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Impacts of Floods on the Agriculture Sector: A Case Study of Porathivu Pattu Division in The East Coastal Batticaloa District of Sri Lanka

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Flood is the most common disaster in Sri Lanka. The Batticaloa District is one of the flood-prone areas in the country and it is also one of the richest districts in terms of paddy and highland crop cultivation, fishing and cattle farming. The current research is focused on the Batticaloa District as a whole and presents a case study on Porathivu Pattu Divisional Secretariat Division (DSD). The objectives of this study were to examine the agricultural impacts of floods in the Batticaloa District during the 2010/2011, identify the flood risk areas of Porathivu Pattu DSD, and to examine the perceptions of agriculture-flood vulnerable communities. Based on the farmers' perceptions, the flood level has gradually increased. A total of 44,179 agricultural farmers faced huge damages and losses due to 2010/2011 flood in 14 Divisional Secretariats. About 143,560 acres of paddy were completely affected by flood. The total economic losses of food grains, highland crops and fruit crops were Rs.73.86 million, Rs. 65.54 million and Rs. 13.78 million, respectively in the Batticaloa District. A total of 198,508 livestock deaths have been recorded, and 22406 fishermen and 11282 Kg fish products were affected. The total economic loss of fisheries activities was Rs. 110.88 million. Flood-prone area of the Porathivu Pattu DSD has been classified into five risk areas. The agricultural community suggested various flood control measures based on their experiences. Unless effective flood mitigation measures are implemented, the Batticaloa District might move to a backward position on agriculture sector and the community.

(***Key words:*** *Agriculture sector, Batticaloa District, Famer community, Flood disaster, Flood impacts)*

Flood is a frequent disaster in the Batticaloa District in Sri Lanka and it causes negative impacts on human life, loss of agriculture production and damage of agriculture lands, fishing activities and infrastructure. There were severe floods in the Batticaloa District in 1878, 1904, 1906 and 1913. In addition, there was a major flood event in 1957 in which the Unnichai Dam was broken and a considerable number of deaths were recorded. No records are available on the economic impacts on agricultural damages and losses. The flood that occurred in 2010/2011 was considered as the next severe flood after 1957. The economic losses due to this flood were about 4540.22 million rupees in the Batticaloa District (DPS, 2011). This flood had destroyed the agriculture and other sub-sectors and made agriculture farmers poor.

Many researchers have studied the flood related damages and losses in flood prone areas (DPS, 2011). Some researchers have collected human responses on flood issues (UNDP, 2008), but no one has examined the flood impacts on the agriculture sector in this particular area. Therefore, the main objective of this study was to analyze the impacts of the flood on the agriculture sector. Mapping of the flood risk areas and examination of the perceptions of the vulnerable agricultural community are also considered as the sub-objectives. The agriculture sector in this district was mainly focused on paddy, cereals, highland crops, fruit crops, livestock, and fishing.

MATERIALS AND METHODS

Study area

The Batticaloa District belongs to the Eastern Province of Sri Lanka. It covers a land area of approximately 2624.19 km^2. The District accounts for 3.8% of the country's total land area. The Lagoon which traverses through the District extends 73.5 km from Verugal (in the north) to Batticaloa town and also extends further from Batticaloa town 35.2 km to Thuraineelavanai (in the south). It has diverse landforms in varying scales such as islands, sandbars, marshy lands, undulating plains and plateau, hills, mountains, valleys in small scales. The relief of the Batticaloa District can be classified into three major parts: coastal

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lowlands (5 m), coastal undulating plains (5-50 m) and coastal uplands (50 m). The maximum elevation within the study area is 15 m in the heartland of Batticaloa.

Around 85% of the land in the Batticaloa District is covered by coastal lowland and undulating plains. The remaining 15% of the land represents upland. The major tanks, both Unnichchai and Rugam are located within two different valleys. This case study was conducted in the Porathivu Pattu Divisional Secretariat Division (DSD) (Fig. 1).

