CHAPTER VI

Floodplain Morphology and Flood and Erosion Hazards

6.1. Floodplain Morphology

Concept of floodplain itself is a dynamic one. Each and every feature developed in floodplain changes over space with time (Davis, 1909) and controlled mainly by the river. No doubt, human beings are also responsible for the changing the floodplain morphology, but their processes are not as great as that of the river as a while. The process and patterns are correlated. Where there is a process there is a pattern. Thornbury (1954) had rightly said that “geomorphic processes leave their distinctive imprints upon landforms and each geomorphic process develops its own characteristics assemblage of landforms.” The river is the chief exogenetic geomorphic agent which has the ability to change the floodplain morphology in a large way. It is that agent which creates landforms during the increase or decrease of flow. Increased flows due to higher runoff or flood pulses can result in channel widening. Here lies the instrument of bank erosion. Flows of water in decreasing amount due to water diversion can also result in short term active channel widening as the river loses its ability to carry sediment through the system giving rise to bar area increase (Knighton, 1984). This is why, fluvial features remain to be always dynamic in nature.

6.1.1 Floodplain Demarcation

Flood means rain water and snow melt input that exceeds the runoff capacity of a river. When a stream rises in flood, the flood water exceeds the capacity of removal by the river channel. The flood water over tops the banks and inundates the area adjacent to the banks. The sediments coming out of the channel spread over the inundated areas. The coarser materials are deposited near the edge of the channel i.e. in the natural levee areas where the rate of deposition is at maximum and the finer materials are carried further and laid down away from the channel. The area that acquires the effects of various floods forms the floodplain that needs to be demarcated. But, the demarcation of flood plain is a very difficult task. The flood
plain may be demarcated differentially at differential stretches based on extent, dimension and damage caused. Flood plain demarcation into its sub-units may performed by using topographical survey maps, satellite imageries and aerial photographs and also through intensive field works. The flood plain of the Kaldiya river has been demarcated following the same tools and techniques. The floodplain in the basin is demarcated on the basis of topographical maps of 1:63,360, IRS- LISS-II imagery and aerial photographs. The entire floor of the valley over which the river spread its water in the time of flood is bounded by low bluff. The gradient is gentle across which the river meanders. The river Kaldiya is an alluvium laden river beyond its channel lie the marshes, oxbows and stagnant creeks, famous of which are the Kapilmara, Chikrait, Dalapathar that makes wetland ecosystem of the basin.

The flood plain of the Kaldiya river is occupied by croplands, such as Panbari, Ratanpur, Bhogpur, Khatlarda, Dalai Pathar, Pursali Pathar, Galir Pathar, Dekada Pathar etc. It may be mentioned here that the Kaldiya and the Pahumara inter-fluvial basin area is the second rice-bowl of Assam next to Narayanpur in Lakhimpur District.

6.1.2. Floodplain Features: Types and Distribution

A floodplain is composed mainly of various types of depositional features of different dimensions. Leopold and others (1964) have identified eight different types of features. To them a typical floodplain includes the features like river channels, oxbows, point bars, meander scroll, sloughs, natural levees, backswamp deposits and sand splay deposits. Happ and other (1940) distinguished six types like the alluvial sediments-channel fill, areas of vertical accretions, floodplain splays, along with the areas of colluvial and lateral accretion, and channel leg. On the other hand, based on the location of deposition Reinec and Singh (1980) and Allen (1969) have classified these fluvial features into three groups. These are channel deposits, bank deposits and flood basin deposits. In the present study the researcher has not concerned with all these fluvial features. Only the major features which are directly and indirectly related with the socio-economic life of the floodplain inhabitants are discussed here. That is why, some features which are not created by the fluvial process are also considered in the study. Thus in the present study in order to classify the floodplain features the researcher has considered the fluvial-origin features. The major fluvial-origin floodplain features of the Kaldiya floodplain are : (i) river channels, (ii) braided river
with channel bars, Sand banks, floodplain (iii) ox-bow lakes/cut-off meanders, (iv) water bodies or wetlands, (v) natural levees and (vi) abandoned channels. Among them, a few prominent features are discussed here.

**Ox-bows**

Ox-bows have been the characteristic feature in the lower reaches of a river. On the other hand an ox-bow lake is a crescent shaped body of water (Brigham, 1892) located along a stream in an abandoned ox-bow which if formed after the cut-off of the neck of a meander. In forming the lake the ends of the abandoned channel are silted up (Holmes, 1964, Parker, 1993). Based on the degree of complexity ox-bow lakes are classified into three categories - simple, compound and complex ox-bow lakes. An ox-bow lake may also be formed when a river creates a meander by eroding the banks its hydraulic action. After a long period of time this meander becomes much acute because of the action of the currents of water of the river. These causes to develop a meander neck abandoning a small crescent – shaped lake i.e. oxbow lake. This may be called cutoff mort lake. In the Kaldiya basin, oxbow lakes (locally known as *beels*) occupy the lower catchment areas, beyond 2 km. downstream of Rihabari. In its left bank there lies the famous Kapilmara *beel*.

**Wetlands**

Lakes or ponds have a good contribution in the floodplain geomorphology, ecology and economy of Assam. A lake is a non-flowing body of water held in depression on the earth’s surface without direct access for mixing with the ocean (Chhatwal, et al, 1988). Unlike a pond, a lake has a wave-washed shoreline. In contrast, a pond is a natural body of standing fresh water filling a surface depression, usually smaller than a lake. The so called lakes and ponds of the floodplain are generally connected with a feeder channel to drain in and out of water (ARSAC, 1997). It is actually different from water logged areas. The water-logged (seasonal) areas are irregular in shape occurring in the low lying areas, usually with a feeder channel and without presence of any vegetation. The water spread areas of the river created lakes and ponds called the wetlands vary in different seasons of the year and are perennial in nature. During the monsoon period due to heavy rainy water majority of the water-logged areas joined together to form a single big wetland leading to loss of their independent identity. Marshes and swamps include peat lands and wetlands.
Based on shape, the wetlands may be grouped into five categories. They are: (i) compact (ii) linear (iii) irregular (iv) discrete and (v) ox-bow.

The formation of the beels (the wetlands are locally known as the beels) in Assam depends both on geomorphological processes as well as on environmental changes. Environmental changes are not necessarily natural; rather such a change may take place as a result of the human interference at various levels. Broadly, the processes of formation of all categories of wetlands are of two types: (i) autogenic and (ii) allogenic. The autogenic process is related to the river regime i.e. channel migration, meander cut off, loop formation, etc. On the other hand, allogenic processes include various types of human interference. (Sarma, 2004)

The middle and lower reaches of the Kaldiya river basin have been characterized different kinds of wetlands as proved by the nature and place name of the areas of wetlands as noted in Table 6.1

Table 6.1: Kaldiya River Basin: Associated Beels with place-names.

