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EXTENT OF DAMAGE AND LIFE LOSS DUE TO FLOODING IN THE LOWER GANDAK PLAIN

Dr. Ramashray Prasad[1*] and Dr. Jitendra Rishideo[2]

[1*]Associate Professor, Dr. Bhimrao Ambedkar College, University of Delhi, Main Wazirabad Road, Yamuna Vihar, Delhi - 110094. Email: drrprasad2007@gmail.com
[2]Assistant Professor, Kalindi College, University of Delhi, East Patel Nagar, Delhi - 110008. Email: jitendradse@gmail.com

ABSTRACT

Flood is a worldwide phenomenon causing loss of life, property, infrastructures and crop damage. In north Indian plain, it is very severe. It is caused by heavy torrential rain particularly in the Himalayan upper catchment in association with huge snow melt in higher altitudinal glaciers during summer when the temperature is high. Thus, precipitous slope, huge water availability and greater carrying capacity of flowing water produce enormous sediment load. When rivers debouch in the plain, slope is reduced drastically. It leads to reduction in water velocity, causing sediment to deposit. Rivers become much wide and later erosion become prominent. All these issues create serious condition for easy and safe passage of additional discharging water. Excess water is bound to spread in the surrounding areas. Therefore, flooding becomes inevitable and stagnating water in any area creates enormous difficulty to the people. Hence, flooding causes damage to crops, houses, roads, and telecommunications other infrastructures, and loss of life of people and their cattle. Apart from them, water-borne diseases are also spreading in the flood affected areas, causing suffering. With respect to the Lower Gandak Plain, these situations are very severe as huge mountainous catchment with small plain basin offers very unfavorable condition and the loss is very high. Hence, an attempt has been made in this article to (i) explain the extent of people affected and damage to crops and houses, (ii) through light the loss of life and cattle and (iii) deliberate on the loss of public utilities and their impact on the society in the Gandak Lower Plain. The analysis of this study will help in suggesting remedial measures to overcome the problems of flooding and its ill-effect.

Keywords: Flood, flood effect, Loss of life and property, Damage to houses and infrastructures, Upper basin and Lower basin

INTRODUCTION

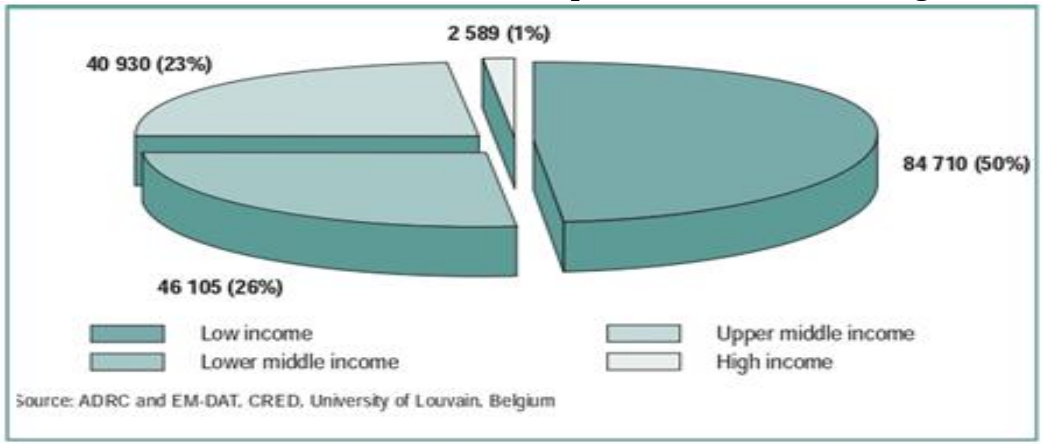
Flood is one of the most widespread frequently occurring hazards causing heavy economic loss to the society as well as lives and cattle. It encroaches and severely affects the lives of millions every year (Forkuo, 2011; Sharma et al., 2011; Menne and Murray, 2013; USAID, 2015; OECD, 2016). Flooding is becoming more and more serious and challenging over time (Messner et al., 2007).Indian Gangetic plain is thickly populated. Flood causes great concern because poor economy of the region becomes poorer due to its destructive and damaging impact. More than one-third of the earth's land surfaces occupying 90 nations are severely affected by flood (UNDP, 2004; Adhikari et al., 2010). These 90 countries constitute more than 80 percent of the world population. Since last few decades, the severity of the flood has

increased very rapidly worldwide. Most of them are attributed to increase in global temperature (Emanuel, 2005; Macklin and Rumsby, 2007'Tschakert et al., 2010; Pall et al., 2011). India is a monsoonal country and northern plain and the Himalayan region receives heavy downpour. It is the time when the temperature is substantially high during monsoon months. It leads to huge snowmelt. Heavy rain and snowmelt, both, are responsible for causing huge water to rush down in the plain from the upper mountainous catchment. In India, more than 90 percent of floods and more than 95 percent of people are displaced due to flooding (Few, 20003; Tschakert et al., 2010). Flood, in India, is the cause of highest damage to crops, property and infrastructural facilities (FEMA, 2000; NDMA, 2008). About 30 million people are affected due to floods in the country and approximately 1500 lives are lost annually. It is about 20 percent lost lives globally because of floods (Gupta et al., 2003). Singh and Kumar (2013) found that approximately 45000 lives were lost in a span of 29 years of their studies (1978-2006) which works out to be 3-human lives every two-million population of India. On an average, it 1551 lives every year.

For centuries before, the severity of the flood was not that high as the population was not large. The flood plains were thinly populated. Natural conditions were prevalent in those days. There were no hindrances and blockages in the passage of flowing water. Many of the roads or bridges and obstructions in the passage of the flowing water are the result of the modern developments by the technologically advanced human beings. But with the passage of time, and with increase in population, the flood plains are densely occupied. In most of the plains of the world, though the flood is a natural phenomenon, flood is triggered more due to human interference and less as a natural one. Therefore, in the present time, large population and high rate of developmental activities have created the plains vulnerable region to flood.

In most of the disasters, poor people are very severely affected. Because of their weak economic status, the conditions within which they are living are very pathetic and more vulnerable. Their houses are also poorly made are subject to submerged and destroyed with increase of river water. Their ability to cope with disaster like flood is very poor and casualties are more in comparison to the economically well-offs (UN, 2004). A diagrammatic presentation of deaths due to flood is given in Figure 1 which is clearly showing higher deaths are of the people coming under low income strata. North Bihar through the Gandak River is flowing and brings flood havoc every year is characterized by economically poor region of the country. To make the region poor, frequent flooding is the primary cause.