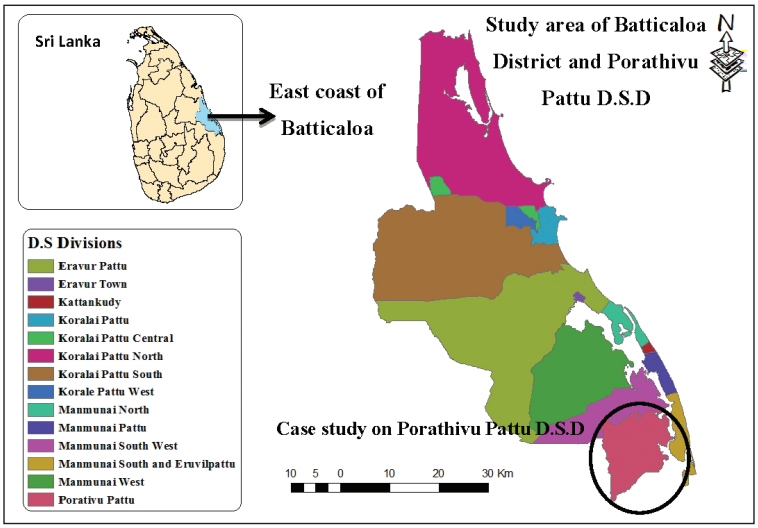

Fig. 1. *East Coastal Batticaloa District of Sri Lanka. The acronym DSD stands for Divisional Secretariat Division*

Methodology

First part of the analysis, the impacts of floods on agriculture sector were assessed by analyzing the data available in published reports in Batticaloa District (DPS, 2011; DAD, 2011; DVO, 2011; DFA, 2011; DMC, 2011). The second part of the analysis, a case study survey was conducted in the Porathivu Pattu DSD. A structured questionnaire survey was carried out in 2018. The questionnaire was targeted to capture the flood disaster impacts on the agriculture sector. The impacts on farmers who have been doing paddy and high land crop cultivation and fishing in the area were given priority. The key informant's interview was done with various stakeholders. The Arc GIS 10.3 software was used for spatial analysis. Flood risk areas were categorized through GIS techniques using the weighted overlay analysis method. Most influencing parameters were considered for flood risk classification. The flood analysis was associated with two river basins (Andella and Navagiri River Basin). This research was focused on the Porathivu Pattu DSD and the families were randomly selected from the agricultural Tamil community. About 20% of the samples were considered (371 families). These families mainly depend on paddy and highland crops cultivation and lagoon fishing activities.

RESULTS AND DISCUSSION

Results and discussion include the flood impacts on agriculture, identification of flood risk areas through GIS mapping and analysis of the perceptions through the questionnaires survey.

Flood impacts on paddy cultivation

This impact study applies to the 2010/2011 flood in the Batticaloa District. Out of 149,657 acres of paddy cultivated in the Batticaloa District, 143,560 acres were completely damaged by the major flood (Fig. 2).

A total of 44,179 farmers were affected by huge damages and losses due to the major flood. This was the biggest loss caused by the flood in 2010/2011 (Economic loss was calculated by the DPS, 2011). Fig. 3 shows the number of farmers affected and the economic losses from the damages to paddy crop due to flood in 2010/2011, in 14 DSD of Batticaloa District.

The economic loss of paddy was estimated as Rs. 68.70 million in the Earvur Pattu DSD, Rs. 54.13

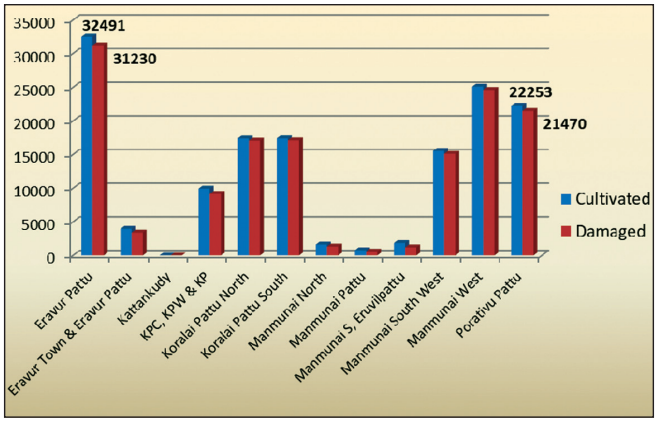

Fig. 2. *Cultivated and damaged paddy land extends (acre), in 14 DSD of Batticaloa District (Source: DPS, 2011)*

million in the Manmunai West DSD and Rs. 47.23 million in the Porathivu Pattu DSD due to the 2010/2011 flood disaster in the Batticaloa District.