<table>
<thead>
<tr>
<th>Place names/nature</th>
<th>Meaning</th>
<th>Associated Beels</th>
<th>Present Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jalah</td>
<td>Water-logged area</td>
<td>Jalah Beel</td>
<td>Extinct</td>
</tr>
<tr>
<td>Dubi</td>
<td>Drowned area with water (Down warped area)</td>
<td>Dala Pathar</td>
<td>Reed-swamp stage</td>
</tr>
<tr>
<td>Amdah</td>
<td>Lowland</td>
<td>Duba, Bhaira, Gali</td>
<td>Active</td>
</tr>
<tr>
<td>Kachari Kur</td>
<td>Pond with deep water but small perimeter</td>
<td>Bakchara Beel</td>
<td>Extinct</td>
</tr>
</tbody>
</table>

Source: Information collected by the researcher from field observation.

Abandoned Channels

There are lot of example and evidences of abandoned channel portions in the middle and lower parts of the Kaldiya basin. The abandoned channels are currently inactive river. By definition an abandoned channel is a left out parts of once active channel through which water uses to flow no longer. At Marka near Patacharkuchi (Bajali Sub-division) the river Kaldiya has left a channel eastward now flowing under the bridge of Patacharkuchi because of its bank shifting. The abandoned channels had
thus developed an ox-bow lake when sediment plugs cause the flow to change course (Julian, et al, 2008). Two processes, viz. natural and engineered cut-off were responsible for the formation of this abandoned channel. The natural process involves the mechanism of neck cut-off and chute cut-off processes of a meander. On the other hand, in the engineered cut-off process a meandering channel is straightened by cutting its neck for the navigation and flood control purposes. One such meander neck cut-off in the Kaldiya basin is the Patacharkuchi cutoff. The purpose behind this human force of cut-off lies on the control of floods and erosions. Most of the abandoned channels that exist are occupied either by dense hydrophytes or by man for the use of agricultural field. Some of them which are shorter in length but deeper vertically are used as fishery ground. At Rihabari, a part of meander of the Kaldiya has been converted to fishery pond. This is known as the Lakhimi Mina Mahal. The lengths of the abandoned channels in the study area range from 1.5 km. to 3.2 km., but the widths are not more than 45 meters. Their courses are meandering, but they are dissected due to the construction of road or other man-made features. Generally their beds are shallow and occupied by small plans and some organic substances. The abandoned channels were developed after the great earthquake of 1897. The Dalapathar in the Kaldiya flood plain is one of such examples. A maximum of the river courses in Lower Assam were changed after the earthquake. Some of the major channels became abandoned while some small tributaries were exposed as master tributaries.

6.1.3 Morphological Features of the Floodplain

The floodplain of the Kaldiya River covers an area of 22.06 sq km. A Channel length of about 20 km of the river passes through this area. The boundary of the floodplain is irregular. Towards the downstream of the river the floodplain becomes wider, and because of the presence of embankments on both sides of the river the flood water is confined within a narrow channel. Deposition on the floodplain consists of two types of materials. These are channel deposits and overbank deposits. Due to the shifting of the channel lateral accretion of channel deposits takes place. During the high flows and high water levels overbank deposition occurs. The flood water loaded with sediments crosses the banks and spreads over the adjacent flat plain. Across the submerged flood plain the depth, velocity and turbulence of water decreases abruptly near the channel margins. The decrease results in sudden and rapid deposition of the
KALDIYA RIVER BASIN IN ASSAM
FLOODPRONE AND WATERLOGGED AREAS

LEGEND
- Floodprone areas
- Waterlogged areas
- Wetlands
- Catchment
- River
- Lakes/ponds
- National Highway
- Railway Line
- International Boundary

Source: Landuse/Lancover Map 2011, ARSAC
Fig: 6.1
coarser materials constituting the suspended load along the channel margins. The finer materials like clay and silt get settled down further away from the channel. So, the floodplain of the river slopes down from the mainstream towards the flood basin.

The floodplain of the river consists of younger alluvial sediments of sand, silt and clay. As the river migrate laterally old meanders are observed on the floodplain from Bhaluki to its confluence in the basins middle and lower parts. Therefore, the floodplain consists of materials accreted by the lateral migration of meandering channel. The younger alluvium is found adjacent to the river from Patacharkuchi onward to the confluence. The upper part of the floodplain is composed of older alluvium which occurs as isolated patches which are higher in elevation than that of the younger alluvial plain. The floodplain is very thick and consists of coarse to fine materials such as cobbles, pebbles, shingles, sand and silt.

The lower course of Kaldiya River occasionally exhibits meandering pattern with some point bars on its bed. The river is flowing with a very gentle gradient. It brings large quantities of sand and silt from the upper catchment which are subsequently deposited along the entire lower course of the river, when the channel loses its hydraulic efficiency. This eventually leads to flooding. An area accounting for about 30% of the flood plain normally gets inundated almost every year.

The floodprone and waterlogged areas are significant events in the Kaldiya basin (Fig. 6.1). An area boardering a stream that will be covered by a stream water at a floodstage is called the floodprone area. On the other hand, waterlogging refers to the saturation of soil with water. Soil may be regarded as waterlogged when the water table of the groundwater is too high to conveniently permit an anticipated activity like agriculture. The waterlogged areas of the Kaldiya basin are seen in the lower course of the river and the floodprone areas are found along the boarder of the Kaldiya river.

6.1.4 Geodynamics of the Kaldiya River Basin

Geodynamic refers to deformation of the process, here the fluvial process under study. Fluvial system is a dynamic system. The river has undergone lots of changes through geological and hydrological events. Human impact, not less responsible for channel dynamism. Forces involved in geodynamics are

a. Diastrophic (tectonic) – Epeirogenic and orogenic forces
b. Climatic forces - Flood
c. Human action – Straightening and cutting the meander necks

Earthquakes of 1950 and 1897 impacted on channel changes. The river originating from sub-terranean water at Duba once ran through Naophuta, Dangarigaon and Golagaon. But now no trace of original channel, instead an abandoned channel at Bhuli left. The river takes its course through Batabari, then runs through Batabari and Dhuragao. At Khaldia the river starts meandering. The river is shifting from west to east as is evidenced in its middle course. At Jalah the river starts its middle course leaving behind the gravel belt. The river formerly cut across the middle of Bajali. The “Mara Kaldiya” at Marka was its former course, but due to hydrological action it shifted to eastward, now flowing under the bridge of Patacharkuchi. At Patacharkuchi Shivadham a meander cut (1962) is left (by human action). This means a few meters shift from west to east. The river came all the way via Kurabaha, Panbari, Ratanpur, Khandapara, Haripur, Marka and Dubi. Three grand meanders hold testimony to the dynamic character of the river. The meanders are locally known as “Tup” e.g. Bisankuchi Tup, Patacharkuchi Tup and Jalikhata Tup. The Kaldiya is too dynamic. All meandering rivers are dynamic in character.

