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FLOOD HAZARDS IN BURHI GANDAK BASIN IN NORTH BIHAR AND REMEDIAL MEASURES : A GEOGRAPHICAL STUDY

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Abstract :

Drainage system of the region clearly indicates that it has a dense network of the rivers and its tributaries. Since the river beds have been raised above the flood plain by depositing vast amount of silts and they flow as elevated channels and they are bound to overtop their both-side banks. The slope of the region produces turbulence and enables the streams to discharge heavily in the region. The shallow but narrow courses of the river fail to cope with the overwhelming value of water rushing down and therefore, turn into devastating flood after crossing theriver-banks andcreating a submerged scenario far and wide in the region. The Geography of the earth has, time and again, been altered byfloods andchanging courses of major rivers systems. However, damage due to floods has tended to increase with rolling time by varitue of human interference by man is natural process and encroachment of flood plain zones and even river beds by them". It means that floods are the important part and parcel of water resource management. But recently, floods are seen as one of the worst consequences of the mismanagement of water resources through the introductionof dams and embankment culture.

Key Words : Encrochment, Consequent, Discharge, alluvial belt, spilling.

Geographical Personality :

The whole of Burhi Gandak Basin except of few pockets is prone to annual flood. Running water on theplain with gentle slope spreads in a tremendous area of the region. The heavy monsoonal rain in the command area of Burhi Gandak Basin poses the problems to the standing crops as well as humanity The flood from the backflow of Ganga River in Khagaria and Begusarai district is a burning example of the influence of site and situation in the region. Through flood leaving a few dry point along the rivers, is a common phenomena in the region which is more frequent as well as more distastrous in the study region,. The region under

study has immense water resources which are contributed by a network of rivers such as the Masan, Sikrahna, Ban Ganga, Baya Burhi Gandak and others. Burthi Gandak River and itstributaries carry most of their discharges during thesourth-west monosoon period, when heavy rainfall occurs in the region. In the upper reaches where the several channels of the river are on the mountainous terrain, there is generally no overflow of the banks during high discharges and problems is confined to bank erosion only. In the lower reaches, especially, where the country under references is flat, the rivers swell several times over and overflow their banks and cause inundation in low lying lands and often submerge the standing crops, property and disrupt all sorts of communications. In many places, inundation is caused due to delay in the discharge of the rain water and situation further becomes worse if there continuous heavy rainfall in the areas. The heavy sediment the rivers to carry the flood discharge, which ultimately results in overtopping of the banks and inundating the adjoining " areas." In such situations, new spillchannels are formed causing immense damage to the neighboring areas. As a matter of fact, a number of important towns and habitations situated on the flood area of Burhi Gandak catchment areas are suffering bitterly. For example- Motihari, Turkaulia, Harsidih, Pakridayal, Mehsi, Mohammadpur, Kanti, Mushari, Dholi, Pusa, Bibhutipur etc. Hajipur on the delta of the Gandak, Khagaria on the delta of the Burhi Gandak, and Darbhanga is situated on the delta of the Adhara group of rivers. Thus, these towns suffer from the problem of flood very measures for their safety and future growth embankment, has, thus, been taken as the most formidable resort of it.

Aims and Objectives :

The main objectives of the present research paper are as follows:

(1) To describe the flood scenario in Burhi Gandak basin.

(2) To find out the responsible factors for the flood hazards in the region.

(3) To analyse the natural responsible causes as well as anthropogenic factors.

(4) To find out the suggestive measures.

Methods applied :

The methods in the present research paper include the intensive study of Govt. reports published by the Govt. of Bihar. Demarcation of flood area or flood zonation in the Burhi Gandak basin by NATMO Atlas was studied deeply. Field visits as per need were regularly performed. People in the study area were interviewed. They were given questionnaire format

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and schedule format to fill up. The river embankments were keenly observed along with a of research scholars. The suggestions given by the persons in the study area particularly interviewee persons along with the accompanying research scholars were collected and analysed in the form of the present research paper.

