope with flood waters entering their house. The average depth of flooding is about 2 feet and the house remains flooded for almost 24 hours.

The worst experience of flooding in the recent past for the respondent households was in November 2010 when the city received 440 mm rainfall resulting in inundation in many areas. Table 7 reveals the impact of the 2010 floods on surveyed families. 87% of families were living in the present house when floods occurred in November 2010 and almost 77% reported flood waters entering their building. 62% of families also experienced water entering their house. The average depth of flooding was 2 feet but in some areas, the depth was as high as 8 ft. In some parts of the city, buildings and houses remained flooded for almost 10 days (240 hours) after the heavy rainfall. In areas, such as, Bloemendhal, Grandpass North, Grandpass South, Mahawaththa, Modara and Kimbulaela, the flood waters remained in the buildings and houses for 5-10 days.

*Table 7: Experience of 2010 floods*

	Response	% of Households
Were you living in the same house during 2010 floods (% of HHs)?	Yes	86.8
Did flood water enter your building compound in 2010 (% of HHs)?	Yes	76.8
Depth of flooding in the building compound in ft.	Average	2.3
	Maximum	8.0
	Minimum	0.3

How many hours did building compound remained flooded in 2010?	Average	37.5
	Maximum	240.0
	Minimum	1.0
Did flood water enter your house (% of HHs)?	Yes	62.4
Depth of flooding in the house in ft.	Average	1.9
	Maximum	6.0
	Minimum	0.3
How many hours did the house remain flooded in 2010?	Average	37.5
	Maximum	240.0
	Minimum	2.0

Households reported damages to the structure of the house, electrical wiring and meter, electronic goods, furniture, plumbing, utensils and vehicles in the aftermath of the 2010 floods. Table 8 captures the damages experienced by BPL families, poor and non-poor households. Although households in all three categories experienced damages to one or more assets or appliances, greater percentage of BPL and poor households have suffered damages than their non-poor counterparts. Among the BPL and poor households, a large percentage experienced damage to the structure of the house, furniture and utensils. Even among them, poor households have experienced more damage to structures, electronic goods, wiring, utensils and vehicles than the BPL families. For the poor families in general, these are the assets they invest in, which are threatened or affected during floods. The actual figures of losses associated with each of the damages could not be obtained from the households. However, for the BPL and poor households, losses on account of damage to house, furniture, electronic goods, etc., would be a significantly high percentage of their total earnings per year.

*Table 8: Percentage of households reporting damages after 2010 floods*

	BPL	Poor	Non-poor
Structure of house	26.5	38.2	23.3
Electrical wiring	5.9	6.9	4.7
Electrical meter	5.9	4.0	-
Electronic goods	17.6	30.6	14.0
Furniture	58.8	53.8	18.6
Plumbing	8.8	12.8	4.7
Utensils	26.5	36.4	20.9
Vehicles	-	4.6	16.3

Besides the damages to household assets and appliances, there are other impacts of floods, such as, non-availability of transport, food and fuel, price rise of essential goods, disruption of power, etc. As Table 9 shows, a large percentage of households reported facing these impacts in 2010. However,

such impacts are faced by some households almost every year and for some, these occur once in 2-3 years.

*Table 9: Other impacts of floods (% HHs)*

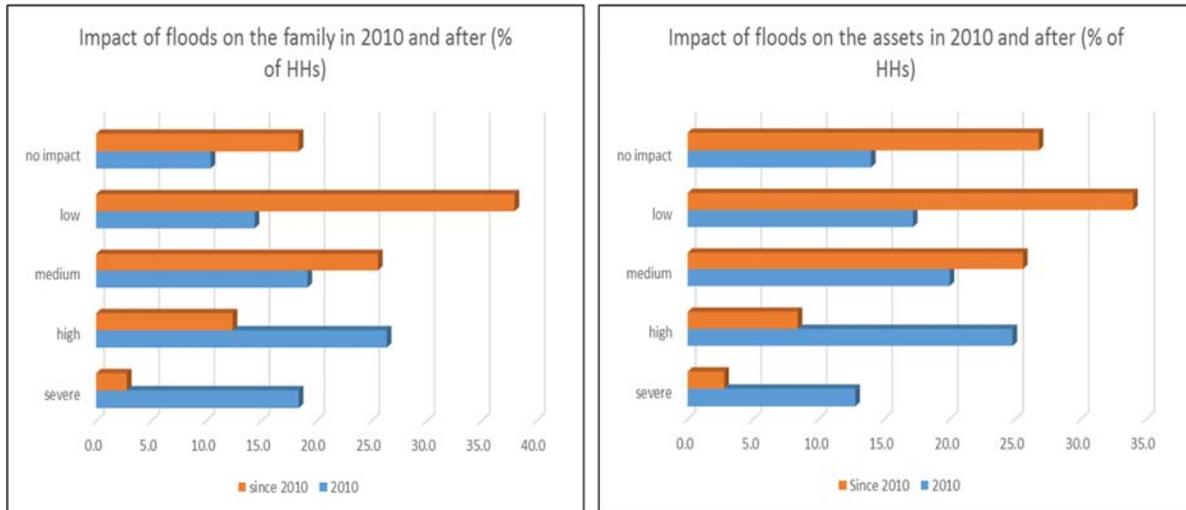
	2010	Every year	Every 2-3 years
Non-availability of transport	34.0	21.6	10.4
Price rise of essentials	17.2	10.4	5.6
No drinking water	16.8	8.8	5.2
Disruption in power	17.6	9.6	8.8
Non-availability of food and other supplies	16.8	10.4	4.4
Non-availability of fuel	8.0	2.0	2.4

Among the surveyed families, the impacts of the 2010 floods were high or severe for more households than subsequent floods, as seen in Figure 7 below. About 18% of families had severe impact and 26% had high impact on their family during the 2010 floods. In the subsequent floods since 2010, for more than half of the respondents, the impact has been low or none at all. However, 25% have reported medium impact, 12% with high impact and only 3% with severe impact during recurrent floods. In terms of the impacts on assets, 37% felt high and severe impacts during the 2010 floods. 60% of them have since felt low or no impact on assets in the subsequent years. 25% have, however, reported medium impact on assets.

These percentages are more or less similar across the three income categories we have considered in this paper. Hence, the figures have not been reported separately. Some households have pointed out the damages to the house, furniture, electronic goods and utensils in the 2012 and 2014 floods as well. As this study was carried out in 2015, the impacts of the May 2016 floods have not been captured here. However, the findings of this study suggest how recurrent floods impose losses on the households who need to cope with them through their earnings.