The effect of floods have played a major role in the changing floodplain morphology of the study area. Before 1950, there was a balance between sediment supply and its transportation. But after 1950, this balance was disrupted as the great earthquake caused generation of extensive pile of sediments (Goswami et al, 1999) and initiated modification and adjustment of channel form (Dutta and Kotoky, 2010).

6.1.5 Floodplain Ecology

The beels of the Kaldiya basin having their relevance to floods, play the role like that of the Tonle Sap of Mekang basin in Cambodia. During the monsoon when floods are in three to four waves, the beels absorb quite a considerable part of surging over-bank flow, thus lowering the flood-level without causing serious damage. Again in the lean period (post monsoon) when the torrents in the river turn tickle, the locked waters in the beels silently retrack their ways to the channel, either through outlets, or by the way of seepage. This phenomena indeed performs a give and take mechanism.

That there has been subsidence in the Kaldiya basin can be evidenced by the existence of the numerous beels. Down-warping and up–warping due to seismic reasons led to serious disturbance in the river courses and cause them wander in great
sweep. As a result, abandoned loops are left behind which in subsequent times turned to ox-bows and finally to elongated active marshes or wetland locally called the beels. Therefore, the annual floods in the river, the meandering of the streams and frequent change of courses are all nature’s answer to problems created by subsidence of the crust. The beels are as if the retarding basins made by the river itself in order to reduce the flood intensity. Suddenly certain areas are uprising and some other areas are progressively sinking. The Himalayas are uprising at the cost of adjacent subsiding basins. Accumulation of even a thin layer of sediment implies that the over-ladden condition had rendered to very slow rate of sinking, for sedimentation is the manifestation of negative epeirogeny. If epeirogeny exceeds the sedimentation, surface drainage would become disturbed and swamp condition would appear followed by formation of beels or lakes.

Beels occur in alluvial river floodplain. The Kaldiya is an alluvial river. The tributaries of Kaldiya flows across thick accumulation of alluvial deposits laid by the river themselves. The floodplain is bounded by bluffs (outer limit of floodplain) and natural levees, a slightly elevated part along the river bank. Rivers traversing the flood plain are usually meandering in nature. Meanders in subsequent time developed narrow necks, which are cut through in the natural or human process of river shortening the course. As a result, meander loops are left behind, the either end of which are silt and sand deposited turning the loops finally to ox-bow lakes. These ox-bows are gradually filled by sediments brought in by the floods and by organic debris produced by aquatic plants. The back swamps are flanked on one side by natural levees and the other side by bluffs. The Beels, abandoned channels, semi-circular marshy lowlands, defunct river courses, cut off channels, etc. are the morphological remnants that reveal the records of changing conditions of the river Kaldiya. In case of investigations of these features the following methods could be followed.

(i) Historical records obtained from the District Gazetteer, Barpeta District. Oral history collected from various respondents.

(ii) Sedimentary evidence i.e. surface soil and sub-surface soil study.

(iii) Studies of old maps, various reports including historical description of the past.
Beels are odd out of wastelands, yet plays a significant role in ecological set up and economy of the area as well. There are about a dozen of beels in the Kaldiya basin alone (Table 2.8). Many are not existent in the mean time. With the introduction of embankments and dykes as flood control measures, the fresh water sediment supplied into the beels are cut-off affecting further subsidence. Secondly beels create their own sediments i.e. organic debris, debris derived from vegetal skeleton.

The soils of the beels render very good natural habitat of micro organism. Soil serves as cross-roads for terrestrial communities to come and settle ecotone areas. Among the communities of primary producers, there are auto-trophs and plankton and algae along with others like

(i) Hydrophytes (submerged and free floating but rooted)
(ii) Hygrophytes (growing in ecotone areas)
(iii) Mesophytes (Bog plants, scrubs, timbers etc.)

Fishes ranging from small to big ones and ornamental ones are available in the beels of Assam including that in the Kaldiya basin. There is a good ecological balance among the soil, plants and animals including micro organism in the beels and their surround water infested areas.

6.2. Flood and Erosion Hazards

Flood becomes hazards whenever it causes damage to crops and property and dangers to life continuously. Economic damage due to floods in a valley depends primarily on the degree of economic development of the flood plain. Previously the Kaldiya basin was sparsed, populated and the economic activity was limited and therefore, the flood damage was insignificant though occurrences of flood were there. The extent and magnitude of the problem can be assessed in terms of the different types of damages brought about by it. Hence it becomes necessary to analyze the available data on flood damages. The extent of flood damages of the Kaldiya basin have been discussed based on the data available.

The Kaldiya is a perennial river. It does not dry up in the post monsoon time also. But the water level goes down appreciably during the post monsoon times. The basin receives an average annual rainfall of 236cm. The rainfall in the catchment is moderate to heavy and characterized by erratic patterns. Flood in the Kaldiya basin is
caused by heavy rains that occur in the Bhutan hills and foothills along with that in the plain portion of the catchment area. The foothill streams fed by high rainfall are adding water to the main channel of the Kaldiya. Flood is imminent if the storm water exceeds the carrying capacity of the river. The Kaldiya is a flood-prone river. The water discharge in the river thus rises very rapidly and overflows the banks inundating large area. Due to sudden flattening of the gradient from foothill to the plain, there occurs spreading of water over the adjoining areas during the time of high flows. The river in the plain tends to raise and silt up its bed through deposition of large amount of sediments brought down from the upper catchment of the river in Bhutan. Being not deep to carry the water, the channel cannot hold the flood water fully and due to overflows the flood plain suffers from the ravages of floods every year. As a result, the villages of the floodplain receive recurring floods of various orders, magnitudes, intensities and danger qualities.

