CHAPTER VII

Landuse Pattern and Nature of Human Action

7.1 Introduction

The development of landuse and its pattern in a certain watershed or areas has been, to a major extent, dependent upon the physiographic elements and their functions, specially of soil, climate and water availability. And, therefore, while studying the existing or future pattern of landuse in the area concerned, there is the need of investigation and assessment of physiographic, climatic and edaphic details in addition to that of social, institutional, economic and overall environmental details.

Furthermore, it has been imperative to come to the close contact with the quality and capability of land and land units, cropping pattern, cropping intensity, crop production pattern along with the problems of landuse, etc. as described in the following few paragraphs in order to understand the nature of landuse and formulate strategies for sustainable utilization of various lands in the area concerned. The Kaldiya Basin should not be exception to this principle of study because a rational study on this line may help to identify the existing landuse developed in the basin in response to physiographic and other influences, and to ameliorate the haphazard and untoward pressure of man on land. Pal (1991) substantiated the meaning of landuse with a connotation of land development plan for the future as derived from the book edited by Jana (1991). Lindgren (1985) stated that investigation on landuse is necessary the landuse as necessary for developing landuse policies and carrying various conservation activities.

Since the bulk of the landuse in the Kaldiya Basin is restricted to agriculture, it can be said that “There is an acute need for a much better adjustment of agriculture to the physical environment, not only to gain a surely needed increase in agricultural production but also to maintain a healthy economy” (Bennett, 1943). Singh and Rastogi (1992) in their analysis on morpho-agricultural regionalization of Belanson interstream areas of the eastern Rewa plateau stated that a number of attempts have been made by scholars only to reveal agricultural aspects without giving serious
attention on the influences of land morphology and the morpho-agricultural regionalization. Studies are also available on world agricultural regions based on different criteria. But these criteria stand either for agro-climatic regions or for crop-combination regions. Of course, in some contributions different factors of agriculture have been discussed time to time to delineate agricultural regions. For example, agricultural regions with reference to climatic conditions were examined by Baker (1926), Hartshorne and Dicken (1935).

A number of models have also been developed to explain regional variation of agriculture. For example, the models of Von Thünen (1826), Jonasson (1926), Baker (1925), Whittesey (1927), in delimiting agricultural regions can be mentioned here. But not a single model can be applicable to explain landuse diversity in Bajali area covering a part of Kaldiya basin. In the Kaldiya basin, the dominating crop is rice which does not leave scope for development of other crops. In the vast agro-landscape there are a few patches of areas devoted to multi-cropping and inter-cropping. In the middle reach, of the basin some areas are devoted to sugar cane, vegetable and garden crops in addition to rice.

Landuse being the conspicuous element in the pattern, explanation requires reference to factors like peasant’s behaviour and decision making. Traditional crop – raising is not substantially replaced by modern crop-raising, because the peasants lack in adequate knowledge and far-sightedness.

Throughout the Kaldiya basin rice as the king crop dominates interspersed with patches of garden crops marked by areca-betel, coconut trees etc. The sole purpose of crop-raising in the Kaldiya basin is the production of food crops i.e. cereals for human and animal consumption.

The terrain characteristics, climatic condition and crop combinations very closely related as stated by Stamp and Weaver (1974) and Erug and Tuneditck (1952). The climatic factors play an important role on determining agricultural regions. But where the climatic variation is not high nor the region is climatically homogeneous, geomorphological characteristics are seen to play their important roles to determine the pattern of variations in landuses. Kamp (1968) used soil capability as the basis for the division of Denmark into agro-geomorphic regions, while Ayyar (1967) divided the Upper Narmada basin into morpho-agricultural regions on the basis of terrain.
characteristics. Sharma (1979) combined the physiographic elements with crop-combinations for the division of the Lower Chambal valley into morpho-agricultural regions. In this regard a few pioneering studies may be alluded, Ghosh and Singh (1965) worked for the villages of Kintond. In a geomorphological study of the Sonar-Bearma Basin, Rai (1980) has observed that erosional plain formed the agricultural land in the basin. In another work Mukhopadhyaya (1986) has studied the relationship between landform and landuse in the Kangasabati Basin. Similar studies were made by Iyer and Srinivasan (1977), Hironi (1991), etc.

Slope also influences the landuse system. Singh and Dhillon (1984) stated that steepness of slope renders limitations to cultivation. They also found that variation of slope leads to variation of climate and soil and therefore, there is the change of practices of cultivation. Mukherji (1985) worked on zonation of the principal landuse components in the Western Himalayas (Himachal Pradesh) based on altitudinal variations. The river basin maintains gentle gradient virtually with no variation of slope. Therefore, there were no hindrances to agro-practices. Climate remains same throughout, only soil conditions vary. To the North gravelly soil stands contrast to silty alluvium in the lower reach of the basin. The upper reach of the Kaldiya basin, therefore, is dominated by garden crops and crops like oil seeds, pulses etc. The middle and lower reaches are dominated by food crops and garden crops together.

An integrated analysis based on physico-socio-economic components and geoinformation is found to render outstanding result. In this context, assessment using integrated and interpolation methods was carried by Rais, Mohmmad and Khan (2000).