Geographical Expansion :

The flood problem in the study area has unique characteristics. It is a playground of Burhi Gandak, Bagmati, Baya and their tributaries particularly in the alluvial belt. Another peculiar feature of the rivers in the area under study is that all of them originate in the hills of the Himalayas or its adjoining parts and reach the study region. All of these are perennial in nature hence no viable food management scheme in this part alone will be of immense help in the long run unless efforts are made to device effectgive system of flood management in region also. Before explaining the causes of floods, it is essential to have a brid's eye view of the foodprone areas.

DISTRICT0WISE FLOOD COVERAGE IN BURHI GANDAK BASIN

S.N.	District	Flood Affected area in km2	% age to the total coverage	Pop. Often affected by flood, 2011	% age to the total pop. coverage
1	W. Champaran	2250.85	17.53	1777801	12.79
2	E. Champaran	2275.62	17.73	2302171	16.56
3	Muzaffarpur	1628.15	12.68	2170075	15.61
4	Samastipur	1215.35	9.47	18725320	13.13
5	Begusarai	763.97	5.95	886294	6.38
6	Khagaria	1098.19	8.55	1019137	7.33
7	Sitamarhi	952.08	7.42	1248618	8.98
8	Sheohar	442.99	3.45	515961.00	3.71
9	Vaishali	1985.16	15.46	1895324	13.64
10	Darbhanga	22.80	1.76	259166	1.86
	Total	**12838.16**	**100.00**	**13899867**	**100.00**

Note : The data is the average of 2008-09, 2009-10 and 2010-11

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The figures of the flood prone areas of Burhi Gangak, the Bagmati, and the Baya etc. are subject to revision. The figures provided the Govt. of Bihar WRD and the Commission do not tally. Thus the region occupies overwhelming position so far flood-prone areas are concerned. As per the state of India's Environment[3] quoted by centre for science and environment more flood prone area is confined in North Bihar and of total damage caused byfloods Bihar's share exceeds 27% in the light of Indiaas a whole. The table-mentioned above clearly expresses that the total flood coverage area in Burhi Gandak basin in 12200.29 sq. km. Burhi Gandak river passes through thedistricts of Purbi Champaran and Paschimi Champaran, Muzaffarpur, Samastipur, Begusarai and Khagaria while the district of Sitamarhi, Sheohar, Vaishali and Darbhanga come under flood coverage of allied rivers like Bagmati and Baya along with tributaries. Purbi Champaran and Paschimi Champaran become the biggest victims of flood during 2008-09. The above mentioned table shows that 18.65% area of Purbi Champaran, 18.45% area of Paschimi Champaran, 13.35% area of Mu2affarpur and 11.04% area of Vaishali districts was the worst sufferer of the flood. 9.96% area of Samastipur district, 9% area of Khagaria district, 7.80% area of Sitamarhi district and 6.26% area of Begusarai district were covered under flood. Only 1.85% and 3.63% area remained under flood water in Darbhanga and Sheohar districts respectively.

So far as people are concerned, Purbi Champaran (16.56), Muzaffarpur (15.61%). Vaishali (13.64%), Samastipur (13.13%) and Paschimi Champaran (12.79%) districts are the vital sufferers in the flood. Sitamarhi district (8.98%), Khagaria district (7.33%) and Begusarai district (6.38%) are the second major sufferer of the flood. In context to the people, Darbhanga district (1.86%) and Sheohar district (3.71%) are the least sufferers during the flood disaster.

Natural Factors affecting flood :

The region under study is one of the most pronounced flood affected zones of Bihar. There are several factors which are responsible for the flood menace. Important factors in summarised form may precisely be discussed here. Before the advent of the concept related to embankment protection measure, floods have been considered as the natural outcome of S.W. monsoon. But its magnitude remained low and its duration was also of short-period. Hence, damage was not so much. But now the landscape has completely been changed. Human factors have become a vital factor in determining the arrival of floods. Even experts'

concerned views of floods are as the consequences of environmental degradation caused by human follies[4].

An interesting case study on the topic "Damage and control in Asia and the East" shows that the necessity for flood control has been in existence since time immemorial in the whole of Asia and the far East. The major section of the population is dependent upon agriculture. The formation of crop suitable fertile alluvium along both sides the river valley is possible only with the help of flood occurrence even yet, the people in the area continuously face the flood disaster continuously consequently always think about protection from floods. So floods have multidimensional causes[2].

