IMPACT OF FLOOD HAZARDS ON THE AGRICULTURAL PRODUCTION AND LIVELIHOOD SHIFTING IN RURAL BANGLADESH: A COMPARATIVE STUDY

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ABSTRACT

The paper efforts to explore the co-relation between two variables- agricultural losses incurred due to floods and change in agricultural population in an area, and thus to identify the extent of 'flood-forced' livelihood shifting from agriculture to other sectors in rural Bangladesh. The study is conducted on four districts having mutually different levels of exposure to floods. The study reveals that in a 20 years period between 1991 and 2011, the number of people engaged in agricultural sectors decreases continuously; the decreasing rate, however, is not equal for all of the study districts. The non-flood prone district has a very slow decreasing rate of 1.52% per year, while the rate is more than 4% in highly flood prone districts that suffer from high agricultural losses every year due to floods. Two statistical analysis tools- co relation co efficient and r-squared value are used in the research to find out the linkages between the two variables. R-squared value, however, calculated in the research shows that more than 76% of agricultural population decrease in a highly flood prone district in Bangladesh could be result of the flood-caused agricultural losses, while the figure is found 41% in case of district less exposed to flood.

Key-words: *Agricultural loss; Co-relation; Flood; Forced livelihood shifting; Migration*

1. INTRODUCTION

Flood is the most common of all of the natural hazards in Bangladesh. Between 30-70% of the country is normally flooded each year (Litchfield, 2010). The country, therefore, is identified by UNDP as the 6th most vulnerable country to flood (Rawlani & Sovacool, 2011: 846). Around 80% of the country consists of floodplains and several other minor rivers. These floodplains sustain a predominantly poor rural population. Once every ten years, roughly one-third of the country gets severely affected by floods, while in catastrophic years more than 60% of the country is inundated (Brouwer, *et al.*, 2007: 313).

The country incurs a huge amount of agricultural losses around every year due to flood. On average, flood causes a loss of TK 2,400.00 (USD 33.8) per year to a poor rural household, whereas the overall Gross National Income (GNI) per capita is USD 1785 (Azad, *et al.*, 2013: 195). A recent flood took place in 2007 which caused damage of around 604,481 metric tons of crops nationwide (BBS, 2011a: 165) and that damage worth around 5.91 billion taka (about 84.4 million U.S. dollars) (People's Daily, 2007). Another dreadful flood occurred in 1998 that affected around 68% of the country (Banerjee, 2010: 341) and caused an overall decrease of 48 percent of agricultural production in rural households (Del Ninno *et. al.* 2001: 54).

More than a third of the country's population is concentrated on the 100-year's floodplain (Banerjee, 2010: 339). The primary source of livelihood of these people is climate-sensitive agriculture (Kartiki, 2011: 26). Therefore, when a major flood hits the country, these people suffer most as flood takes away their crops- their only source of income, making them highly vulnerable to the subsequent poverty. The agricultural damage incurred by floods, thus, may instigate affected rural people to go for alternative livelihood options leaving agricultural sectors since majority of them are subsistence farmer in nature and therefore, don't have enough capacity to cope with the flood shock instantly. Predominantly, almost all of the rural population in Bangladesh was engaged in agriculture decades ago. With time, however, they change their livelihood from farming to other options due to different factors, such as natural hazard risks, more earning opportunities, occupational comfort etc. Even if there wouldn't be any natural hazards, rural people might have gone for changing their livelihood options from agriculture to others with a view to earning better livelihoods and/or getting a more comfortable occupation.

Flood hazard- the most common natural hazard in Bangladesh, however, might have a significant impact share on this rural people's livelihood shifting. This portion of rural livelihood shifting incurred by flood requires special attention since this shifting- unlike others- is a forced shifting in most cases. When rural agriculture dependent people lose their crops by floods, they are forced to go for alternative livelihood options to survive. The current research aims at determining the extent of this forced shifting incurred by floods and flood caused agricultural losses in rural areas of the country. To be specific, the objective of the research is to identify the impacts of flood hazards on the agricultural production losses and subsequently, to determine the extent of forced livelihood shifting from agriculture to other sectors incurred by the flood caused agricultural losses in the flood prone rural areas of Bangladesh. The current research, in this regard, would identify the percentage of flood-forced livelihood shifting in rural Bangladesh that could be minimized if flood-exposed rural people are made resilient to the flood hazards.

