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The economic impact of flood on fisheries in Assam, India

Hoilenting[1], Rama Sharma[2]
[1, 2] Fisheries Economics, Extension and Statistical Division, ICAR-Central Institute of Fisheries Education, Panch Marg, Off Yari Road, Mumbai, India

Abstract
Flood in Assam is characterized by their considerable magnitude, high frequency, and extensive devastation. Monsoon flooding is particularly damaging to farming in Assam. This paper presents the nature of flood and the results from an evaluation of the impacts of the monsoon flooding 2017 monsoon flood events on the fishery in Assam. High economic losses were incurred in the fishery sector. Fish farmers incurred direct losses in fish loss, damages in pond dykes and embankment, stock damages, etc. due to flooding and associated water inundation in ponds and fish farms. An average amount of ₹ 55,461(60 %) of loss is incurred in fish and followed by damages or losses in pond dyke or embankment, ₹ 20908 (22.64 %) in 1 acre of pond. Although total costs to the fishery were small compared with urban flood costs, they were typically large at the individual farm scale. The results presented here provide valuable insights into how flooding affects fisheries and can inform future priorities in policy development and research in flood risk management.

Keywords: monsoon flood, economic loss, flood mitigation, fishery, Assam

1. Introduction
Assam is one of the flood prone States in the north-eastern region of India. Floods are annual recurrent event in Assam, causing damage worth of crores and affecting thousands of lives year after years. During monsoon, Assam suffers enormous losses due to recurrent and extensive flooding within the short duration and causing extensive devastation. This natural hazard repeats year after years and not only costs human lives but also causes irreparable loss to the state's economy, which is largely agrarian (Borah, 2019) [1].

Floods in Assam happen to be mainly due to two river systems – the mighty Brahmaputra in the north and Barak in the south. The geographical location of the region, high intensity rainfall, easily erodible geographical formations, earthquakes-prone zone, massive deforestation and explosive population growth are some of the dominant factors that cause floods in Assam. Monsoons rains from June to September, feed the Brahmaputra and the Barak along with their tributaries with excessive water. Instability in the river occurs due to high precipitation, sedimentation and steep slopes that allow the state to be influenced by the runoff from plateaus and hills of the surrounding states (Bujarbaruah, 2013) [3]. Besides the natural calamities, floods are also caused by human interventions like encroachment, lack of drainage, hill cutting, deforestation and filling up low lying areas for construction of buildings and reckless urban developments.

The geographical area of Assam is 78,438.00 Sq. Km., out of which 56,194.00 Sq. Km. and 22,244.00 Sq. Km fall under the Brahmaputra and Barak Valley including two hill districts respectively. As per Rastriya Barh Ayog report, flood prone area of the state is 31,500.00 Sq. Km. which is about 39.58 % of the total land area of Assam. This is nearly 9.40% of total flood prone area of the whole country (GOI, 2018). The unique geographical location, criss-crossed by a vast network of major and minor rivers originating from the hills and mountains are largely responsible for recurring floods and erosion of river banks. When the discharge in the rivers along with their tributaries synchronises during monsoon, the state faces flood devastation and the damages caused are colossal.

So far several studies had been conducted to assess the impact of floods on the agriculture sector of India, but similar assessment on fishery sector has been lacking till date. It is obvious that flood related havoc may also be impacting the life and livelihood of the fishers and other stake holders in the state, who are dependent on these natural resources (Borah, 2019) [1]. Another study conducted by Wilby *et al.*, (2008) [16] also reported that due to climate change, rural areas could face an increased incidence of flooding and a change in the nature of flood events in future. Thus, to fill this research gap, the current study was carried out to estimate economic losses in fishery sector of Assam, during 2017.