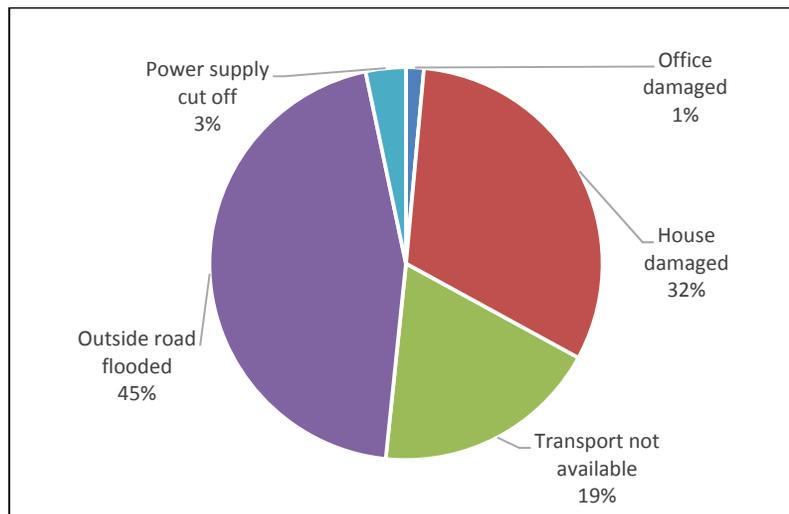
Another interesting point is that even non-poor households continue living in flooded areas and face recurrent floods, although impacts on them are much lesser in severity compared to BPL and poor households. This might be one of the reasons why they continue to live in such areas. Another important reason would be the immovable assets they have invested in, e.g., house in single or multi-story building. It would be difficult for them to shift to safer areas given such investments.

*Figure 7: Impact of floods on family and assets*



Yet another impact of floods is the loss of workdays and school days. On average, 4.5 workdays and 5 school days have been lost for the surveyed families during the 2010 floods. However, these families also report 5 workdays and 5 schooldays lost during recurrent floods. The main reasons for losing workdays, as shown in Figure 8, are outside road being flooded, houses damaged and transport not being available. This clearly shows that although the November 2010 floods were caused by very heavy rainfall, the households, most of them poor, continue to suffer from similar impacts during recurrent floods when rainfall intensity is far less than the November 2010 event.

*Figure 8: Reasons for losing workdays*



One of the crucial impacts of recurrent floods is health effects suffered by the families in the aftermath of flood events. As seen in Table 10, dengue, diarrhea, viral fever and chronic cold and cough have been the most important health impacts after the 2010 floods. Fungi has also been reported by 15% families after flood waters entered houses and remained for as many as 5-10 days in 2010. However, households continue to suffer from most of these effects almost every year after

recurrent floods. Thus, recurrent floods cause significant health impacts besides damage to assets and appliances and non-availability of essential goods and services.

*Table 10: Health impacts after floods (% HHs)*

Health effects	2010	Every year	Every 2-3 years
Malaria	2.0	0.4	0.4
Dengue	19.6	10.0	5.2
Typhoid	5.2	2.8	4
Diarrhea	13.6	7.2	4
Viral fever	34.8	33.2	17.2
Asthma attack	3.2	4.8	
Chronic cold and cough	40.4	42.4	13.6
Fungi	15.2	10.4	4.4

### 4.3 Ability to respond

Given the impacts on households from recurrent floods, it is now important to examine their ability to respond to floods effectively. There are a number of socioeconomic factors that determine this ability. Income or financial resources is obviously the main determinant. Households undertake some measures almost on a yearly basis to cope with floods and reduce their impacts on families and assets. However, other factors like early warning, awareness, training and social networks also enhance their resilience or ability to respond. The short-term measures undertaken by the households to respond to floods and the costs of such measures are captured in this section. The section also discusses the option of relocation, households' perception about it and factors considered important for them to avail of this option.

#### 4.3.1 Short term measures

Households try to reduce the impacts of recurrent floods in their own way to the best of their ability given the constraints on technical and financial resources available to them. Some short-term measures undertaken regularly by the surveyed households are given in Table 11 below. Cleaning the surroundings, cleaning the canal or gutter nearby and repairs inside the house are regular measures used by households to cope with floods. Households belonging to the BPL, poor and non-poor category use these measures with varying costs. The range of costs for each measure depends on the area covered and gravity of the problem. Further, the average costs of each of these measures are high for the BPL and poor families with limited incomes at their disposal. Since these measures are undertaken every year, the costs are also recurrent in nature and have to be borne by households themselves. However, it should be noted that households of all categories are actively trying to improve their conditions rather than wait for some other agency to help them fight floods.

*Table 21: Short-term measures to cope with floods*

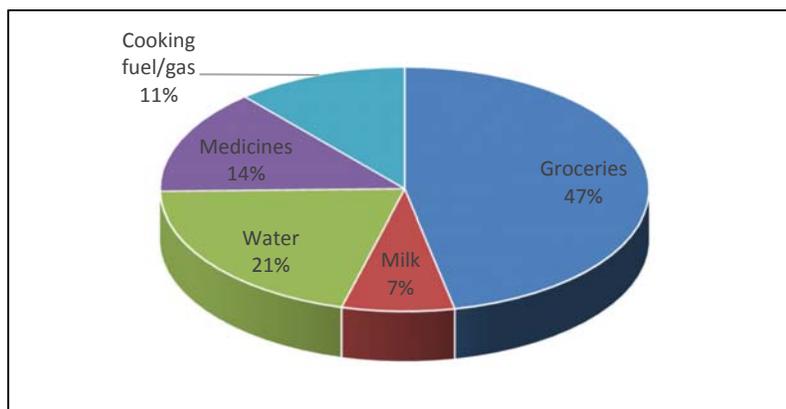
	BPL		Poor		Non-poor		Overall Range (LKR)
	% HHs	Average Cost (LKR)	% HHs	Average Cost (LKR)	% HHs	Average Cost (LKR)	
(Figures in bracket as % of monthly household income)							
Cleaning house surroundings	73.5	1500 (15.0)	78.6	5000 (12.5)	79.1	7500 (9.4)	500-20,000
Cleaning canal or gutter	41.2	500 (5.0)	39.9	5000 (12.5)	32.6	5000 (6.3)	100-10,000
Repairing roof	8.8	250 (2.5)	15.6	10000 (25.0)	11.6	2500 (3.1)	500-15,000
Overhauling vehicle	-	-	7.5	5000 (12.5)	9.3	5000 (6.3)	500-20,000
Repairs inside house	35.3	1000 (10.0)	26.6	10000 (25.0)	7.0	2500 (3.1)	500-30,000

The short-term measures listed above are typically undertaken before the rainy season each year to cope with anticipated flooding. The spending of the three categories of households on short-term measures provides very interesting insights into how the costs of these measures might put a burden on their resources. For the BPL households, the overall costs of the short-term measures are lower compared to other households. But as a percentage of their average monthly incomes, these costs are quite significant. These costs are also to be borne every year by them before the rainy season begins. Another important issue is the large percentage of BPL families who have to spend money on these measures every year. For instance, 35% of them have to repair their houses every year, since the overall housing condition may be poor. However, for the non-poor households, the costs incurred on the measures are a small percentage of their monthly incomes. They also do not have to spend large amounts on repairs inside the houses, as their houses are in better condition than those of their poor counterparts. Further, only 7% have reported repairing their houses to cope with floods.

The poor households bear the largest burden of short-term measures to cope with recurrent floods. They spend relatively larger percentages of their average monthly incomes on these measures. The money spent on measures such as repairs inside houses and repairing roofs also seem to be much higher than either the BPL families or non-poor houses. This is not surprising since they would have bigger houses than the BPL families but not in as good condition as the houses of the non-poor.

Besides cleaning and repairs, households stock up on essential items in anticipation of floods every monsoon as seen in Figure 9 below. The most important items to be stocked up are groceries, followed by drinking water and medicines. Many families also stock up on cooking fuel during monsoon.