Table 1: Income Class and Number of People Killed Due to Flooding

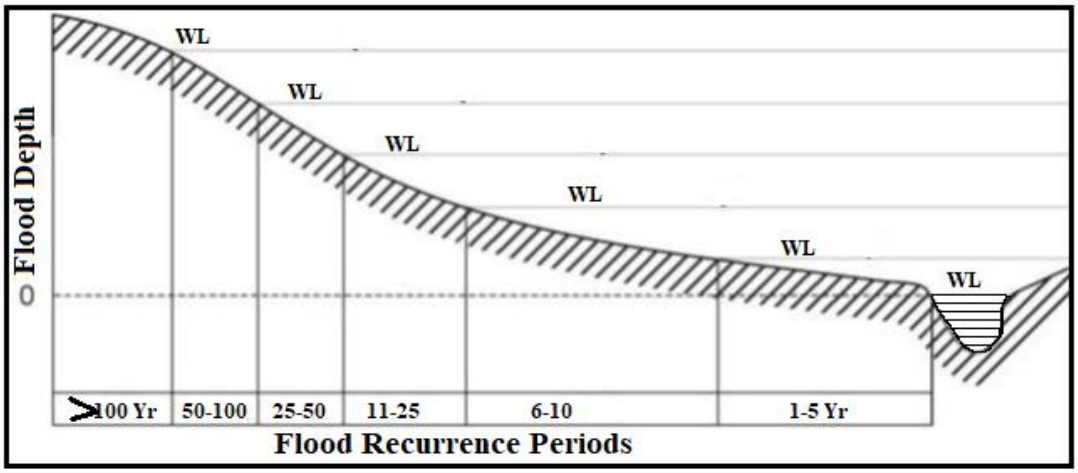


Source: https://sustainabledevelopment.un.org/content/documents/flood_guidelines.pdf (Last accessed on 25 October 2021)

Idealized Flood Situation

River water flows through the trough area in the plain. The river banks are made up of alluvium brought very year with flood water. Levees/banks are easily eroded by high discharge. Lateral erosion and its migration/channel shift of the river are normal activities, especially in the plain. When discharge becomes bankfull, overspill of river water beyond its levees causes inundation of the surrounding areas, called flood. Since the lowermost areas lies near the river, away from the river in cross-sectional direction is more in height. Therefore, the severest and most frequent floods are along the river. In terms of recurrences interval of floods, severest floods are rare and it occurs over longer periods and smaller level floods are very frequent. The same can very well be visualized by Figure 2.

Figure 2: Area Inundation at Different Levels of Recurrence Interval



Modified from: https://www.eolss.net/sample-chapters/C01/E4-06-02-07.pdf (Last accessed on 25 October 2021)

Bihar: A Flood Disaster Prone State

India is one of the most flood disaster prone countries in the world because of its geophysical and climatic conditions. It is only second to Bangladesh in terms of flood grim situation. About one-eighth geographical area of the country is flood prone and it constitutes approximately 40 million hectares (Bapalu and Sinha, 2005). But Bihar is one of the worst flood affected states of the country. North Bihar plain is most vulnerable because of its location at the outfall of the Himalayan catchment, new weak geology, fragile ecosystem and precipitous slope associated with heavy rain and snowmelt. The plain, being flat with low slope, has lesser velocity of water and exit of water becomes sluggish. Kale (1997) explained that north Bihar plain has witnessed highest number of floods on the basis of 30 years of data analysis in comparison to other parts of the country. North Bihar is primarily drained two big rivers Kosi and Gandak and other smaller BurhiGandak, Baghmati-Adhwara, Kamal-Balan, Bhutahai-Balan, Karehetc. Apart them, there are other several rivers in north Bihar adding to the grim situation of flood misery.

Bihar is India's one of the most flood-prone state. About 76% population of north Bihar is living under the recurring threat of flood devastation. According to the Rashtriya Barh Ayog (1980), 16.5% of the entire flood prone area within the country is located in Bihar while 22.1% of the total flood affected population within the country resides in the flood plains of the state. This implies that the number of persons hit by flood per unit area in Bihar is quite large. In fact, it is the highest as compared to the other flood prone states within the country. The total area of Bihar is 94160 km² out of which 68800 km² is flood affected. It works out to be a 73.07% flood affected area of the state of Bihar. The most flood affected area lays in North Bihar. North

Bihar has several rivers originating in the Nepal Himalaya and descends down in the plains. The Himalayan catchment receives very high rainfall as well as snow-melt during summer/monsoon season. Torrential rain under climatological synoptic conditions also brings huge amount of water in a short duration. That much of huge amount of the rain water is not easily and quickly passed downward and hence, the flood is caused.

OBJECTIVES, DATA AND METHODS

Objectives

The objectives of this study is to (i) explain the extent of people affected and damage to crops and houses, (ii) through light on the losses of life and cattle and (iii) deliberate on the loss of public utilities and their impact on the society in the Gandak Lower Plain.

Data Source and its Characteristics

The main emphasis in this article is to analyze the damage occurred due to flood. For this purpose, the data used here is secondary in nature and is collected from two sources – (a) Ganga Flood Control Commission (GFCC), Patna from 1968 to 2001 and (b) Disaster Management Department, Patna from 2002 to 2016. There are 11 districts through which the Gandak River is occupied. Though the river basin boundary, in most of the cases, does not coincide with the political boundary of any district, here the data available is district-wise. Therefore, the data used here is district-wise and roughly, it may be considered as the representative of the lower Gandak Plain. The collected data is pertaining to (i) total population affected by flood, (ii) total area affected by flood, (iii) extent of crop damage, (iv) crop damage converted into monetary (price index 2016) value, (v) damage to number of houses, (vi) value of damaged houses, (vii) number of cattle lost, (viii) number of human life lost, (ix) damage to public utilities (infrastructures) and (x) total damage to crops, houses and public utilities

Just by giving a glance on the data, it is apparent that both set of data has a big gap. The recorded data from 1968 to 2001 collected from GFCC is drastically very low while for the data from 2002 to 2016 collected from Disaster Management Department excessively very high. Since the data is secondary, the researcher does not have any control on it. Hence, it is analyzed as it has been received. Sometimes it becomes very difficult to justify the authenticity of the data, but nothing can be done except to point out the possible error with the data. The available categorized data has been analyzed and presented.

Methods

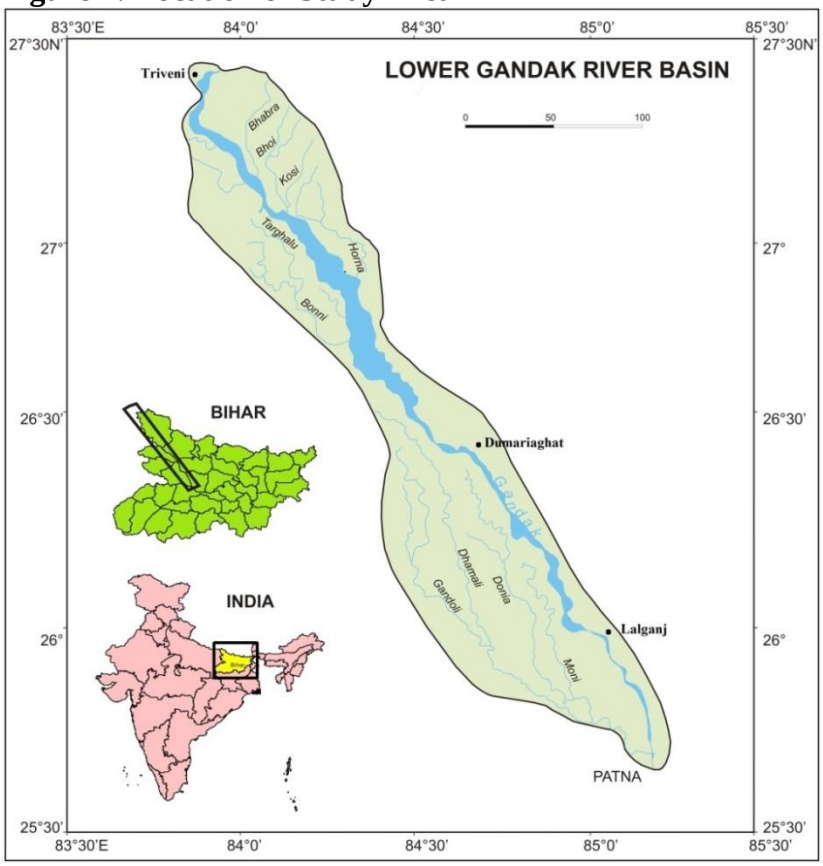
The collected data is analyzed and represented to show the meaningful trend and patterns over the period of study (1968 to 2016: 49 years). The trends of damage The total population, total area affected and damage to crop area is plotted to give a relationship between the intensity of flooding and the mentioned components. The number of houses damaged due to flooding is also presented graphically to show the trend over the period under study. Loss of human life and cattle are also graphed on the same base to see the association between them. Damage to crops, houses and public utilities are converted to the price index to 2016 to standardize the figures over time. Total damage due to flood was calculated and plotted the same to see over all damage under the study period.