2. METHODOLOGY

2.1 Study Area Selection

In order to carry out the research, two districts of Bangladesh having high exposure and two with low or no exposure to flood hazard are selected as study areas. The aim of the research, as mentioned previously, is to determine the extent of impact of flood hazard on the livelihood shifting of rural agriculture dependent population. In districts with low or no exposure to flood, however, livelihood shifting takes place anyway. This indicates that livelihood shifting in rural Bangladesh happens due to not only flood but many other factors. Therefore, to explore whether flood hazard plays significant role in shifting rural people's livelihood options, districts with low and no exposure to flood are considered for the study as well. A comparative analysis of the livelihood shifting trends over two types of spatial locations would give necessary justification to the extent of shifting incurred by flood.

According to Dewan *et. al.* (2003: 54-55), four types of flood are prevalent in Bangladesh- river flood, flash flood, rain fed flood and tidal surge. River flood, however, is the most common and severe one. The research paper, therefore, focuses mostly on the river flood issue. Accordingly, two districts with high exposure to river floods are considered as first two study areas. Two other districts- one having low and another no exposure to river flood- on the other hand, are deemed study areas for the research as well. However, the level of exposure of all districts of Bangladesh to different types of floods is showed in Figure-1. Kurigram and Faridpur districts having high exposure to river floods, Kushtia with low exposure and Joypurhat with no proneness to flood at all (BARC, 2010) are considered as four study districts for the research.

Kurigram and Faridpur districts located on the bank of the *Tista- Jamuna*, and the *Padma* respectively- as presented on Figure-1, are highly exposed to river flooding. Kushtia district, on the other hand, is located on the bank of the *Ganges*; however, relatively higher land types of the district make it less exposed to river flooding. Joypurhat, in transposition, being located at quite far distance from the major rivers hardly gets flooding.

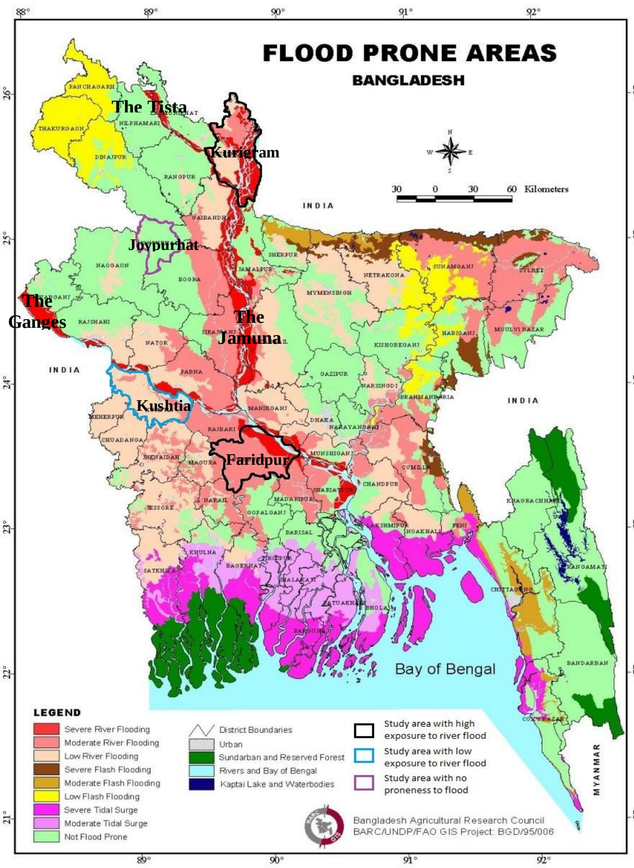


Image source*: Internet; <http://www.apipnm.org/swlwpnr/reports/y_sa/z_bd/bdmp261.htm>*

Figure-1: Exposure of districts of Bangladesh to floods

2.2 Data Collection and Analysis

The research is purely secondary data based. Most of the data required to conduct the research are collected from Bangladesh Bureau of Statistics (BBS) and the rest from related journal articles and official reports. To be mentioned here, twenty years period between 1991 and 2011 is considered as the study period in the research due to two reasons-i) to keep the research outcomes up-todated and ii) availability of necessary data. The research, accordingly, needs total population data for the study districts at the year of 1991, 1996, 2001, 2006 and 2011. The number of total population of the study districts in 1991, 2001 and 2011 are collected from population census data. Population data for 1996 and 2006, however, are enumerated using the annual exponential population growth rate of the corresponding districts as following:

$P_t = P_0 \times e^{r \times t}$; *Where,* P_t *= Population at end year/target year,* P_0*= Population at initial year,* r*= Annual population growth rate,* t*= Time interval*

Therefore, Annual average population growth rate of a district between the initial and end years,
$r = [\ln(P_t / P_0)/t] \times 100\ \%$

This annual population growth rate of the district between the initial and end year is used thereafter to enumerate the population figure of the district at an intermediate year availing the same equation.