2. Materials and Methods
Assam is divided into six agro climatic zones viz., the North bank plain, Upper Brahmaputra Valley, Lower Brahmaputra Valley, Central Brahmaputra Valley, Hill zone and Barak valley zone. Except the Hill zone and Barak valley zone, the mighty Brahmaputra River flows through the other four agro-climatic zones in Assam. From each of the four zones, one flood-affected districts were chosen for the study viz; Dhemaji, Morigaon, Jorhat, and Dhubri, based on the flood hazard ranking index (1) and annual flood wave index of 2 or 3 (Table 1) reported by National Remote Sensing Centre, ISRO (DOS), Govt. of India. According to ISRO report, flood hazard ranking index is the multiplication of Weightage for Hazard Zones (H) with weightage for percentage of District Hazard area (A) and weightage for annual flood wave index (F).

Table 1: Flood Hazard Ranking Index of the selected districts of Assam

Districts	District Area (ha)	Total Flood Inundated Area (ha)	% Flood Inundation (ha)	Flood Annual Wave Index (F)	Flood Hazard Ranking Index
Dhemaji	2,52,572	1,15,304	46	2	I
Morigaon	1,49,300	1,05,160	70	2	I
Jorhat	2,83,860	1,23,037	43	3	I
Dhubri	2,02,844	87,199	43	3	I

As reported by Department of Fisheries, Assam, ponds are mainly used for culture fisheries by respondent fishers in Assam. For the current study, only those ponds were considered that were temporarily covered by surface water due to overtopping of watercourses or restrictions on arterial drainage and destruction of ponds/dyke or wash off of ponds. For these districts of Assam, information about number of flood-affected blocks, number of fish farmers, culture area under pond/tank and the affected fish culture area were collected from DoF, Assam and are mentioned in the Table 2.

Table 2: Flood affected information on fisheries of the selected districts of Assam

S. No.	Selected districts	No. of blocks affected in the district	Total no. of fish farmers affected in the district	Total culture area under pond and tanks (ha)	Total fish culture area affected (ha)
1	Dhemaji	4	1,504	476	218.00
2	Morigaon	3	3,980	1,739	714.20
3	Jorhat	8	800	1,067	188.53
4	Dhubri	12	5,481	2,883	1196.97

(***Source*:** Department of Fisheries, Assam, 2017)

In this study, sample of 120 flood affected fishers from these districts of Assam were purposively chosen and primary data was collected by using structured interview schedule during the period October, 2017 to February, 2018. Here, quantitative approach was used to collect the information on various aspects of fisheries related to 2017 floods in Assam, such as farm/pond characteristic, nature and duration of flooding, impact on fisheries loss/damage, type and cost of damages, including the attitude and perceptions of fish farmers related to flood risk management (Table 3).

Table 3: Contents of structured questionnaires for flood affected fish farmers

S. No.	Particulars
1	Farm/Pond characteristics
	Area of pond, ownership, type of culture/farming practices, stocking density, fish species, culture period, production/yield per year, farm gate price, soil type
2	Flood characteristics
	Area flooded, duration of surface flooding and water logging, depth of flood
3	Flood damage/loss:
	i) Fish stock
	Species, size of fish, quantity, farm gate price
	ii) Farm house
	Type of farm house, Area, year of construction, partially or fully damage, cost of repairing
	iii) Farm machinery
	Type of farm machinery, year of purchase, purchase price, partially or fully damage
	iv) Input stocks
	Types of stocks, quantity loss, purchase price per kilogram
	v) Pond structures
	Dyke/drainage/embankment, year of construction, partially or fully damage, cost of repairing or reconstruction
	vi) Disease
	Type of disease, cost of treatment
	vii) Emergency expenses
	Labour cost, raising of pond dyke
	viii) Pre mature harvesting
	Fish species, quantity, selling price
4	Responses
	Warning received, assistance received and provided during and after flood events, perception of farmers on flood mitigation.

2.1 Methodology Adopted for Estimation of Losses

Although, there has been a great need for a real-time loss estimation model for flood disaster mitigation in the country, but after the review of previous research works on this subject, it is realized that only a handful of researchers had undertaken such damage estimation modelling. The main difficulty associated with such modelling approach is in obtaining adequate flood inundation parameters, which are the most important inputs in loss estimation modelling.