Flood impacts on cereal and other crops

Corn, pulses, peanut, green gram and grains were cultivated in 4173 acres. The entire cultivated area was damaged due to the flood. Particular damage (extent acres) was noticed for various crops such as corn (2068 acres), pulses (495 acres), peanut (830 acres), green gram (392 acres), and Ulunthu (388 acres). About 10340 kg of cultivated grain seeds were affected due to the major flood. About 485 metric tons of chemical fertilizers were used for the grain crops. Therefore, farmers suffered economic loss through fertilizer usage too. About 56% (Rs. 41.36 million) of the total economic loss in grain cultivation (Rs. 73.86 million) in the Batticaloa District was due to damages to the corn fields. This was the major part of the losses in total grain cultivation caused by the flood. Damages to peanut crop were estimated at 20% (Rs. 14.94 million) of the total economic loss in grain cultivation (the calculation of the Economic loss was taken from the DAD, 2011).

Flood impacts on highland crop cultivation

Out of the cultivated vegetables, brinjal, ladies-finger, tomato, beans, bitter gourd, snake gourd, leafy vegetables, cassava, chillies and red onion were affected due to the severe flood. The total cultivated seed was 54936.42 kg and the damage extent was 2483 acres. Cassava, beans and chillies are most affected vegetables. Cassava (Highland crops) damage resulted in about 37% (Rs. 24.05 million) of the total economic loss (Rs. 65.54 million). This was the highest loss in the

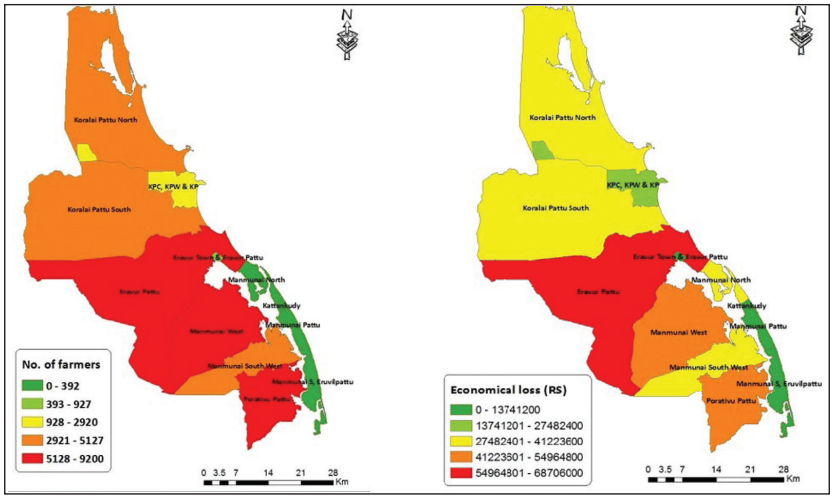

Fig. 3. *Distribution of a) farmers affected by the flood, and b) Economical losses from the damages to paddy crop due to flood in 2010/2011 in Batticaloa District. (Data Source: DPS, 2011)*

total highland crops. The damage to chilli crop caused was 21% (Rs.13.92 million) of the total economic loss in the highland crop. About 585 metric tons of chemical fertilizers were used in the highland crop cultivation. The economic loss occurred to the affected farmers due to the fertilizer usage was also therefore high (Economic loss was calculated by DAD, 2011).

Flood impacts on fruit crop cultivation

Out of the cultivated fruit crops, papaw (Papaya), mango, banana, pomegranate, guava, and sweet lemon were affected due to the severe flood. Those fruit crops were cultivated in 194.5 acres and all were affected. A total of 69230 fruit plants were damaged by the flood. About 105 metric tons of chemical fertilizers were use in fruit crop cultivation. Damages to Papaw crop resulted in about 50% (Rs. 6.84 million) of the total economic loss (Rs. 13.78 million) from the fruit crop cultivation. This was the highest loss in the total fruit cultivation caused by the flood. The banana crop damage contributed 38% (Rs. 5.2 million) of the total economic loss in fruit crop cultivation (Economic loss was calculated by the DAD, 2011).