*Figure 9: Stocking up items in anticipation of floods*



Despite measures undertaken by the households, they experience the impacts of floods in terms of damage to assets and health. In order to rebuild the houses damaged and replace or repair other assets, they need financial support which often comes in the form of loans taken from family or friends and informal money lenders as seen in Table 12. There are some obvious and subtle differences across income categories. For instance, in the case of BPL households, 59% depend on friends and family and 41% seek assistance from money lenders. Only 6% approach formal banks for loans. In the case of poor households, 60% once again depend on family and friends but only 27% go to informal money lenders and 14% approach formal banks for loans. For the non-poor households, 56% seek help from family and friends and more than 33% take loans from formal banks. Only 11% have taken financial assistance from informal money lenders. These findings suggest how the poor have less access to formal support systems like loans. Hence, their vulnerability to natural hazards increases not just with damaged assets but also with no access to resources to recover and rebuild them.

*Table 32: Sources of loans after floods*

Source of loan	BPL	Poor	Non-poor
<b>Family and friends</b>	58.8	60.0	55.6
<b>Informal moneylender</b>	41.2	27.2	11.1
<b>Formal bank</b>	5.9	14.4	33.3
<b>Government</b>	5.9	4.0	0.0

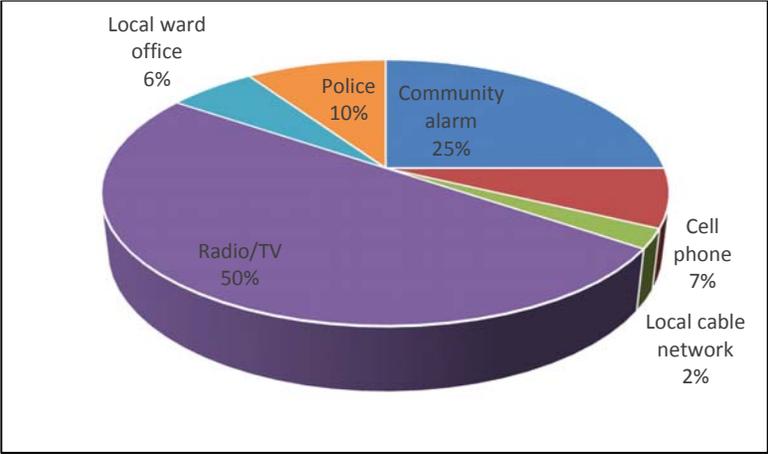
#### 4.3.2 Training and awareness building

In addition to the short-term measures to cope with recurrent floods, training, awareness and early warning also play an important role in determining the ability of households to cope with floods. However, we find that most of the households have not gone through any training on flood response. For instance, 94% of BPL households have not undergone any training. The remaining have received

training from CMC. Among the poor and non-poor households, no training has been received by 98% and 100% respectively. Most of the BPL families (94%) are further unaware of a nearby shelter they can shift to when flood waters start rising. However, in case of poor and non-poor households, more than 80% of families are aware of nearby shelters. Thus, the poorest families do not know where to shift when flooding occurs thereby increasing their vulnerability further.

91% of BPL households also do not get any early warning and those who get some warning do so through the community alarm. However, in the case of poor families, 25% get some type of early warning and this percentage is higher at 37% for non-poor families. The most important source of warning for the poor and non-poor families is radio or television followed by community alarm as seen in Figure 10. Police, ward office, cell phones and local cable network are other sources through which warning is issued to the people.

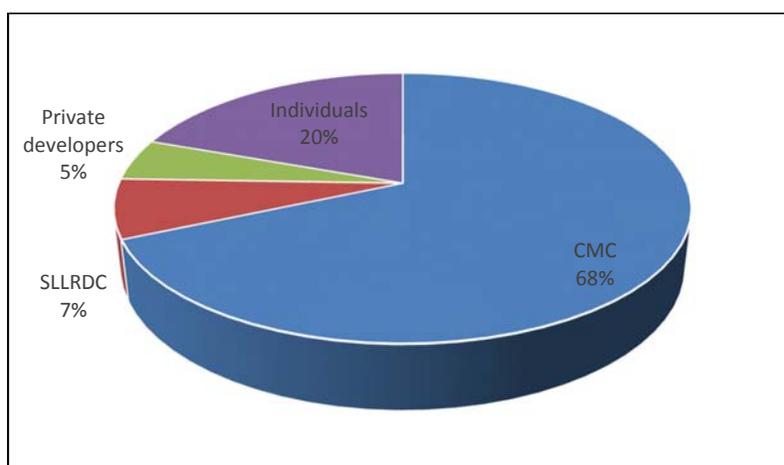
*Figure 20: Sources of flood warning*



For families who receive some warning, the average time for warning is about an hour. 32% have stated that they receive warning about floods an hour in advance, 20% receive it barely 15 minutes in advance and another 23% have claimed receiving warning 12 hours in advance. About 17% of families have also stated that they get the warning 24 hours in advance. These percentages are only among families who receive some form of warning.

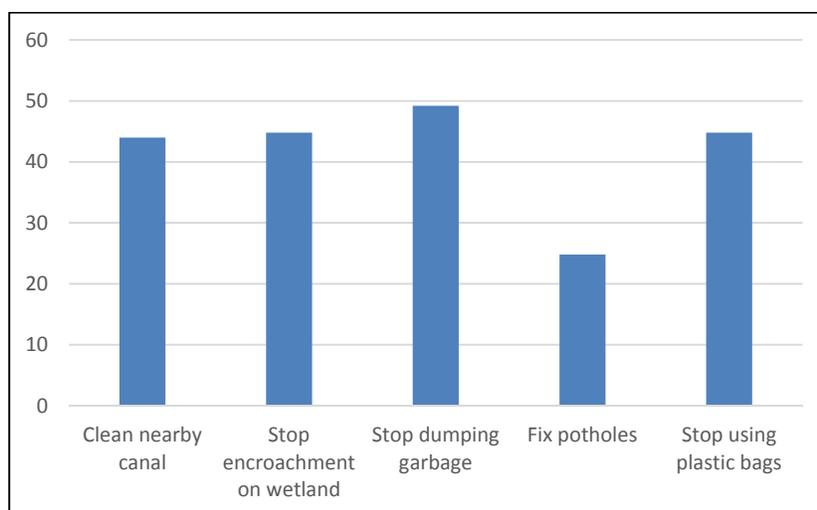
Respondents have also been asked to name the agency they contact when flood waters start rising. 65.6% have responded that they do not contact anyone. 20% contact the Municipal Council, 10% contact the police station and only 4% contact the DS office.

Figure 31: Responsibility to reduce floods



Households further believe that the responsibility to reduce floods lies with the CMC as well as individuals as seen in Figure 11. They have also suggested the steps that can be taken to reduce floods as shown in Figure 12. Some of the steps are meant to be taken by the local government, e.g., cleaning the canals, stopping encroachment on wetlands and fixing potholes. Individuals can also help in reducing floods by refraining from dumping garbage and stop using plastic bags.