7.2 Existing Landuse Pattern in the Kaldiya Basin

So far the landuses of a basin are concerned, they may be classed into five major groups (District Census Handbook, 2010). These landuse categories are (i) forestlands (including some areas under reserve forests), (ii) cropland with irrigation facilities, (iii) cropland without irrigation facilities, (iv) cultivable wasteland and (v) the area not available for cultivation. (Table 7.1)

Data show that the forest area including some areas under reserve forest (R.F.) in the basin covers an area of 4670 hectors equivalent to 10.60 per cent of the basin’s total area. But in 2010, the estimation of the areas under the category of land use rose
to 10.78 per cent or 4750 hectares of the basin’s total area. This is far below the required mark (33%) of forest cover for keeping sound ecological balance in the basin. The remaining 89.40 per cent basin’s total areas in 2001 and 89.22 per cent in 2010 were devoted to various crops (with or without irrigation facilities) and wastelands, etc. (Table 7.1). The total area under cropland amounts to 24540.65 hectares or 55.70 per cent of the basin’s total area. Of this 6.28 per cent equivalent to 2765.25 hectares of land is marked by cropland ‘with irrigation facilities’. On the other hand, an area of 21.775.4 hectares or 49.42 per cent of the total cropland goes to constitute ‘cropland without irrigation facilities’ in 2001. So far the percentage distributions of 2010 are concerned a share of 8.04 per cent equivalent to 3543.02 hectares of cropland goes to constitute ‘cropland with irrigation facilities’, and 50.60 per cent or 22292.4 hectares of land represents ‘cropland without irrigation facilities’. The shares of ‘cultivable wasteland’ and the ‘area not available for cultivation’ as per 2001 record are respectively 13.31 per cent equivalent to 5865.63 hectares and 20.39 per cent or 8982.72 hectares. The two aforesaid distributional extent of landuse in the basin are seen to mark 11.11 per cent or 4894.81 hectares and 19.47 per cent equivalent to 8578.77 hectares respectively as per 2010 data.

**Table: 7.1 Kaldiya Basin- The Landuse Categories (2001-2010)**

<table>
<thead>
<tr>
<th>Landuse categories</th>
<th>Area (in hect) 2001</th>
<th>Percentage to total area, 2001</th>
<th>Area (in hec) 2010</th>
<th>Percentage to total area, 2010</th>
<th>Increase or Decrease in 2001-2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forests land</td>
<td>4670</td>
<td>10.60</td>
<td>4750</td>
<td>10.78</td>
<td>102</td>
</tr>
<tr>
<td>Irrigated Crop land</td>
<td>2765.25</td>
<td>6.28</td>
<td>3543.02</td>
<td>8.04</td>
<td>128</td>
</tr>
<tr>
<td>Unirrigated crop land</td>
<td>21775.4</td>
<td>49.42</td>
<td>22292.4</td>
<td>50.60</td>
<td>102</td>
</tr>
<tr>
<td>Cultivable wasteland</td>
<td>5865.63</td>
<td>13.31</td>
<td>4894.81</td>
<td>11.11</td>
<td>83</td>
</tr>
<tr>
<td>Area not available for cultivation</td>
<td>8982.72</td>
<td>20.39</td>
<td>8578.77</td>
<td>19.47</td>
<td>96</td>
</tr>
<tr>
<td>Total</td>
<td>44059</td>
<td>100.00</td>
<td>44059</td>
<td>100.00</td>
<td></td>
</tr>
</tbody>
</table>

**Source:** Based on data collected from Census Bureau of India, Guwahati

Table 7.1 reveals certain significances in the changes of landuse in the basin during 2001-2010. In all the cases of landuses, there has been very little increase or
decrease either of total area or of percentage shares of land. This phenomenon has its substantial relationship with percentage growth of +ve or –ve nature as shown in table 7.1. Even there is application of modern techniques in landuse and at the same time there is need of increasing land for productive practices, the forestland has increased only to 102 percent in 2010 as compared to 100 percent in 2001. The unirrigated cropland has increased marginally by about 517 hectares because of land made available with cropland transformed from cultivable waste land etc. Because of this, the cultivable wasteland has reduced to 11.11 percent in 2010 from 13.31 percent in 2001. Again, of late, there has been some advances in the use of irrigation in the agricultural fields of the basin. As a result of the increase of the irrigated land, the change of landshare at the end of 2010 is estimated at 128 percent after the interval of 10 years. There has been soft decrease (by about 4 percent) of the area not available for cultivation. Such a distributional pattern of static landuse during a span of 10 years will definitely help in formulating strategies for sustainable and productive landuses.

**Table 7.2a : Kaldiya River Basin : Classification of Landuse, 2006**

The landuse classification in the Kaldiya basin in 2006 grouped into 17 categories. The categories are

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Category</th>
<th>Area (Sq.km.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Built-up Area (Rural)</td>
<td>128.74</td>
</tr>
<tr>
<td>2</td>
<td>Rabi Crop Area</td>
<td>0.47</td>
</tr>
<tr>
<td>3</td>
<td>Natural Wetlands</td>
<td>10.14</td>
</tr>
<tr>
<td>4</td>
<td>Scrub Land-Dense</td>
<td>0.12</td>
</tr>
<tr>
<td>5</td>
<td>Scrub Land-Open</td>
<td>2.75</td>
</tr>
<tr>
<td>6</td>
<td>River/Stream</td>
<td>13.11</td>
</tr>
<tr>
<td>7</td>
<td>Two Crop Area</td>
<td>13.18</td>
</tr>
<tr>
<td>8</td>
<td>Grass/Grazing land</td>
<td>5.68</td>
</tr>
<tr>
<td>9</td>
<td>Sandy area-Riverine</td>
<td>0.45</td>
</tr>
<tr>
<td>10</td>
<td>Built-up Area (Urban)</td>
<td>2.87</td>
</tr>
<tr>
<td>11</td>
<td>Lakes/ponds</td>
<td>0.20</td>
</tr>
<tr>
<td>12</td>
<td>Agricultural Land-Fallow</td>
<td>2.09</td>
</tr>
<tr>
<td>13</td>
<td>Agricultural Plantation (TE)</td>
<td>11.17</td>
</tr>
<tr>
<td>14</td>
<td>Scrub Forest</td>
<td>20.58</td>
</tr>
<tr>
<td>15</td>
<td>Evergreen/Semi Evergreen Forest</td>
<td>12.78</td>
</tr>
<tr>
<td>16</td>
<td>Moist Deciduous Forest</td>
<td>11.49</td>
</tr>
<tr>
<td>17</td>
<td>Kharif Crop Area</td>
<td>213.19</td>
</tr>
</tbody>
</table>

*Source : Assam Remote Sensing Application Centre, Guwahati, 2006.*
Source: Landuse/Landcover Map, 2005-06, ARSAC

Fig: 7.1
From Table 7.2a, it has been seen that the agricultural land under Kharif crops occupies 213.19 sq. km. which is the highest among all the categories. Secondly, the built-up (Rural) category covers 128.74 sq. km. of the basin. The Scrub Forest occupies 20.58 sq. km. The Scrub Land Dense covers only 0.12 sq. km. which is the lowest among all categories (Fig. 7.1).

