CHAPTER 3
AGROECOSYSTEMS IN THE BRAHMAPUTRA VALLEY

3.1 Conceptual framework

Ecology and agriculture have been intimately and effectively interlinked ever since the beginning of agriculture (Conway, 1984). Agricultural ecosystem, covering 37% of the earth’s land area and providing livelihood to 45% of the world’s population, has been emerging as an important life supporting system of the earth (Sarma, 2006).

Although, the term ecosystem was proposed by Tansley in 1935, the concept of ecosystem was expanded to agricultural system by Odum (1984), who defined the agroecosystem as a domesticated ecosystem, which is in many ways intermediate between natural ecosystem and human-managed ecosystem. The contemporary use of the term agroecology dates back to the 1970s, but the science and practice of agroecology is as old as the origin of agriculture (Hecht, 1987). The study of agroecosystem basically deals with the reciprocal relationship between the organisms and their physical habitats. The agroecosystem provides the conceptual framework within which the effects of human manipulation of crops, livestock, physiography and climate on the basic ecological processes of energy flow, nutrient cycling, competition and ecoregulation can be effectively studied (Tivy, 1990).

Agroecosystem is a most complex biological and natural resource system, managed by humans for the primary purpose of producing food as well as other non-food goods and environmental services (Wood et al., 2000). It is a human managed production system superimposed on a natural ecosystem. Agricultural systems are complex interactions between external and internal social, biological and environmental processes.
Interestingly, the domestication of wild plants and animals in the varied physico-cultural environments in order to get food, fibre, fuel and other necessary goods for consumption and processing had developed different types of agroecosystems in the world. All these together with the needs and aspiration of the people have given rise to distinctive agro-ecological systems within it. The nature and characteristics of agroecosystems are determined by both the environmental conditions and by the prevailing social-cultural, historical, economic and political factors. Agricultural systems are a result of the co-evolution that occurs between culture and environment, and a sustainable agriculture values the human as well as the ecological components (Gliessman, 2004).

Agroecosystems may exist at different stages, such as a farming system, a field, pond, a home garden or watershed system which can be combined to form a hierarchy of agroecosystems. It is a hierarchy of integrated systems (e.g. farms within communities, within watersheds, within regions and so forth) composed of interrelatedness and interconnectedness of biophysical elements (soil, water, air, climate, plants and animals), and socio-economic elements (social, cultural, economic, institutional and political) (PCA, 2001). All the elements of the agroecosystem are strongly linked, and any disturbance in one element disturbs the whole balance. Therefore, the natural balance among the elements in the agroecosystem is very important to develop a healthy agroecosystem. The interactions among these elements determine the properties of the agroecosystem (Van de Flier and Braun, 1999).

The nature of an agroecosystem depends on the productivity, stability, sustainability and equitability of the system. Productivity implies the yield or net income per unit of resource. Stability indicates the degree to which productivity of an
agroecosystem is stable in spite of small disturbances that may occur with the variations in environmental and cultural conditions. Sustainability is the ability of a system to maintain its productivity in spite of a major disturbance caused by intensive stress or a large perturbation. Equitability means the even distribution of the products and services of an agroecosystem among its human beneficiaries (Conway, 1985).

The structure of an agroecosystem implies the organization and functional connection of all the elements that shape the agroecosystem. The results of the interplay between endogenous biological and environmental features of the agricultural field, and exogenous social and economic factors determine the structure of agroecosystem (Tivy, 1990). Agroecosystem function, on the other hand, is the result of the structure of the agroecosystem. Ecosystem function implies nutrient cycling, water and energy flows, soil retention and production, crop yield that result from the interactions among ecosystem components, i.e., plants, animals, decomposers, climate, soil environment, etc (Drinkwater et al., 2008).
Agricultural ecosystems differ from other ecosystems in the sense that apart from the environmental components and energy flow and nutrient cycling, there are many human-manipulated processes of mostly modifying inputs that come from outside the system (Fig. 3.1).

Unlike the natural ecosystem, the net productivity in an agroecosystem is higher, trophic interactions is simple and linear, species diversity and genetic diversity are low, nutrient cycle is open, resiliency (stability) is low, human management is dependent,
temporal permanency is short, structural heterogeneity and habitat heterogeneity are simple (Odum, 1984). The ecological contrasts between natural ecosystem and agroecosystem are that the natural ecosystems have higher degree of stability than human managed agroecosystems as the natural ecosystems have greater species diversity and trophic complexity which allow them to maintain a steady-state in the face of normal environmental variability.

3.2 Environment and agroecosystems

The diverse climatic, edaphic and topographic conditions of the Brahmaputra valley have developed diverse agroecosystems within the valley. However, soil, climate and environmental factors play important roles in shaping the base of the agroecosystems.

Soil and agroecosystem

The soils of the Brahmaputra valley have been playing an important role in the development of its peculiar agroecosystem. The spatially diverse soil types make the valley's cropping pattern and practice and crop productivity diverse. The soil is the nutrient pool or reservoir of nitrogen, phosphorus, potassium and other minerals which are the primary fertilizing elements of agriculture.

The alluvial soils, viz, younger alluvium and old alluvium which are extensively distributed in the Brahmaputra plain are very much fertile. The younger alluvium, developed by the recurring flood deposits of sand and silty loams lacks in phosphoric acid, nitrogen and humus contents. These soils occurring mainly in the floodplains and
charlands of the valley are mostly suitable for growing of oilseeds, jute, pulses and other rabi crops. These soils also favour the growth of extensive paddy cultivation. On the other hand, the old alluvium, with texture of fine loams to coarse loams is slightly to moderately acidic (Bora, 2001). These acidic alluvial soils, distributed in the upper Brahmaputra valley with a good proportion of phosphoric contents, are highly favourable for tea plantation. The alluvial soils in general are favourable for cultivating rice, horticultural and plantation crops. It is observed that the crop productivity and cropping intensity in the alluvial soil zone of the valley are very high.