The term flood is somewhat ambiguous. Generally, it denotes both the discharges of river under condition of excessive rainfall and the inundation in. the low lying land which may result from it. It is virtually a special case of local effect produced when the capacity the river channel at any point is inadequate to carry off the abnormal quantity of water from heavy rainfall causing the river to overflow and inundate the surrounding low lying area. According to International Commission on Irrigation and drainage[3] (IC1D) Flood is defined as a relatively high flow or stage in a river markedly higher than the usual and also the inundation of low land due to which result may appear. A body of water rising swelling and overflowing land not usually thus covered is generally known as flood.

When such heavy rainfall takes place there is usually heavy influx of water into the rivulets and streams. They cause high and sudden spate especially in the rivulet with heavy concentration of silt. Usually, it is observed that some of the dormant streams suddenly revive under such heavy- spell of rains. The rain fed rivers along with their important tributaries are such dormant rivers of the region which is turned into sudden spot of disastrous floods. Fields of forests have been devastated by them. It is now an accomplished fact that the natural vegetative cover protects the land surface from the erosive attack of rains and winds. This has taken place as follows:

(a) The vegetation reduces the volume of precipitation by direct dispersion and evaporation of rain drops falling on leaves and foliage.

(b) It protects the soils from violent impact of rain drops which tends to loosen the soil particles.

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(c) It increases the friction with the flow of run-off thereby reducing the volume and the velocity of surface run off and lengthening the time of concentration of rainfall with consequent in soil loss.

(d) The knitting and binding effects of the intricate root system make the soil moreresistant to erosion.

(e) Decay of penetrating root-system leaves tubular cavities promoting infiltration race the rabbi reducing off flowage.

(f) Transportation through the tisanes and leaves of vast quantity of moisture fromsub-soil layers.

(g) Abundant supply of organic matter leaf-fall and litter improves soil structure thereby increasing the absorptive capacity of soil and reducing the surfacerun-off. The combined effect of all these phenomena is reflected in the verysmall volume and velocity of run-off and a very insignificant amount of soil loss resulting from a given amount of rainfall in a forested area.

Destruction and overgrazing of pastures, practices of shifting cultivation, faulty methods of cultivation, nature of crops grown and economic and social factors combined together also affect the rate of soil erosion. Spilling of rivers over natural banks and the rising of the river beds, the destruction of the forests in the upper catchment areas of the streams and its tributaries caused rapid run-off and erosion leading to the accumulation of increasing mass of debris on river bed, Consequently spilling of river over the nature banks and rising of the record bed takes place.

The Burhi Gandak, Bagmati and the Masan rivers can be cited as its best examples. U.P.Flood[4] commission has submitted in its report it's quoted here. The increasing severity and frequency of floods in recent years in the region is particularly due to man's invasion on the cradle of streams and trees. The removal of soil-cover of the whole valley by erosion has led to the silting up of the river bed and the meandering river-courses. The swamping has also forced on exceedingly heavy run-off. Deforestation and human interference with the behaviour of the rivers are root causes of the spelling and rising up of the river beds.

Inadequate Drainage Arrangements :

This factor is assuming alarming proposition day by day. The region under consideration is a region of monotonously flat land surface with normal slope. The

gradient is extremely gentle. In hydrological terminology, such situation is known as unfavorable land slope. This sort of land slope results in inadequate draining to carry away surface run-off due to heavy rain and overflowing of the river banks with desired quickness.

This factor[5] is considered as a case of drainage congestion and therefore termed drainage problem in which there becomes stagnation of water behind embankments due to insufficient capacity of drainage sluices.

Water accumulation on the surface is usually the result of heavy precipitation or overbank spill combined with deficiency of drainage capacity. Sometimes such situations also arise on the countryside of the embankments as stated above, when the water stage in the main river is high and the accumulated water is unable to drain off into the river till a lower river stage is reached. Dr D. Jha[6] has opined about the effect of Triveni Canal with such an acute drainage congestion in the basin course during his investigation. Such congestion can also occur due to existence of numerous depressions known as "Manus". 'Chaurs' and the old abandoned courses of the river. This can also result as seepage from canals, tanks, earthen embankments and sub-soil flow from higher ground. Apart from this, sub-soil drainage congestion due to rise of sub- surface water on account of irrigation and percolation from other source may also create sub-soil drainage congestion in the crop root-zone and ultimately creating salinity of the soil and rendering land unfit for cultivation. B.G. Pattegar[7] studied the deltas of the Mahanadi, the Godavari, the Cauvery and the Krishna and his conclusion was that inadequate drainage was responsible for regular floods in the coastal plains of Andhra and Tamilnadu. Due to hindrances in its natural flow water remains stagnant and creates the scene of floods even after the receding not water level to or below the brim. As progress is to be made due to mushrooming population floods have now become a permanent feature for the region under study.