**Table 7.2b Kaldiya River Basin : Classification of Landuse, 2011**
The landuse in the Kaldiya basin in 2011 grouped into 19 categories. The categories are -

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Category</th>
<th>Area (in Sqkm.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Agricultural Plantation</td>
<td>11.68</td>
</tr>
<tr>
<td>2</td>
<td>Kharif crop areas</td>
<td>228.30</td>
</tr>
<tr>
<td>3</td>
<td>Wetland/Zaid</td>
<td>5.40</td>
</tr>
<tr>
<td>4</td>
<td>Double Crop areas</td>
<td>22.58</td>
</tr>
<tr>
<td>5</td>
<td>Scrub land-Dense</td>
<td>0.53</td>
</tr>
<tr>
<td>6</td>
<td>Scrub Land –Open</td>
<td>4.07</td>
</tr>
<tr>
<td>7</td>
<td>Evergreen/Semi Evergreen</td>
<td>13.45</td>
</tr>
<tr>
<td>8</td>
<td>River/Stream-Dry</td>
<td>0.19</td>
</tr>
<tr>
<td>9</td>
<td>Quarry</td>
<td>0.03</td>
</tr>
<tr>
<td>10</td>
<td>Built up (Rural)</td>
<td>162.37</td>
</tr>
<tr>
<td>11</td>
<td>Rabi</td>
<td>0.67</td>
</tr>
<tr>
<td>12</td>
<td>Scrub Forest</td>
<td>6.05</td>
</tr>
<tr>
<td>13</td>
<td>Grass/grazing land</td>
<td>7.56</td>
</tr>
<tr>
<td>14</td>
<td>River/Stream-Perennial</td>
<td>12.33</td>
</tr>
<tr>
<td>15</td>
<td>Lakes/Ponds</td>
<td>0.36</td>
</tr>
<tr>
<td>16</td>
<td>Fallow Land Agricultural</td>
<td>7.05</td>
</tr>
<tr>
<td>17</td>
<td>Built up (Urban)</td>
<td>4.89</td>
</tr>
<tr>
<td>18</td>
<td>Riverine Sand</td>
<td>0.62</td>
</tr>
<tr>
<td>19</td>
<td>Deciduous forest</td>
<td>15.07</td>
</tr>
</tbody>
</table>

Source : Assam Remote Sensing Application Centre, Guwahati, 2011.

From Table 7.2b, it has been clear that the agricultural land under Kharif crops occupies 228.30 sqkm. (45.38%) and the Rabi crops occupy 0.67 sqkm. On the other hand, the built up (rural) areas cover 162.37 sqkm. (32.28%) and built up (urban) areas cover 4.89 sqkm. The total forest cover including evergreen/semi evergreen, mixed deciduous and scrub is 38.63 sqkm and the percentage will be 7.68 which is very less than normal coverage. During the field study, it was observed that even the northern foothill areas have also now going to be deprived from forest cover. The river/streams occupy only 12.33 sqkm. of the basin (Fig. 7.2).
Source: IRS LISS III Image Nov'2011, ARSAC

Fig: 7.2
The landuse map of the Kaldiya river basin, 2011 (Fig 7.2) shows nineteen categories of landuse pattern. On the other hand, the landuse map of the same basin in 2006 (Fig. 7.1) shows seventeen categories of landuse. In 2006, quarry category and river/stream-dry categories are not seen in the map. There is a marginal increase of landuse of Rabi crop and decrease of Kharif crop in 2011 than 2006. The percentages of forest cover are also decreasing in the year 2011 in comparison to 2006. But the built up (Urban) category has increased from 2.87 sq. km. to 4.89 sq. km. in the year 2006 and 2011 respectively.

### 7.3 Problem of Landuse

Land which is one of the important components of life support system has been now overused and abused (Khoshoo, 1987) almost everywhere especially in the river valleys. In 1972, the late Prime Minister, Shrimati Indira Gandhi said about the land as “we can no longer afford neglect our most important natural resources. This is not simply an environmental problem but one which is basic to the future of our country” (quoted from Khoshoo, 1987). Here actually lies the real spirit and purpose as regards importance of landuse.

Problems of lands and landuses in the Kaldiya Basin are numerous. Flood, erosion, siltation and sand deposition, water-logging and land wastage, etc. have been the regular features in the basin. The quality of land resource including its capability and productivity has been going to deteriorate day by day because of combined action of both the natural and human factors. Most rampant factor is the erosion of land and soil. The complex nature of problems, may, however, be estimated by considering the agents and processes discussed in the following few paragraphs.

#### 7.3.1 Problems Associated with Flood

Seasonal floods are common in the Kaldiya basin. The successive floods of 1998, 1999, 2000 and 2004, to mention only a few, may be considered here so as to grasp at the problem related to landuse. A field survey conducted in 2008 by the researcher reveals that there have been failures of the ‘Sali’ and the ‘Ahu’ rice crops year after year in most of the parts of the basin. The 1998 and 2000 floods were so devastating that these events caused almost total failure of the agricultural crops in many areas of the basin during the years. In 1998 there were seven successive floods in the rainy season from April to July and the water level rose up to 1.5 meters above
the general level of the agricultural field. Great damage was caused to crops in the year 2000 also. There were ten successive floods during which water level rose up to 2 meters above the general ground of the agricultural fields. So far productivity of agricultural crops is concerned, in the normal case rice is produced by about 18 to 22 quintal per hectar of agricultural land. Floods are seen to happen in the basin, like other areas of the Brahmaputra Valley very erratically. Sometimes they occur heavily during the month of May; sometimes they take their disastrous positions during June or July or August or even during September. Because of uncertainty of flood occurrences, great damage to standing rice crops comes almost every year. As a result the production of crops and the soil fertility (discussed already in the part of soil capability) used to go down. The production of rice ranges from very low to around 8 quintals per hectar of land. Of course, a bit high crop production prevails where there were no disastrous floods.