Figure 42: What can be done to reduce floods (% of HHs)



#### 4.3.3 Relocation as an option

When the impacts of floods are recurrent and short-term measures do not work well to prevent loss and damage from floods, households often consider the option of moving out of the area to a safer and flood-free location. At times, the local authorities take the initiative to relocate people out of flood-prone areas. In this context, we have asked households about relocation as a possible option, reasons for not moving out of the frequently flooded area earlier and factors that they would

consider important for relocation in future. As seen in Table 13, 44% of BPL households have considered moving out of the flood-prone areas vis-a-vis 35.6% of poor and 23.3% of non-poor households. This indicates how recurrent floods are a serious problem for the very poor and poor households more than the non-poor ones. However, only 8.8% of BPL families and 9.3% of non-poor families have actually moved out as compared to 17.3% of poor families after the 2010 floods. Further, greater percentage of BPL and poor families would consider the relocation option given by the government than those belonging to non-poor families.

Figure 13 shows the reasons for majority of the families not moving out of the flood-prone areas they are currently residing in, despite the recurrent floods. The most important reason is that the families are not comfortable about moving to a new area. Around 20% of households have also stated lack of financial resources as a reason for not relocating to a flood-free area. Some important reasons for remaining in the same area are proximity to work place and school/college, good transport network around and strong social networks. Some households also feel that transport and other services will be very costly if they move to other areas. A few households have cited unavailability of loan as a constraint for remaining in the same area.

*Table 43: Relocation as option*

	Response	BPL	Poor	Non-poor
Have you considered moving out because of floods	Yes	44.1	35.6	23.3
Did you move out after 2010 floods	Yes	8.8	17.3	9.3
Will you consider relocation option given by the government	Yes	73.5	63.6	34.9

*Figure 53: Reasons for not moving out*

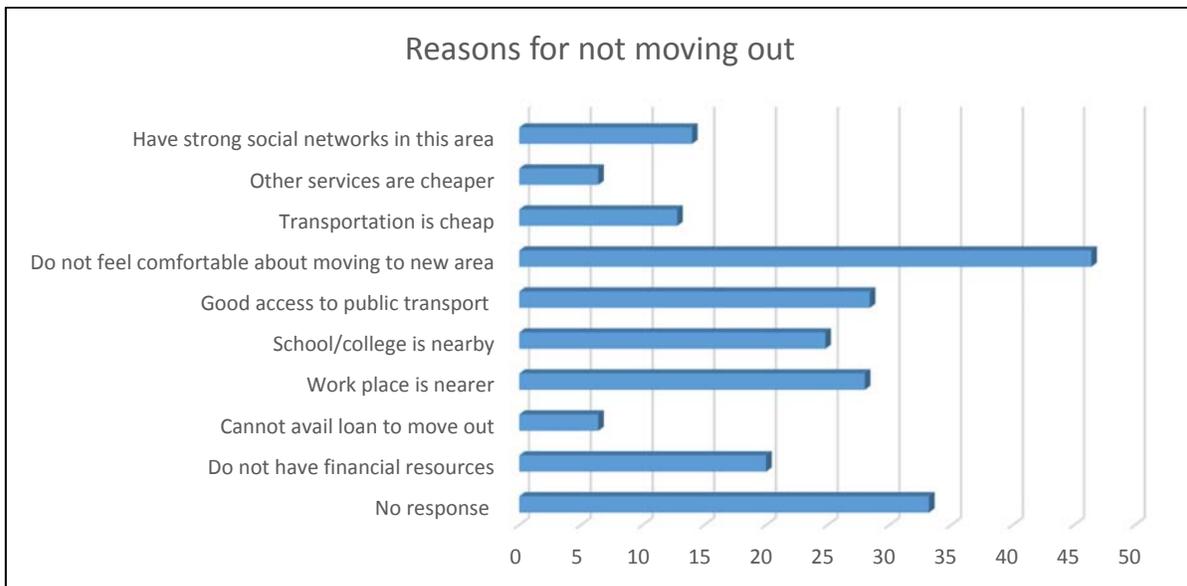
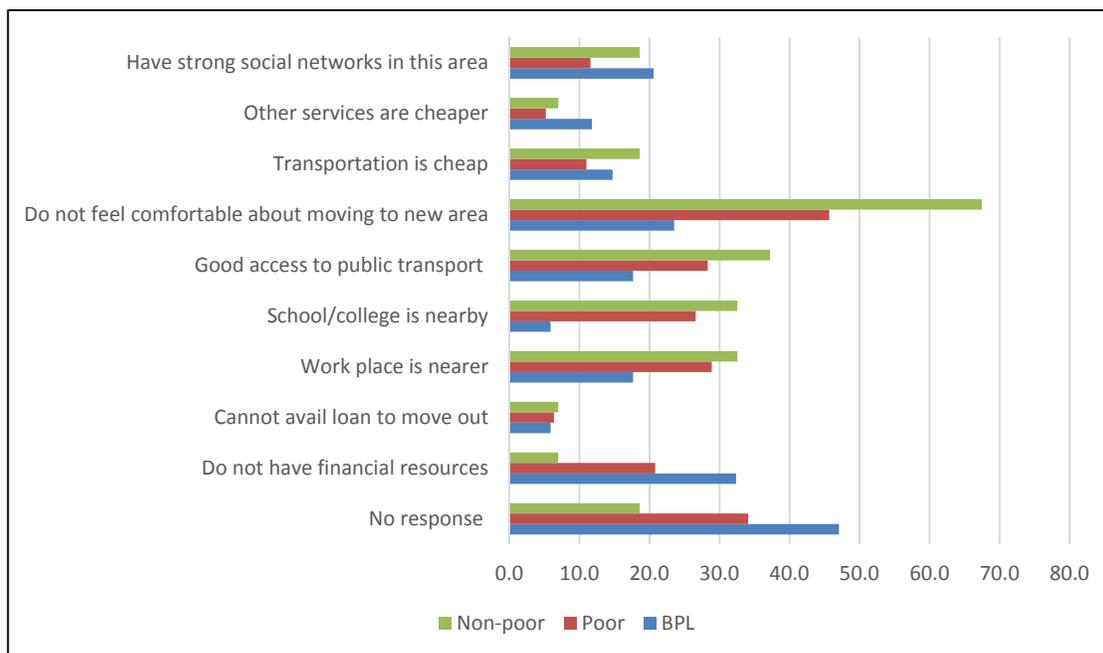