The narrow and high bhabar soil zone, made up of coarse river deposits which are distributed in the northern part of the valley along the Himalayan foothills favours dense forest. The tarai soils, located in the south part of the bhabar soil zone, where the ground remains damp and sometimes springs ooze out, favour the growth of tall grasses, orchards and citrus fruits.

Climate and agroecosystem

Successful production of crops requires a close synchronization of the crop growth cycle with the climatic regime. Climate plays most important role in the cropping pattern, crop production, crop productivity, crop diversification and methods of farming. Among the climatic parameters, rainfall is the important one which provides required water and moisture for plant growth. Besides, precipitation and atmospheric moisture in combination with temperature, may also act as a controlling factor in the rate of occurrence of pests and diseases.
The length and distribution of precipitation also affect the cropping system. The Brahmaputra valley with an average annual rainfall of about 2208.97 mm has given rise to a peculiar cropping system dominated by the cultivation of rice. The requirement of rainfall for the growth of paddy right from sowing to grain formation is nearly 200 mm per month, that is 1000 mm for a season in aggregate (Sen, 2007). Therefore, the rainfall (average 1568 mm from 1993-2006) that occurs during the monsoonal period is sufficient for the growth of the crops. Since rice needs more water and can tolerate flooding, it is mainly grown at the peak of the rains.

Located in the monsoon belt, the Brahmaputra valley has been experiencing hot-moist summer with heavy rainfall and cool dry winter with little rains. The spatial and seasonal variations of the climatic conditions, especially the rainfall (Table 3.1) in the valley have made the valley's agricultural system more diverse. The practice of different crops in the valley is basically dependent on the seasonal variation of rainfall (Fig. 3.2). The farmers of the valley are well accustomed with the seasonal pattern of rainfall and temperature, and accordingly they perform the agricultural activities such as seed sowing, ploughing, transplanting and harvesting of crops. Again, the crop productivity, cropping intensity and crop diversification in the valley are still mostly dependent on the timely occurrence of monsoonal rainfall as the valley lacks sufficient irrigational facilities.
The winter season (from December to February) in the valley is very cool and dry with scarce or no rainfall. The average rainfall in this season is only 75.19 mm. The average relative humidity and temperature in this season are recorded at around 77% and 12.6°C. The winter season is the *rabi* cropping season that favours the luxuriant growth
of the rabi crops, such as vegetables, pulses like lentil, khesari, black gram, mustard, potato and spices like ginger, chilly, garlic, onion etc. But due to heavy rainfall during the monsoon period the fields except for the upland ones remain moist even upto the month of October. This compels the farmers to sow the rabi crops late resulting in lower yield. During winter, harvesting of winter rice is completed. The wetlands become dry. The livestock can be set free in the field as most of the paddy fields remain free from crops. The winter season is usually the livestock breeding season.
Table 3.1: Seasonal distribution of rainfall in Brahmaputra valley, 2004-2005

<table>
<thead>
<tr>
<th>District</th>
<th>Winter (December - February)</th>
<th>Pre-monsoon (March - May)</th>
<th>Monsoon (June - September)</th>
<th>Post-monsoon (October - November)</th>
<th>Annual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dhubri</td>
<td>7.1</td>
<td>928.0</td>
<td>1862.0</td>
<td>428.1</td>
<td>3225.2</td>
</tr>
<tr>
<td>Kokrajhar</td>
<td>22.0</td>
<td>853.6</td>
<td>2348.9</td>
<td>543.2</td>
<td>3767.7</td>
</tr>
<tr>
<td>Bangaigaon</td>
<td>11.6</td>
<td>1039.2</td>
<td>1760.9</td>
<td>407.4</td>
<td>3219.1</td>
</tr>
<tr>
<td>Goalpara</td>
<td>13.0</td>
<td>600.2</td>
<td>1611.2</td>
<td>234.3</td>
<td>2458.7</td>
</tr>
<tr>
<td>Barpeta</td>
<td>33.2</td>
<td>506.0</td>
<td>1183.4</td>
<td>186.5</td>
<td>1909.1</td>
</tr>
<tr>
<td>Nalbari</td>
<td>59.6</td>
<td>636.3</td>
<td>1087.0</td>
<td>121.5</td>
<td>1904.4</td>
</tr>
<tr>
<td>Kamrup</td>
<td>20.9</td>
<td>421.7</td>
<td>847.4</td>
<td>138.6</td>
<td>1428.6</td>
</tr>
<tr>
<td>Darrang</td>
<td>51.0</td>
<td>617.4</td>
<td>997.4</td>
<td>130.8</td>
<td>1796.6</td>
</tr>
<tr>
<td>Sonitpur</td>
<td>36.2</td>
<td>659.6</td>
<td>924.7</td>
<td>25.6</td>
<td>1646.1</td>
</tr>
<tr>
<td>Lakhimpur</td>
<td>141.7</td>
<td>491.3</td>
<td>870.5</td>
<td>41.1</td>
<td>1544.6</td>
</tr>
<tr>
<td>Dhemaji</td>
<td>243.9</td>
<td>901.5</td>
<td>2222.4</td>
<td>103.9</td>
<td>3471.7</td>
</tr>
<tr>
<td>Marigaon</td>
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<td>334.2</td>
<td>681.6</td>
<td>113.2</td>
<td>1165.8</td>
</tr>
<tr>
<td>Nagaon</td>
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<td>507.5</td>
<td>802.7</td>
<td>165.8</td>
<td>1541.7</td>
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<td>Golaghat</td>
<td>87.8</td>
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<td>1145.2</td>
<td>141.7</td>
<td>2118.6</td>
</tr>
<tr>
<td>Jorhat</td>
<td>87.4</td>
<td>738.6</td>
<td>914.4</td>
<td>63.0</td>
<td>1803.4</td>
</tr>
<tr>
<td>Sibsagar</td>
<td>160.2</td>
<td>644.8</td>
<td>996.7</td>
<td>99.1</td>
<td>1900.8</td>
</tr>
<tr>
<td>Dibrugarh</td>
<td>149.3</td>
<td>702.5</td>
<td>1260.8</td>
<td>137.2</td>
<td>2249.8</td>
</tr>
<tr>
<td>Tinsukia</td>
<td>126.1</td>
<td>1177.2</td>
<td>1180.8</td>
<td>125.5</td>
<td>2609.6</td>
</tr>
<tr>
<td>Brahmaputra valley (average)</td>
<td>75.19</td>
<td>694.63</td>
<td>1261</td>
<td>178.13</td>
<td>2208.97</td>
</tr>
</tbody>
</table>