STUDY AREA

The area under this study is Lower Gandak Plain. The lower Gandak basin extends from $25^0 21' 23''$ north to $27^0 26' 54''$ north latitude and $83^0 49' 00''$ east to $85^0 15' 52''$ east longitude. It occupies 7620 km^2 in Indian Territory (Figure 3). Large upper basin is lying in Nepal and Tibet constituting area of 38980 km^2, hence total area of the basin is 46600 km^2. The upper

catchment is equivalent to 83.65 percent of the total Gandak basin while the lower basin is only 16.35 percent. Entire plain area is almost flat except little area under foothills in the northwestern fringe. The study area extends from Triveni (in Nepal at the border) in the north along the Gandak River to the confluence of the river with the Ganga at Hajipur, near Patna. The gradient of the plain is relatively higher in the northwestern part of the plain in comparison to the southeastern part. Geologically, it is composed of newer alluvium in the south but in the northern part, it is older alluvium. The southern part is known as *Khadar or Diara*, which gets submerged almost every year and for several times in the year with increasing water level of the river and flooding. The upper part is known as *bangar*, above the flood level. The Gandak has several tributaries in the plain and most of them are originating from the Himalayan foothills. Most of them area seasonal rivers carrying water only during monsoon months. Majority of them are running almost parallel and finally meeting with the Gandak in the lower part of the plain basin.

Figure 2: Location of Study Area



Source: Prepared by authors based on Plate 11 & 12: Soil and Land Use Survey of India (SLUSI) Atlas (1988)

RESULTS AND DISCUSSIONS

Analysis of Flood Damage

Flood affects everyone in its area of occupancy. The effect of flood on people and the area is very direct and severe, and it depends on the intensity of the flood. The intensity may be seen in terms of quantity of water supplied and the duration of supply. It will determine the spillover of the water from the two banks of the river. In the same way, the discharging or removal of spillover water depends on the nature of the rocks/soil, slope and the capacity of the river to carry out the water.

Land and people are affected in multiple ways by floods. It is the cause of people sufferings on many fronts. The mental agony before it occurs in flood-prone areas, physical hardship and non-availability of life sustaining items during the flood, and complete wear and tear of the whole setup of the area and bringing them in right track are some of the after effects of floods. The agriculture, backbone of the rural economy, is devastated. Crops are destroyed; people, cattle and other domesticated animals are affected severely. Public houses are challenged. Infrastructures like roads, railways, electrical supplies, other means of communications, dams, embankments/bunds, schools, hospitals, government offices etc. are negatively affected. The effects of flood on land and people could be grouped into several classes. The Ganga Flood Control Commission (GFCC) and Department of Disaster Management have been collecting the flood impact data into the following categories:

1. Total population affected by flood
2. Total area affected by flood
3. Damage to crop area
4. Damage to crops converted into monetary value
5. Damage to number of houses
6. Value of damaged houses
7. Number of cattle lost
8. Number of human life lost
9. Damage to public utilities (infrastructures)
10. Total damage to crops, houses and public utilities

The compiled and calculated table of the above categories is presented in the Table 1.

Table 1: Damages Due to Flood in in Lower Gandak Plain
Price under different heads are converted to 2016

Years	Total pop. affected (lakh)	Total area affected (lakh hectare)	Damage to crops area (lakh Hectare)	Crops damage (lakhs Rs.)	Damage to house (No.)	House damage (lakhs Rs.)	Number of cattle lost	Number of human lives lost	Public utility damage (lakhs Rs.)	Total damage to crops, houses and public utilities (lakhs Rs.)
I	II	III	IV	V	VI	VII	VIII	IX	X	XI
1968	-	0.2958	0.0216	832.73	442	77.85	2	2	-	910.58
1969	-	1.0092	0.0989	3936.26	16554	1058.67	231	5	24.45	5019.38
1970	-	1.4234	0.4099	11239.03	3373	170.53	41	2	11.5	11421.06
1971	-	4.044	5.0444	16.48	7	21.94	9	10	30.12	54
1972	-	-	-	-	-	-	-	-	-	-
1973	-	1.6134	1.6134	3.17	1	4.4	2	2	4.4	11.97
1974	-	4.6514	4.6514	12.68	4	12.68	5	5	12.68	38.04
1975	-	2.4207	2.4207	6.11	2	6.6	2	2	6.6	19.31
1976	-	1.7917	0.6767	19515.81	27740	1859.68	10	4	-	21375.49
1977	-	0.3	0.1007	2556.29	286	51.45	-	3	-	2607.74
1978	-	2.4826	1.0074	24145.49	25022	2253.42	30	26	-	26398.91

1979	-	0.7406	0.2444	3399.63	4742	275.02	-	1	39.74	3714.39
1980	-	1.7035	1.1961	11876.76	17860	1139.24	-	-	-	13016
1981	-	0.0059	0.0494	12162.15	4771	578.61	1	2	163.6	12904.36
1982	-	1.5911	0.591	19118.89	20126	2169.96	2	18	5899.11	27187.94
1983	-	0.5484	0.195	1968.91	2226	138.19	8	1	731.77	2838.87
1984	-	-	-	-	-	-	-	-	-	-
1985	-	-	-	-	-	-	-	-	-	-
1986	-	-	-	-	-	-	-	-	-	-
1987	-	-	-	-	-	-	-	-	-	-
1988	-	-	-	-	-	-	-	-	-	-
1989	-	-	-	-	-	-	-	-	-	-
1990	2.1755	0.9285	0.176	243.6	351	70.06	-	-	-	313.66
1991	3.3411	0.8929	0.3866	2134.91	1322	322.32	3	2	20.79	2478.02
1992	0.072	0.072	0.006	2.8	160	25.18	-	-	-	27.98
1993	8.9812	2.2203	0.6662	22845.63	32220	4602.98	179	10	453.84	27902.45
1994	6.971	1.005	0.574	4031.63	1811	65.02	8	9	2.49	4099.14
1995	2.171	0.6145	0.417	2180.21	4354	390.14	-	10	105.41	2675.76
1996	5.513	1.0576	0.70817	4761.03	3352	134.68	6	12	404.97	5300.68
1997	0.939	0.887	0.123	224.75	484	32.85	-	1	1	258.6
1998	14.5049	4.2142	2.2575	20762.63	22276	2200.32	21	38	1704.42	24667.37
1999	4.6444	1.4812	0.35596	6665.19	2245	306.76	-	16	79.91	7051.86
2000	1.163	0.3773	0.23815	901.53	1120	185.13	2	8	53.39	1140.05
2001	21.152	3.3089	2.278	25896.54	65651	4474.38	266	80	2233.64	32604.56
2002	40.5	7.67	3.064	51050.86	59048	11473.71	992	195	28242.2	90766.72
2003	32.11	7.29	3.87	14251.98	13001	4406.95	18	132	862.16	19521.09
2004	60.13	6.46	0.85	59186.25	192469	34087.07	1060	279	84326.4	177599.8
2005	6.68	2.83	0.75	719.44	390	140.93	-	20	37.32	897.69
2006	3.78	3.41	1.23	1790.59	13265	3240.26	10	14	16315.9	21346.73
2007	118.84	9.88	5.49	96015.49	250696	59579.35	1468	651	25512.6	181107.4
2008	2.49	0.49	0.14	101.36	2071	54125.19	-	16	116.77	54343.32
2009	3.07	0.46	0.18	1551.7	1725	33.06	2	14	-	1584.76
2010	5.3	1.61	0.05	180.18	4373	351.47	-	8	227.76	759.41
2011	12.96	4.99	1.12	1888.02	4359	734.54	85	75	51.23	2673.79
2012	1.17	0.27	0.14	385.59	384	65.4	-	9	203.85	654.84
2013	13.89	0.19	3.16	607.43	2256	4460.73	5	63	32.44	5100.6
2014	4.61	0.21	0.16	6046.65	1044	4.61	1	6	43.93	6095.19
2015	-	-	-	-	-	-	-	-	-	-
2016	20.922	1.31	1.12	22765.19	23410	1487.85	143	93	10094.1	34347.16
Total	**283.03**	**88.751**	**47.83**	**457981.6**	**826993**	**196819.2**	**4612**	**1844**	**178050**	**832851.2**
Average	**10.89**	**2.165**	**1.67**	**11170.28**	**20170.56**	**4800.47**	**153.7**	**48.53**	**5395.468**	**20313.44**