7.3.2 Problems of Slope and Deforestation

Slope failure and deforestation in the basin, especially in its hill and foothill areas are seen to accentuate various kinds of erosion and problem to landuse. It is found through measurement and estimation that the velocity of flowing water increases twice when there is an increase of degree of slope by four times. The ravine areas of North-East India has soil erosion rate of 33 tonnes/hector/yr, while the Assam Valley is marked by soil erosion amounting to transferred materials to about 28 tonnes/ha/yr. The Kaldiya Basin is no exception to such a dimension of erosion and degradation in case of arable land. Thus erosion, sedimentation and degradation of arable lands in the Kaldiya Basin have been forming a problem with great stress and strain. Soil erosion by faulty agro-practices associated with bank erosion by the river accentuates the problem especially during flood time. The force of the currents impinges against the bank. The result is under-cutting and slumping of masses of the bank.

It has been pertinent to mention here the sedimentation and degradation of arable land in the Kaldiya Basin based on a case study of the Helona gaon (between built-up plain and chronically flood-affected land). The researcher while conducting a field survey in 2008 identified a thick coverage of silt and sand in this village. Such an environmental development of micro landform badly hit the productivity and economy of the area. Actually this scenario of the part of the basin owes its origin to
upstream action of streams carrying water and sediments in excess and yielding debris to move and deposit in the downstream areas.

Decrease of productivity of arable land has now been world-wide concern. In the Tenth Session of the F.A.O. Conference held in Rome in 1973 (F.A.O., 1977) it was concluded that “The major environmental problems facing agriculture were not only the avoidance of environmental pollution but also the ensuring in the development process, of the maintenance of the production capacity of the natural resources for food and agriculture through rational management and conservation measures.” Therefore, productivity should be increased through soil management programme.

7.3.3. Problem of Irrigation

Another stress of landuse in the basin is with irrigation to agricultural land. As per 2001 data, the land under irrigation in the Kaldiya Basin stood at about 7 per cent of the total geographical area of the basin. It is also estimated that about 1 percent of the total geographical area of the chronically flood-affected land is under irrigation. But in the built-up plain as high as 10 per cent of the total geographical area of this plain is under irrigation. It is, however, observed that in this part of teeming population in the Brahmaputra Valley, the existing dimension of irrigated land lies far below the optimum effective quanta of irrigation requirement. Sluice gate at Rihabari point and the diversion canal in the middle course of the river is seen to help in the slight progress of irrigation in the basin.

In spite of ample scope for supply of water through various means, such as the river lift irrigation (R.L.I.) tube well, shallow tube well and cannel irrigation any part of the basin has not been able to increase either irrigation intensity, thus edging the area from high production areas of agricultural produces. Of course, in the field it is seen that there persist today some unsystematised time-consuming and less-effective irrigation means among the hardworking peasants of the basin. If the government incentives and proper inputs are given to and cost-effective approaches are made with the existing means of irrigation, definitely a sort of persistency in irrigation and faith of the peasants will, no doubt, come with the irrigation sector.
7.3.4 Problem with Small-Holding of Agricultural Land

Small landholding per family prevents from supplying necessary inputs in right time at right place. The overall scenario of the landholding in Assam based on a survey by Bora (1987) shows that about 65 per cent of the sampled households of the state have land below the minimum requirement of holding of only 2 hectares (for economically viable pursuits). In the study area it is observed in the field that the landholding per family is high in the terai region because of its infertile land and sparse distribution of population. But in the built-up areas, the landholding is small. Here the rate of fragmentation is more. On the other hand, in the chronically flood-affected land the landholding is big in comparison to that of the built-up plain.

Variation of landholding is mainly due to the effect of the physical environment. The landholding at present is going smaller and smaller because of increasing pressure of population on land.

7.3.5 Relationship between Slope and Existing Landuse

The Kaldiya basin is a represents mostly cultural landscape that suffers from acute human pressure. Landuse changes in the basin therefore takes a very serious forms. For the present purpose, landuse changes can be described based on two-phase processes, viz.

a) Forest clearance for the purpose of cultivation and grazing.

b) Urbanization.

Both the processes contribute to sediment yield way back in the beginning of the 20th century. The areas to the north of the Gohain Kamal Ali now converted to National Highway No. 31 were covered by thick forests as evidenced from the place names partly with plants and animal names. Now no trace of forests can be seen. Instead croplands, transport routes, settlement units and institution have been the obvious scenes.

During the last 50 years, the urbanization and market centre development process have gone at their rapid pace. Although these are too localized, their effects are far-reaching on geomorphic landform and landuses. The rapid growth of landuses has led to development of less in impervious layer of soil and derangement of drainage system in the areas of urbanization and market centres.
The slopes have great influence on landuse. In the field under study, it was observed that landuse varies from north to south in the basin according to the decreasing slope. The highlands of the north are covered by forests even as there are also croplands. But agricultural practices are seen in the plain areas of the Kaldiya basin in a large way. The chronically flood affected areas in the south of the basin are put to agricultural as well as non-agricultural uses.

7.4 Strategies for Landuse Management

As regards the historical development of landuse it is observed that landuses in the basin ranges from very simple to most complex one. It is further observed that the history had its own course to develop and modify human habitation and the use of land mainly for raising agricultural crops for subsistence or life support of the people of the area. However, there is felt the utmost need for better landuse management as because the land in the basin is now managed haphazardly and the production is very low which can not feed the existing population. The land of the basin is fertile and, therefore, there is a good prospect for better landuse management in the basin.