The Kaldiya floodplain and the locations of the flood affected villages are therein. The flood water usually enters into agricultural field either through the banks devoid of embankments or embanked after their breaches. The waters causing flood affect the villages. The flood affected villages include Galibandha, Kawaimari, Finguwa Pathar, Chagalchari and Pitadipam etc. In recent years, flooding as a result of breaches of embankment has become a recurring feature. For example on the right bank of the river the embankment was breached in recent years more than ones and inundated the village Kalakuchi Gaon, Kachkuri and some others. The flood plain of the Kaldiya river is densely settled and the villages in the floodplain are inhabited by the Hindus and the Muslims and some other people who belong to both the tribal and non-tribal communities. The people are primarily engaged in agriculture. Agriculture the mainstay of the people is heavily affected by floods. As the people mainly practise cultivation of summer crop, the flood damage becomes more and more acute. Therefore, people’s economic conditions get bad to worse in recent years.

As a common feature, recurring floods enhance bank erosion. In the lower course of Kaldiya where flood is a common phenomenon, bank erosion has also become a chronic problem. Bank erosion starts right from Jalalghat in the middle reach of the river. The reaches under heavy and chronic erosion are stated as:

In the right bank villages like - Bhogeswar Mandir (Ulua), Kaharpara, Sariha Chakla, Jalikhata, Kawimari, Galibandha, Uparnai and Golagaon are largely
disturbed. In the left bank – Bhaktardoba, Balapara, Ghoramara and Helona are the
villages suffering from heady erosion (Fig. 6.2).

The state as well as the central government should give attention to protect the
bank erosion of the Brahmaputra river and its tributaries like the Kalidya. Thousands
of people have lost their land. Agriculture is the lifeline of the people living in the
active and chronically flood affected zones. Bank erosion adversely affects the
livelihood of the people. From the field study, it is found that in the active flood plain
zone more than 45 percent of the people have been compelled to change their
occupation only due to river bank erosion and channel migration.

6.2.1. Nature of Flood Hazard

Floods in the river Kaldiya occur only when the river is incapable for
accomodating all waters supplied to it. The stage of flood comes after bankful stage of
the water along with the river. All the floods in the river are due to rain waters. But in
the year of 2004 heavy flood had occurred due to collapse of embankments. Flood in
the basin is an important geomorphic as well as hydrologic event that occurs due to
several causes like heavy precipitation, sudden release of water resulting perhaps from
cyclonic rains and storms, etc. Thus, in the study area floods generally occur due to
the heavy rain and also storm rain during the monsoon months May to October. The
Kaldiya river takes a furious look when it is in high spate. At that time the
Brahmaputra River also maintains a high water level. Most frequently the water level
of the Brahmaputra river remains above the level of low lying regions near its bank
and back water from the Brahmaputra generally spreads into the tributaries. Although
the floods of this region are of climatogenic in origin, there have been influences of
past tectonic, physical, hydrologic conditions and human interferences on their
intensification (Barman, 1986, p69).

Although defining the term flood is a difficult one as observed by Roy Ward
(1979), in this study it is defined “as a body of water which rises to overflow land,
which is not normally inundated”. In the present context another definition of flood
can be used considering the devastating nature of the hazards. According to this
definition, the flood is a natural calamity which disturbs the ecological balance,
degrades the quality of environment, destroys the socio-economic functions of the
region and enlarges inter personal and inter- spatial disparities (Das, 1984). It is a
catastrophic agent which causes erosion, deposition and damages and changes the physiographic character of the valley, (Stewart, 1967).

Thus, the floods in the Kaldiya basin creates problems and damages by destroying standing crops, lives of both human and cattle, lands of both the built up and flood plain lands and river banks, the floods lead to sand deposition on agricultural land reducing productive capacity. References of such floods are found in ancient history books on Assam and the books like the Yogini Tantra, Gurucharit etc. Flood intensity in the study area has close relationship with the tectonic activities of the whole region. Thus the flood of this region is somewhat of tectono-climatogenic origin. In the 1897 Earthquake, the lower catchment area in the south of NF Railway has gone down (down warping). The place name ‘Dubi’ testifies the fact. ‘Dubi’ means drowned in Assamese terminology. Dubi Area south of Pathsala Town has gone down with its deity Parihareswara Siva. Now Lord Siva is seen in the sub-surface area, worshipped in an underground cave. Since that time the flood intensity has been going high and higher in dimension and extent of damage.

Although the detailed records of floods due to tectonic activities prior to 1897 are not available, yet from Oldham’s Records (1899, 1981 reprint) of the great earthquake of 12th June, 1897 (Mem, G.S.I. Vol XXIX) and those of the one on 15th August 1950, one may appreciate the intensity of flooding just after the occurrence of a severe earthquake. Due to the earthquake of 1897 considerable topographic changes had taken place in the study area. The drainage systems of the area (northern part of old Kamrup district) changed significantly. The beds of rivers like Manas, Beki, Pahumara, Kaldiya, Pagladiya, Puthimari, specially in their lower courses, sank down (Revenue Department, Govt of Assam, 1966; Barman, 1986). On the other hand, in the middle and upper portions of its course in the plain, the beds of most rivers as mentioned already were raised resulting in floods immediately after the earthquake. There are records of human migration after the 1897 great earthquake from the lower valley portion of these rivers to the higher lands in the middle and upper catchment sections because of continuous high floods for many years. The people of the village Barala migrated northward and started a new settlement called the Natun Barala village. The people from Kaljar moved to north and settled now at the Kaljirapara village. Similarly due to the earthquake of 1950, heavy landslides had occurred in the upper courses of these rivers in the Himalayan region and blocked the normal flow of
some of the rivers for sometimes. But the upper parts of these rivers suddenly released large volume of water caused heavy floods in the down stream areas. During the high downpour of monsoon months (May to October), the Kaldiya remains in high spate. The high flood levels and the high water discharge of the river at N. H. crossing gauge station for the period 1992- 2010 are shown in Table 5.6

During the monsoon months (May to Oct) generally floods occur in 2 to 4 waves. Prior to 1957-58, the occurrence of flood in the basin was a regular annual phenomenon of slightly different nature than that of the present one. This happens because at that time embankments for the river were not built. The floods were regular annual features in the past as the old men of the locality say during interviews at the time of field surveys. These floods, however, did not cause much harm to agricultural croplands much as the flood water did not remain for a long time over the agricultural field.

6.2.2 Flood Zones

On the basis of the field study of flood hazard in the basin, the study area can be divided into three main flood zones. These are

1. Occasionally flood affected Zone of the built up area.
2. Chronically flood affected zone of the lower flood plain of the Kaldiya river.
3. Chronically flood affected and water-logged zone of the study area.

The first zone covers a vast area lying in the north up to railway line. High flood occur suddenly mainly due to the breaches of embankment creating heavy losses of life and property here.

The second zone covers the lower active flood plain in the Kaldiya basin. Here, flood water from the Kaldiya enter the low lying areas including the beels and marshy lands and create drainage congestion and inundation.