Data Yrs	26	41	41	41	41	41	30	38	33	41
Total revenue loss in **common 33 years** is Rs. 766616.08 Lakh. Hence, average loss for these 33 years is **Rs. 23230.79 Lakh per year**.										

Source: Ganga Flood Control Commission, Patna and Disaster Management Department, Patna

The given data in ten columns have been regrouped into practically four classes. They are:

a. Affected People, Land and Crops
b. Damage to Houses
c. Lives Lost: Human and Cattle
d. Loss of Revenue from Different Categories

A fifth category may also be looked as the Total Revenue Loss from crop damage, house damage and public utilities damage. In fact, it is the addition of the three categories of losses.

Effects of Flood on People, Land and Crops

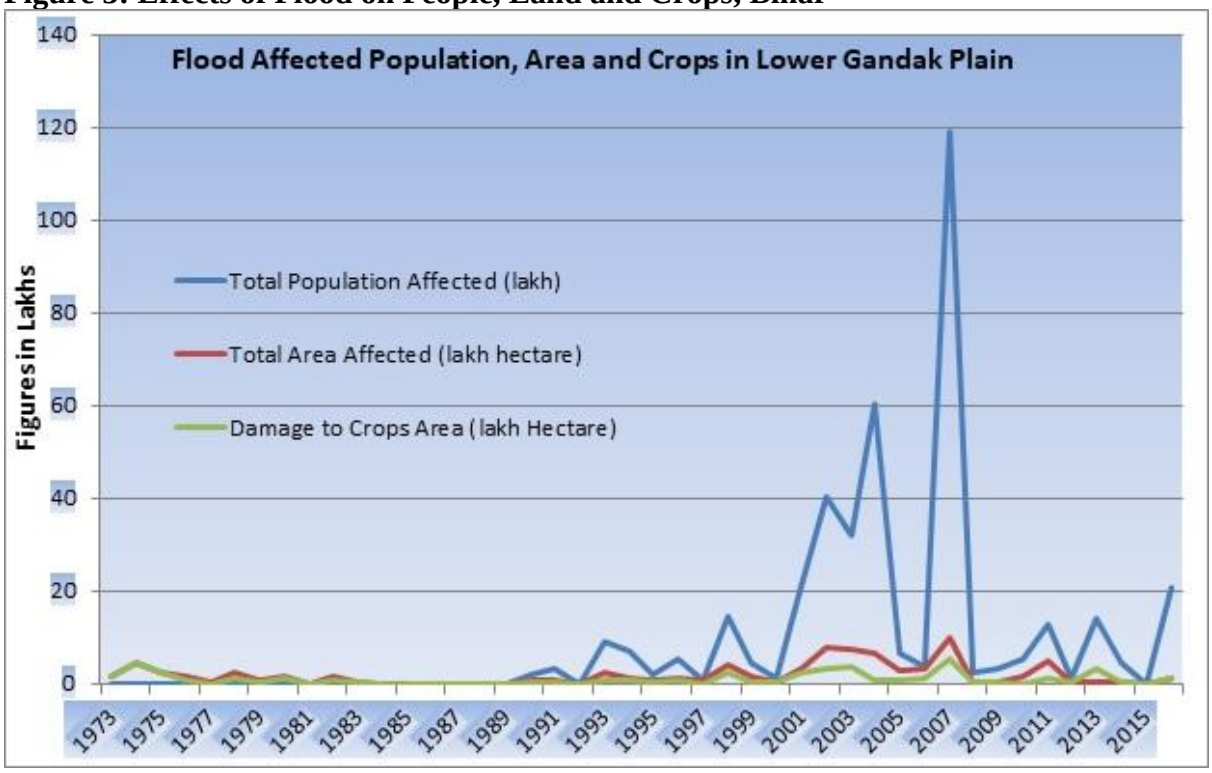
As mentioned before, flood inundates everything in the area of its occupancy starting from the land, micro-organisms, plants, animals and entire ecosystem. People, their pets and cultural landscape are most directly and negatively affected. The effects of flood are directly proportional to its severity in terms of the duration of incoming flood water. It is determined by several factors, flood water depth and duration of water stagnation. Technologically advanced human beings have altered the plain area to a great extent which is just for their livelihood as well as for their comforts. Many of their activities are not in harmony with physical and natural landscape, particularly in terms of exit of surface water. Hindrances in free flow cause water to stagnate. It is generalized to the entire world, wherever there is more human encroachment in natural landscape with an area having more rainfall, flooding has become a challenging issue to manage. It is also more so, where the density of population is more. It is increasing more pressure on the area to fulfill the need of increasing people. North Bihar area of the Lower Gandak Plain is one of the heavily populated regions of the world. The torrential rain in plain as well as heavy downpour in its Himalayan catchment generates huge quantity of surface water in the monsoonal months. The Lower Gandak Plain is relatively very flat area and exit of huge water through its channel is not possible. Hence, flooding is a regular affair every year.

Due to flood; people, land and crops grown in the area is severely affected. The same can be seen from Table 1 from its columns II,III and IV. In general, intensity of flood has strong and positive correlation with effects on people, land and crops. Greater flood is associated with severity of impact on masses, land and field over which the crops are grown.