Morris and Hess (1988) conducted a case study to assess the cost of flooding on agricultural land, to justify levels of protection to agricultural land which could suffer increased flood risk due to urban development in South West England. They mentioned that where flooding is frequent, the cost of flooding on farm land depends on land use, on the frequency, seasonality, duration and depth of flooding and on water quality. They also reported that average annual cost of flooding is directly proportional to the likelihood of inundation and developed the method to calculate the average annual cost of flooding.

Based on these facts, flood and inundation impacts in the current study have been estimated at the farm scale and at the scale of individual blocks of ponds, i.e. units of ponds, in some cases comprising multiple fields that are managed similarly and demonstrate similar physical and hydrological characteristics, such as soils, topography and flood frequency.

Estimates of financial losses from floods have been calculated based on estimates of physical damage and unit prices (Morris and Hess, 1988). The average annual flood loss of a given frequency of occurrence has been estimated by summing up the products of the seasonally weighted flood cost for single or multiple flood events and the relative probability of those single or multiple events given as under:

$$Average\ annual\ flood\ loss = loss(1) * P(1) + loss(2) * P(2) + \cdots loss(n) * P(n)$$

Where, $P(n)$ = Probability of occurring n floods in a year

$loss(n)$ = Seasonally weighted annual damage resulting from n floods in a year

For estimation of losses in fishery sector of Assam, average farm gate prices during the monsoon season, 2017 had collected with reference to different sizes and species based on the responses reported by flood affected fish farmers.

Depreciated values (time value) on assets like culture ponds, farm house and farm machinery have been calculated based on the formula adopted by Penning-Rowsell *et al.* (2003). These values will reflect the value of goods at the time when it was damaged by a flood event. Losses in input stocks such as feeds, lime, fertilizers and medicine etc. have been calculated based on the prevailing market prices.

3. Results & Discussion

3.1 Nature and extent of floods during 2017 in the selected districts of Assam

In Assam, during 2017, flooding started from the month of July and extended till October. Overall, 20,868 number of villages got affected with floods and damaged more than 10 lakh total crop area. From the selected districts, it was observed that large number of fish farmers got affected by 2017 recurrent floods which had not only damaged their crop area but also damaged their ponds area utilized for culture fisheries and are given in the table 4:

Table 4: Nature and extent of floods in the selected districts of Assam

Districts	Flooding Period	Land area (in ha)	No. of Villages/ Localities affected	Total Population affected	No. of fish farmers affected	Total crop area affected (in ha)	Pond area affected (in ha)
Dhemaji	July-October	2,52,527	1,422	5,49,881	1,504	85,214	199.80
Dhubri	October	2,02,844	1,827	19,73,681	5,481	21,735.5	167.00
Jorhat	June-July	2,83,860	403	1,54,444	800	14,458.83	239.66
Morigaon	August- September	1,49,300	3,840	26,15,730	3,980	26,854.44	703.90

(***Source*:** ASDMA, 2017 and DoF, 2018)

During 2017, Dhemaji district of the North bank plain agro climatic zone of Assam started flooding from the month of July and continued till first week of October. The district has a total land area of 2,52,572 ha., from which total 1,15,304 ha. of land area was reported to be inundated and 85,214 ha. of crop area got affected by 2017 floods. During the year, about 1,504 fish farmers were found to be affected by the flood with pond area of 199.8 ha. utilized for culture fisheries. The respondent farmers reported that flood water remained in ponds for nearly one week to a month and on an average for three weeks. After floods, their ponds remained inundated for another 3 weeks or sometimes, were totally wash off causing total economic loss.

In Dhubri district of the lower Brahmaputra Valley, occurrences of 2017 floods were reported towards of end of monsoon period during the month of October. About 87,199 ha. of the total district area was reported to be inundated from which 21,735 ha. of crop area got affected by 2017 floods. During the year, about 5,481 fish farmers were found to be affected by the flood with pond area of 167 ha utilized for culture fisheries. The respondent farmers reported that flood water remained in ponds for nearly one day to six weeks and on an average for two weeks.

In Jorhat district of the upper Brahmaputra Valley, occurrences of 2017 floods were reported from the month of June and continued till the end of July. About 1,23,037 ha. of the total district area was reported to be inundated from which 1,44,58 ha. of crop area got affected by 2017 floods. During the year, about 800 fish farmers were found to be affected by the flood with pond area of 239 ha utilized for culture fisheries. The respondent farmers reported that after the flash flood, flood water remained in ponds for nearly one to six weeks and on an average for two weeks.