Data source: *Statistical Hand Book, Government of Assam*
The soil of the Brahmaputra valley gets saturated with the emergence of pre-monsoon periods (March to May). The average rainfall in this season is 694.63 mm. The average relative humidity and temperature become approximately 64.66% and 25.53°C respectively as recorded in the year 2001. The harvesting of *rabi* crops is completed before rain. In the beginning of this season, farmers start ploughing their fields especially for autumn rice cultivation. The occasional rains in this period are also favorable for the cultivation of jute and tea.

It is observed that more than 85% of the annual rainfall of the valley occurs during the summer season (June to September). Average rainfall and mean temperature during this season are about 1261 mm and 28.72°C respectively. The relative humidity in this season remains above 80%. The air and soil during this season get exceedingly saturated with moisture and water. All the farmers of the valley become active in their fields for the cultivation of winter rice. Because of heavy rain, most of the rivers and other wetlands overflow and cause floods and erosion and thereby damage the standing crops and livestocks.

The rain in the valley gradually decline in the months of October and November. The average rainfall in post-monsoon season is 178.13 mm. The mean temperature become 24.80°C and relative humidity reaches around 78%. In this season farmers extensively cultivate a variety of *rabi* crops.

It is already stated that the valley’s agroecosystems have evolved mainly on the basis of its peculiar climatic conditions. Different varieties of crops are grown in different climatic seasons. As the valley does not have sufficient and well-distributed irrigational facilities the cropping seasons are closely linked with the climatic seasons. The
influences of rainfall, humidity and temperature on the cropping seasons and the net sown area can be understood from Fig 3.3. Although, rain is the dominant climatic factor in determining the cropping seasons in the valley, temperature and humidity also play an important role in the pattern of cropping.

It is observed that there is a marked spatial variation of rainfall in the Brahmaputra valley. In 2005, the districts Dhubri, Kokrajhar, Bongaigaon, Dhemaji received the highest rainfall, i.e more than 3000mm, while the districts Nagaon,
Morigaon, Kamrup and Lakhimpur experienced rainfall of 1541.7 mm, 1165.8 mm, 1428.6 mm and 1544.6 mm respectively. The spatial variation of rainfall causes notable variation in crop output and cropping intensity in different parts of the valley.

Wind can cause direct physical damage to plants by tattering leaf or plant breakage. Wind is also an important agent in the spreading of pests and pathogens. Sometimes, extreme climatic hazards like storm, flood and erosion can damage the standing crops, plants, livestocks and thus cause great loss of crop production and income.

Source: Peasant Agriculture in Assam, 1984

Fig. 3.4
Thus, the different physico-climatic and edaphic conditions prevalent in different parts of the valley have caused considerable spatial variation in respect of the land use pattern, cropping intensity, crop diversity and crop productivity. As such, 4 broad agro-ecological zones can be delineated within the Brahmaputra valley (Fig. 3.3). Based on physiography, climate, soil, water retention/stagnation, flood, cropping pattern, Bhowmick et al. (1999) categorized the micro-agroecological situations under the 4 distinct agro-ecological zones of the Brahmaputra valley (Fig. 3.4).

1. Lower Brahmaputra valley zone

This zone, comprising the districts of Kamrup (rural), Kamrup (metro), Goalpara, Dhubri, Kokrajhar, Bongaigoan, Barpeta, Nalbari, Chirang and Baksa, covers a total geographical area of 19,04,851 hectares. This zone is mainly characterized by plain topography with isolated hills and hillocks, wetlands and perennial rivers. The elongated foothill region in the north and south, extensive built up plain in the middle and the active floodplains of the Brahmaputra river within this zone have made distinctive agricultural ecosystems. Bhowmick et al. (1999) identified 9 agro-ecological situations in this zone—

(i) foothills old mountain valley alluvial plain, (ii) foothills old mountain valley alluvial forest, (iii) flood-prone recent riverine alluvial plains, (iv) flood-free old riverine alluvial middle plains, (v) forest land old alluvial plains, (vi) hills and hillock old alluvial, (vii) beels, (viii) highland tea garden, (ix) charland.

Both new and old alluvial soil, the texture of which varies from sandy to sandy loam, silty loam, clay loam and clay characterize the pedological condition of this zone.
This zone experiences the highest temperature up to 38°C with 80% of relative humidity during summer. The average rainfall varies from 1065 mm to 3864 mm.

This zone covers an area of 9,07,598 ha under net sown area and 4,09,751 ha under forest cover accounting for 47.64% and 21.51% respectively of the total geographical area of the zone. There are 1,100 wetlands covering an area of 31,723.9 ha. The southern side of the northern foothills favours the growth of luxuriant vegetation, which provides congenial site for the reserved forests and wildlife habitats. The widespread built up plain of this zone is used to cultivate mainly rice in summer and various rabi crops in the winter. The main rabi crop, grown in the active floodplains are vegetables, pulses, oilseeds, fibre crops, etc. This zone is also endowed with rich grazing lands. Besides, the summer rice is extensively cultivated in the char-chapari areas.