The third zone is the water logged area of the study area. The severity of flood over the whole area is not equal. Therefore, on the basis of severity and intensity of flood, the basin may be further marked by some micro flood pockets and villages (Fig. 6.2) as described below:
KALDIYA RIVER BASIN IN ASSAM
MAP SHOWING FLOOD AFFECTED VILLAGES

Source: Assam Circle/Village Map & LULC Map 2011, ARSAC
Fig: 6.2
Table 6.2: Kaldiya Basin: Villages Located in the different Flood Zones

<table>
<thead>
<tr>
<th>Zone – I (Less affected area)</th>
<th>Zone – II (Moderately affected area)</th>
<th>Zone – III (Severely affected area)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Bhulkamari</td>
<td>2. Barnalikuchi</td>
<td>2. Galibandha</td>
</tr>
<tr>
<td></td>
<td>5. Pipla</td>
<td>5. Chagalchari</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6. Pitadi Pam</td>
</tr>
</tbody>
</table>

Source: Based on the field study by the researcher

The villages of Zone I is located beyond Rihabari northward. Agricultural fields and village roads are inundated during flood times in this Zone. During high floods due to breaches of embankments even human settled areas of these villages are inundated.

The villages of Zone II is located beyond middle Bajali from Bangaon northward upto Rihabari. These villages are comparatively slightly more affected by the flood as compared to those in the first set of spots. The height of villages are more than that of the third zone.

The villages of zone III is located beyond south Bajali from Bhaluki southward. The villages are situated in the comparatively low-lying areas. These villages are surrounded by beels. Floods here generally occur during the period of June to September. The highest of flood water some times in the recent past rises up to 2.0 meters above the normal ground level of the surrounding fields. In comparison to Pahumara river, the Kaldiya river has a very negligible flood protection measures.

### 6.2.3 Flood Mitigation and Management in the Basin

According to the Oxford dictionary (1995) the word ‘mitigation’ means to make something less severe, violent or painful. According to Webster’s dictionary the definition of mitigation is to make or become milder, less severe, less rigorous, or less painful, or more reliable, to relieve (TCL, 2006). Therefore, the words “flood mitigation” in case of flood would imply to decrease the intensity and extent of severe flood. In order to reduce the intensity of flood some methods have to be adopted.
Implementation of these methods to reduce the intensity of flood implies management of flood. Therefore, flood mitigation and management are interrelated and in many occasions they are used for the same meaning.

The formulation of a flood mitigation policy involves the determination of optimal quantities of the various flood mitigation measures, namely optimal capacity of reservoirs and channels, optimal measures of levee system and landuse, optimal magnitude of flood insurance premium and investments while attending to flood warning systems and flood proofing. On the other hand, flood management refers to the overall process involved in mitigating the extent of flooding and the resulting damage by flooding (ICID, 2000). In India the Rashtriya Barh Ayog (1980) has classified the flood management activities into four major groups, such as (i) attempts to modify the flood, (ii) attempts to modify the susceptibility to flood damage, (iii) attempts to modify the loss burden, and (iv) bearing the loss.

Attempts to modify the floods involve flood protection by means of physical measures such as construction of embankments, construction of detention reservoirs, channel improvement, etc. Measures taken to treat the catchment area with a view to reducing flood volumes or pattern of flows or attempts to alter “precipitation pattern” through weather modification are also classified as “attempts to modify the flood” (INCID, 1993). As mentioned by the Rashtriya Barh Ayog (RBA), attempts to modify the “damage susceptibility” involve action design to reduce the vulnerability of property at other developmental activities in the floodplains to the flood hazards. Attempts to modify the ‘loss burden’ consist of actions designed to modify the incidence of the losses either by spreading them over a larger segment of the community who are immediately affected, or spreading them more evenly over time, and bearing the loss connotes living with floods.

Techniques for flood damage reduction encompass structural and non-structural measures that reduce or eliminate flood hazard and the potential for future flood damages. These measures are presented in table 6.6. The structural measures include construction of levees, ring dykes, reclamation of low lying areas, floodwater diversion channels, storage reservoirs etc. On the other hand, the non-structural damage reduction measures include floodplain management and flood forecasting/warning services (Townsend and Bartlett, 1992; Sargent, 1992; Heijne,

**Structural Measures Already Adopted**

It is well recognized that complete immunity from floods of any river including the Kaldiya is not possible and economically viable. However, the measures taken so far in the Kaldiya basin are the construction of embankment and medium irrigation project through canal from the river. The total length of embankments along the Kaldiya river is 21.11 Km. The left bank has a total length of 12.81 Km., while the right bank has 8.30 Km. (Table 6.3). The construction of Kaldiya irrigation project at Rihabari village was completed in the year of 1995 at a total cost of Rs. 8.11 crores (Table 6.4).

**Table 6.3 : Existing Flood Management Structure (embankments) in the Kaldiya River.**

<table>
<thead>
<tr>
<th>Tributary</th>
<th>Length (km)</th>
<th>Total length (km.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Left Bank</td>
<td>Right Bank</td>
</tr>
<tr>
<td>Kaldiya</td>
<td>12.81</td>
<td>8.30</td>
</tr>
</tbody>
</table>

Source: Executive Engineer, Pathsala Division, Irrigation Department, 2008.

**Table 6.4 Details of Kaldiya Irrigation Scheme, Assam**

<table>
<thead>
<tr>
<th>Name of Irrigation Scheme</th>
<th>Type of Scheme</th>
<th>Estimated cost (Rs.Crores)</th>
<th>Year of commencement</th>
<th>Year of completion</th>
<th>Gross Cultivable Area (ha)</th>
<th>Net Irrigated Area (ha)</th>
<th>Potential estimated (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kaldiya</td>
<td>Medium</td>
<td>8.11</td>
<td>1975-76</td>
<td>1995</td>
<td>11,398</td>
<td>9716</td>
<td>16,500</td>
</tr>
</tbody>
</table>


The main objectives of this medium irrigation scheme was to control flood and to provide irrigation facility to the farmers.

The study of Kaldiya Irrigation scheme focusses the following objectives.

(a) Performance of the irrigation scheme with regards to the irrigation potential created, potential utilized and the reasons of the gap between potential created and potential utilized,

(b) Impact of introduction of irrigation system in terms of pre project status and post project changes in the agro-economic scenario,
(c) Impact on socio-economic conditions of the villages located in the canal command area due to the project and the affect on the environment.