Flood impacts on livestock

A total of 198,508 numbers of livestock deaths were recorded in the entire District due to the flood in 2010/2011 which include 26695 cattle, 10621 buffaloes, 25859 white goats, 118070 hens, 956 ducks, 285 rabbits, and 22 pigs.

Cattle death resulted in 67% (Rs. 837.9 million) of the total economic loss (Rs. 1220 million) of livestock in the Batticaloa District. This was the highest economic loss in the total livestock sector. Death of buffalos caused 17% (Rs. 209.4 million) of the total economic loss in the livestock sector in the Batticaloa District followed by 11% economic loss from the death of white goats (Economic loss was calculated by DVO, 2011).

Flood impacts of fishing activities

A total of 22406 fishermen were affected by the 2010/2011 flood and the fishing activities were limited in this period. Fishermen from the Valaichenai and Vakarai have lost Rs. 45 million (DFA, 2011). The sea and lagoon fishermen were affected, but most affected persons were lagoon fishermen. They lost their job for one month during the flood. All equipment used for fishing activities were significantly damaged. A total of 135 canoes and 22 engine boats were damaged, and 75 fishing nets and 2650 projectile nets were misplaced (Virakesari Newspaper, January 24, 2011). A total of 1628 cast nets were fully damaged, 48 lagoon canoes were fully damaged and 614 lagoon canoes were partially damaged. 2404 drift nets are fully damaged and 203 sea canoes were partially damaged (DFA, 2011). In total, Rs. 110.88 million losses were caused to the fisheries activities in the Batticaloa District (DFA, 2011). In total, 11282 kg fish products were affected due to the flood, especially 2930 kg in Koralai Pattu South, 2261 kg loss in Koralai Pattu North, and 1937 kg in Eravur Pattu fish products were affected. When compared with the economic loss of the freshwater fishing, Rs. 0.29 million loss occurred in Koralai Pattu South DSD (21%), Rs. 0.28 million loss in Manmunai West, (20%), and Rs.0.22 million loss in Koralai Pattu North, (16%) (DFA, 2011).

Identification of flood risk areas

Two river basins namely Andella River and Navagiri River in the Porathivu Pattu DSD were selected for mapping flood risk areas. Four main parameters, i.e. elevation, distance away from the river, land-use pattern and existing soil types were considered based on the reports of the Provincial Irrigation Department and Disaster Management Center at Batticaloa. As the study area is small, rainfall was excluded assuming that the rainfall was uniformly distributed in the study area. The ranks were allocated to each parameter considering their influence on causing a flood. After consulting with the Irrigation Engineer of the region, ranks were assigned for each parameter based on different conditions within the parameter and weightages were assigned for each parameter based on the influences on creating floods. Based on these weightages and ranks, the flood risk map was created using weighted overlay analysis method. Some selected factors were considered when preparing the flood hazard map. For example, low porous and low permeable soils were assigned high ranks; high ranks were assigned for the shorter distance away from the rivers and low elevated areas were assigned higher ranks. The weightage was given to each parameter based on the Analytic Hierarchy Process (AHP).

Each parameter was assigned weights considering the influence of flood hazard based on the Pairwise Comparison Matrix. The weightage of all four