In Morigaon district of the central Brahmaputra valley, occurrences of massive 2017 flash floods were reported from the month of August and continued till the end of September. About 1,051,60 ha. (70% of total land area) was reported to be inundated from which 26,854.44 ha. of crop area got affected by 2017 floods. During the year, about 3,980 fish farmers were found to be affected by the flood with pond area of 703.9 ha utilized for culture fisheries. The respondent farmers reported that after the massive flash floods, on an average, their ponds were inundated for almost four weeks and some the ponds were totally wash off by the flood.

The affected fish farmers of the four selected districts of Assam reported that due to 2017 floods, they had suffered huge economic losses in their culture ponds with the loss of fish stock/yield, followed by damage and destruction of pond

dyke/embankment (Figure 2). In addition, respondent fish farmers also reported they also incurred losses due to damage to farm houses, input stocks, fishing gears etc. in Assam 2017 floods.

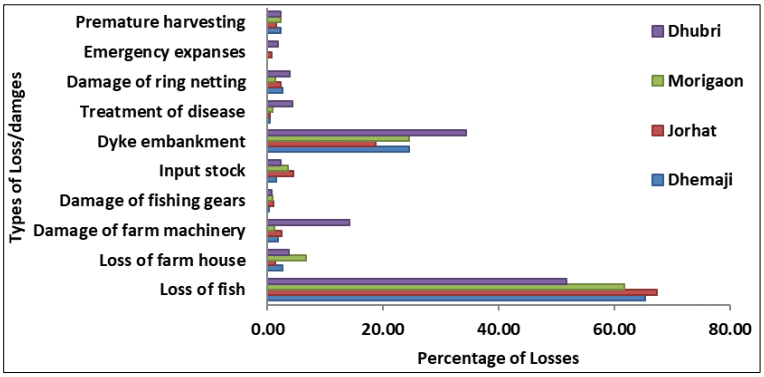

Fig 2: Losses reported by the selected districts fish farmers

3.2 Classification of loss or damages in fishery and its estimation

Losses incurred due to floods in fishery sector of Assam can be broadly classified into direct and indirect damages. Direct damages are usually caused by direct exposure or physical contacts with floodwaters especially incurred to infrastructure, since majority of the buildings and residential properties within these areas have thatch/bamboo roofs and are highly vulnerable to flood hazard risk. Losses of crops, livestock and human lives; immediate health impacts; and losses of ecological goods also fall in the category of direct damages. On the other hand, indirect damages are mainly caused by disruption of physical and economic linkages and other losses, such as loss of production at flood-affected factories and companies and costs of traffic disruption and emergency services (Merz, *et al*. 2010, Bremond *et al.*, 2013, Messner *et al.*, 2006, Messner *et al.*, 2007) [8, 9, 10].

Direct and indirect damages can further be classified here into tangible and intangible damages. Tangible damages are usually specified in monetary terms, such as damage to buildings, residential properties, assets, agricultural crops and loss of production especially in fishery. Intangible damages are mainly specified in terms of casualties rather than monetary such as health impacts, and damage to ecological goods and to all kind of goods and services (Merz, *et al.*, 2010, Messner *et al.*, 2006, Messner *et al.*, 2007) [8, 9, 10]. Classification of flood damages in fishery is shown in fig.1.