Villages, towns or settlements are affected by flood by way of hampering normal living conditions. It includes flood water surrounding settlements, cutting off their movements and obstructing transport of their products and needed items as well as displacing them completely from their place of stay. They face acute hardship in leading their life smoothly. From Table 1, it is obvious that data for many years is not available. It makes a hindrance in proper analysis of data, about which the authors have no control. But with the available data, it is quite evident that during 2001 to 2007, the impact of flood is excessive except two years (2005 and 2006). It is also very interesting but to note that large population affected by flood in 2007 (118.84 lakh). This period mentioned here is probably not very well coinciding with the other years of data. The authors are also surprised to find the excess number of people affected, land and crops due to flood in the study area. Except this period and 2016, none of the given periods are showing people affected more than 20 lakh. It is 14.5 lakh in 1998 (Figure 3 and Table 1). In rest of the years, it is a smaller number of people getting affected by flood.

The trend of effects of flood on land and cultivated crops remains the same. Primarily, area affected and damage of crops in the Lower Gandak Plain has a similar trend. When area affected is more by flood, damage to crops in the same area has to be high. Area affected signifies the zone over which the flood water is spread during high river flow. It is quite natural that the crops standing in those areas will also be affected adversely. In principle, crop damaged has to be less than the area over which flood water reaches. Crops damaged area cannot be more than the area of flooding. This general principle is observed except in three years – 1971, 1981 and 2013. In these years, flood affected cropped area is more than area affected by flood. Here, authors are handicapped as no proper explanation was made by data acquisitioning authority – GFCC and Department of Disaster Management, Bihar.

Figure 3: Effects of Flood on People, Land and Crops, Bihar



Damage to Houses

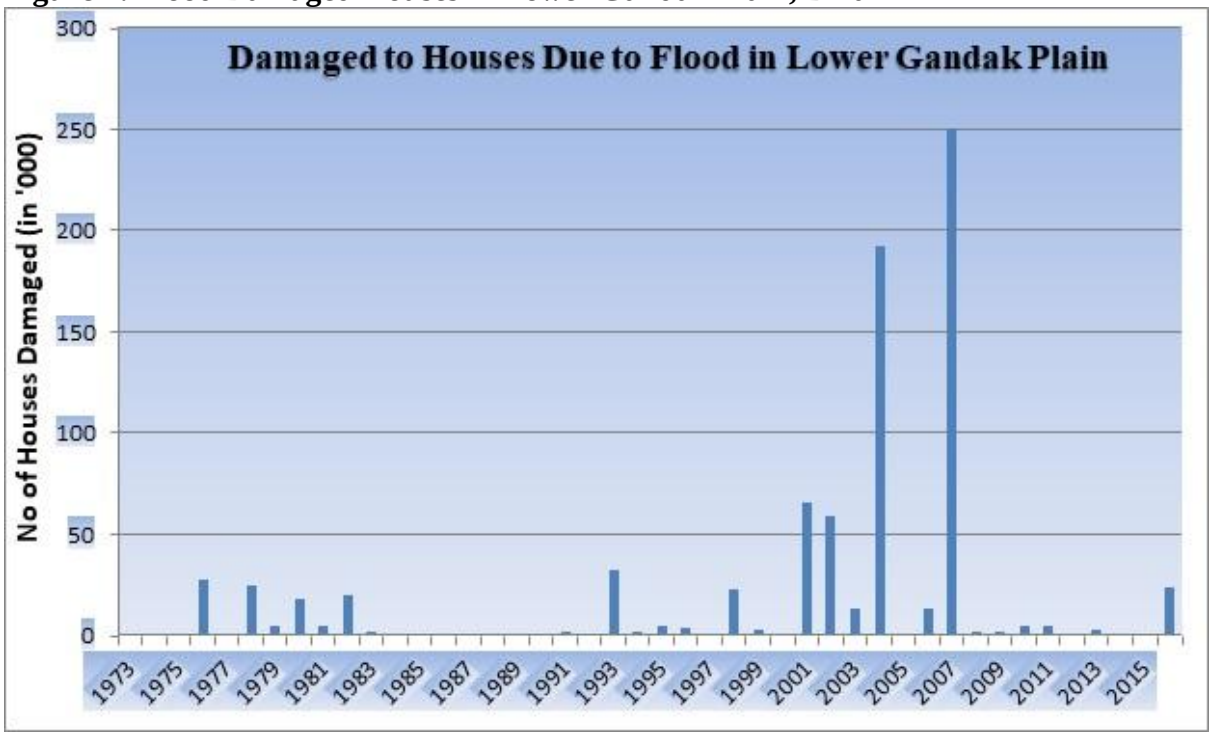
House is the basic need of the people and no proper life could be imagined without it. For survival, one needs to have food, cloth and shelter. After that only, someone could think of comfort. The flood in any area affects all the three basic requirements. In fact, flood makes the area hostile and it is not at all good for habitation. But people have no other options to choose. They are forced to live with flood. In due course, living condition is deteriorated and causes various types of hardships.

Economically poor people do not have sufficient resources to build better conditioned houses. In the Lower Gandak Plain, houses of poor people are made mainly of mud, thatched huts or even of bamboo shades. Most of the times, the houses are surrounded by the flood water on yearly basis or even it happens several times in a year during monsoon months. They are almost destroyed every year as they are not in opposition to stand in flood water. The weakening of foundation of the mud houses lead to its collapse. The poorer quality houses made of thatched huts are completely washed away. The destruction of houses is not only shelter-less condition for the people, but all articles lying in the house is also carried away by flood water. In other words, flood is a curse to them which snatches everything they have

collected with great efforts. The modern pucca houses made up of bricks, cement, iron rods and stone chips have better strength. They can, to some extent, bear the wrath of flood. But these sorts of houses are very less in the Lower Gandak Plain.

There is a big range of damaged houses in the area under study. For some years, data is not available. The data of damaged number of houses is available for a period of 41 years. The variation of damaged houses varies from a few in some years to more than 250000 houses in other year. The maximum number of houses destroyed is in 2007 and it is 250696 in number. The second maximum destroyed houses are in 2004 to a tune of 192469. Other years have a record of less than 65651 houses. On an average, annually the number of destroyed houses is 20171. The details of the same may be seen from Table 1 and Figure 4.

Figure 4: Flood Damaged Houses in Lower Gandak Plain, Bihar



Lives Lost: Human and Cattle

When flood is on and water is rushing swiftly, human beings are capsized into it. It becomes the cause of losing life for many people. Loss of life by flood is very scary as it is seen by others and help to concerned person is beyond the reach to the common people as their might is not capable to match with flood furry. Just in front of people, life is lost and no help is extended due to poor ability to fight the flood. Therefore, the government has established disaster management schemes at several levels starting from the national, state, district, block and panchayat as well as. Paramilitary forces are also deployed at several occasions when the situation becomes severe. In spite of all efforts taken, loss of life, so far, has not yet been eliminated. As long as excess water coming from upper catchment are not properly managed/ temporarily trapped, flood would be an affair of great concern. Therefore, it is a great tragedy for the family losing its member due to rising water and finally turning into hazard.