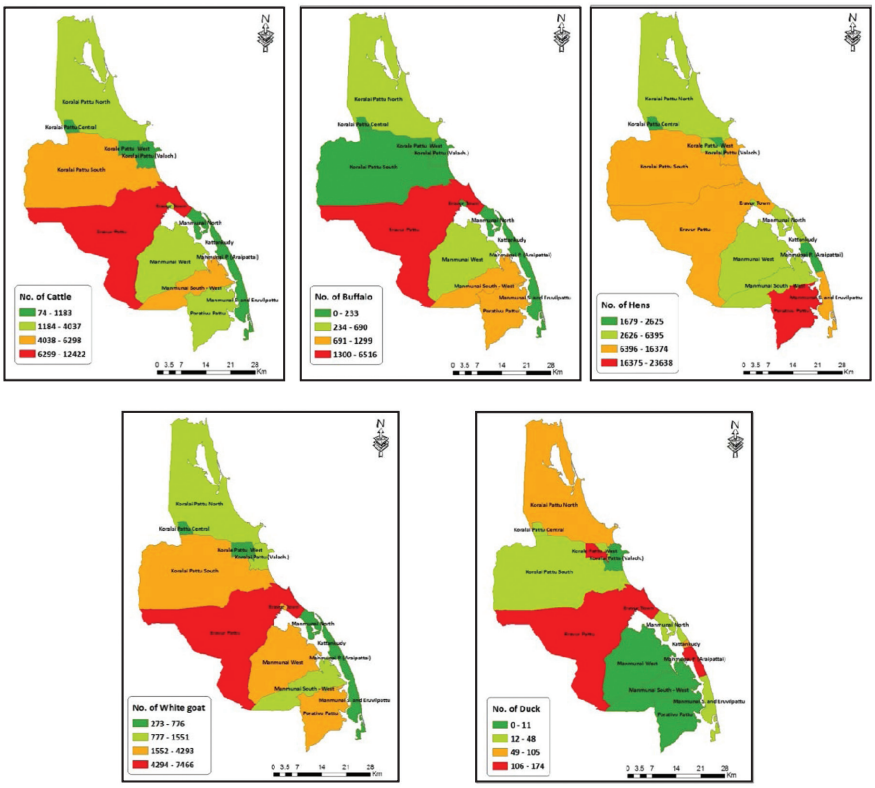

Fig. 4. *The impact of 2010/2011 flood on the death of a) cattle, b) buffalo, c) hens, d) white goat, and e) ducks. (Data Source: DVO, 2011)*

parameters for flood hazard of the study area included: river (weight 35), elevation (weight 25), Land-use (weight 20) and soil (weight 20). The flood hazard map was created using the weighted overlay analysis based on the weightages (Fig. 5). The flood risk of the Porathivu Pattu DSD was classified into five categories namely very low hazardous, low hazardous, moderately hazardous, highly hazardous and very highly hazardous.

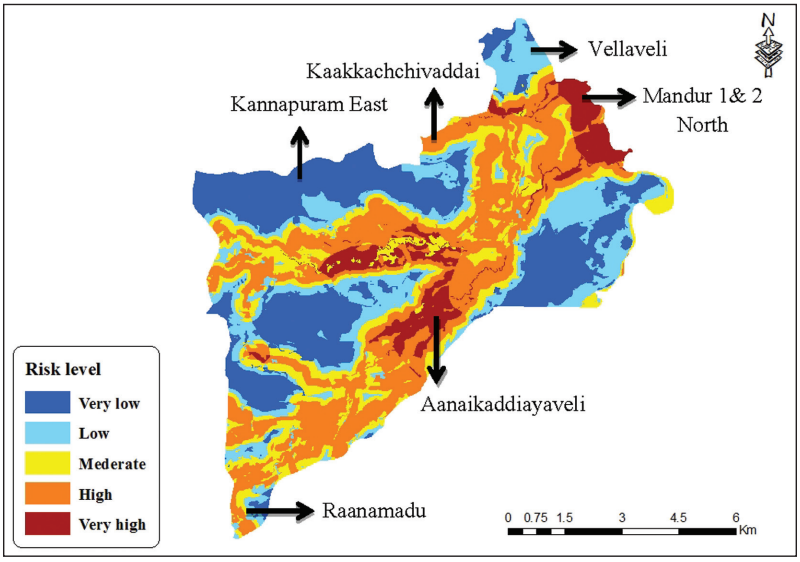

Fig. 5. *Flood Hazard Map of the study area of Porathivu Pattu DSD (Data Source: DS, 2019)*

The study area (76 km^2) was classified into different risk areas as shown in Fig. 5. About 17% of the area was categorized in the moderate flood risk level, 30% was in high-risk level and 8% was in the very high-risk level in the study area.