2. Central Brahmaputra valley

The districts of Nagaon and Morigaon fall in this zone. It includes small hills and hillocks extended to Karbi Anglong, some high land areas in the eastern and southern sides, floodplain tract along the Brahmaputra, chars and chaporis and large number of wetlands.

Based on physiography, climate, soil, flood and cropping pattern, this zone is divided into 9 agro-ecological situations (Bhowmick et al., 1999), (i) humid alluvial non-flood situation, (ii) sub-humid alluvial non-flood situation, (iii) alluvial flood situation, (iv) char land, (v) humid piedmont and high land, (vi) sub-humid piedmont and high land, (vii) hill area, (viii) forest and (ix) tea estates.
The soil of this region is sandy alluvial, distributed in the char areas and alfisols in the hilly parts. Temperature varies from 8° to 34.3°C with humidity of 37% - 97%. The average rainfall ranges from 1200 to 2000 mm.

The total geographical area of this zone is 5,73,684 hectares, of which 3,25,880 hectares are under net sown area accounting for 56.80% of the total geographical area. The total area under forest is 1,19,449 ha accounting for 20.82% of the total geographical area of the zone. There are 523 wetlands covering an area of 22,953 ha.

Rice is the dominant crop in this zone. Among the plantation crops tea, coffee, rubber etc are noteworthy. The fruit crops grown in this zone include banana, coconut, areca nut, jackfruit, mango, papaya etc. Besides, a variety of vegetables like brinjal, tomato, potato, cabbage, cauliflower, carrot, bean, lady’s finger, gourd, pumpkin and leafy vegetables are also grown. Jute is also extensively cultivated in this zone.

3. North bank plain

This extensive plain lies parallel to the course of the Brahmaputra between the *Tarai* belt on the north and the floodplain on the south. It comprises the districts of Darrang, Sonitpur, Lakhimpur and Dhemaji. Bhowmick *et al.* (1999) identified 8 agroecological zones under the north bank plain, e.g., (i) medium land with medium rainfall, (ii) medium land with high rainfall, (iii) low land, (iv) deep water, (v) riverine area, (vi) upland with medium rainfall, (vii) upland with high rainfall and (viii) foot hills.

The soils of this zone are mainly characterized by old alluvium along the foothills and new alluvium along the riverine tract. This zone experiences the highest temperature
in summer (35°C) with mean relative humidity of 81%. The average annual rainfall varies from 1500 mm - 3400 mm.

The north bank plain covers an area of 14,40,905 ha. Here, the net sown area is 5,25,933 ha and forest area is 2,83,325 ha accounting for 36.50% and 19.66% of the total geographical area respectively. There are 599 wetlands that occupy an area of 14,160.5 ha. This region is characterized by extensive rice fields. The higher patches of older alluvium with an average height of 2-3 metres above floodplain are favourable for tea plantation (Das, 1984). Fruit crops like banana, lemon, pineapple, papaya, coconut and vegetables such as potato, onion, cabbage, brinjal etc. are grown in this zone.

![AGRO-ECOLOGICAL ZONES](image)

Source: Bhowmick, B.C. et al., 1999

Fig. 3.5
4. Upper Brahmaputra valley (south)

This zone comprises the districts of Golaghat, Jorhat, Sibsagar, Dibrugarh and Tinsukia. The zone covers a total geographical area of 16,17,923 hectares. The soils of this zone are composed of immature alluvium in charland and old alluvium in piedmont, highland and hill areas. Bhowmick et al. (1999) identified 8 agroecological situations in this zone: (i) char areas, (ii) sub-humid alluvial flood free, (iii) humid alluvial flood prone, (iv) high land, (v) hill area, (vi) forest area, (vii) tea growing areas and (viii) humid alluvial flood free areas.

The temperature ranges from 7°C to 37°C with an average relative humidity of 80% in summer. The zone receives yearly average rainfall of 2050mm. Out of the total geographical area of this zone, 3,85,272 ha (23.81%) is under forest and 6,08,571 ha (37.61 %) is under net area sown. There are 708 wetlands covering an area of 15,195 ha. The main crops in this zone are rice, maize, wheat, rapeseeds, mustard, potato, maize and vegetables. Tea is the most dominant plantation crop.

3.3 Culture and agroecosystem

Agriculture itself implies culture. Agriculture determines the culture of an area, while culture determines the nature of crop cultivation, cropping pattern and cropping practice, land use and agricultural tools. Agriculture influences the mode of living, economic condition, social status, house type, traditional festivals and ceremonies, food and dress habits of the people in an area. In Anthropology and Sociology the term 'culture' refers to shared symbols and meanings, established roles, institutions and values
(Uphoff, 2002). However, in Agricultural Geography, culture refers to the ways crops and animals are raised human supervision.

The Brahmaputra valley has a rich and diverse cultural background which influences the agroecosystems of the valley. In spite of having similarity in the agroecological conditions from broad perspectives, there are many micro-agroecological zones in the valleys which have been shaped by different social groups. It is noteworthy that the pattern of agricultural production differs at agroecological levels being guided by the food habits and traditions of the social groups sharing the agroecological zones.

Agriculture is the primary source of livelihood of the people of the valley. Out of the total working force of the valley, 52.96 % (as per 2001 census) are engaged in the agricultural sector. The agricultural landscape of the valley is the manifestation of small and fragmented landholdings, subsistence type of farming with very low level of technology application (Bhagabati and Dutta, 2001). For centuries, agriculture had been practiced based on the local resources of land, water, and other organic elements as well as local seeds and indigenous knowledge that were nurtured traditionally. It is noteworthy that the agriculture of the Brahmaputra valley is characterized by both peasant agriculture and capitalistic tea plantations (Das, 1984). However, the peasant agriculture continues to be dominant in the valley. The peasant agriculture is rooted in local culture and ecological conditions. It is characterized by limited cultivable land, low intensity of cropping and low yield per hectare (Das, 1984). Except for the large scale commercial tea plantations, the technologies used in cultivation in the Brahmaputra valley are mainly traditional.
Culture and intensity of cropping

The index of cropping intensity reflects the cultural advancement of an area. The growth of cropping intensity in an agrarian region largely depends on a number of cultural and economic attributes like, literacy, physiological density, use of fertilizer, irrigation, HYV crops, mechanization in agriculture, proportion of agricultural work force etc.