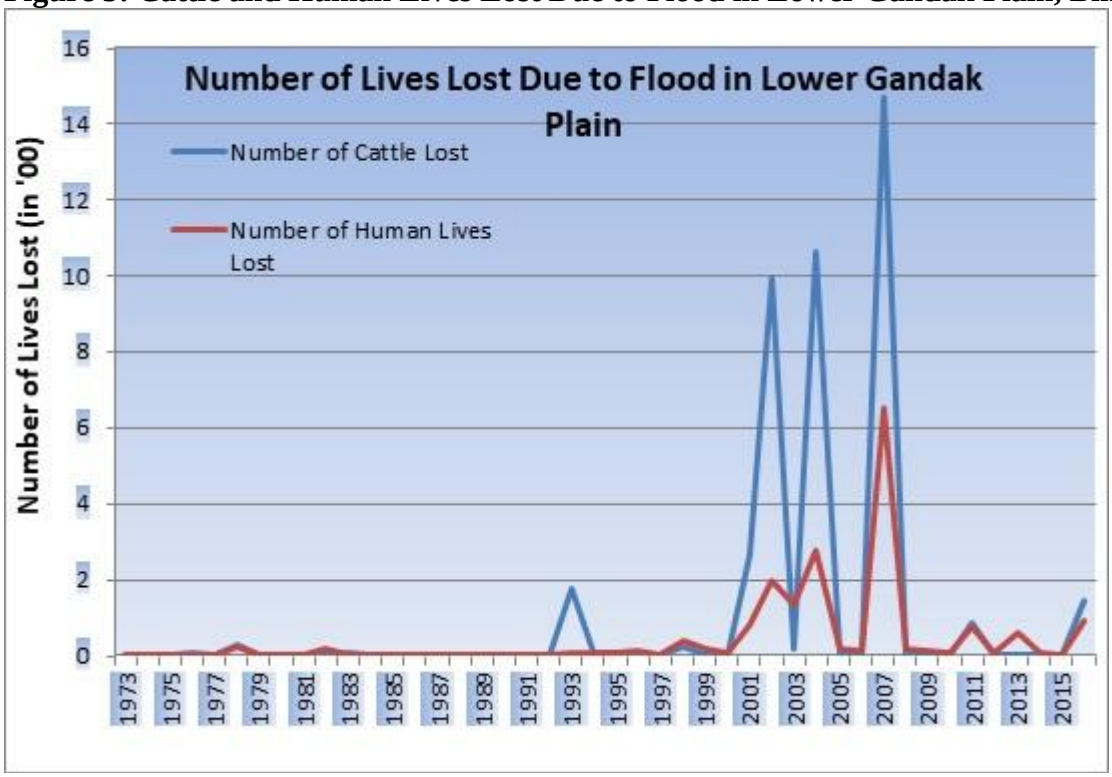
Human life is not only lost due to rushing water but also due to poor infrastructure of the society in general and concerned family in particular. Collapse of houses is also a concern leading to life loss. It happens due to poor economic conditions of the people as their houses

are not properly built. The collapses of houses are numerous. It is not only the life is lost but also brings economic hardship to them. It happens in a vicious cyclic poor becomes further poorer.

Flood shatters the economy as well the concerned area. Spread of mud and filth, dead animal unpotable water use and overall poor sanitary conditions cause health hazard in the affected area. The means of transport is also hampered seriously. People get ill and health is at risk. The patients are not able to reach to the hospitals. Even hospitals are also flooded. The patient treating places are not in a condition to treat them properly. Hence, ultimately, all these situations lead to loss of human lives. Poor sanitary condition is also responsible for unhygienic living. Ultimately, people get ill, and in many cases, it leads to death. It is an indirect impact of flood turning into hazard.

The maximum number of human lives lost during 2007 accounted for 651, while in it was 279, 195 and 132 lives in 2004, 2002 and 2003 respectively. In other years, the number of lives lost due to flood in the Lower Gandak Plain is less than 100 persons. If average of lost lives during the period of study (1968 to 2016) is calculated, it is 49 lives per year. In this period, 1844 people lost their lives. Out of (from 1968 to 2016) 49 years of period, life loss data is available for 38 years. So, the average is calculated dividing 1844 by 38 (Table 1 and Figure 5).

Figure 5: Cattle and Human Lives Lost Due to Flood in Lower Gandak Plain, Bihar



The same situation is also applicable to cattle and other domestic animals. Though, the term cattle is used here, it is implied all sorts of domesticated animals. Since this nomenclature is adopted by the disaster management department, hence, it is used here as well. Under this category, all domesticated animals like cow, ox, buffalo, goat etc. are counted. Poor health of the domesticated animals is also due to literally non-availability of fodder for them during flood period. Out of49 years of study period, during 2007 and 2004, death of animals is 1468 and 1060 respectively. The death of animals during 2002, 2001 and 1969 is 992, 266 and 231 respectively. The average animal's death is 154 per year. The details of the information are

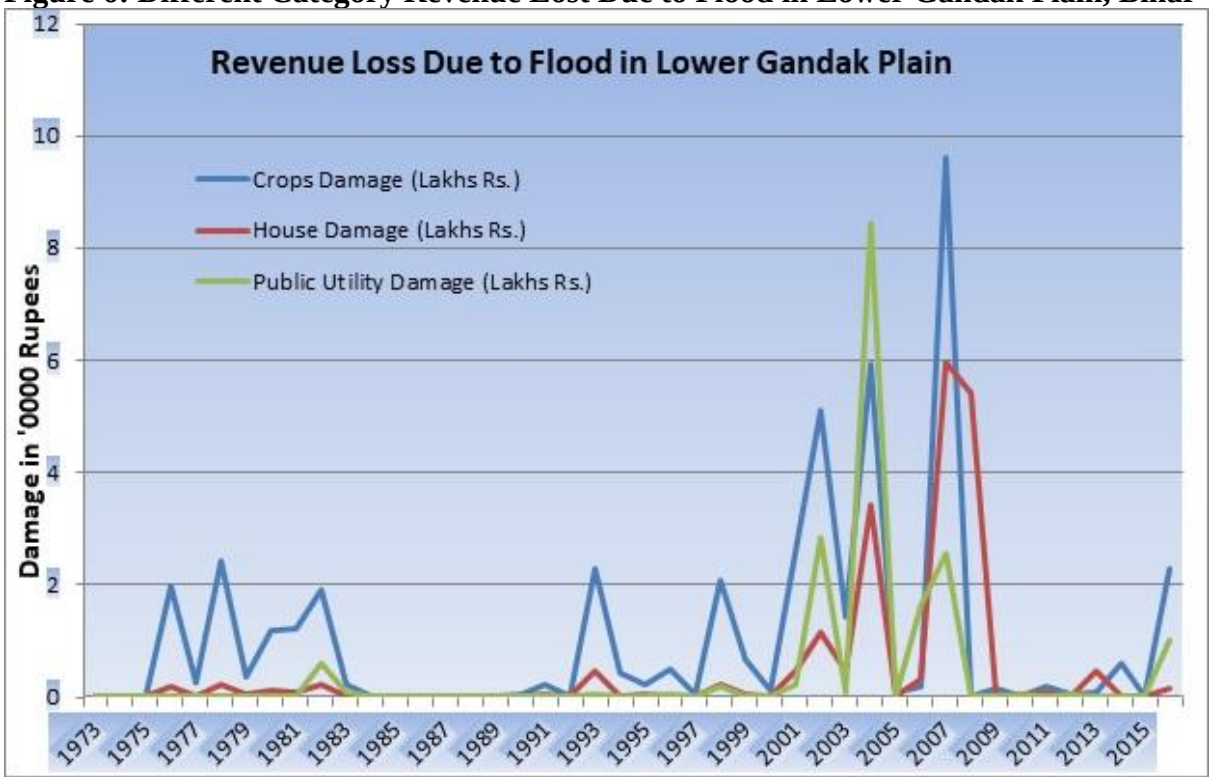
given in Table 1 and the same is diagrammatically presented in Figure 5.