Evils of Embankment :

The spirit behind the construction of embankment was to safeguard the populace from the deluge of floods. It has been in practices since long time as the most economical method of protection virtually in every country of the world. In china the great levee system on the yellow river appears to have been started before the 7th century B.C. The Po river in Italy has an early record of embankments which have successfully served their purposes.[8] In the study

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area extensive embankments have been made along the Gandak the Burhi Gandak the Bagmati the Kosi and Kamla Blan and several others.

Despite their long history and widespread use these have converted into an inviter of deluge of floods. Because they act against the natural flow of water. They further reduce the natural storage for flood waters both by preventing water from spilling on to much of the flood plain and by stopping bank storage in cases where impermeable flood walls are used whenever excess pool of water accumulates. It over tops them and flood the locality. Sometimes these become prey to breaches and bring untold miseries. In that case they drown millions of hectares of rich fields Embankments created for irrigation and power reservoirs become the agent of siltation of reservoirs often panic discharges from these reservoirs have led to the destructive flash floods in the valleys downstream. The flash of 1987 and 1994 of North Bihar was the resultant of the panic discharges from reservoirs in Nepal.

But no concrete observation can be made regarding the embankments either as a protector or destroyer. Every time any disastrous breaches occurred following very high flood opinion sharply goes against construction of them later to gradually year round in their favour with dimming memories of disasters and losses which have resulted from failure of embankments. In 1937, a conference was held at Patna to consider the flood situation in North Bihar with particular reference to the river Burhi Gandak. At this deliberation Captain Yall, the then chief Engineer, Bihar made a strong plea against embankments and suggested that the existing embankments in North Bihar which had caused a deplorable flood situation by impending the free flow of flood water should be dismantled as far as possible. B.B. Bohr of the National Committee of Environmental planning negated the importance of embankments as flood control measures. Besides these inadequate capacity of water ways in roads and railway bridges and lack of drainage arrangements at the crossing of two roads and railways roads and canals and canals and drainage channel/river etc. are also responsible for floods' as they obstruct the free spread of overtopped water. Thus, it can be concluded that floods are caused by the mutual combination of many factors which either act in isolation or in unison.

The Burhi Gandak Basin :

The catchment area[10] of the Burhi Gandak is 12.021 sq km. put or which 2420 sq. km, of the hilly catchment lies in Nepal and the rest 9601 sq, lies in Bihar. The Burhi Gandak

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river basin is bounded by the Someshwar range of hills in north Bagmati basin in the east. The Gandak river basin in the wet and the main Ganga stem in the south. The river bed slope in the hilly and foothill region in Nepal is very steep and is of the order of about 2 m. per km, to 5m. Per km. and is fiat in the plains of Bihar. The river system of the Burhi Gandak originating from the Someshwar range of hills has played a major role in building up the land formation of this basin. The sediment brought by the system formed inland deltas where the sleep slope of Terai converged into the flat along of the plains. This resulted in the meanderinc and braiding tendencies in the river leading to shifting of courses. Such" changes in the river courses and avulsions and cut-offs of the meander loops formed local depressions.

The Burhi Gandak river basin has numerous locally known as Chaurs. The southern portion of the basin however is fairly level and without much undulation. The average annual rainfall in the basin is 1283 mm, and varies from 1041 mm, in the lower catchment to 1569 mm in the upper catchment. During monsoon period due to heavy rainfall in catchment of the Sikrahana River as it is* known in the upper reaches spilling over the banks cause inundation in the area. Flood in the main stream also occurs due to floods in the tributaries.