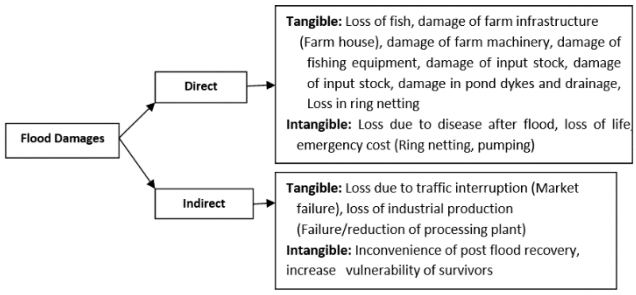

Fig 1: Classification of flood damages in fishery

3.3 Formulation of mathematical models for estimation of loss in fishery due to floods

Formulation of an adequate loss estimation model involves many issues due to the nature of damage caused by floods. Some of the important issues are obtaining detailed flood parameters such as duration of floods at a location, proper classification of damage categories considering nature of damage (partially or fully) and establishment of relationships between flood parameters and damage for different categories. The models developed for the damages/losses are described below:

3.3.1 Estimation of direct tangible losses due to floods:

a. ***Loss of fish stock/yield*:** At the time of flood inundation, economic loss in fish stock/yield has been calculated by collecting fishers' responses on fish species stocked, size of fish (small when <1 kg and large when >1kg), quantity of fish, farm gate prices. These costs have been used for particular area/unit of pond affected by 2017 floods. The total fish loss (FL) incurred in the flooded area of a particular district has been calculated by using the formula:

$$FL = \begin{cases} \frac{1}{n}\left[\sum_{i=1}^{30}\sum_{m=1}^{12} ps_i(qs_i < 1) + \sum_{i=1}^{30}\sum_{m=1}^{12} pl_i(ql_i > 1)\right], if\ loss\ reported \\ 0, \qquad otherwise \end{cases} \quad \text{(i)}$$

Where, FL = Average loss of fish stock/yield (value in ₹), ps_i= price of small size fish, qs_i= quantity of small fish, pl=price of large fish, ql=quantity of large fish and n=no. of respondents.

b. ***Loss of farm assets*:** Farm house, farm machinery and fishing gears are considered as the farm assets and are mainly affecting fish farmers while flooding. Type of farm house, year of construction/purchase, area of farm house, farm machinery (partially or fully damage), cost of repairing have been considered for calculating loss/damages of farm assets. The formulas used for calculating losses/damage in farm house (FHL), farm machinery (FML) and fishing gears (FGL) are given as under:

$$FHL = \begin{cases} \frac{1}{n}\left[\sum_{i=1}^{30} (frhc_i)_{pd} + \sum_{i=1}^{30}(fhdv_i)_{fd}\right], if\ loss\ reported \\ 0, \ otherwise \end{cases} \quad \text{(ii)}$$

Where, FHL = Loss or damage of farm house, $frhc_i$= farm house repairing cost, $fhdv_i$=farm house depreciation value, pd= partially damaged, fd= fully damaged and n=no. of respondents.

c. *Loss or damage of farm machinery*

$$FML = \begin{cases} \frac{1}{n}\left[\sum_{i=1}^{30}(fmrc_i)_{pd} + \sum_{i=1}^{30}(fmdv_i)_{fd}\right], if\ damage\ reported \\ 0,\ otherwise \end{cases} \quad \text{(iii)}$$

Where, FML = Loss or damage of farm machinery, $fmrc_i$ = farm machinery repairing cost, $fmdv_i$= farm machinery depreciation value, *pd*= partially damaged, *fd*= fully damaged and n= no. of respondents.

d. *Loss or damage in fishing gears*

$$FGL = \begin{cases} \frac{1}{n}\left[\sum_{i=1}^{30}(fgrc_i)_{pd} + \sum_{i=1}^{30}(fgdv_i)_{fd}\right], if\ damage\ reported \\ 0,\ otherwise \end{cases} \quad \text{(iv)}$$

Where, FGL = Loss or damage in fishing gears, $fgrc_i$= fishing gear repairing cost, $fgdv_i$= fishing gear depreciation value, *pd*= partially damaged, *fd*= fully damaged and n=no. of respondents.

e. *Loss in input stocks:* Types of stocks (eg. feeds like – pallet feeds, mustard oil cake, rice bran, lime, fertilizers etc.), quantity loss, and purchase price per kilogram. These costs have been used by considering the quantity of loss and its purchase market price. The input loss estimation has been calculated by using the formula:

$$ISL = \begin{cases} \frac{1}{n}\left[\sum_{i=1}^{30}[\ lime\ c_i + fert\ c_i + feed\ c_i\ ]\right], if\ loss\ reported \\ 0,\ otherwise \end{cases} \quad \text{(v)}$$

Where, ISL = Input stock loss, *lime* c_i= lime cost, *fert* c_i= fertilizer cost, *feed* c_i = feeds and n= no. of respondents.