7.4.1 Historical Development of Landuse in the Kaldiya Basin

A qualitative analysis of development of landuse from historical perspective indicates that not only the northern and middle parts of the Kaldiya Basin but also the northern part of undivided Kamrup district (now divided into Barpeta, Nalbari and Kamrup districts) was up to about 1950 devoid of even the medium concentration of populations and market centres. Now it is observed that though there are scattered areas of scanty population because of physical constraints many areas, specially the built-up and flood free areas of the basin are having high concentration of population and more than 12 market centers. Such areas are characterized by density of population of 398 (persons/km²) as per 2011 census.

A study on population growth between 1872 and 1971 of the district of undivided Kamrup indicates that the district’s total population in 1872 was 5,61,681 persons. However, it has increased to about 1.36 times in 1921, while it became greater than 2.2 times in 1941, whereas in 1961 the population of 1872 rose to 3.67 times and in 1971 it stands at 5.08 times (Barman, 1986). Again it is interesting to note here that population of the district is growing tremendously to exercise immense pressure on land and environment of the district. The increase of population were 7.96
and 8.74 times at the ends of 2001 & 2011 respectively over the population of 1872. The present study area being a part of the undivided Kamrup district also experiences population pressure over its land and landuses.

A study by Barman (1986) reveals that in the recent past most of the areas north of the present railway line were devoid of heavy population concentration as because these areas were covered with forest and grasses. Moreover, there were then only the rivers as the communication lines. The land was of course, occupied by aboriginal tribes constituting the Bodo groups living hither and thither on the bank of the river Kaldiya and its tributaries. On the south there were, however, some indigenous non-tribal and tribal villages on the levees of the rivers and streams. As a result there was neither ample use of land for cultural development nor there was complexity of landuses.

Again, the above study revealed that a catastrophic event due to most disastrous earthquake of 1897 disturbed many of the areas of Assam including the present study area. The areas of the district of undivided Kamrup, specially in its part nearer the Brahmaputra where population concentration was comparatively much more suffered a lot. Because of depression caused by the earthquake, disastrous floods did occur every year subsequently after the earthquake. As a result most of the people were compelled to flee to the northern part of the basin where flood affect is comparatively low and the land was available for easy habitation and raising crops at least for their subsistence. For example, there are many villages in and around Jalal, Thamna, Choibari, Pipla, Bamunpara, Saderi, etc. which are having the people of migration origin. They came from the flood-affected areas of the Sarukhetri Mouza near the northern bank of the river Brahmaputra. Again, the lowlying areas scattered over any geomorphic units are now occupied mostly by the Muslim peasants of erstwhile East Pakistani origin. All these have made the present landuse practices in the basin a complex one, even though the basin landuses are mainly of horizontal nature.

7.4.2 Need of Better Landuse and Landuse Management

In the present context of problematic situation the land resources are deteriorating everywhere resulting in adverse effect on natural, cultural and social and economically relevant ecological settings. Thus, there are needs of cost-effective and
cost-benefited principles and policies of landuse management in the Kaldiya basin. According to J.N. Murthy (1995) “Land Management invites surveys as to the extent of the soil capability and optimization of environment managing the physical, chemical and biological components of the land.” The purpose should be to minimize run-off and erosion, ensuring adequate water storage, and accreting and developing green cover.

In the study area prospect of land resource management by adopting proper plan and programmes in the watershed region in terms of fluvio-geomorphological and socio-economic perspective is found to be bright. According to Tripathi and Singh (1993) “watershed management involves management of the land surface and vegetation so as to conserve and utilize the water that falls on the watershed and to conserve the soil for immediate and long term benefits to the farmer, his community and society.” He also stated that “the integrated landuse planning for watershed management in the limited sense, aims at comprehensive development of whole of the watershed in accordance with its potentialities and capabilities for different landuses. In the broader perspective such a planning deals with the total development of all kinds of resources of the watershed, namely, land, water, climate, plant, animals and man. The ultimate aim is to improve the economic status of the inhabitants of the watershed.”

**7.4.3 Prospect of Landuse Management**

In broader perspective the Kaldiya river and its resourceful watershed which represents highland-lowland interactions have the potentiality to overcome many of the social and economic problems entangled with the basin’s land and environment. The foothill region on the one hand, and the built-up along with lowlying areas on the other, have the every possibility to embrace planned and conducive management measures for better allocation and investment of human efforts which in turn enhance the purpose of and satisfaction with the goal of effective production and sustainability of land and society in future. The people of the Kaldiya Basin as a whole depend upon agriculture as more than 80 per cent of the basin’s people are engaged in cultivation.

A partly abnormal behaviour of the river Kaldiya frequently damages the cropland areas hampering badly the basic economy and normal livelihood of the poor masses, specially in the flood prone areas. Therefore, it has been imperative to think
to investigate the scope for better human survival and opt, amongst many, for enhancement of better production. The growth rate of the population in the basin is 2.914 per cent per year within 1991-2011. If this rate goes for another three decades i.e. up to 2041, then the population of the basin will rise with an extra population of 85.52 percent. As a result of such an increase the density of population (504 person/km\(^2\)) as per 2011 will rise to 827 persons/km\(^2\) in 2041 (§ 2.3.2). To mitigate the problem of the teeming population there is the need of effective and integrated landuses.