In order to find out the factors behind the growth of cropping intensity, correlation analysis was done considering cropping intensity as the dependent variable (y) and a number of variables as independent ones (x) (Appendix II). The independent variables include literacy rate, proportion of immigrants to total population, fertilizer consumption, and proportion of cultivators to total work force, physiological density and irrigation facility.

The correlation co-efficient (r) value of cropping intensity (y) and physiological density of population (x) is found to be +0.25 which indicates that there is weak positive correlation between the two variables. The physiological density or nutritional density indicates the pressure of population on agricultural lands which encourages intensive use of agricultural lands. The correlation between the proportion of cultivators to total work force and cropping intensity is found to be +0.50, indicating considerable influence of agricultural work force on intensity of cropping. The relationship between irrigation facility and cropping intensity appears to be almost neutral, i.e. +0.090. However it is noteworthy that in the Brahmaputra valley irrigation facilities are generally not used for intensive crop cultivation, but for those areas where there is a scarcity of water. Similar is the case for the relationship between cropping intensity and use of fertilizer (+0.085). The
level of literacy has a negative correlation with cropping intensity, the r value being -0.42. This indicates that there is an ambiguous link between the two. It is a fact that unlike the developed areas, the growing literacy results in occupational shift of the rural people from primary to secondary and tertiary sectors. The agricultural activities in the valley are now most in the hands of illiterate people having some adverse impact on the agricultural development. The positive relation (r = +0.22) between the proportion of immigrant population to the total population and cropping intensity reflects that intensity of cropping is relatively high in the areas inhabited by Muslim peasants of mostly of immigrant origin. It is worth mentioning that these peasants are hardworking and devote most of their times in agricultural practices. They are also advanced in using different innovative measures like the use of HYV seeds, fertilizers and pesticides, sprayers and power tillers etc. These also result in the increase of productivity of crops, specially the rabi ones.

Culture and crop diversification

Crop diversification forms the basis of rural economic diversification. In the Brahmaputra, crop diversification is the results of allowing arable land for cultivation of a number of alternative crops. A group of food crops are cultivated which ensure the maximum output from a given amount of land during the growing season. The study of crop diversification is very important for an understanding of the cropping pattern in a particular area. The climatic variability, physical and cultural diversity and peasant mode of farming in the Brahmaputra valley have given rise to different level of diversity of crops in different parts of the valley. The valley is characterized by varied physio-
climatic conditions, diverse ethnic composition, and different farming practices in terms of irrigation, crop specific farming technologies, fertilizer and pesticide inputs and diversified demand for crops. The crop diversification is subjected to resource endowment of farmers, i.e. land, labour, technology, water availability and seeds, besides externalities such as agroclimatic conditions, sustainability and the response to market. Diversification of crops can contribute towards reducing farming risk caused by adverse climate, market uncertainty, pest damage on the one hand and improving nutritional productivity, ecological sustainability, maintaining a productive and equitable agroecosystem on the other (Marten, 1988; Tivy, 1990; Weltzien and Christinck, 2008).

The selection of crops by the farmers is usually based on their observation and understanding of the environment, and is thus closely related to local knowledge and cultural traditions (Weltzien and Christinck, 2008; Khishan, 1992).

The rural areas of the Brahmaputra valley are characterized by the subsistence mode of livelihood, small size of landholdings, economic backwardness and traditional method of farming. In such a situation, farmers cultivate a variety of crops to obtain their day-to-day needs and other demands. Different communities in the valley have been cultivating a number of crops in their agricultural lands at a given period of time according to their choices. Besides, the vagaries of weather compel the farmers to cultivate a variety of crops so as to get at least some return under adverse weather conditions.

The crop diversification pattern in the Brahmaputra valley has been analysed by applying the Bhatia’s method. The index of crop-diversification as devised by Bhatia (1965) is as follows-
Where, X crops are those that individually occupy 10% or more of the cultivated area in a regional unit. In order to measure the spatial pattern of crop diversification in the Brahmaputra valley the above method has been used in a modified form considering the unique cropping pattern of the region so that it suits micro level analysis.

The modified method is—

\[
\text{Percentage of total sown area under n crops} \times \frac{100}{\text{Number of n crops}}
\]

Where, n crops are those which individually occupy 1% or more of the gross cropped area. A district level observation in the valley reveals that in all the districts several crops are grown in an agricultural year. There is spatial variation of crop diversification among the districts of the valley (Table 3.2). It is evident from the table that the index of crop diversification of the valley stands at 12.42. Three categories of crop diversification regions in the valley may be demarcated. Index value below 12.00 is taken as 'high', between 12.00-14.00 as 'medium' and above 14.00 as 'low' degree of diversification.
Table 3.2: Crop diversification index for different districts of the Brahmaputra valley, 2006

<table>
<thead>
<tr>
<th>District</th>
<th>CD index value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goalpara</td>
<td>12.48</td>
</tr>
<tr>
<td>Dhubri</td>
<td>12.49</td>
</tr>
<tr>
<td>Kokrajhar</td>
<td>12.49</td>
</tr>
<tr>
<td>Bongaigaon</td>
<td>12.48</td>
</tr>
<tr>
<td>Kamrup</td>
<td>12.44</td>
</tr>
<tr>
<td>Nalbari</td>
<td>12.48</td>
</tr>
<tr>
<td>Barpeta</td>
<td>12.48</td>
</tr>
<tr>
<td>Darrang</td>
<td>12.45</td>
</tr>
<tr>
<td>Sonitpur</td>
<td>11.11</td>
</tr>
<tr>
<td>Nagaon</td>
<td>11.00</td>
</tr>
<tr>
<td>Morigaon</td>
<td>12.41</td>
</tr>
<tr>
<td>Jorhat</td>
<td>14.24</td>
</tr>
<tr>
<td>Golaghat</td>
<td>12.43</td>
</tr>
<tr>
<td>Sibsagar</td>
<td>19.67</td>
</tr>
<tr>
<td>Lakhimpur</td>
<td>14.21</td>
</tr>
<tr>
<td>Dhemaji</td>
<td>14.26</td>
</tr>
<tr>
<td>Dibrugarh</td>
<td>15.85</td>
</tr>
<tr>
<td>Tinsukia</td>
<td>14.24</td>
</tr>
<tr>
<td>Brahmaputra Valley</td>
<td>12.42</td>
</tr>
</tbody>
</table>