For each of the three flood affected study districts, thereafter, a statistical co-relation between two variables- the amount of agricultural losses incurred by flood and people's livelihood shifting from agriculture to others in the district is built up in the research. The value of co-relation co-efficient, however, ranges from (-ve) 1 to (+ve) 1, where (-ve) 1 stands for perfectly negative co-relation, 0 for no co-relation at all, and (+ve) 1 for the perfectly positive co-relation between the selected variables. For instance, a co-relation coefficient value of (+ve) 0.9 indicates that the variables are strongly connected to each other. In addition to using co-relation co-efficient tool, r- squared (square of co-relation co-efficient) is used in the analysis. The r-squared gives a percentage of variance of the dependent variable that can be explained by the independent variable. For instance, an r-squared value of 0.87 for two variables- 'x' and 'y' indicates that firstly, these variables are strongly connected to each other and secondly, 'x' can explain 87% of variance of the 'y'; in other word, 87% variance of 'y' can be an effect of 'x'.

3. RESULTS

Bangladesh- being a low lying delta receives a 'normal' flood almost every year. Every 10 years, in transposition, the country has high possibility to get an 'extreme' flood. In a 20 years period between 1991 and 2011, the country had three major river floods at 1998, 2004 and 2007. The 1998 flood is considered as the largest flood of the century in Bangladesh that flooded around 68% of the country lands (Banerjee, 2010: 341). The 2004 flood, on the other hand, affected around 38% of the country (Banerjee, 2010: 341). The 2007 flood, however, was not as severe as 1998 or 2004 floods; only 18% of the country was affected by this flood (LCG Bangladesh, 2007: 2). All these river floods, however, generally take place in the country during July through September when *aus* and *aman* varieties of paddy, several cash crops (e.g. jute, sugarcane etc) and summer vegetables are in field (Del Ninno *et. al.*, 2001: 44).

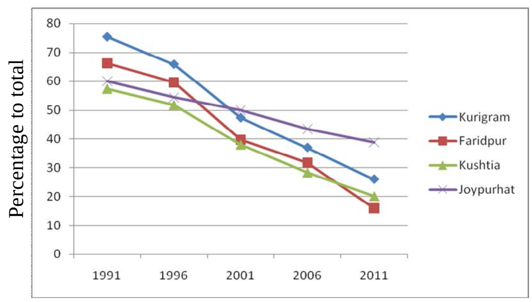
The analysis shows that the 1998 flood destroys around 252,660 metric tons of crops in Kurigram district, 418,044 metric tons in Faridpur and 127,527 metric tons in Kushtia (BBS, 2005b:451 & BBS, 2004). This crop damage in the three study districts was equivalent to BDT 4318.85 million (USD 91.89 million) in total. In other word, the agricultural loss incurred by the 1998 flood in only these three study districts was equivalent to the 1.34% of total national crop GDP of that year (BBS, 2005c: 484). The 2004 flood, on the other hand, incurred an agricultural loss of value BDT 2502.93 million (USD 41.71 million) in the three study districts which was equivalent to the 0.6% of total national crop GDP of the country (BBS, 2011e: 363; BBS, 2005a & BBS, 2005c: 484). The country suffered from another major river flood in 2007 that caused crop damage of worth BDT 1500.27 million (USD 21.80 million) in the study districts (BBS, 2011e: 363 & BBS, 2011a). This amount of agricultural loss in the three districts was equivalent to the 0.25% of the total crop GDP of the country in that year (BBS, 2011c: 395). However, the total agricultural losses in selected study areas incurred by major flood events over the periods of 1991-1996, 1996-2001, 2001-2006 and 2006-2011 are presented in summarized form in Table-1 that are used, later on, in the co-relation analysis.