The headwork of the project is designed to tap 10 cumecs of water from the perennial flow in the river. The headwork is a diversion structure and is designed for a peak flow of 25,000 cumecs with a safety for super flood of 30,000 cumec. The canal system consists of one main canal and eight branch canals along with a sub-branch canal and distributory.

Table 6.5: Kaldiya Irrigation Scheme: The Details of the Branch Canal-wise Potential Created and Present Utilization

<table>
<thead>
<tr>
<th>Name of the Canal</th>
<th>Proposed length (km)</th>
<th>Constructed length (km)</th>
<th>Length of water reach (km)</th>
<th>Designed cultivable area (ha)</th>
<th>Actual Cultivable Command Area created (ha)</th>
<th>Actual utilization (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Link Canal</td>
<td>0.88</td>
<td>0.88</td>
<td>0.88</td>
<td>22.00</td>
<td>22.00</td>
<td>22.00</td>
</tr>
<tr>
<td>Main Canal</td>
<td>23.163</td>
<td>23.163</td>
<td>12.00</td>
<td>3757.50</td>
<td>3757.50</td>
<td>1946.64</td>
</tr>
<tr>
<td>Branch Canal -1</td>
<td>11.342</td>
<td>11.342</td>
<td>8.000</td>
<td>3333.63</td>
<td>3333.63</td>
<td>2351.35</td>
</tr>
<tr>
<td>Branch Canal -2</td>
<td>2.160</td>
<td>1.680</td>
<td>1.400</td>
<td>191.90</td>
<td>149.26</td>
<td>124.38</td>
</tr>
<tr>
<td>Branch Canal -3</td>
<td>3.990</td>
<td>3.690</td>
<td>2.800</td>
<td>228.75</td>
<td>211.55</td>
<td>160.53</td>
</tr>
<tr>
<td>Branch Canal -4</td>
<td>2.580</td>
<td>1.500</td>
<td>1.500</td>
<td>257.50</td>
<td>149.71</td>
<td>149.71</td>
</tr>
<tr>
<td>Branch Canal -5</td>
<td>1.640</td>
<td>1.640</td>
<td>0.915</td>
<td>102.40</td>
<td>102.40</td>
<td>57.13</td>
</tr>
<tr>
<td>Branch Canal -6</td>
<td>2.640</td>
<td>2.500</td>
<td>2.000</td>
<td>569.60</td>
<td>539.39</td>
<td>431.52</td>
</tr>
<tr>
<td>Branch Canal -7</td>
<td>2.535</td>
<td>0.360</td>
<td>-</td>
<td>351.40</td>
<td>49.90</td>
<td>0</td>
</tr>
<tr>
<td>Branch Canal -8</td>
<td>2.430</td>
<td>1.250</td>
<td>-</td>
<td>238.50</td>
<td>122.69</td>
<td>0</td>
</tr>
<tr>
<td>Sub branch</td>
<td>3.870</td>
<td>3.870</td>
<td>0.504</td>
<td>445.00</td>
<td>445.00</td>
<td>57.95</td>
</tr>
<tr>
<td>Distributory</td>
<td>2.243</td>
<td>2.243</td>
<td>-</td>
<td>240.00</td>
<td>240.00</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>9738.18</strong></td>
<td><strong>9123.03</strong></td>
<td><strong>5301.21</strong></td>
</tr>
</tbody>
</table>

Source: Project Report prepared by the North Eastern Regional Institute of Water and Land Management, Dolabari, Tezpur.

In Table 6.5, it is seen that there is one main canal of length 23.163 kms and eight branch canals of total length 24.962 kms. Besides, there are Link canals of a total length of 0.88 km, Sub branch canal (3.870 km) and one distributory (2.243 kms). The actual Cultivable Command Area (CCA) created is 9123.03 ha.
Non-Structural Measures

The non-structural measures of flood management in the Kaldiya basin are yet not remarkable, except some valuable suggestions given by the government authorities and other NGOs. However, a few raised platforms have been constructed in the active floodplain zone. The approach of flood plain zoning is also under consideration. Flood forecasting is also not efficient in the region. There is no other forecasting provisions in the Kaldiya basin.

It is widely accepted that soil conservation measures are essential for preventing soil erosion, replenishing ground water and increasing productivity of land. A comprehensive plan for watershed management is necessary for the basin. Large scale deforestation is going on in the Bhutan foothills in huge way and as a result, sediment discharges along the Kaldiya river is increasing. The watershed management programmes that are taken by the government are not found to be effective. Table 6.6 gives a picture of structural management adopted in the Kaldiya river basin.

Table 6.6 : Kaldiya River : Proposed Structural Flood Management Measures

<table>
<thead>
<tr>
<th>River</th>
<th>Proposed measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kaldiya River</td>
<td>(a) Raising and strengthening of the existing embankments.</td>
</tr>
<tr>
<td></td>
<td>(b) Construction of Kaldiya Sluice Gate.</td>
</tr>
<tr>
<td></td>
<td>(c) Construction of raised platform in the lower part of the basin.</td>
</tr>
</tbody>
</table>

Source : Master plan of the river Kaldiya, Irrigation Department, Govt. of Assam, 1995.

6.2.4 Erosion in the Kaldiya Basin

Fluvial processes - erosional and depositional, etc. are similar in all the rivers, but the scale of erosion and deposition vary enormously. The load of this river is of tertiary origin and the volume is many times greater because of heavy on-slaught of flows of water in the windward slope of the mountains. This besides, landslides due to seismic instability add to the load volume in the form of gravels i.e. boulder, cobbles, pebbles, shingles, sand and silt.
The erosion in the Kaldiya basin area however is affected by

(i) rain-drop impact,
(ii) unchannelled flow over the surface and within the soil,
(iii) formation and enlargement of net-work of rills, gullies, ravines and channels

**Channel Bank Erosion**

The river Kaldiya causes low to high bank erosion. Such a bank erosion in the Kaldiya river along with some of its tributaries have been responsible to the degree of cohesiveness or non-cohesiveness of bank soil, configuration of the bank and nature and force of flowing water along and across the river channels.

The process responsible for erosion in case of the Kaldiya river may primarily be fluvial entrainment, weathering and weakening of the bank materials. All these conditions reduce the strength of the bank materials and decrease bank stability. During monsoon time due to prolonged rainfall, the increase of pressure and weight of water and bank materials reduces the bank strength. In cohesive materials, bank stability is strongly dependent on bank angle and height, as well as soil properties.

In case of the Kaldiya river both rotational slip and slab failure occur. Cycles of wetting and drying too cause swelling and shrinkage leading to bank collapse and erosion. Table 6.7 shows the locations of erosion points in the Kaldiya river basin.