Figure 64: Reasons for not moving out category-wise

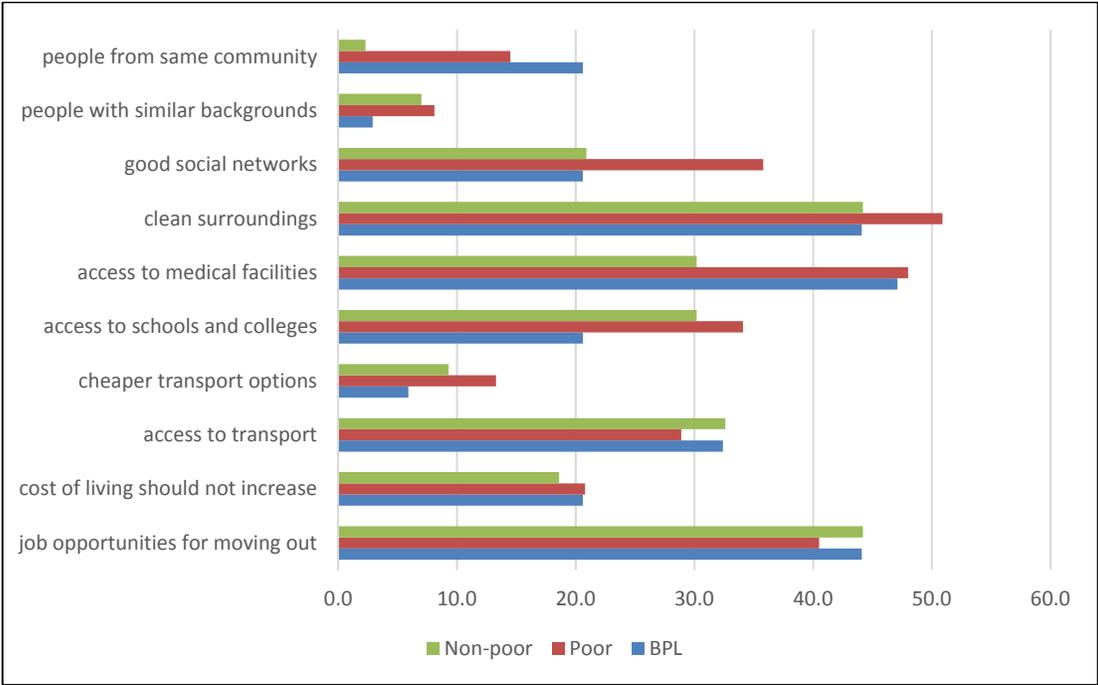


There are subtle differences across different categories of households for not moving out, as seen in Figure 14. For the BPL households, the most important reason is the lack of financial resources (32.4%) followed by other reasons, such as, not feeling comfortable about a new area, having strong social networks in the present area and work place being near the house. In the case of poor households, the main concern is that they do not feel comfortable about moving to a new area. The other important factors are proximity to work place, schools and colleges and access to public transport. Only 20% poor families have stated lack of financial resources as an important reason for not moving out. For the non-poor families, the overwhelming reason (67.4%) for not moving out is that they do not feel comfortable about a new area. Other important reasons are access to good public transport and proximity to schools and colleges. Only 7% of non-poor households have stated lack of financial resources as the reason for not moving out. Thus, what is the most important reason for not moving out for BPL households is the least important one for non-poor households. For both poor and non-poor households, proximity to work place, educational institutions and access to transportation are very important reasons for continuing in the same area despite recurrent floods. This only shows how priorities for families differ depending on whether they are below the poverty line or relatively better-off.

Households have further been asked to state which factors would induce them to move out if they are given the option of relocation by the government. As seen in Figure 15, for all categories of households (more than 40% each), clean surroundings and job opportunities in the new area are the most important factors. Other important factors for the BPL households are access to medical facilities and transport. For the poor households, access to medical facilities, access to educational

facilities and good social networks are the important factors. In the case of non-poor families also, their main considerations are exactly those of the poor households. For all the three categories, no increase in the cost of living is not the main consideration for relocation.

*Figure 75: Factors important for relocation category wise*



### 5. Policy implications

The primary survey carried out in flood-prone areas of Colombo city gives valuable insights into how city households are impacted regularly by recurrent flood events and have to bear the cost of damages as well as the cost of short-term measures to protect themselves. Majority of the households interviewed in the survey are either below the poverty line or are poor with limited education, limited access to facilities and services and limited financial resources. It is also clear from the findings that the households bear the brunt of floods due to vulnerability of assets, limited ability to cope and recover and inadequate access to formal resources to recover and rebuild. Poor families suffer more impacts than the non-poor families. The latter also have significant impacts of floods on them, but their ability to cope is better than the poor or families below the poverty line. Most households also do not have adequate training and early warning which limits their capacity to respond.

The severe floods of November 2010 caused inundation in most parts of Colombo city with significant damages to housing and infrastructure. Almost all surveyed households reported being severely affected by these floods with damages to the structure of houses, electrical wiring, electronic goods, furniture, plumbing, utensils and vehicles. The houses remained flooded for 5 to 10 days in many

areas. There were health impacts such as dengue, diarrhea and viral fever in the aftermath of the floods. Although these floods occurred after very heavy rainfall, some of the important causes of severe flooding in most parts of the city are man-made. For examples, floods are caused by changing land use, clogging of drains and canal systems and increasing run-off due to construction activity. These man-made causes need to be addressed through land use planning, stricter enforcement to stop encroachments on canals and wetlands and behavioral change among city residents to stop dumping garbage or using plastic bags. The city administration and the planning authorities need to address these issues urgently to prevent recurrent floods and avoid the costs of damage suffered by the poor households.

There is a limited database on recurrent floods, extent of flooding and land use around chronic flooding spots in Colombo city. However, the findings of the primary survey suggest that the households face floods almost every year and suffer damage to houses, furniture, utensils and vehicles along with other impacts like non-availability of transportation, food shortages, loss of workdays and school days etc. The households living around flooding spots are poor and bear the severe brunt of recurrent floods. Even as the survey was completed in 2015, another major flood event has affected a large number of households in Colombo in May 2016. With the recurrence of floods and severe impacts on poorer sections in the city, it is important for planners and policy makers to have well-directed adaptation planning and programs. Such programs must specially be designed keeping in view the target areas where the poor reside and are most vulnerable to floods.

As shown by the study, the vulnerability of poor households is enhanced due to impacts on assets in which they have invested their incomes and savings. The poor tend to invest in houses, utensils and vehicles that are the worst affected during floods. In the face of inadequate financial resources, the poor have to rebuild their assets damaged during floods either through their own savings or have to borrow from elsewhere. Most of the surveyed households have either borrowed resources from family or friends or from informal moneylenders. This dependence on informal sources may push poor families into indebtedness and poverty. Therefore, well-directed efforts are required to reduce the extent of floods as well as offer compensation to the affected families to prevent adverse monetary impact on them.

Households in Colombo are undertaking some short-term measures every year to protect themselves from floods. However, their response to floods is restricted by the lack of awareness, training and early warning mechanism. 94% of the households below poverty line, for instance, do not receive any flood warning, are not aware of nearby shelters to move to in case of floods and have not been given any training for flood response. The local government has to focus on creating more awareness and capacity building to prepare families for future risks. The focus also needs to shift from engineering solutions alone that the CMC and SLLRDC are planning to community measures that can bring in a lot of benefits by improving the solid waste management, cleanliness of the surroundings and hygiene. The solutions should aim at behavioral changes among households.

As regards the option of relocation to flood-free areas, many poor and below poverty line families have expressed willingness to consider such an option if provided by the government and when the new areas offer what is important to settle in an area. These important considerations are job opportunities, clean surroundings, access to medical facilities, access to transportation and good social networks. Relocation will be considered by poor families only when these factors are addressed carefully by the government relocation schemes. Poor households tend to move back to flood-prone areas when they do not get job opportunities elsewhere and have limited access to basic services. For the long-term success of such schemes, these important considerations need to be incorporated into the design of the schemes.

To sum up, this study has effectively demonstrated how poor households are more vulnerable to risks from recurrent flooding in Colombo city. The poor suffer damages to assets and appliances due to floods, but have very limited capacity to respond given the constraints on their resources. Therefore, well-directed adaptation efforts with focus on the poor are required in order to protect them from future climate risks. Mainstreaming adaptation into the larger developmental processes will help the city achieve economic growth as well as assist in poverty alleviation.