Prior to developing the co-relation, however, trend of people's livelihood shifting from agriculture to other sectors in the study districts is analyzed in the research. The trend, as illustrated in Figure-2, indicates that the number of people engaged in agricultural sector is decreasing continuously from 1991 to 2011; albeit the decreasing rate is not equal for all of the study districts. The non-flood prone district- Joypurhat has a very slow decrease of agricultural population over the period of 1991-2011, while the rate is drastic in Kurigram and Faridpur- highly exposed to floods and even in less flood prone Kushtia. In other word, the annual average decreasing rate of agricultural population in flood prone districts like Kurigram, Faridpur and Kushtia are calculated 4.28%, 6.13% and 4.13% respectively, whereas the figure is only 1.52% for Joypurhat- a non-flood prone district.

Table-1: Agricultural losses in study areas due to flood over the period of 1991-2011

Periods	**Kurigram** (Metric tons)	**Faridpur** (Metric tons)	**Kushtia** (Metric tons)	**Joypurhat** (Metric tons)
1991-1996*	0	0	0	0
1996-2001*	252660	418044	127527	0
2001-2006**	217539	62402	13111	0
2006-2011***	70050	58331	5628	0

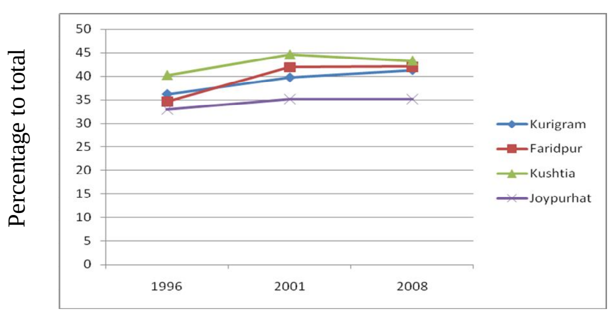
Source: *BBS (2004); **BBS (2005a); ***BBS (2011a)



Source: BBS (2012), BBS (2011d: 119-120), BBS (2011b: 253-254), BBS (2001), BBS (2005d: 167), BBS (1991a), BBS (1991b)

Figure- 2: Percentage of people engaged in agriculture to the total population in study areas between 1991 and 2011

One possible justification indicator used in this regard is the augment of non-farming households in respective study districts between 1991 and 2011. The study shows that the percentage of non farming households to the total households is increasing in all the study districts (see Figure-3). This rate of increase, however, is very slow in Joypurhat compared to others. This could provide a meaningful justification to the slow decrease of agricultural population in that district.



Source: BBS (2005d: 167), BBS (2005e: 215-216), BBS (2011d: 154-155)

Figure- 3: Percentage of non-farm households to the total in study districts between 1991 and 2011

Now, the percentage decrease of agriculture based population to the initial year of the corresponding period in study districts is calculated to be used as another variable for co-relation analysis (see Table-2). Thereafter, the co-relation between agricultural losses and decrease in agricultural people over respective periods is developed for each of the flood prone study districts.

The co-relation co-efficient value for high flood prone Kurigram district is calculated 0.542768 (see Table-3). The figure indicates that agricultural damage incurred by floods is positively related to the decrease in agriculture dependent people in the district. In addition, the r-squared value is calculated 0.294597 which indicates that around 29.46% of decrease in agricultural population in the district could be regarded as forced decrease by floods.

Table- 2: Percentage decrease of people engaged in agriculture over 1991-2011 in study districts

Periods	Kurigram (%)	Faridpur (%)	Kushtia (%)	Joypurhat (%)
1991-1996	9.71	4.56	4.71	6.97
1996-2001	25.84	29.29	22.56	5.48
2001-2006	16.14	16.59	21.02	9.55
2006-2011	24.41	47.85	24.93	7.33

Source: Calculated by the researchers from the data presented in BBS (2012), BBS (2011d: 119-120), BBS (2011b: 253-254), BBS (2001), BBS (2005d: 167), BBS (1991a), and BBS (1991b)

In Bangladesh, however, mobile communication develops revolutionarily between 2004 and 2007 that enhanced people's mobility to a great extent throughout the whole country (Deloitte, 2008: 141 and Bairagi *et. al.,* 2011: 44). Easy communication and information availability encouraged many rural people to migrate for long term and/or permanently in urban areas. This external phenomenon could be a major factor for the decrease in agricultural population throughout the country during the period of 2006-2011. Now, as conceptualized from the review of literatures, flood rarely causes to the long term migration of the rural agricultural people (Motsholapheko *et. al*., 2011: 992; Uy *et.al.*, 2011: 147-148; Gray and Mueller, 2012: 6003-6004). For this reason the period of 2006-2011 is excluded from the co-relation analysis as this period includes a huge rural-urban migration invigorated explicitly by the improved mobile communication throughout the country. In order to come up with a more realistic analysis, therefore, another co-relation matrix is built up excluding the period of 2006-2011 for each of the study districts.