**Table 6.7 : Kaldiya River : Erosional Points from North to South**

<table>
<thead>
<tr>
<th>River</th>
<th>Spot of erosion</th>
<th>Causes responsible</th>
<th>Nature of erosion</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kaldiya</td>
<td>Golagaon</td>
<td>Moisture condition and properties of bank material coarse</td>
<td>Slab failure</td>
<td>May – Sept.</td>
</tr>
<tr>
<td></td>
<td>Ujanullua</td>
<td>Fluvial entrainment</td>
<td>Rotational slip</td>
<td>May – Sept.</td>
</tr>
<tr>
<td></td>
<td>Tangarkur</td>
<td>Fluvial entrainment</td>
<td>Rotational slip</td>
<td>May – Sept.</td>
</tr>
<tr>
<td></td>
<td>Kawaimari</td>
<td>Bank angle height</td>
<td>Circular slip</td>
<td>May – Sept.</td>
</tr>
</tbody>
</table>

**Source** : Based on field observation by the Researcher, 2010.

The banks of the Kaldiya river are composed mostly of sandy soils overlain by comparatively cohesive silt and loam. Weathering on the bank material and the entertainment of weathered materials by fluvial action along the channel could block somewhere in the channel which ultimately lead to further under cutting, wetting and
cracking the banks. At Patacharkuchi, for example bank-retreat follows a cyclic pattern initiated by under-cutting. These is followed by failure of the overhanged rooflike earthblock and washing out of the fallen materials. At many spots of the Kaldiya river, it is observed overhanged roof collapse after under-cutting.

The Fluvial entrainment operates to erode the bank and to scour the bed at the base of the bank increasing bank angle and height. At Kuwara and Vishankuchi the gravitational failure of the intact bank is sometimes noticed.

In the upper reaches of the river, beyond Rihabari, because of non-cohesive nature of bank materials, individual grains are entrained by pivoting, rolling and sliding. During the flood time secondary currents become strong enough producing a rapid rate of bank erosion.

6.3 Geomorphic Changes

The geomorphic changes are usually very slow. The factors or forces affecting changes in landforms are of two categories: (i) endogenetic forces and (ii) exogenetic forces. Among these two, the exogenetic forces are produced by external agents such as wind, water and snow etc. They erode the surface of the earth and transport the eroded materials and make depositions somewhere at congenial conditions. These external forces are also called ‘exogenetic processes’ which possess a great importance in the study of geomorphology of an area.

River and streams have a prominent place in geomorphic changes through the processes of erosion and deposition. Every stream tries to produce a slope from its source to mouth that erosion and deposition activities are balanced.

In the Kaldiya basin the changes have been observed to be not very slow. Both the erosional and depositional activities of the Kaldiya river have been prominent in different physiographic settings. In the foothill zone the erosional processes are more active with the following three actions: (i) hydraulic action, (ii) abrasion action and (iii) solution action. In the hydraulic and abrasion action the water coming down from Bhutan foothill lifts the rock fragments and strikes against one another and wears them down. The stream water also carries some soluble components with the flowing water. The eroded materials are transported from upstream to downstream by the Kaldiya and other rivers. After the rivers come down from the hills and foothills towards plains, the slope becomes gentle (Fig.3.2). This reduces the energy and
competence of the rivers. However, new researches point out that it is not easy to understand the process of sediment deposition on flood plains especially with braided river morphology (Richardson & Thorne, 2001).

The nature meandering and changes of channel in the Kaldiya river has also been observed to be complex. The Kaldiya river has developed many meanders in its course in the middle built-up plain due to affects erosion and deposition of sediment at various places. The river erodes rapidly mostly due hydraulic pressure of water at the concave sides of the river thereby creating undercutting of river bed. On the other hand, the river flows with a lower velocity on the convex side and therefore, more deposition takes place as compared to erosion. The bank erosion has its significant effect on the changing of geomorphic features. During the flood time when there is high velocity in the movement of water lateral erosion on the banks occur.

6.3.1 Impact of Flood and Sand Deposition

Flood and the deposition of sediments have the two faces of a coin in the Kaldiya river basin. They have their pronounced impact on the geomorphic changes in the study area. They also influence the size, site, distributional pattern and morphology of rural settlements in the flood plains. Different types of human settlements in a riverine plain are the results of human adjustment with the environment in the face of prevailing flood, erosion and depositional hazards.

Flood is a common geographic event. It has considerable impact on physical landscape in the flood plains. The study area is almost a flat alluvial plain with minor variations of relief having foothills zone, built-up areas, active flood plains, waterlogged areas, marshes, beels, abandoned channels and ox-bow lakes. Accordingly, variation of intensity and frequency of flooding in these areas are observed. Generally the damages and displacement of settlements during flood times are caused by inundation and associated with bank erosion. The study area accounts nearly for 3 per cent of the total flood damaged area in Assam.

Sand deposition by flood water in the basin is another geomorphic process and hazard as well faced by the settlers of the basin. Due to heavy siltation and sand deposition on the river beds and within embankments have continuously raised the beds of the Kaldiya like other nearby river like Pahumara, Mora Pagladiya etc. The
beds of Kaldiya rose from 0.5 to 1.3 m on average above its surrounding areas. It is higher than 1.3m in some places like Kuwara, Bhaluki and Helona villages.

Heady floods in some spots and places along the banks of the Kaldiya river occur mainly due to breaching of embankments. During flood times the river carry huge amount of suspended load and deposits the same over the fertile agricultural fields and other areas used for human settlements. The thickness of sand deposition decreases as the distance from the river increases. On the other hand, silt deposition of only a few centimeters may enhance the fertility of soil. In the built-up areas of the basin, floods caused by breaching of banks and embankments create sand deposition hazard which has a great impact on the surface configuration of the area, particularly along the river banks. This has changed the area and reduced the productivity of land by about half. This is confirmed by the observation and interaction with the local people during field study. Digging out of sand from the vulnerable bottom and bank spots of the river has also highly the morphology and environment of Kaldiya river. This sort of problem has been highly observable in the eastern bank of the Kaldiya river at the village Kuwara.

6.3.2 Impact of Flood Control Measures on Rural Settlements:

Struggle against floods is an unceasing and regular process. No part of the world, however, has solved the flood problem, nor does have any controlling monopoly upon it. Flood always overtaxes states’ exchequer (Mitra, 2002). Flood hazard increases day by day with its devastating effects on life and property including physical changes on land by erosion and silting. The resultant effect of floods is not only because of the fluvio-morphological changes that take place but also the increasing human activities in the floodplain have rendered the fatal results.