The indices of crop diversification, when mapped, exhibit a significant spatial variation in the pattern of diversification in the Brahmaputra valley (Fig. 3.5). It is observed that only two districts namely Sonitpur and Nagaon exhibit high degree of crop
diversification. On the other hand, all the districts of Lower Brahmaputra valley show a medium level of diversification. On the other hand, all the districts of the upper Brahmaputra valley excluding Golaghat exhibit a low degree of crop diversification.

Ethnic groups and agroecosystem

Different ethnic groups with their own culture and traditions also influence the intensity and types of farming practices. In ancient India, every caste was assigned with a peculiar occupation. Based on their inherited knowledge and belief systems they developed certain techniques of agricultural operations. However, over time,
occupational structure has also undergone a considerable change due mainly to the economic development of the society. However, caste-occupation relationship still exists at certain levels (Mohammad, 1992). Some primary occupations in the Brahmaputra valley also are still associated with certain castes, for example, cropping with Brahmin, Kalita, dairy farming with the Nepali, fishing and poultry farming with the Scheduled Castes, piggery with the Scheduled Tribe, and vegetable growing with the Muslims of immigrant origin.

The Brahmaputra valley is inhabited by different ethnic groups such as indigenous general castes, scheduled castes, scheduled tribes, Muslims and Nepalese. In spite of appreciable assimilation, each social group in the valley has their own tradition and customs and mode of living. Therefore to meet their needs and aspiration they have traditionally developed certain agricultural practices. The low-caste people are generally less adaptive to modernization of agriculture compared to the high-caste people.

The Muslims of immigrant origin mainly inhabit in the char-chaporis of the Brahmaputra valley. These areas are characterized by fertile alluvial soil that favours the growth of agriculture. However, such lands are chronically affected by flood in the summer for which kharif cultivation has become a neglected practice. Therefore, such lands are increasingly put to rabi crops by the char dwellers, especially for vegetables, jute, baro rice, mustard and pulses. At present, the char-chaporis have become the main areas of vegetable production from where volumes of vegetables and pulses are supplied to the urban areas of Assam. The immigrant community of the valley now usually prefers mechanized or innovative agricultural practices. They are very much interested in enhancing productivity and cropping intensity by using modern inputs and implements.
The Nepali people inhabit the riverine tracts and foothill areas of the valley and are traditionally engaged in dairy farming and horticultural practices. Moreover, the Nepalis cultivate sugarcane, rice, oilseeds, maize and vegetables. It is found that the Nepalis made considerable expansion of sugarcane cultivation in the districts of Lakhimpur, Darrang and Sibsagar (Phukan, 2004). However, unlike the immigrant Muslims, Nepalis are poor in using modern agricultural inputs and implements.

Being the staple crops, rice has been traditionally cultivated by all the social groups of the Brahmaputra valley. They have been still practicing certain traditional techniques in their agricultural activities.

The indigenous scheduled tribes mainly the Bodos Mishings, Ravas and Tiwas have been producing substantial proportion of cash crops, pulses and oilseeds. Low level adoption of modern agricultural inputs and implements among the tribal farmers is responsible for a slow growth of the agricultural sector in terms of productivity and cropping pattern.

The indigenous scheduled caste population belonging mainly to Kaibartas and Banias take fishing as their primary livelihood. A general reluctance to mechanization and innovative practices, the farmers of this community still maintain a subsistence character in all fronts of their agricultural activities. The commercial production of fish traditionally lies with the scheduled caste people. The correlation co-efficient between the proportion of SC population to total population and fish production in the valley is found to be +0.27. This indicates that there is some positive relationship between these two variables. Most of the SC population are engaged in fishing as their occupation. They
generally prefer to dwell around the water bodies, such as rivers, dead channels, swamps, *beels* etc. which provide favourable environment for fishing.

3.4 General characteristics

The agroecosystem of the Brahmaputra valley basically centers around rice farming. Rice has been cultivated here since the dawn of the Brahmaputra valley civilization. The cultivation of rice in the valley is governed by its ecological and cultural characteristics. Although the micro-environmental conditions play the most significant role in the process of rice cultivation, the method of cultivation, application of fertilizer and pesticides, harvesting, threshing, and preservation of crops, consumption and selling of the products reflect the unique culture and traditions of the local people which notably deviate from other floodplain environments of the world. In fact, the rice cultivation in the valley manifests the interplay of a complex of culture and ecological elements operating in the valley.

Rice forms the foundation of life of the people of the Brahmaputra valley. Rice is not only related to the economy of the people but also intimately associated with the culture of the valley. Therefore, the culture of the Brahmaputra valley may be called *dhanya sanskriti* (rice culture) (Bhagabati, 1984). Rice, especially the winter rice variety (*sali* rice) is closely related with the tradition and custom, ritual, food habit, house type, and even social status of the people in the valley. Therefore, in spite of the advent of the high yielding varieties, the people of the valley still continue to cultivate some of the traditional *sali* rice varieties which have special demand in the society.
Being staple food, rice is the dominant food-grain in the agriculture of the Brahmaputra valley with an area of 18,33,832 hectares accounting for 66.16% of the valley's total cropped area in 2006-07. After the independence of our country, due to agricultural modernization during the plan periods, rice area has increased from 14,35,136 hectares in 1958 to 18,33,832 hectares in 2006, registering a growth of 27.78% during the period. The winter rice area of the valley cover an area of 11,86,425 hectares accounting for 64.69% of the total rice area. The autumn and summer rice area, on the other hand cover an area of 3,50,654 hectares and 2,96,753 hectares accounting for 19.12% and 16.18% of the total rice area of the valley respectively.