The perceptional study

A total of 371 families were interviewed for the perceptional study. The responded persons represented only the Tamil community. Among them, 77% are dependent on natural resources for their livelihood (e.g. farmers, fishermen, small industry proprietors, etc.) (Fig. 6). A majority of them are engaged in agricultural activities. About 62% of the respondents cultivated paddy, and 28% of the farmers did highland crop cultivation and 10% performed fishing activities for

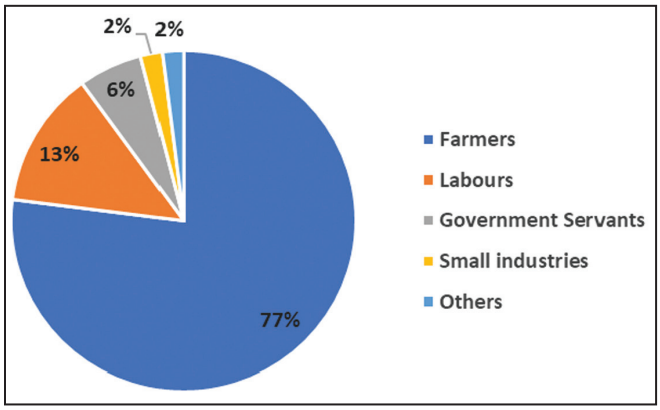

Fig. 6. *Occupation types of the respondents of Porathivu Pattu DSD (Source: Peoples' Perception Survey, 2018)*

their livelihood.

About 38% of the affected people were in the age group of 19-59 years and 27% of the people were in > 60 year age group and 26% of the people were in 6-18 year age groups.

Flood history of Porathivu Pattu DSD

Flood history analysis showed that various degrees of flood events occurred over time. The floods in years 1978, 2004, 2010, 2011 and 2014 were considered as severe floods with the major impacts. More than 40% of respondents stated that the worst flood occurred in 2011. About 38% said that 2010 was the worst flood and more than 15% of respondents stated that the 2014 flood was the most severe. The impacts may vary with their resilience of coping capacity and preparation. All of them agreed that the agriculture sector was completely damaged due to those major floods in Porathivu Pattu. Respondents stated that they have been facing either minor or major floods in their area one or two times a year. The floods occurred from December 2010 to February 2011 caused the worst impacts not only to the Porathivu Pattu, but also the entire Batticaloa District. The flood has occurred three times in 2011, two times each in 2010 and 2014, and it damaged the agriculture sector and cultivation practices.

Main reasons for the frequent flood in Porathivu Pattu DSD

The intensity of the flood level has been increasing in the Porathivu Pattu. About 67% of the farmers have confirmed that the intensity of the flood level has increased with time. The respondents have stated various reasons for increases in flood level such as; i) low lands have been filled, especially in Vettuchenai, and Kaakachiveddai areas, ii) unplanned colonization established near the rivers, lagoon and small tanks in Mandur 1 and 2 North, Aaanaikattiyaveli, and Vilanthoddam, iii) sand mining near the banks of water reservoirs (Mandur South, Koyilporativu South, and Raanamadu area), iv) deforestation in the catchment area, e.g. Palugamam area, v) destruction of the wetland for some needs, such as firewood and landfilling, e.g. Palugamam area, vi) inadequate drainage maintenance around the agricultural areas in Porathivu Pattu DSD, e.g. Vettuchenai area, and vii) low landfilling near the Andella and Navagiri River Basins. Porathivu Pattu DSD has been facing floods more than once every year, which resulted in huge destructions. A heavy rainfall in a certain period and time has been recorded in flood years. An accumulated rainfall of 968 mm was recorded from 08th to 12th of January, 2011. An accumulated rainfall of 431 mm was recorded from 01st to 04th of February, 2011. The rainfall, which was recorded in January and at the beginning of February 2011 (1685.1 mm) was more than the annual average rainfall of 2011 in the Batticaloa District (1606 mm). There are no tanks to capture the rainwater in the study area like Unnichai in Manmunai West DSD. The available small tanks are also not maintained properly. After the sediment is accumulated, no one cleans, e.g. Mandoor Koottamunai Kulam, Pankulam, and Periyakulam. There is also no proper drainage maintenance in Porathivu Pattu, e.g. Vettuchenai area. Failure to open the drainage

channels in proper time, and constructions near the cultivated lands were the other factors. Encroaching of the protected lands by people, was very common in the areas of Aanaikattiyaveli, Mandur 1 and 2 North, and Vellaveli. Unplanned development projects e.g. road development projects sometimes were discontinued in the middle. Therefore, those roads are again highly eroded by the flood water and sustain for a long period of time, e.g. Vettuchenai, and Kannapuran East. Constructing the residences in the lowlands flood areas, e.g. Aaanaikaddiyaveli, Vettuchenai, Vilanthoddam and Palaacholai. Out of the respondents, 41% have stated that this area is receiving heavy rainfall within a short period. The second priority answer was that "no big tanks (18%) are built to save rainwater".