However, different flood protection and controlling measures were taken by the state and central government to minimize or mitigate flood damages by means of structural measures. In 1951, The United Nations Organization had evolved the following four main approaches to mitigate the flood hazard (Mitra, 2002). These are:

(i) The construction of embankment (sometimes referred to as dykes or levees and flood walls) to confine the flood waters,

(ii) The improvement of river channels to enhance their discharge capacity, e.g., by straightening, widening or deepening,
(iii) The construction of by-pass and diversion channels to carry some of the excess flood water away from the area to be protected, and

(iv) The construction of reservoir for the temporary storage of flood waters.

A combination of two or more such approaches is required to combat or mitigate adverse effects of flood geomorphology and hazard caused by the river. Among them the raising of embankment along the river banks is the most simple which were adopted as the measures to combat floods right from 1952 onwards. As in the cases of other important rivers in Assam, the state government had constructed sluice gate at Rihabari across the Kaldiya river to control flood. Along with the construction of embankments, some other anti-erosion works and straightening of the course by cutting the meandering bends or draining out the excess water through other channels are also used in the Kaldiya basin.

Both good and bad effects of such flood control measures are experienced in the floodplain. From the field study in the area, it is observed that 60 per cent of the people are not satisfied with the existing structural flood control measures like embankment, ring bund, dyke, etc. It is seen that the construction of embankment leads to

(i) increases the intensity and severity of floods,
(ii) rises the river beds by heavy siltation and sand deposition,
(iii) reduces the fertility of soils outside the dykes,
(iv) turns vast tract of cultivated and settled areas falling within the embankments into wasteland,
(v) causes displacement of earlier settlements forcing the settlers of the river bank areas to change their earlier sites of settlement. These has additional pressure on agricultural land somewhere else,
(vi) decreases the natural production of fishes outside the embankments, and
(vii) does not provide any permanent and practical solution to the flood problem.
it has been observed that such structural measures have to a great extent change the riverine ecology and small ecosystem in the concern areas.

A large section of the people (40%) suggest that embankment should be constructed more scientifically and other measures like digging of river beds, training and straightening the river channel etc. be taken up simultaneously.

6.4 Environmental Perception and Human Adjustment to Fluvio-geomorphic Environment

6.4.1 Environmental Perception

Perception itself is a cognitive process and environmental perception of man is how to conceive or know the environment and act accordingly. Therefore, it plays a great role in affecting and shaping the human behaviour in a variety of ways (Kayastha and Jadava, 1977). People of different communities and locations have different perceptions about the same environment. As already mentioned in different contexts, the study area is composed of monotonous flat land with less physiographic variations. It consists of a narrow strip of foothill zone, built-up plain, active flood plain, marshy and swampy land, beels etc. The severity and intensity of flood occurrence are not same in the whole region. People of different communities are living here. The indigenous high caste communities or the caste Hindus of Assam live in the built-up areas, whereas the scheduled castes and immigrant Muslims mainly occupy the bank of rivers and beels in the lower active flood plain. The scheduled tribes prefer highlands in the north at the foothill zone of the study area.

The sites selected for settlement, design of houses and pattern of adjustment to the fluvio-geomorphic environment are controlled by the environmental setting and human perception about the environs. It is observed that some people of Maguri and Theka areas have temporary farms or pams (locally known) in the flood free northern part of the study area. There are permanent to semi permanent settlements. But in the south, on the active flood plain areas some indigenous dwellers have periodic pams and khuti or bathan (places/spots used for keeping mostly buffalos). The animal keeper used to settle there only during the non-monsoonal months. Along with the livestock keeping they raised some crops too. During the flood time displacement
occurs of such temporary settlements due to their shift with all belonging to their original flood free settlements.

6.4.2: Human Adjustment to the Fluvio-Geomorphic Environment

Despite the human losses that have been experienced, floods have yet to highly discourage settlements in river valleys. On the contrary, there is substantial evidence that occupancy on the flood plain in many parts of the world is increasing. The Yellow and and Yangtse rivers in China have over flowed their banks many times in the past for thousand of years and millions of people were drowned as a result, yet the peasants continued to settle in flood plains. The people living since long back by the side of Kaldiya and other rivers in the study area exhibit different modes of adjustments to the floods.

The people themselves adopt different measures to minimize the damage caused by recurrent flood. The most common nature of human adjustment to floods in the region is found to be the ‘accepting the loss’. The people have the general attitude of accepting the losses but doing for compensating the loss in the next year or so. Again the people have the general attitude of accepting the losses as because they are poor and think they can do nothing to reduce flood damage that happen to be. Therefore, they accept the loss caused by floods as a nature’s curse on them.

The settlements in the flood plains are related to the prevailing fluvio-geomorphic environment of the study area, characterized by floods, erosion, sand deposition, channel changes, levee formation etc. However, in the study area people have taken various measures to adjust with these processes. Even as the government have rendered structural as well as non structural measures to control flood in the Kaldiya river basin, the dwellers of the flood prone areas have rightly adopted their own measures to save themselves from the menace and damage of floods. The measures taken so far are of the following categories

(i) Raising of homesteads (*basti*) by earth filling and erection of houses well above the average flood level;

(ii) Raising of bamboo and wooden platforms for placing straw heaps, cow shed etc;

(iii) Cultivation of varieties of crops before and after flood; and
(iv) Plantation of trees namely – coconut, betel nut, bamboo, banana etc. to check erosion and severity of damage to their homestead lands and plants.

These traditional and temporary as well as permanent adjustments are still predominant as the majority of the people in the area are economically poor. In the annually flooded and low-lying areas of Kawaimari, the homestead areas are sufficiently raised by earth well above the average flood level. Their *chotalas* (the courtyards) are much higher than roads, even 1 to 3 steps requires for climb up from the road.

Besides, during the flood times the dwellers of active floodplain areas tries to get rid of flood hazard migrating from the hazard infested areas to nearby high lands. It happens that many a time at the high stage of flood, the dwellers used to get shelter for days together on the roofs of the dwelling homes. During flood times (3 to 4 waves) in the comparatively low lying areas, the dwellers use rafts made of plainrain trees for moving.

Although different adjustment measures are practised by the people to minimize the loss and damages due to floods, still the flood damages are increasing year by year. Therefore, people’s adjustment to flood, bank erosion, sand deposition and channel change hazards are accepted as an unavoidable loss. This type of approach is an indication of lake of measures to be adopted by the appropriate agencies to protect the people from floods and check recurrent displacement of settlements of other kind of devastations. The flood hazard and disaster risks should be studied well by the appropriate authorities and according methods and strategies are to be formulated for mitigating floods and protecting the people from the onslaught to be caused by floods.
References