The major part of the prospect for proper landuse may be entangled with the agricultural and agro-based industrial sectors even as land to be devoted to other uses can never be denied. The physiographic, climatic and edaphic conditions and the human resource behaviour in the basin are such that they can evolve and extend help in producing and enhancing a better-off situation for all kinds of resource development. The basin provides differential land units and land systems covered by foothill, built-up and chronically flood-affected areas bearing differential prospects for land management. The foothill, the bhabar and the terai zones of the basin have the Reserved Forests (R.F.) wastelands along with land not available for cultivation are scattered hither and thither. For better economy of these part of land on the one hand, and to keep the ecological balance and to protect the bio-diversity on the other, some areas not suitable for habitation and crop-culture can be brought under new forest cover. The old trees can be felled down for commercial and household purposes and new plants may be replaced in these areas. The built-up and the chronically flood-affected lowlying areas are identified under good capability land. The downtrend of productivity is not only due to natural disturbance (flood and other hazards) but also due partially to human ignorance to land and its management, economy and education, etc. The dimension of the adverse or poor impact of people on the land and its management for production may be grasped at the pattern of literacy and levels of education in the basin. In the context of proper landuse management and production, it can be said that the modern techniques of landuse development would be fruitful only when the peasants have the adequate knowledge through education. Thus, this needs the training of the peasants for their quality development. Also the appropriate agencies should come forward with steps and strategies to uplift the health and mentality of the peasants.
Flood has been a more sensitive natural hazard in Assam as a whole. In the Kaldiya Basin frequent occurrences of flood of different intensities and durations have been a common phenomenon affecting land and landuses of the basin. The anomalous run-off on the basin causes great damage to standing crops on the one hand and the human habitats on the other. A field observation and study conducted during 2008 by the researcher has revealed that most of the flood occurrences are caused and enhanced due to stressed condition of unscientific construction of embankments and ring bunds. The study further reveals that there are some areas in the basin which should not actually fall under serious flood menace. For example, the researcher observed such a flood menace in the village Bhaluki and its nearby areas located on the built-up plain. A sluice gate placed on the ring bund is sometimes kept open in order to protect agricultural land from sudden and strong outflow of flood waters. Various measures including opening or closing the gates may be extended to other areas where there occur floods of local nature. The reticulated nature of drainage system in the Kaldiya river basin also sometimes leads to inefficient flow of water along the channels. Therefore, the river managers and the land planners and users should think of appropriate measures as explained in the strategy formulation (§ 7.4.4). The built-up and the chronically flood-affected areas are now devoted mostly to double cropping practices to feed the concentrated population and to increase economy of the areas. Since there is ample scope for enhancing irrigational facilities by harvesting water from different sources, there is high prospect for enhancing both the net sown area and the gross cropped area. In spite of good potential of water for irrigation in the basin there exists till today only 10 per cent of the built-up land under irrigation. The land under organized irrigation in the chronically flood-affected areas is negligible as per 2001 record. The record shows that land under such a vital facility for agricultural development is only 1 per cent of the total chronically flood-affected land. For viability of greater and qualitative coverage and development of agriculture and raising agro-based economy in the basin, land now remaining unused should be developed by adopting techniques of reclamation, etc. Moreover, most modern techniques and practices of agriculture are found to be imperative in this sector of regional development.

In order to fulfill the goal of self-sufficiency and growing market demand, no room having resource potentially should remain unused. Every part of the basin, as
observed by the researcher, is full of beautiful resources. It is estimated by the researcher that around 10 per cent of the total cultivated land of the basin is engaged in production of vegetables of different kinds. They have high demand as every family on the average needs two kilograms of green vegetable, potatoes, onion, etc. per day to fulfil their food essentials combination. As there are vegetable deficit areas in and nearby the basin and also there is demand of the items in the urban and semi-urban areas of the surroundings, there occurs a great prospect of devoting gross cropped areas to the cultivation of the items.

The people of the basin like other areas of the western part of the Brahmaputra Valley are immensely indebted to ‘Nature’ as the land here is having high potentiality to grow crops. The basin favours in yielding high quality coconut (*Cocos nucifera*) betel nut (*Areca catechu*), betel leaves, black peper (*piper nigrum*), ginger (*Zingiber officinale*), turmeric (*Curcuma longa*), chilli (*Capsicum frutescens*), pineapple (*Ammanas comssus*), jackfruit (*Aetocartus integrifolia*) etc. Some of them have medicinal values. All these products have market demands in, around and outside the producing areas.

Another major prospect for development in the Kaldiya Basin lies with the wetland’s aquatic resources. The wetlands are the storehouses of the aquatic flora and fauna. Today, there has been a growing tendency to protect and preserve wetlands to keep balance of eco-bio-diversity. Tall grasses, reeds, etc. are found to grow in the wetlands. These reeds have the potentiality to manufacturing of ‘Dhari’ and ‘Pati’ (kinds of mat) etc. A section of people around these wetlands have their work culture and expertise to make high quality ‘show-pieces’ small containers, baskets, etc with locally available natural resources. Moreover, the wetlands are storehouses of aquatic food items like ‘bethphul’ (*Nymphaca lotus*), ‘nickheri’ ‘seluk’ (*Nymphaea nausalia*), etc. All these have commercial values. The ‘seluk’ is collected by the muslim peasants of immigrant origin from the wetlands of Pitadipam area. They earn money by selling it in the market. The ‘seluk’ is behaves as nutritious food item.

A survey on the location of the wetlands has revealed that there exist as many as 12 wetlands in the Kaldiya basin, which may bring economic, ecologic and hydrologic balance and prospects to the people of the surrounding areas. Most of the wetlands are till today treated as the habitat of a variety of fish and other aquatic organisms. If these wetlands are protected from their degradation and extinction, they
may satisfy the demand of fishes and aquatic resources of the area. Again the wetlands act as the major sources of grasses (*dal ghah* in Assamese, *Hygroryza aristata*). For this reason of availability of grasses in numerous wetlands and lowlying areas, the whole of the Barpeta district including the Kaldiya-Pohumara basin had developed rearing of buffaloes to a great extent. A comparative study on the distributional pattern of buffaloes in the three districts, viz., Kamrup, Nalbari and Barpeta can substantiate the fact. There were 6, 8 and 12 heads of buffaloes per square mile respectively in the three districts as per an estimate of 1972 (Barman, 1986). Though at present, there has been deterioration of stocks buffalos in all the districts, the dominance of the Barpeta district still persists. This can further be authenticated by the researcher’s observation in the field that there were as many as 6 buffalo rearing points (*Moh khuti* in Assamese) scattered over 6 villages of the basin.