The flood situation in the area further aggravates due to inadequate waterway provided in the some of the bridges culverts in the roads and railway falling in this basin. The areas generally affected by the floods in the Paschimi Champaran are the areas around Ramnagar, Narkatiyaganj, Mainatanr and Champaran etc. and Sugauli. Semra, Motihari, and Lalbagia Ghat etc. in the Purbi Champaran, Motihari town is frequently affected due to the spill of the Sikarahana River. Flood in the basin also occurs due to spilling of the tributaries and streams.

Hydrology of flood producing rivers :

The normal annual rainfall in the basin lying in North Bihar is about 1311mm. Generally, monsoon starts in the basin from 15th June and lasts till 15th October. The monsoon gives about 83% of the total rainfall of year. July and August are the peak period of flood. The Sikrahna which is fed by a number of hil torrents namely the Masan the alone I responsible for about 30% of tota discharge of Burhi Gandak. Th maximum discharge of the Masan river water during 2008 was observed a 359.6 and 951.5 cusecs at Chanpati and Rosera respectively. Meanwhile th minimum discharge was witnessed as 8.6 and 23.6 cusecs at Chanpatia an Rosera respectively. In this context, the statement which shows the average

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maximum and minimum discharge during the period 2008-2010 at the different sites of the river Burhi Gandak and its tributary like Masan.

From the above table it is clear that the maximum discharge at Chanpatia comes to about 1467 cusecs in 2000. During 2001-2010 is constantly declining without any break. This fact may be proved with the index numbers of maximum water discharge during 2000-2010 index number goes down to 36.81% in 2001 from the base year 2000. Henceforth, it remained constant up to 2004 with slight fluctuations. But in 2005, it declines to only 13% from base year 2000. The main reason of this declining trend is nature of rainfall in the catchment areas. The index number of minimum discharge of water declined to 9.2% in 2003 assuming the base year 2000. There have been wide variations of index numbers during 2000 to 2004 and there after it has been steady. The Burhi Gandak[11] is known for its clear water. The hilly catchment is only 2130 sq. kms. out of the entire catchment of 12,500 sq. kms. Consequently, the silt content by the river is not as much as compared to other river system of North Bihar.

Other Natural Factors Affecting Floods :

Floods are normally caused by the heavy downpours during relatively short periods and absence of a quick run off. But flood may also result from other physical causes such as due to soil erosion landslides earthquakes and changes in the courses of the rivers. Landslide blocks a stream and a temporary lake is formed. But after some time on account of the pressure of the water it bursts suddenly and causes floods. Sometimes floods are also caused as an after effect of an earthquake. At the time of earthquakes huge quantity of water and sand gush out of earth fissures or cracks and inundate the affected area and cause submergence of roads rails and settlement. They also create change of levels resulting into changes in the courses of rivers which result into floods either immediately or in the following rainy season.

Soil Erosion and Flood :

Soil Erosion is both the cause and effect of floods. Among the various physical causes of floods soil erosion is one of the most important. Soil erosion is the wearing a way of rocks and the wearing a way of soil by wind and water. (Junior Science Digest. 1980). In fact, soil erosion will take place on the surface where the force provided by the flow exceeds the resistance of the soil (Leopold L.B1964, p.358). Floods are caused by soil erosion when the channels of the rivers are blocked by the deposition of the eroded soli in the bed of the rivers and obstruct the flow of excess water during periods of heavy discharge in the rainy season.

As a result excess water is spilled over its banks and submerges the adjoining areas and cause floods- In the catchment area of the rivers soil erosion is in many places a serious menace. The rapidity with which development has occurred has often led to the employment of agricultural methods conducive to erosion and in consequence a large tact of the region the silt blocks the courses of the big rivers and produce floods. Although soil erosion does not take place on very large scale but soil erosion in the limited catchment areas in the Himalayas has a great influence on the magnitude of floods in the study region. Mechanical disintegration is seen in the large magnitude in this region. Again, the period of high temperature also coincides with the period of high precipitation. These factors combine to produce the maximum disintegration and erosion of the rock. Furthermore the rocks of the Siwalik and Someshwar range are also very liable to be eroded. As a result of excessive sediment load due to soil erosion the river channels may be blocked in the lower part of the basin. An idea of the magnitude of silting in the region can be gained from the data of sediment load of Burhi Gandak, The total annual amount of sediment 56% is about 100.000 acre-feet. This refers only to the sediment in suspension while that rolled down along the bed is probably 15% to 20% of the suspended load. Now the ratio of approximate discharge of water of the Burhi Gandak represented by the major streams in 8:7226. Thus if the sediment discharge of the Burhi Gandak is 1 lakh acre-feet it is about 6 lakhs acre-feet or roughly speaking I million acre-feet. This results in overflowing flood.