## Annex 1: Flooding spots within CMC area

Sr. no.	Flooding Locations – Colombo municipal Council Area.
	District -01
1	Bloemandhal road Arther De Silva Mawatha Junction
2	Madampitiya Road at Kimbula Ela
3	Nagalagam Street at Garden 175 and 211
4	Aliwatta Mattakkuliya
5	Kadirana Wattta, Mattakkuliya
6	Oxygion Flat Paramananda Mawatha
	District -2A
7	Opposite Kettarama Ground & Bodhiraja Mawatha
8	Opposite Muslim Burial Ground –SRI Saddarma Mawatha (100’-0” Road)
9	Sea Beach Road, Reclamation road, St. Anthony’s Mawatha
10	Olcott Mawatha, Bastian Mawatha and Saunders Place
11	Armour street, Sangaraja Mawatha, Jethawana road (Opposite Diesel and Motor Eng PLC and Prince of wales Avenue).
12	Green lane , George R De Silva Mawatha and Rathnam Play Ground Area
	District -2B
13	School lane, (Dematagoda)
14	Farm Grove Avenue
15	Maligawatta Flat
16	Sri Saddarma Mawatha (Opposite CGR Land)
17	Norris Canal
	District -03
18	Bava Place
19	Prof. Nandadasa Kodagoda Mawatha (Near Medical College)
20	Gregories Road, Road Kyncey Junction
21	Sri Dhamma Mawatha (261 Housing scheme to Camble Place)
22	Wijerama Road , Horton Place Junction
23	Reid Avenue (Race Course and Royal Collage)
24	Fair Feild Garden, Cotta Road
	District -04
25	Devi Balika Roundabout (Castle Street Baudhdhaloka Mawatha Junction)
26	Model Farm Road
27	Koswaththa Road
28	Kirulapone Junction up to Police Station (Off High Level Road)
29	Poorwarama Road, Kirulapone
30	Kandewaththa Road , Kirulapone
31	Torrington Avenue , Near Canal Torrington South canal
32	Robert Gunawardhena Mawatha
33	Sulaiman Terrace
34	Area between Kirula Kirula Road and Thimbirigasyaya Road
	District -05
35	Baudhdhaloka Mawatha Sambuddathwajayanthi Mawatha Junction (Thunmulla Junction)
36	40th Lane, Dr. E. A. Cooray Mawatha and Vivekananda Mawatha
37	I. B. C. Road, Fernando Road, Vevaset Place
38	Gover Street, Police park avenue
39	Marine Drive- Nelson Place junction
40	Marine Drive –Milagiriya Avenue
41	Farried Place
42	Veluwanarama Flat , Arthusa Vidyalaya
43	Boswell Road and Lilly Avenue