3.3.2 Loss in structural damage: Damages in dyke, drainage, embankment, and ring net were considered as structural damages in pond. For estimating structural damages, year of construction (whether it was partially or fully damage) and cost of repairing have been considered for the calculation. Only repairing cost is considered for the estimation of loss. If reconstructed, reconstruction cost will be added to the next year production cost. For estimating the structural damages in rupees, following formula has been used:

f. *Damages in Dyke or embankment*

$$DEL = \begin{cases} \frac{1}{n}\left[\sum_{i=1}^{30}(derc_i)_{pd} + \sum_{i=1}^{30}(derc_i)_{fd} + \sum_{i=1}^{30}[crn_i]\right], \ if\ damage\ reported \\ 0,\quad otherwise \end{cases} \quad \text{(vi)}$$

Where, DEL =Structural damages in Dyke or embankment, $derc_i$= dike and embankment repairing cost, *pd*= partially damaged, *fd*= fully damaged, crn_i=cost of ring net and n=no. of respondents.

g. *Loss due to damage of ring net*

$$RNL = \begin{cases} \frac{1}{n}\left[\sum_{i=1}^{30}[crn_i]\right], & if\ damage\ reported \\ 0, & otherwise \end{cases} \quad \text{(vii)}$$

Where, $RNL =$ Damage of ring net, crn_i=Cost of ring net and n= no. of respondents.

3.3.3 Estimation of direct intangible losses due to floods:
It includes losses include losses due to disease, emergency expenses and premature harvesting. These losses are reported by very few of the flood affected respondent. Type of disease, cost of treatment, labour cost during the flood for rising of pond dyke or netting have been considered as losses due to disease and emergency expenses and following formula has been used to calculate the same:

a. *Losses due to disease*

$$CDTL = \begin{cases} \frac{1}{n}\left[\sum_{i=1}^{30}[cdt_i]\right], & if\ disease\ reported \\ 0,\ otherwise \end{cases} \quad \text{(viii)}$$

Where, $CDTL$ =Losses due to disease, cdt_i= cost of disease treatment and n=no. of respondents.

b. *Losses due to emergency expenses*

$$EEL = \begin{cases} \frac{1}{n}\left[\sum_{i=1}^{30}[cee_i]\right], & if\ emergency\ reported \\ 0,\ otherwise \end{cases} \quad \text{(ix)}$$

Where, EEL =Losses due to emergency expenses, cee_i= emergency expanses and n= no. of respondents.

c. *Loss due to premature harvesting*

$$PMHL = \begin{cases} \frac{1}{n}\left[\sum_{i=1}^{30}[pmhl_i]\right], & if\ premature\ harvesting\ reported \\ 0,\ otherwise \end{cases} \quad \text{(x)}$$

Where, $PMHL$ = Loss due to premature harvesting, $pmhl_i$ =premature harvesting loss and
n= no. of respondents.

Overall average losses due to direct damages: The overall average losses in culture fishery due to direct damages have been calculated by using the given formula:

$$OAL = \frac{1}{k}\sum_{k=1}^{4}(tl_k)$$

Where, OAL = Overall average losses due to direct damages, k= no. of districts used in the current study, tl_k = total losses in culture fisheries of a particular district/location and can be calculated by summing up the losses obtained from equation (i) to (x) as given below:

Total Losses = $FL + FHL + FML + FGL + ISL + DEL + RNL + CDTL + EEL + PMHL$

3.4 Average annual loss due to 2017 floods in the selected districts of Assam

By using the above-mentioned mathematical models, estimated average annual loss (in ₹) in culture fishery in the selected districts of Assam due to 2017 floods have been calculated per acre and are presented in the following Table 5.

Table 5: District wise average annual loss in fishery of Assam due to 2017 floods (in ₹.)