Sediment yield or one of its many variants is most widely used[1]. It expresses in tons/km/per annum (or similar unit) the removal of sediment from drainage basins. It may be used on measurements of river load being discharged past a measuring point or upon the amount of sediment which has accumulated in reservoir. Because bed load and dissolved load in river are rarely measured many estimates of flowing water. Unfortunately the data relating to erosion rates are often not comparable because so many different techniques have been used. Another problem is that in order to obtain reasonable averages data are required for long periods and this requirement is often not satisfied28.

Flooding may also result from soil erosion indirectly due to a change in the course of the rivers caused by the choking of river channels.

Landslides & Floods :

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Landslide is another most important physical cause of flood in this region. Although landslide does not occur in the study region but they do occur in the catchment of the rivers of the region mostly falling in the Nepalese territory. The word landslide means the downward movement of a large mass of earth or rocks a mountain or cliff. Landslide denotes also the mass movement of lubricated rock debris on hill slopes under the influence of gravity. They are mud flows of finer and coarse debris rock of glaciers consisting of angular boulders and snow avalanches. Sometimes a portion of the hillside slips into the valley of a river causing a temporary dam of the river. When the water in the temporary reservoir overcomes natural dam washing the artificial dam an unprecedented flood is experienced by the people in the plains. Such situations do occur in the valley of the rivers of region.

Slump is a movement of rook for short distance. Frequently slumping takes place as small independent units. It increases the sediment load of a river, Slump mass has a number of step like terraces. Generally slumping takes place In the hilly region. The term 'debris fall is used to denote free fall of earth debris from a vertical or over hanging face. This type of landslide is generally found on the steep river banks undercut by rivers. Rock slides are "masse sliding or slipping along bedding joints or fault surfaces3. Rock fall consists of free falling or rock blocks over any steep slopes. Creep is downward movement of soil or rock debris.

Earthquakes & floods :

Earthquake is another factor that indirectly responsible for floods. It affects floods in many ways.

(i) By permanent changes in drainage.

(ii) By changing the level of the surface.

(iii) By raising the bed of the rivers.

(iv) By the emission of sand & water.

(v) By the formation of the fissure.

North Bihar falls within a very sensitive seismic zone. Within the recent past, the following earthquakes were in memory and they were of 1803. 1833, 1897 and 1934 and 1988. Records of the former three are not available but latter are under the record.

Changes of Level in North Bihar :

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A severe earthquake of high intensity occurred on the 15th January 1934 a 2.14 p.m the effect of which lay between Madhubani and Motihari Earthquakes may cause floods by changing level of land. Shortly after the 1934 earthquake the survey of India, the govt. undertook the proper step about two lines in North Bihar. (1) Bagaha- Motihari, Muzaffarpur-Darbhanga, Purnea and (11) Bagaha - Raxaul-Sitamarhi- Darbhanga. The result of these surveys were published in the Geodetic Reports for 1934 (p. 24) 1935 (p. 11) and 1935 (p.93) (memoirs G.S.I Vol. 73, p.40) In the Geodetic report for 1934 p.25 it is stated.The circuit Bagaha Motihari-Darbhanga Sitamarhi had a closing 1.0 to 1.5 error of 0.696 ft. Which has been adjusted? The table shows the accuracy of the levelling which may be due to earthquake or to a slow rise at Bagaha. During the 60 years since the old line was levelled.

Raising the bed of the river :

As a result of this earthquake many rivers of North Bihar plain showed rise in their water level during the earthquake. The observations of Sir J. Williamson, Agent of the Bengal and North Western railway of the effects of earthquake on the rivers described. According to him the river banks were further lashed by huge waves a planter who happened to be standing on the banks of the Burhi Gandak at Muzaffarpur. This was corroborated by broken down sand banks and diara lands.