The new co-relation co-efficient for Kurigram district, as mentioned in Case II in Table-3, is calculated 0.872033 which indicates that flood-caused agricultural damage in the district is strongly connected to the trend of people's leaving agricultural livelihoods. In addition, the new r-squared value of 0.760442 points to that around 76% of agricultural population decrease in the district could be an outcome of flood-borne agricultural loss. For Faridpur- another high flood prone district, the co-relation co-efficient after excluding 2006-2011 period is obtained 0.932632 (see Table-4) that indicates, again, strong influence of flood-caused damages on the decrease of agricultural people in the district. The r-squared value calculated in this case, moreover, indicates that flood and flood borne agricultural damages might have played role in displacing around 87% of agricultural population from agriculture to other livelihood options. The less flood prone district- Kushtia, in transposition, also faces flood forced livelihood shifting from agricultural to other sectors. Around 41% of agricultural population decrease takes place in Kushtia probably being forced by flood and flood caused agricultural losses (see Table-5).

4. DISCUSSION

The research results indicate that the agricultural population decrease in flood prone districts of Bangladesh is proportional to the level of exposure of the district to flood. More a district is exposed to flood, more agricultural damages takes place in there due to flood hazards.

Table-3: Calculation of co-relation between the agricultural losses and decrease in agricultural population for Kurigram district

Kurigram		
Periods	Agricultural Loss (M. tons) [Variable-1]	Decrease in Agricultural Population to the Initial Year (%) [Variable-2]
1991-1996	0	9,71
1996-2001	252660	25,84
2001-2006	217539	16,14
2006-2011	70050	24,41

Case I (considering all flood periods)	Variable-1	Variable-2
Variable-1	1	
Variable-2	0.542768	1
Co-relation co-efficient , r= 0.542768		
r- squared, r^2= 0.294597		

Case II (excluding 2006-2011 period)	Variable-1	Variable-2
Variable-1	1	
Variable-2	0.872033	1
Co-relation co-efficient , r= 0.872033		
r- squared, r^2= 0.760442		

Source: Table-1 and Table-2

Table-4: Calculation of co-relation between the agricultural losses and decrease in agricultural population for Faridpur district

Faridpur		
Periods	Agricultural Loss (Metric tons) [Variable-1]	Decrease in Agricultural Population to the Initial Year (%) [Variable-2]
1991-1996	0	4,56
1996-2001	418044	29,29
2001-2006	62402	16,59
2006-2011	58331	47,85

Case I (considers all flood periods)	Variable-1	Variable-2
Variable-1	1	
Variable-2	0.266881	1
Co-relation co-efficient , r= 0.266881		
r- squared, r^2= 0.071225		

Case II (excluding 2006-2011 period)	Variable-1	Variable-2
Variable-1	1	
Variable-2	0.932632	1
Co-relation co-efficient , r= 0.932632		
r- squared, r^2= 0.869802		

Source: Table-1 and Table-2

Table-5: Calculation of co-relation between the agricultural losses and decrease in agricultural population for Kushtia district

Kushtia		
Periods	Agricultural Loss (Metric tons) [Variable-1]	Decrease in Agricultural Population to the Initial Year (%) [Variable-2]
1991-1996	0	4,71
1996-2001	127527	22,56
2001-2006	13111	21,02
2006-2011	5628	24,93

Case I (considers all flood periods)	Variable-1	Variable-2
Variable-1	1	
Variable-2	0.366131	1
Co-relation co-efficient , r= 0.366131		
r- squared, r^2= 0.134052		

Case II (excluding 2006-2011 period)	Variable-1	Variable-2
Variable-1	1	
Variable-2	0.640471	1
Co-relation co-efficient , r= 0.640471		
r- squared, r^2= 0.410203		

Source: Table-1 and Table-2

This flood caused agricultural damage directly results income loss of agro-based rural people and thus, forces them to shift from agriculture to non-farming activities. In highly flood prone districts, more than 75% of agricultural population decrease may take place due to flood. To be mentioned here, Islam (2012:112) found in his study that around 79% of households in flood prone villages of Bangladesh shift their livelihood options from agricultural sector to non-farming earning options being forced by flood caused income losses.