Revenue Loss from Different Categories

Flood is one of the most severely affecting hazards recognized all over the globe. It impacts the society in multiple ways. Billions of dollars of damage are recorded in different parts particularly in heavy rainfall and snowmelt areas of the world. The data of flood damage recorded by disaster management department in Bihar can very easily be grouped into three. They are (i) crop damage, (ii) house damage and (iii) damage to public utilities. The damage to various aspects could very well be understood when they are converted into a comparable unit. Crop damage may be seen in many ways like – damage of different crops, loss of crop production, production unit may be different, rates of different products is diverse. Therefore, to understand crop damage, or to quantify it, one needs to convert the values of loss in monetary terms. It is also necessary to convert at a comparable price index. It has been done here, and its price is for the 2016. In other words, the value of loss during different years has been converted to 2016 price.

The crop loss is the highest during 2007 and it is equivalent to approximately Rs. 96015 lakhs at the price of 2016. It is followed by Rs. 59186 lakhs and Rs. 51051 lakhs in 2004 and 2002, respectively. There are five years when revenue loss is between approximately Rs. 26000 lakhs to Rs. 21000 lakhs. The plotted graph in Figure 6 vividly shows these facts. During six years (1976, 1982, 2003, 1981, 1980 and 1970), crop damage is less than Rs. 20000 lakhs but more than Rs. 11000 lakhs. For 13 years, loss varies between less than Rs. 7000 lakhs to more than Rs. 1000 lakhs. For rest of the years it is less than Rs. 1000 lakhs. The minimum loss is Rs. 2.8 lakhs during 1992 followed by Rs. 3.17 lakhs, Rs. 6.11 lakhs and Rs. 12.68 lakhs in 1973, 1975 and 1974, respectively at 2016 price. The crop damage data is available for 41 years. During these years, the total crop damage in the Lower Gandak Plain is to the tune of Rs. 457981.6 lakhs and its average is Rs. 11170.28 lakhs per year at 2016 price (Table1 and Figure 6).

Figure 6: Different Category Revenue Lost Due to Flood in Lower Gandak Plain, Bihar



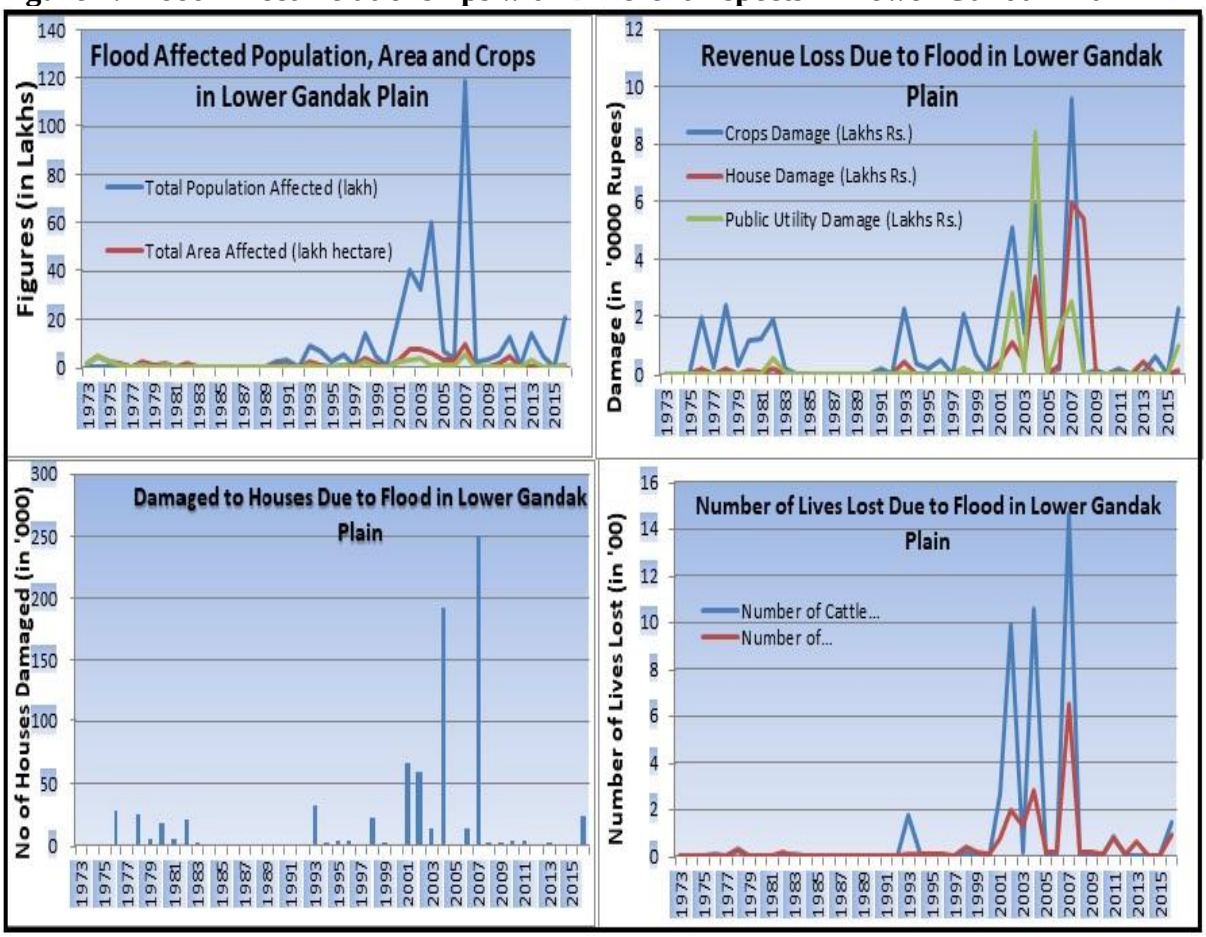
Severity of loss is directly proportional to the intensity of flooding. Therefore, theoretically speaking, there has to be very good correlation between flood and types of damages with slight degree of variations due to some local synoptic conditions prevailing to that certain years. The damage to houses is very highly seems to be related with that of damages occurred with crop loss. Therefore, there is almost similar trend of damage to some extent. The maximum number of houses was damaged during 2007 accounting to a total revenue loss of Rs. 59579 lakhs followed by Rs. 54125 lakhs, Rs. 34087 lakhs and Rs. 11474 lakhs in 2008, 2004 and 2002, respectively. During other remaining years, it is less than Rs. 5000 lakhs. The minimum damage is recorded in 1973 which is only Rs. 4.6 lakhs and Rs. 6.6 lakhs in 2014 and 1975, respectively. During 12 years of study, yearly damage varies from more than Rs. 134 lakhs to less than Rs. 740 lakhs (Table 1 and Figure 6). The total damage to houses is Rs. 196819.2 lakhs in 41 years of study. Its average is worked out which is equal to Rs. 4800.47 lakhs per year in the Lower Gandak Plain.

The flood damage under the head – public utility damage includes all types of infrastructures developed by government or public sector. It could be roads, railways, bridges, embankments, means of communications, public/ government buildings, schools, hospitals, panchayat buildings, common places and utilities etc. They are primarily common set-ups and arrangements which facilitate the people in every walk of life. As per the recorded data available with authors, the highest damage is Rs. 84326 lakhs during 2007 followed by Rs. 28242 lakhs, Rs. 25513 lakhs, Rs. 16316 lakhs and 10094 lakhs in 2002, 2007, 2006 and 2016, respectively. During next four years, revenue loss is between Rs. 1700 lakhs to Rs. 5900 lakhs. Further next, annual damage amount varies between Rs. 100 lakhs to Rs. 900 lakhs. The minimum damage is as low as Rs. one lakh in 1997 followed by Rs. 2.49 lakhs, Rs. 4.4 lakhs and Rs.6.6 lakhs during 1994, 1973 and 1975, respectively (Table 1 and Figure 6). The total revenue loss is to a tune of Rs 178050 lakhs in 33 years of record period. It works out to be an annual average revenue loss is 5395.47 lakhs per year. All the figures mentioned in the above paragraphs are referring to the converted price of 2016 and not of the year against which it is mentioned.