He further gave account of an eye witness. "The scene on the river was frightful. In a few second the level of the river had raised again bind it spread from bank to bank (Ibid.p.43). This caused heavy inundation in the entire area. In conformity with the general rise in the ground water level throughout North plain due to earthquake and as a consequence water level also raised throughout North Bihar. This was especially noticed in the Burhi Gandak River where the level of the water was found to be 3 or 4 feet above the normal height while in the Ganga water was deeper by 26" between Colgong and Goalundo.

Earthquake causing changes in the course of the rivers :

Not only were this some changes in permanent river courses also observed. After the earthquake the river Bagmati adopted new course north of Muzaffarpur in the following rainy season and in succeeding period till 1939. The earthquake had badly damaged the level bank along the river the current immediately took advantage of this breach and swept away a large section of the embankment and it became obvious that during the succeeding monsoon the stream would add still further to this lateral erosion.

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Artificial factors : Role of Human Interference on Floods :

The incidence of floods and the magnitude of damages caused by them, have been attributed increasing day by I day. These tragedies cannot solely be to nature's vagaries but they arise out of man's inadvertent hand work. The floods are getting aggravated and more destructive than their previous records in spite of our technological advancement and application of flood control measures. Apart from the physical causes of floods man is also to a great extent responsible for floods. Because he is a voracious creature and always trying to alter the nature for own benefit and hence there is adverse effect. Despite the flood ravages man has persistently settled in flood plains because of many benefits be obtains there. The land on either side of the river is called "flood plain" due to several advantages. The flood plain had been encroached during intervals of large floods in the past8. In most of the cases, the river cross section is reduced considerably due to depositing of slit causing higher water level at low discharge.

Encroachments into the flood plains and river bed cultivation even into smaller drains cause obstruction and flooding. The study area is the most populous region due to fertile tract of land and huge water potential both the surface and underground. Many families are also staying deep inside the flood plains. The reasons for the above may be as follows. (The high level committee on Flood. Vol.1.)

(i) The flood plain areas are very fertile and thus the people are attracted for cultivation.

(ii) The cost of agricultural inputs is least in such areas. Thus, an efficient agricultural production is possible.

(iii) Aqua-culture (water-culture) and fish production are very beneficial and possible in such areas only.

(iv) Owing to great scarcity of land and high density of population the people of the region have no alternative than to occupy the flood plains for their survival.

(v) To a Certain extent Socio-economic and Political interferences are also responsible, for forcing the people to occupy and stay on within the flood belts so as to fetch their fortune in respect of getting free relief from the Government. In general, the level of river beds has raisedconsiderably providing inadequate drainage for the flood water. As a

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result, of this most of the recent floods even with smaller discharge have proved disastrous. With the increase In flood protection works, the flood damage is also increasing.

1 -Deforestation. 2- Artificial levees or embankments. 3 -Construction of dams or reservoirs. 4-Others developmental works or structural works.

Deforestation :

Natural vegetation or forest is essential for prosperity of any region. It has got many economic utilities for mankind. For the balanced growth of any region 25% of the total area should be under vegetation cover38. But ecological imbalance in the catchment areas, following unregulated felling of trees, removal of vegetative cover mainly due to man's voracious appetite for timber. clearing of more and more land for agriculture. This was performed for any other reason that has also contributed towards the flood problem. Forests and green belts serve as shock-absorbers during periods of excessive rainfall. They retain much of the precipitation, decelerate the flow of water and prevent soil erosion. The denudation of traditional forest land has led to accelerate water flow in the catchment areas and increased soil erosion during the rainy season. Because of unabated increase in human activity in the river basins, the carrying capacity of the channels gets reduced and water spills over the banks. Thus, we see that within last 50-60 years about 190 sq. kms. Of forest have been cut ruthlessly. Consequently, frequency of floods has increased in the, districts of Vaishali and Khagaria. When ecologists speak of the protective role of trees, they mean dense natural forest with the crowns almost touching one another. If the forest cover is thinned by 40 to 50 percent, its power to protect water and soil is significantly reduced. Experiments, confirm that during heavy rains, water can flow through such thinned, out forests at almost the same speed as through unf rested areas especially when, overgrazing or cattle tracks have destroyed the green cover of pastures beyond the forested land. Most of the Someshwar's forests are in a badly depleted state and are not able to fulfill the soil and water conservation tasks expected.