Three different groups of rice are cultivated in the valley based on the climatic seasons, level of flood water and soil conditions. They are autumn rice (*ahu dhan*) cultivated in intermediately low lands (*madhyam mati*), winter rice (*sali dhan*) cultivated in the low lands (*da mati*) and bao rice (*bao dhan*) cultivated in very low lands. The process of producing rice involves a long course of actions, i.e. from the preparation of seed bed to the threshing and storage and milling.

**Autumn (ahu) rice farming:** *Ahu* is the earliest rice variety cultivated in the Brahmaputra valley. *Ahu* rice is cultivated following three different methods: i) *Dhulia ahu*, i.e. broadcasting on dry land, ii) *Acchra ahu*, i.e. broadcasting on muddy land, and iii) *Rowa* or *kharma ahu*, i.e. transplanting on muddy land.

(i) *Dhulia ahu*: *Dhulia ahu* is grown in the *Sali* rice fields. Seeds are broadcast in dry and dusty fields prepared for the purpose. Seeds of *dhulia ahu* is sown in the month of March.
The farmers start ploughing their agricultural land in the first half of February and the fields are left fallow up to the sowing period. This process of ploughing in certain plants of the valley is known as ‘marachah’. It is done to make the soil loose so that the soil organisms can multiply to enhance the fertility of the soil. This also facilitates the subsequent monsoon rains to get absorbed into the soil without any surface runoff. During the period of broadcasting the seeds, the field is again ploughed four to five times. In this period, the moisture content of the soil becomes very less due to dry weather condition. Thus the soil becomes dry and dusty after ploughing. In this method the land is generally not harrowed. Some farmers break the clods of soil by a wooden mallet. After broadcasting the dry seeds, the land is again ploughed one or two times to ensure that the seeds get thoroughly mixed with the soil. After that some farmers again plough the land in order to break the soil clods. When the plants attain a height of six inches and weeds grow largely along with the plants, a large wooden rake (locally known as bindha) drawn by bullock is dragged over the crop to remove the weeds and for appropriate spacing of the thickly grown rice plants.

It is noteworthy that in recent years the traditional preparing of land and weeding have gradually been disappearing from the rural scene. The relatively rich farmers are now more interested in tilling lands by power tiller. Now-a-days, just after ploughing by power tiller seeds are sown and the land is ploughed once or twice using bullocks only to mix the seeds with the soil.

**Late sown dhulia ahu:** If rains do not occur in spring upto the month of May or drought condition prevails, ahu rice can be cultivated belatedly following the dhulia method. The
lands which were ploughed in the month of February are again ploughed and harrowed
two to three times. When the tilled soil becomes fine, seeds are sown using broadcast
method. In the case of late dhulia ahu, instead of sowing dry, the seeds are steeped in
water at least for a night. After broadcasting the seeds, the field is once again ploughed to
mix the seeds with the soil. Presently, the farmers prefer to cultivate only the kharma ahu
instead of late dhulia ahu as soon as the rains occur.

(ii) Acchra ahu: Acchra ahu is sown by broadcast method in the relatively highlands
from the last half of May to the first half of June. Farmers start ploughing and harrowing
their land as soon as the soil is softened by the spring rain in the month of April and
repeat the process of ploughing and harrowing four to five times till the land is reduced to
a rich puddle (Allen, 1905).

At present, the dhulia and acchra systems of ahu rice cultivation are not preferred
much by the farmers because of its low productivity. Now the ahu fields are put to HYV
rice. However, some farmers still cultivate kharma ahu although its area has been
gradually decreasing.

(iii) Rowa or kharma ahu: Rowa or kharma ahu is cultivated by transplantation method
and the system of cultivation does not materially differ from that practiced in the case of
Sali rice (Allen, 1905). For transplanting the seedlings, the fields which were ploughed
across (Samaar) in the month of February as marachah is again ploughed and harrowed
four to five times in the month of June. Unlike in the case of the sali rice, the dykes are
made thicker with five to six plots in one bigha of land so that water can be retained in
the field. While ploughing and harrowing, the weeds are removed from the field by using bamboo or iron weeder or akra (akra is a traditional agricultural tool made of a tree branch with a bend in its head). When the field becomes muddy the four to five plants (seedlings) are planted together at an interval of 7-8 inches.

**Sali (winter) rice practice:** During the monsoon period the transplanted winter rice commonly known as sali dhan is grown as principal crop in the Brahmaputra valley. Sali rice is generally cultivated in moderately low lands using transplantation method except the bao variety. The plantation of sali rice begins in the month of August and continues upto the first week of September. Farmers plough their sali fields by using a dwarf plough (buta nangal) and level the land by lotamoi (concave side of bamboo ladder of a harrow). Like that of ahu rice fields, the weeds are removed at the time of ploughing and harrowing. The existing dykes are repaired by cutting their edges by a hoe and raised their height by putting mud and uprooted weeds over them. When the fields become fine, bunch of seedling (gosa) containing four to five plants are planted 3 to 4 inches apart.

**Bao** is a long stemmed sali rice variety, which is cultivated by both broadcasting and transplantation method in the low-lying lands where cultivation of other varieties are difficult due to flood and water logged condition prevailing during April to September. For broadcasting the bao rice seeds, the fields are prepared in the month of March. The rice straws of the previous year existing in the fields are burnt. The method of cultivation of broadcasting bao rice is same as that of dhulia ahu. When the plants of rice become 3-3.5 feet high in the last half of June and the first half of July cattles are carefully allowed
to feed the upper part of the plants in order to make them stronger with the growth of more shoots.