Annex 2: Micro drainage intervention sites

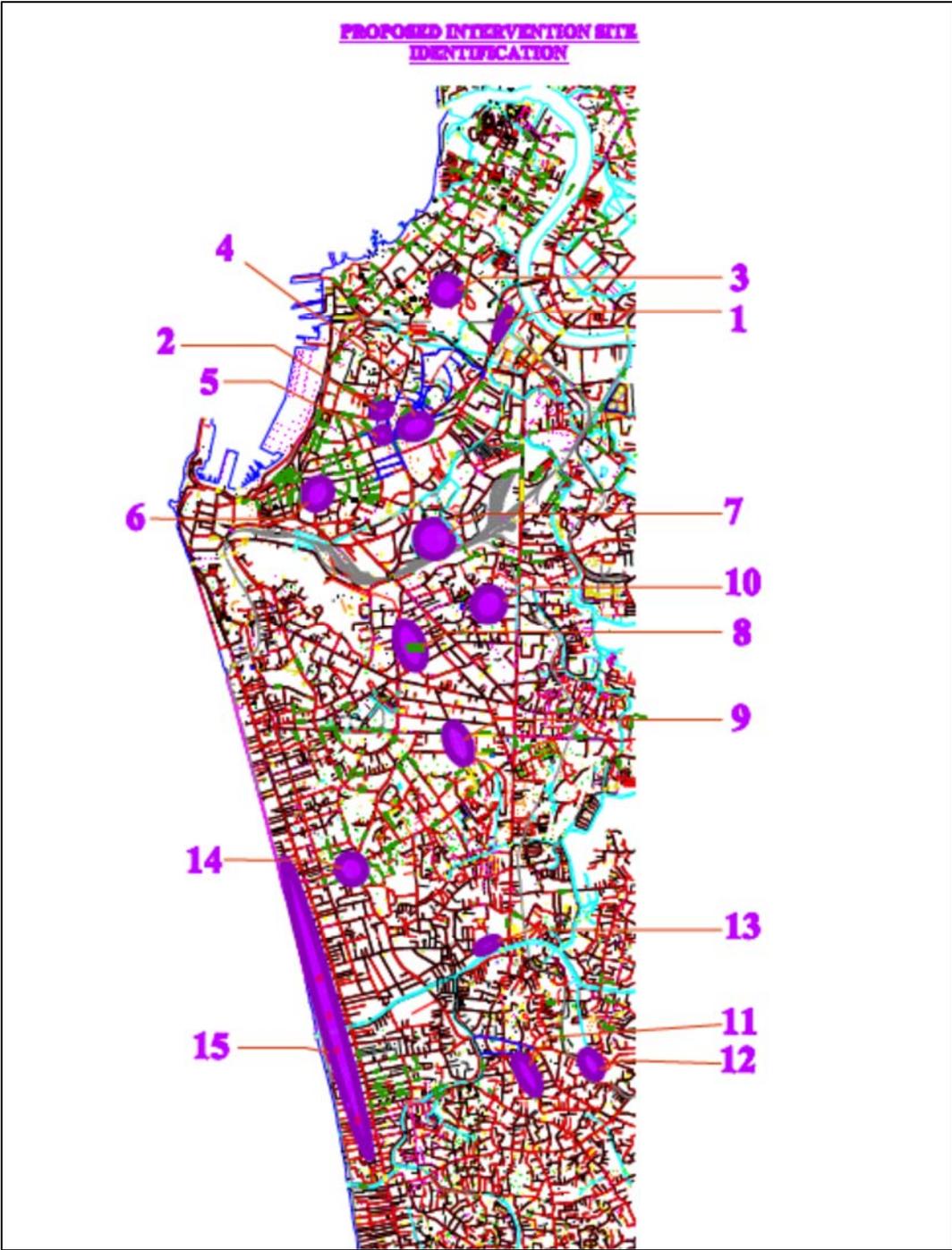


Figure A.1: Surveyed areas in District 1

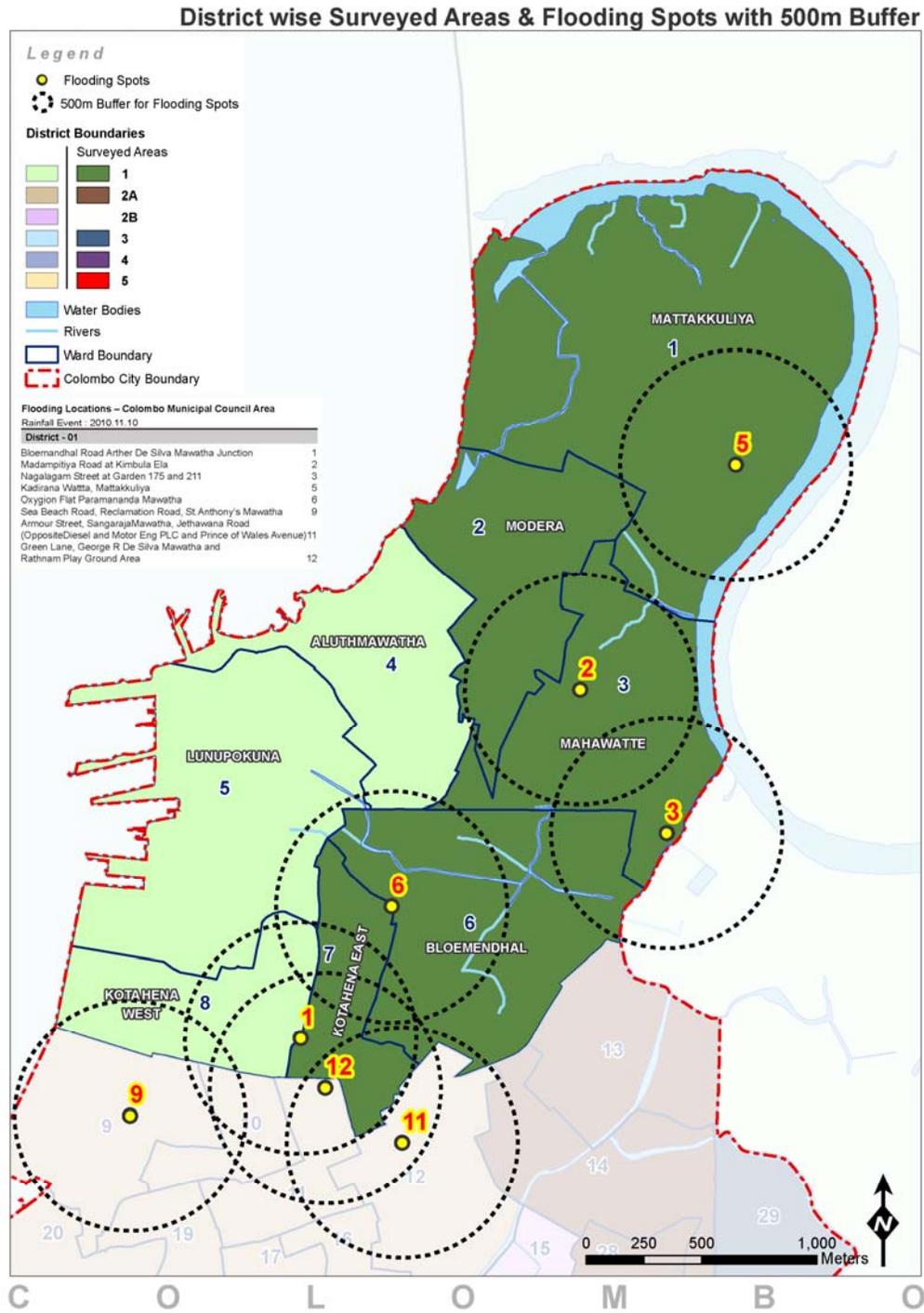


Figure A.2: Surveyed areas in District 2A