The result could be discussed from another perspective. The strong positive co-relation between the study variables could be justified more by taking a comparative example of Kurigram- a highly flood prone and Joypurhat- a no flood prone district. In 2011 census year, the percentage of urban population to the total population figure in Joypurhat is found 15.75% while the figure is 15.78% for Kurigram district (BBS, 2012). The figures imply that both districts have around same level of urbanization; the rate of decreasing agriculture dependent population, yet, is much higher in Kurigram. Joypurhat, in addition, has more easy and direct access to Dhaka than Kurigram in terms of physical proximity and transportation network and facilities. It should be mentioned here that Dhaka- the capital city of Bangladesh is the major destination for poor rural-urban migrants (German, 2010 cited in Ishtiaque and Ullah, 2013:46). Now, physical distance of Joypurhat from Dhaka is 249 km, while the distance is 348 km for Kurigram (Roads and Highways Department of Bangladesh, 2007). It is very likely, therefore, that the overall rate of rural-urban migration for agricultural labors would be higher in Joypurhat compared to that of Kurigram. The research, yet, finds out that the rate of decreasing agricultural population in Kurigram is much higher than Joypurhat.

Taking another comparative example of a highly flood prone and a less flood prone district, quite similar outcome is obtained. Kurigram and Kushtia with respectively 15.78% and 15.73% of urban population are characterized by around same level of urbanization again (BBS, 2012). However, Kushtia has more physical access to Dhaka (Roads and Highways Department of Bangladesh, 2007) and therefore, people living in this district have access to more economic options compared to that of Kurigram. Trend of decreasing agricultural population in Kurigram, yet, is to some extent higher than that of Kushtia. This aspect, in addition to the co-relation analysis, pleads for the significant impact of flood and flood borne agricultural losses on forcing rural people's livelihood shifting from agricultural to non-agricultural options.

It is very unlikely that people who shift from agriculture being forced by floods would return back in agriculture again. This is because in case of flood forced shifting, people leave agriculture after losing all of their livelihood means. Now, if they continue leaving agricultural sector at so drastic rate as explored in the research, Bangladesh- the agro-economy based country might experience decreased growth in future. Moreover, when the country is fighting for achieving the Millennium Development Goal (MDG) for food security for all, rapid decrease in agricultural population could largely be an impeding factor to this endeavor.

Livelihood shifting from agriculture to non-agricultural sector would continuously take place in rural areas of Bangladesh anyway. Natural rate of decreasing agricultural population, however, wouldn't be as high as hazard forced rate. For instance, annual average rate of decreasing agricultural population in Joypurhat- a no flood prone district is 1.52% whereas the rate is 4% or more in districts exposed to flood. Therefore, if proper measures are deployed by the rural development authority in Bangladesh in enhancing flood exposed rural people's coping capacity to flood, a significant percentage of livelihood shifting from agriculture to other sectors could be minimized in flood prone areas.

5. CONCLUSION

The analysis results that the rate of rural people's leaving agriculture increases with the extent of agricultural losses incurred by flood in the district. Quantification of this impact of flood on rural people's livelihood shifting was necessary since flood is the most common natural hazard in the riverine Bangladesh. The current research, in this regard, reveals that up to 87% of rural livelihood shifting could be forced shifting due to flood and flood caused agricultural losses in a highly flood prone district. In a district- less exposed to flood, on the other hand, the extent of flood forced livelihood shifting could be up to 41% to the total.

In this connection, it is very unlikely to have flooding events controlled in the country because this is a natural phenomenon that is- in most cases- out of human control. What could be achieved rather, the impact of floods on agricultural loss and rural livelihood settings minimized through some interventions. For instance, the rural agriculture based population could be made resilient to the flooding hazards by providing them with more flood resisting crop varieties, expanding economic options in local level etc. If the rural agriculture dependent people have more economic options secured in their vicinity- especially for the flood period, it is more likely that they would not leave agricultural sector completely. If proper measures are adopted by the rural development authority in enhancing flood exposed rural people's coping capacity to flood, up to 87% of agricultural livelihood shifting in high flood prone areas and up to 41% in low flood prone areas could be minimized.

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