It is further observed that the number and areas of wetlands are more in the Barpeta district in comparison to the other two districts (Barman, 1986).

The wetlands have other prospects too. If some of the wetlands are managed properly and beautifully, they may be converted to be the spotted with economic resource base cum tourist spots. Moreover, they may be associated with some parks for developing aesthetic and recreational facilities and kinds of scientific plans and programmes.

### 7.4.4 Suggestions for Landuse Management

The land, water and resources of the basin have a great value to different kinds of developments and sustainability of nature, man and society. They have at the same time prospects for better organization, better utilization and accelerated but balanced development. In this context, it may be argued that the Kaldiya Basin, like other areas of the Brahmaputra Valley, has plenty of diverse resources not only for subsistence of the people but also for growing commercial economy. On the other hand, it is seen that the basin itself like other areas of the Brahmaputra Valley is least developed. A number of Government plans and programmes have been adopted for the purpose of development. But in the real sense they are far away from the warm touch of action. Perhaps the strategies adopted for getting examined the conditions or the pattern of formulation of strategies might be wrong. Based on such discrepancies the researcher has attempted to shape some strategies for evaluation, use, reuse and development of land and economic sectors etc. of the basin.
An ideal drainage basin like the Kalidya Basin characterized by differential landforms and socio-economic developments in terms of pattern and processes must be approached by following the integrated norms and practices while achieving sustainable development in all respects—natural as well as cultural. For this reason different resources and assets including their processes must be explored.

The following few paragraphs are however, devoted to formulation of strategies of landuse management in the basin:

1. The pattern and dynamics of differential developments including their history in the Kalidya Basin must be explored so as to understand the changing characteristics of different aspects. This may help in understanding the genesis and nature of the problems and their future impact,

2. However, since a drainage basin contains the combination of land and people, an integrated approach on the physical dynamics on the one hand and human ones on the other must be taken for assessment,

3. For this purpose the pattern of interaction of high-lowland relationship of all the aspects must be taken into consideration,

4. A well-established geomorphological study will be helpful in identifying areas of geomorphological vulnerability in the basin in respect of slope and erosion in the foothill areas and the sheet and bank erosion along with shifting of channels in the plain areas. Moreover, floods are to be investigated as a geomorphic, ecologic, environmental and socio-economic agent as they do influence on the land and people of the basin specially in the parts of the built-up and lowlying areas. Heavy sedimentation on the bed of the Kalidya and its tributaries has been a problematic phenomenon in the basin. In order to get rid of all these problems necessary steps should taken either check or ameliorate or eliminate the problems. Side by side conservation of land and resources of the area needs due attention. To arrive at the solution a well-designed decision may be made for this area based on the geomorphological conditions,

5. The erosion of land and soil in the upstream areas may be checked if landuses are managed and deforestation is controlled. However, if afforestation is made step by step in the areas of erosion or degradation, land degradation would reduce ultimately to almost nil after few decades. Definitely it will result in almost no supply of sediments to be deposited continuously in the bed of the
river Kaldiya and its tributaries. Side by side a step can be taken to make the slope of the streams efficient to increase carrying strength and carrying capacity of water along the river channels.

6. Scouring or aligning may be done along the streams which have now remained either abandoned or become inefficient in the reticulated pattern of drainage network, specially in the built-up and lowlying areas of the basin. In this case most of the areas of the rivers in the basin, specially in its built-up and lowlying areas need proper training and channelizing.

7. As regards flood, there must be joint attempt of the Bhutan Government and the Indian counterpart. There must be an agreement on river regime and flood amelioration. In order to ameliorate the flood intensity in the downstream areas a number of ‘bunds’ across the river and the basin should be constructed in the land of Bhutan. The ‘bunds’ should have outlets through adjustable sluice gates. Moreover, terracing of landuse in the upstream areas may control direct on-rush of storm waters and sediment flow.

8. In the downstream areas floods may be controlled or mitigated by the distributing the onrushing waters through the Kaldiya river and its reticulated branches, provided the reticulated streams are made efficient by adopting the means as stated already in point 6. As regards water-logging areas, one can suggest for conversion of the areas into natural reservoirs and lakes to give impetus to natural fishing and aquatic resources on the one hand and source of perennial waters for raising crops all the year round in the basin. This may also boost the economy of the area.

9. Another step for mitigation of flood damage and the enhancement of people’s interaction in the basin may be adopted by constructing embankment cum roads along the river Kaldiya. Side by side, the gap areas between the embankment and the river should be planted with flood resistant and climate-friendly trees of ecologic and economic importance. In this context it can be mentioned that the government of India had already progressed in the construction of an express highway along the duab of the Pohumara and the Kaldiya river,

10. There are scattered pockets along the levees of the river where vulnerable floods do occur frequently. However, these areas have high potential for growing cash crop like jute, flood resistant paddy and vegetable. In order to
have more production and yield along with management of land and crops, few Muslim peasants of immigrant origin may be given settlement and engagement in these pockets. Such an attempt must be given effect with the knowledge of the government and the local people of the areas concerned. This may broaden the interaction between the Hindus, the Muslim peasants and other local people. They may boost the economic development on the other. However, in this case the authorities and the local people should see that there might not be any problem in future in the land and society of the areas. The viability of the concept and methods to be adopted must be thoroughly examine taking man and mind of the people of the localities,

11. Identification of wetlands, wastelands, and areas not available for agricultural activities should be made and rational uses of land in these areas be made for the socially significant productive economy and conservation of environment,

12. To follow the real meaning of land and land management there is the need of identifying the soil characteristics and capabilities so that this may lead raising of economic, social and eco-friendly crops and plants. A good study, therefore, be made on physical, chemical and biological analysis of land in the areas. Depending on this a micro regional classification of soils may be made,

13. There is every possibility of developing scenic beauty and resource extraction from the scattered wetlands of the area. The wetlands may be made storehouses of needful waters as already mentioned in §7.4.3. Therefore, all the wetlands must be identified and their strength and capacity in different aspects must be monitored and explored. For this purpose a Wetland Board and Aquatic Resource Management in the purview of land regulation and management act may be made operated,

14. As a duly educated experienced man can understand, identify, evaluate, make decisions and manage natural as well as derived resources, there is the strategic need of educating and training the peasants, workers, land managers, planners and administrators. They must be given proper inputs by educating them in favour of balanced use, production, development and sustainability of land,

15. Moreover, a good participation of people of different strata of economic groups must converge to a properly formulated goal towards the development and sustainability of land and resources in the basin.
7.5 Nature of Human Action in the Basin

Running water everywhere, all the time remains a matter of great human interest, for water provides a logical link between man and his physical environment. Water has been one of the basic elements of human activities and water interaction. Water, therefore can be viewed as a natural resource and a resource producing factor.