Flood risk management

The respondents have proposed some suggestions to minimize the flood risk such as i) prevent the building of houses in the lower lands (Batticaloa Lagoon banks, Andella and Navagiri river banks), ii) the height of the tank bunds should be increased, e.g. Thumpangerny tank, iii) increase the depth of the small tanks/kulams, e.g. Menaatchi, Punang, Aanaikkaran, Vatti, etc., iv) constructing a major tank to store the rainwater like Unnichchi tank in Manmunai West, v) prevent sand mining on the banks of rivers, e.g. Kovil Porathivu South, and Mandur area vi) prevent the destroying of the wetlands near the lagoons and rivers, e.g. Palugamam area vii) open the drainage channels constructed near the cultivated lands at the proper time, viii) construct the flood-resistant houses, and ix) prevent the unplanned development roads projects, e.g. Kannapuran east. About 28% of the respondents have stated that the flood risk can be reduced if encroaching and constructing residences near the banks of the water reservoirs are avoided. About 15% responders said that the opening the drainage channels in the correct time will be a good option to minimize the water accumulation. People are doing some measures themselves to protect their belongings from the flood risk. More than 35% of the respondents have practiced placing sandbags around the house to prevent the water from coming in. About 17% of respondents have constructed drainage channels around their houses. However, they don't know about the flood water level. Some of them are not practicing any action to prevent the flood. Some respondents are not interested to cope with this issue. They feel that "flood comes and goes every year". There is no such appropriate place to protect the belongings. People feel that the prevention of floods should be carried out only by the government.

The damages and losses of agriculture sector occurred due to the flood occurred 2010/11 in Batticaloa District were examined, particularly in paddy, highland crops and fruit crop areas, livestock, and fishing activities. A total of 44,179 agricultural farmers had huge damages and losses due to this major flood. About 143,560 acres of paddy were damaged. The total economic loss from damages to grain crops, highland crops and fruit crops were Rs. 73.86 million, Rs. 65.54 million and Rs. 13.78 million, respectively in the Batticaloa District. A total of 198,508 livestock deaths were recorded. This study mapped flood hazard risk areas. The flood risk areas were classified into five hazardous categories namely very low, low, moderate, high and very high. The perceptional study resulted in many suggestions from the vulnerable community to minimize the flood impacts. The intensity of the flood level has increased with time. This study made some recommendations on the flood disaster management strategies to minimize the impacts of flood on the agriculture sector. It is recommended to build a proper water discharge drainage network around the cultivated lands, e.g. in Vettuchenai and Vellaveli. Building more tanks will help to preserve the rainwater and control the excess water drainage to agricultural lands. Small tanks should be reconstructed and maintained in proper time, e.g. Mandoor Koottamunai Kulam. There should be a prohibition in using the wetlands for firewood and landfilling, e.g. Palugamam. The construction of the residences near the rivers should be banned. There is a need to prevent the low landfilling, e.g. Vettuchenai, etc. Sand mining near the river banks should be controlled. The study suggested building flood-resistant elevated houses. The flood victims and the stakeholders gain confidence with the above structural measures. This study also suggested introducing the agriculture community savings, e.g. mobilize farmer groups into savings and credit funds, and water-tolerant paddy and highland crop seeds, e.g. transplanted rice during *aman* season "T. *aman*" (modern rice varieties). Introduce alternative crop practices like integrated farming e.g. hydroponics and multi-crop practices in paddy land during the non-cultivation season. Create alternative

agriculture jobs, e.g. curd, and milk productions and cow dung production as a natural fertilizer. It is important to implement the flood risk transfer insurance program which will give more benefits to the farmers. Unless the suggested management activities are implemented, Batticaloa District might move to a backward position not only in its agriculture sector and community but also in the socio-economic sector.

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