S. No.	Losses due to	Districts				Average loss/acre (In ₹.)	% Share
		Dhemaji	Jorhat	Morigaon	Dhubri		
1	Loss of fish	59,213.60	89,411.67	45,302.00	27,920.67	55461.99	60.38
2	Loss of farm house	2,333.33	1,741.94	4,877.78	1,966.67	2729.93	2.97
3	Damage of farm machinery	1,700.00	3,310.34	900.00	7,672.22	3395.64	3.70
4	Damage of fishing gears	289.44	1,415.48	658.89	414.33	694.54	0.76
5	Input stock	1,366.00	5,953.55	2,611.67	1,205.17	2784.10	3.03
6	Damage in dyke/embankment	22,237.78	24,903.23	17,920.00	18,571.11	20908.03	22.76
7	Treatment of disease	353.33	603.33	594.23	2,316.67	966.89	1.05
8	Damage of ring net	2,376.67	3,066.67	1,043.33	2,043.33	2132.50	2.32
9	Emergency expanses	-	1,000.00	-	1,022.22	1011.11	1.10
10	Premature harvesting	2,080.00	2,080.00	1,664.00	1,248.00	1768.00	1.92
Total Estimated Loss		92,345.98	1,34,819.54	75,605.79	64,687.06	91852.72	100

Results mentioned in the above table indicates that on an average the flood damage total loss has been found out to be ₹ 92,370/- per acre of pond among the districts, but the maximum loss has been reported by Jorhat district fish farmers (₹ 1,34,819/-) followed by the fish farmers of Dhemaji (₹ 92,345/-), Morigaon (₹ 75,605/-) and Dhubri district (₹ 64,687/-). It was found that Jorhat district fish farmers had suffered maximum losses mainly because of frequent floods during 2017. As far as contributions of different type of losses are concerned, Jorhat district farmers had incurred maximum losses due to loss of fish during 2017 floods followed by other district farmers. The average loss incurred among the four districts due to loss of fish is ₹ 55,461/- in one acre of culture pond with almost 60 % share of total annual losses. This is followed by structural damages like damage in pond dyke or embankment (₹ 20,908/-) with almost 22 % share of total annual losses. Losses due to floods were also found to be incurred owing to other damages like farm machinery, Input stock, and farm house, fishing gears, premature harvesting and costs incurred at field and farm level (fig.3)

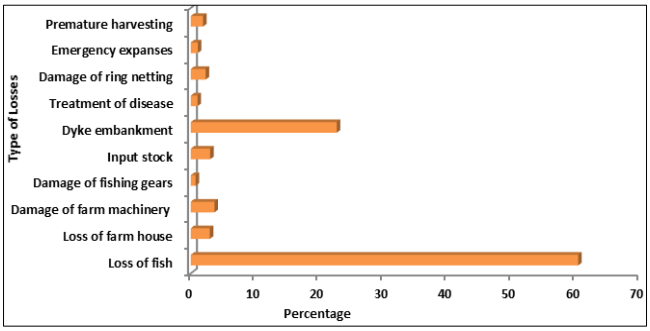

Fig 2: Percentage of loss incurred in a different type of loss and damages

4. Conclusion

During 2017, state of Assam received floods from the month of July to till October. Due to frequent flood, farmers of the North bank plain zone had suffered maximum losses of ₹ 1,34,819/- as compared to the farmers of Upper Brahmaputra Valley zone (₹ 92,345/-). Whereas, Central Brahmaputra Valley Zone and Lower Brahmaputra zone, which gets flooded due to pluvial flooding and over flow of river, the losses are found to be relatively lower. On an average, the total estimated economic loss has been found out to be ₹ 92,370/- per acre of pond among the districts. The maximum average loss incurred was due to loss of fish (₹ 55,461/-) in one acre of culture pond with almost 60 % share of total annual losses followed by structural damages like damage in pond dyke or embankment (₹ 20,908/-) with almost 22 % share of total annual losses. Thus, it is suggested that proper river embankment and improvements of river maintenance may reduce the impact recurrent floods in the fishery sector of Assam. Therefore, initiatives on these fronts can be taken by state departments to minimize the losses, which are vital for the state economy.

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