Artificial Levees or Embankments :

In the flood plains lack of proper control on land use and developmental works for tanning the flood, result in flooding due to obstruction to natural flow, construction of levees or embankments along the rivers have failed to check the recurring floods in some rivers of study region. By construction of embankments drainage systems of study region have become

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congested. Drainage congestion can result from heavy precipitation and lack of sufficient capacity in drainage channels. The flood waters are confined between the embankments. The water level of channel starts rising and the result, is breached or overtopped. For example in 1923 the flood situation in the east of river Sikrahna was aggravated by Tribeni canal embankment.

The breaching of the embankments takes place time to time because best materials for the construction of embankment are not always available in situ. This often results in excessive seepage into the embankment, particularly during periods of prolonged high water, which may lead to wetting of the dry slope (the landward side of the embankment), thereby causing instability. The embankments provide only temporary relief from floods and put off the problem for future generation45.

There is no guarantee of even temporary relief also, as breaches in earthen embankments are unavoidable. The Burhi Gandak in the lower reach where it is embanked has now changed its course subjecting the embankments to river attack at vulnerable places. Other embanked river is also posing the same problems. Their river beds have risen. The floods are now comparatively higher. Erosion and breaches of embankments has become a common feature. Thus protected areas of these embankments occasionally get flooded catching the people unaware and bringing untold miseries.

Construction of Dams or Reservoirs :

Dams or reservoirs are constructed across the natural flow of river for storing the maximum discharge of water. This damping raises the level of water above the dam. This obstruction naturally sometimes causes the disasters. When dam disasters do occur the accompanying violent flooding normally causes considerable damage and loss of life. In times of unusual rain during short period, the storage above the dam may become so much as to cause inundation and flood to the lower region even if the sluice gates are kept open, because the sluice gap is never as wide as the undammed width of the river channel. The dams are responsible for floods in other way also. Sometimes, during the period of storm rainfall the catchment has contributed so much water to the reservoir that the dam has burst, causing disastrous floods. The same was the case when bursting took place near the reservoir in the month of October, 1961 and high flood occurred inundating about 25 villages. Paddy

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crop was damaged and some cattle were washed away. Thus dam proved to be a source of flood in the region, if not maintained properly. There are several examples of dam failure.

Other Developmental Works :

This includes bridges and culverts, rail embankments, roads, canals, etc. In certain cases bridges and culverts have been constructed to ensure the flow of water but these cross-passages of water prove to be impediments to proper discharge of the flood water. This also results only in partial discharge of flood and before the necessary flow takes place flood has already caused sufficient damage. Natural arrangement has been disturbed by the embankments of the road and railway lines passing through the low tracts liable to be flooded. In the district of Muzaffarpur, form and obstruction to drainage as present opening in the road seem to be inadequate to drain out the accumulated torrential rainfall. Owing to this inadequacy during the 1953, flood water overtopped the road at a number of places by 1ft. to 1.6 ft. of water. Chapra Sugauli, Raxaul road, Bettiah section, Senaghat, Minatpur road and Motihari- Sugauli - Bettiah road have got inadequate opening during rainy season which are liable to cause flood (Technical Expert Committee, 2004)12.

The Sugauli Raxaul railway line was responsible for flood in the area in 1988 as it is at right angles to the drainage line and cross-passage was not in a position to carry away the accumulated water. Consequently the line was washed away completely at some places as the accumulation of flood water increased in volume and velocity. Hence the resulting flood was very destructive. Hence, these roads and railway embankments and paucity of bridges and culverts are responsible for floods in the region.

Canals :

The canals have also the same role as that of communication embankments. There are many canals and their distributaries in the region which run across the natural drainage line. The Tribeni canal, crosses many drainage lines. As a matter of fact the canals embankments are more water tight than the embankments of railways and road where culverts and bridges occur. To some extent these canal embankments are responsible for floods in the region by encroaching the natural drainage lines.

Conclusions :

Thus, it is clear that man's affinity for flood-plains exposes him to the risk of flooding. This re-emphasis a theme which has been implicit that flood only becomes a hazard when

they impinge unfavourably upon human activity and that the flood hazard must therefore be considered not similarly as physical but as a socio-economic phenomenon.

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