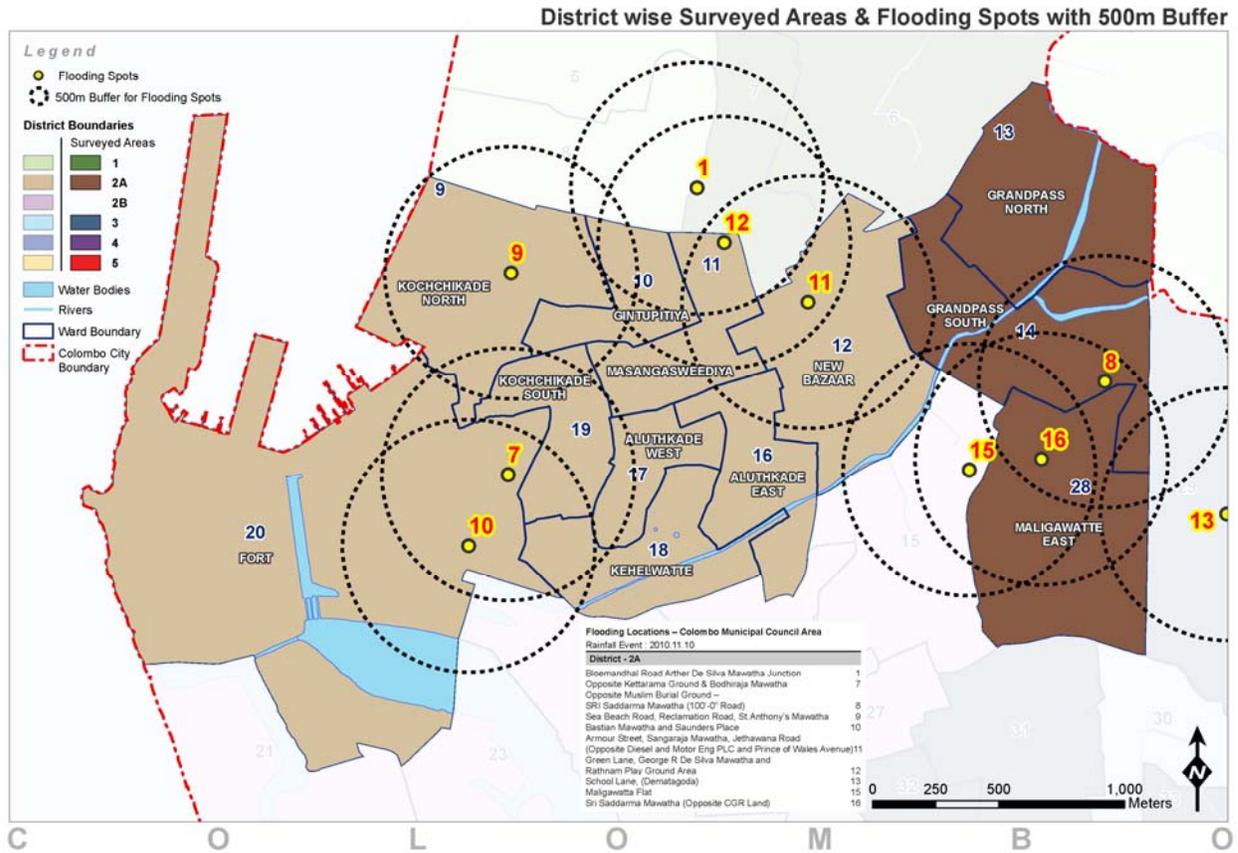


Figure A.3: Surveyed areas in District 3

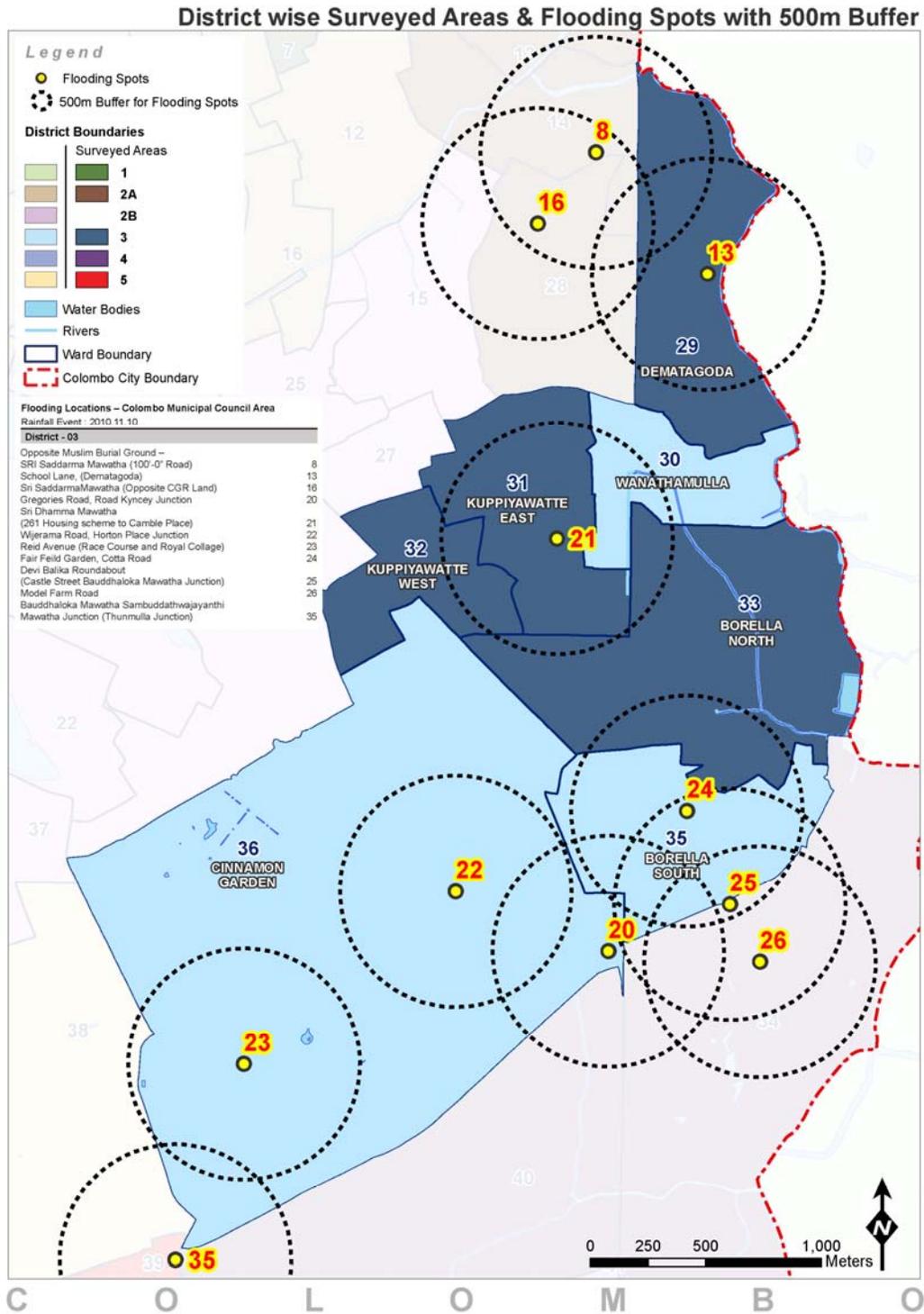


Figure A.4: Surveyed areas in District 4

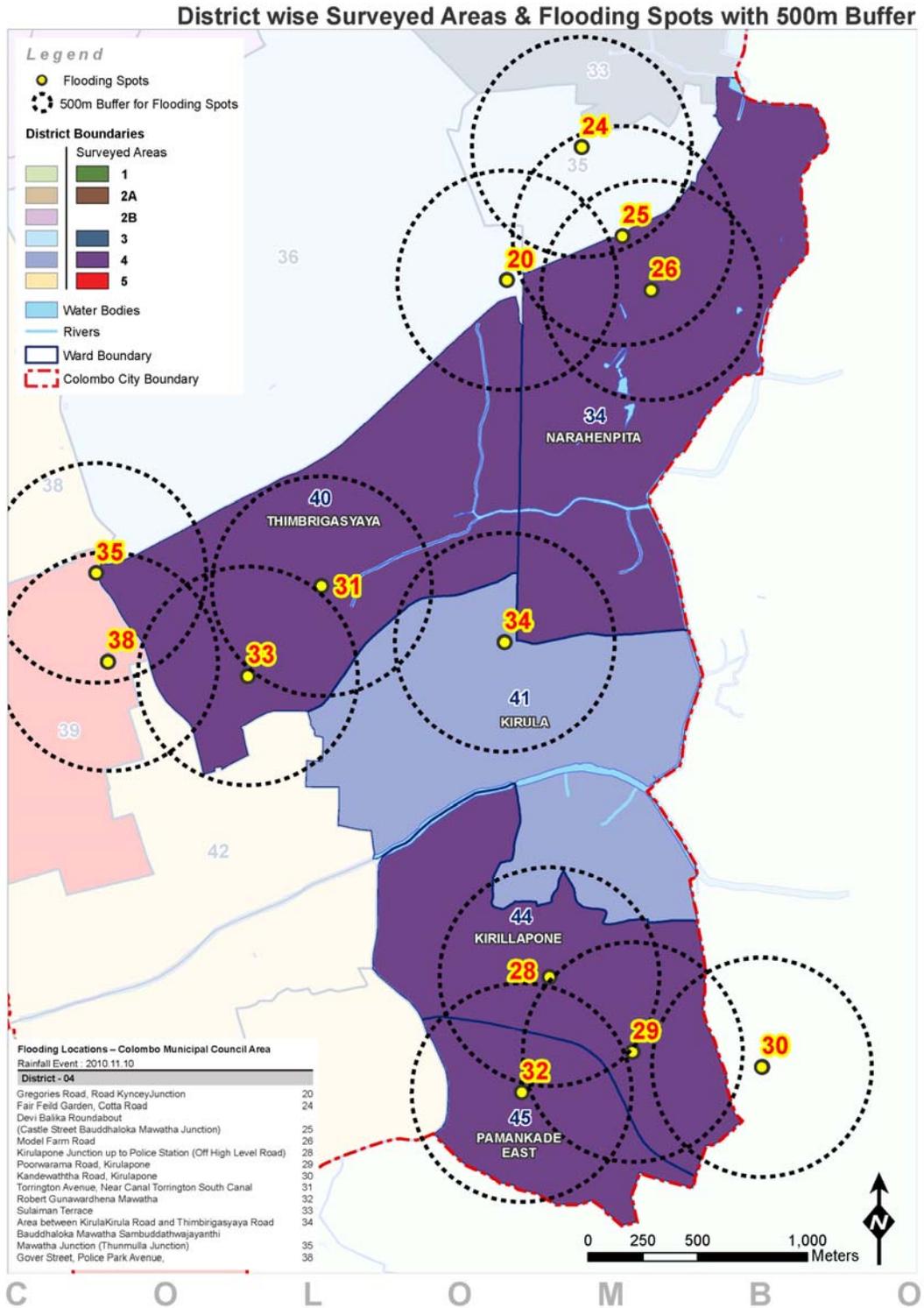


Figure A.5: Surveyed areas in District 5