Relationships of Flood Effect

The above discussed four sub-headings and their presentation on a single illustration very clearly shows the interrelations among them (Figure 7). The effects of flood on all the components have a very high correlation. The maximum damage is recorded during 2007 in every component under study in comparison to any year, but population was most affected in 2004. Theoretically, it should have been associated with 2007, but it is not the case. Since, it is secondary data collected from the Department of Disaster Management Authority; it has been put as it was collected. The authors tried to get the clarification from original source of data collection, but answer was not satisfactorily given. It is the limitation of the data where the researcher is handicapped. It is the case not only for the just one year but for other 15 years as well when the people affected number is higher than 2007. Apart from the population affected, all other data is higher with respect to 2007 again except damage to public utility during 2004 and 2002. During 2004 and 2002, public utility damage is bigger than 2007. All other components are almost in congruence with the intensity of effect of floods with marginal variations. These variations are based on the reporting. All of them are showing at 2016 price index as it was mentioned earlier as well.

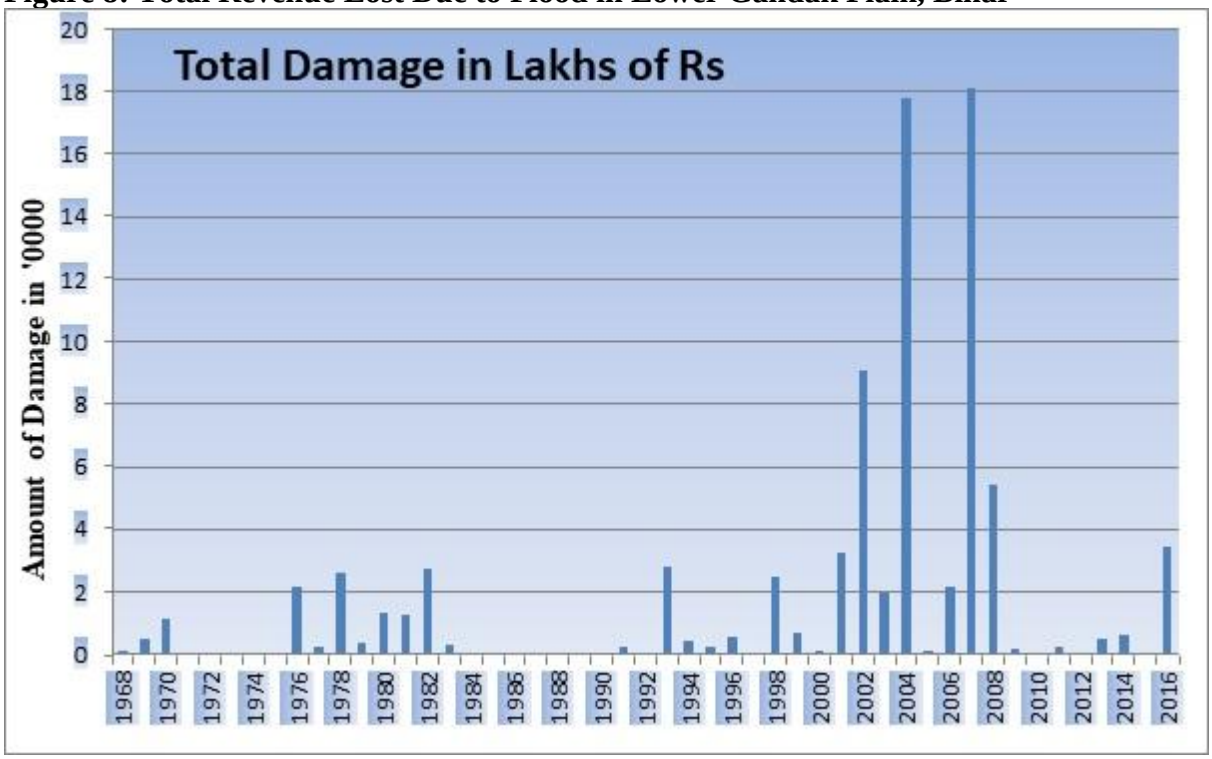
Figure 7: Flood Effect Relationships with Different Aspects in Lower Gandak Plain



Total Revenue Loss

Total revenue loss from the Lower Gandak Plain is presented in the last column of Table 1. It is the addition of (i) crop damage, (ii) house damage and (iii) public utilities damage given in columns V, VII and X of the table. They are plotted and shown through Figure 8. The maximum loss is accounted in 2007 and it is to a tune of Rs. 181107.4 lakhs. It is followed by Rs. 177599.8 lakhs, Rs. 90766.72, lakhs and Rs. 54343.32 lakhs in 2004, 2002 and 2008, respectively. These three years are showing very excessive revenue loss. Other years are showing moderate loss. During 11 years of recorded data, the total revenue loss varies between more than Rs. 11000 lakhs to less than Rs 35000 lakhs. During six recorded years, it is between more than Rs. 250 lakhs to less than Rs. 911 lakhs. The lowest total revenue loss is Rs. 11.97 lakhs in 1973 followed by Rs. 19.31 lakhs, RS. 27.98 lakhs and Rs 38.04 lakhs in 1975, 1972 and 1974, respectively. For majority of recorded years, data is available under all the three categories namely crop damage, house damage and public utility damage. There are eight years when public utility damage data is not available. For other two categories, data is uniformly available for 41 years. When we assume that there was no damage during data none available years, the average total revenue loss is Rs. 20313.44 lakhs per year. The data related to public utility damage is available only for 33 years. If the mean is calculated based on those 33 years, it works out to be Rs. 23230.79 lakhs per year.

Figure 8: Total Revenue Lost Due to Flood in Lower Gandak Plain, Bihar



CONCLUSIONS

Flooding in the plain is more of a curse than boon for the people. River/ running water as an agent of exogenic force creates numerous micro to macro landforms along its course and in the area of its influence. It is said to be a force which lowers the elevated landmass and elevates the low laying areas. Hence, it is known as grading agent. In the process of gradation, high discharge performs bigger work than the low flow. Therefore, impacts of flood are varying in nature. Though every creature and biotic life in the flood affected area is endangered, hue and cry of human beings are more loudly heard. This article described the study of flood impact in the Lower Gandak River Basin. As per the available data for analysis, collected by Ganga Flood Control Commission (GFCC) and Department of Disaster Management both located at Patna, the analytical study is grouped into four – (i) affected people, land and Crops, (ii) damage to houses, (iii) lives lost: human and cattle and (iv) total loss of Revenue. All these aspects are duly dealt and elaborated upon. It is quite obvious that the hardest hit by flood is human beings and their severity is associated with the intensity and duration of flooding which itself is the function of several factors. A word of caution is that if we live with nature, we will face less severity of natural wrath but when we try to overpower the nature, one day nature will overpower us and, on that day, we will not have any option left.

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