The Kaldiya basin is full cultural landscape and significantly important part of Assam. The area has quite a deep rooted agrarian base. Its flood plains have been attached with human settlements and economic development ever since man set his footprints on its face. Everywhere there is an overwhelming concern of man here in his relationship and interaction with the environment. The river, therefore carries facts about man’s action upon nature and natural systems in the basin. Therefore, there is a need of holistic approach to account for multifarious role of man on the basin.

Human action, interaction and relationship on the basin can well be understood in terms of increasing human pressure on the catchment area in respect of upper, middle and the lower portions, and also in terms of use of flood plains and the channel itself. Any human action in channel and extra channel areas naturally brings change in the processes of humanization of basin lands.

Water is the sovereign wealth of a state and its people. It is nourishment, it is fertilizer, it is power, it is transport (Brumhos, 1920, p. 93). Most of the dwellers of the Kaldiya basin are culturally rich and therefore there are varacious users of water and sediment in the ways of their traditional and modern activities. Especially its middle and lower catchment are intensively used and misused for human purpose. Human pressure upon the basin land and resources is on the increase. The result is the high changes in nature and culture.

In the Kaldiya basin two broad-based changes can be identified. These are-

a) Changes caused to channel itself directly by engineering works designed to alleviate the effect of flooding, erosion and sand deposition,

b) Changes caused in extra channel areas which inturn affect discharge and load in the stream and ultimately result in stream channel response.

Since the primeval tribe appeared on this land, till today the stream network in the Kaldiya river basin are directly linked to human activities that can be categorically...
apprised of primate, medieval (before the railway age) and modern (after railway age). The primary linkage is related with the uses of river water for domestic purpose.

i) Every village, every family occupying the immediately neighbouring areas of the river thus have its common or personal river ghat (bathing ghat) from where water is supplied for domestic and extra domestic purpose (for animals).

ii) The river Kaldiya is well known for its fish and game especially at certain time during monsoon (breeding season of fishes), the local people call it “Jaur”.

iii) The Kaldiya, for hundreds of years has been a water highway. The river maintains a link with Barpeta and places of the Bajali area. From time immemorial there continued role of the river in the movement of man and materials between Barpeta and Bajali. Country boats were used to carry from Barpeta and its adjacent areas the earthen wares, dugwell rings (earthen) etc. to Bajali. In return Bajali used to send bamboo and betel leaves to Barpeta. The river Kaldiya thus facilitated for locating a number of river port like spots known as the “Ghats”, Patarghat (Patacharkuchi), Golaghat (Nityananda), Jalsikar Ghat (Jalah) etc. along the banks of the Kaldiya river.

The second category of human action on this river can be traced back to pre-railway stage. The stream network and accessibility therefore remained at the topmost importance in the mind and methods of material transfer and transformation of the upper basin dwellers. Place names and archaeological evidences in Bajali reveal the importance of the major river systems in the area. The settlements very close to the river bank are nucleated and away from the bank are scattered. Units of settlement obviously extended far beyond the navigability limit of the rivers. Primary settlement of the main valley continued to retain leadership commanding colonization in the area away from the bank. Agro colonization (Pamkheti) is a new direction in the production of extra resources.

In the pre-railway times water transport was more efficient. Therefore the rivers as the highways were intensively used wherever facilities were available. The trades between Barpeta and Bajali were performed through the Nakhanda, Chawlkhowa, Pahumara and the Kaldiya rivers. The traders of Barpeta used to touch
the possible river ports called the ‘ghats’ (in Assamese). On the waterway from Barpeta to Bajali there lie Barpeta on Nakhanda on one end Bhablaghat at the north-east of Jalalghat on the other end.

The Kaldiya river, therefore, served as an artery of the flow of commodities nourishing riverine settlements. The bridge points and road crossing points served as sites for development of extra points. There developed hardly any township during the pre-railway days. Therefore, only the river ghats acted as the central place and transit point as well. It would, therefore, be easier to account the importance of river navigability. The upper catchment areas which thickly forested (rainforest) in recent past could be exploited and settled thereon by the people migrated from other areas. For these purpose the river waterways were used at that time. “The drainage basin, therefore, was the natural sphere of activities and linked with one another (Brebner, 1933). From the old settled areas colonial settlers (Pam peasants) spread to remote areas through water routes in quest of natural resources. The lower piedmont and the old alluvial plains were spotted with the latest settlements. These settlements of late origin were of the land-hungry peasants belonging to nucleated settlements in the areas far away from the piedmonts.

Climatically Assam is pre-humid to humid in nature. Moisture deficit in the soil is not very acute. Therefore need of irrigation network is not very seriously felt. Similarly the Kaldiya river basin cannot be categorized as water stressed. According to the international standards an area defined as the water stressed if the annual per capita water availability is below 1700mm and with scarcity of water if that is below 1000mm respectively.

Nevertheless, the Kaldiya basin has only a single canal system. A canal from Rehbari Gate (at the middle catchment) is running through the middle of flood plain up to Kawaimari with a total length of 51 kms. The middle and the lower catchment area of the Kaldiya river is a underground storage of plenty of water. These store houses of water have been largely disturbed owing to the increase of population causing high pressure on landuses.
References