The transplantation of bao rice begins in the month of May. Transplanting is done just like the other varieties of Sali rice. The difference lies only in the spacing of the plants. Bao rice is transplanted with wider spacing (1-1.5 feet). It is important to note that the cropping practice of bao rice has remained almost static since long. However, in the case of other sali rice variety there have been some changes in the method of cropping. In the recent years, most of the farmers are opting for ploughing by power tiller. Therefore, the time gap between ploughing and planting has been reduced leaving no chance for the land to regain its natural fertility promoted by microbes.

The popular sali rice varieties grown in the valley are Jaha, Barni, Boka, Mainagiri, Gajia, Bardhan, Monohar, Hati, Lati, Lau Dumra, Prasad Bhog, Badsah Bhog, Bar sali, Saru sali, Kala Sali, Ahom sali, Kajeli bao, Bangla bao, Paita bao etc.

Earlier, sali cultivation was completed in time with the mutual help rendered by the villagers. Now, there have been certain changes in the method of cropping of sali rice. In the recent years, many farmers are opting for ploughing by power tiller.

**HYV rice cultivation:** The cultivation of HYV rice is done in the month of July following a combination of traditional and modern methods of cropping. The land ploughed in the month of February is again ploughed and harrowed in the month of July. Like sali rice, weeding, supplying water and making dykes etc. are done by following the age-old techniques. Some changes have been seen only in the case of tilling and application of fertilizer and pesticides. In the recent years, most of the farmers use power
tiller for ploughing their HYV rice fields. Just before ten days of plantation, farmers plough their lands by power tiller and then the land is left fallow. At the time of plantation, the land is again ploughed and harrowed by traditional tools (wooden plough and harrow) to make the land fit for transplantation. At present most of the farmers apply chemical fertilizer in the HYV paddy fields.
Plate 3.1 Preparation of paddy field
A. Removing weeds by zaboka  B. Weeds being transported by dhakua  C. Raising dyke by mud and weeds  D. Traditional ploughing in sali rice field  E. Harrowing to remove weeds and to level the field  F. Transplanting sali rice  G. Uprooting of weeds from rice field  H. Scene of a rice field after two months from transplantation.
Besides the extensive rice cultivation, the agricultural lands of the Brahmaputra valley are also cultivated for raising other crops. The farming practices of some important crops cultivated in the valley are discussed in the following section.

**Mustard:** The cultivation of mustard is done by the method of broadcasting particularly in the *ahu* rice fields. After harvesting the *ahu* rice, ploughing for mustard starts during October-November. From the month of October to first half of November, fields are ploughed and harrowed 10-12 times to make the soil very fine and dry. The weeds grown in the field are removed at the time of ploughing and harrowing. At present, many farmers plough their land by power tiller. The selected land is first ploughed 2-3 times by power tiller and then leveled by bullock driven harrow. For leveling, farmers use *kamra moi* (convex side of the bamboo ladder of a harrow).

The *Kamra moi* is very effective in breaking the clods of the soil as well as for removing the weeds. The clods are also broken up by a mallet (*Dalibari*). When the soil becomes fine, seeds are broadcast. Before sowing, some farmers put the seeds in citrus juice so as to make them easy to sow. After sowing, the land is again ploughed to mix the seeds with the soil. Mustard is harvested during December-January by uprooting the matured plants. The threshing and storage methods of this crop are similar to that of rice.

**Sesamum:** The cultivation of sesameum (*til*) is done on a slightly higher land composed of sandy alluvium. Sesamum is of two varieties – winter sesameum (*sali til*) and autumn sesameum (*ahu til*). The winter sesameum is cultivated during July-August, while the autumn one is cultivated during March-April. In some areas, the autumn sesameum is
cultivated by transplantation method, while the winter sesamum is grown by broadcasting method.

The preparation of nursery bed for the autumn sesamum is done on a fairly high land. The land is ploughed and harrowed 3-4 times and then the seeds are broadcast. When the seedlings become 4-6 inch high, these are uprooted to make ready for transplantation.

The land selected for transplantation is ploughed and harrowed 4-5 times. When the soil becomes fine, the seedlings are planted following the lining method at a pace of 2.5-3.0 feet. In the day of plantation, water is provided around the root of the plants. When the plants become bushy with branches, they are tied up with the stakes and pushed slightly towards the ground so that they do not lie down. Autumn sesamum is harvested by uprooting the plants in the month of September and the winter one is harvested in the month of December.

*Khechari or Kala (Lathyrus sativus)*: The cultivation of *Kala* is done by broadcasting method during the period from the last part of October to the first part of November. During this period, if the land under *sali* rice remains soft and damp then the seeds of *Kala* are sown there. When the *sali* rice is harvested in the month of December, the *kala* plants climb luxuriantly on the rice stubble. *Kala* is harvested by uprooting the matured plants in February-March. The methods of threshing and storage of grains are same as that of other grain crops.
**Blackgram:** In the Brahmaputra valley, two varieties of blackgram (*mah*), namely *matimah* and *katiamah* are cultivated, although majority of farmers now prefer to cultivate *katiamah* as it is a short duration variety.

*Matimah* is cultivated in *ahu* rice fields from the month of September to October. After harvesting *ahu* rice the land is ploughed superficially one or two times and then the seeds of *matimah* are sown by broadcast method. It is harvested during the period from the second half of December to the first part of January.

*Katiamah* is cultivated by broadcast method in July-August. The seeds of this variety of blackgram are sown on a relatively high land such as grazing land, rice seed beds or on the banks of ponds or channels.

Some farmers sow the seeds directly in the field without tilling, while some other plough the land once or twice and sow the seeds sparsely. After sowing the seeds, the land is again ploughed and harrowed to mix the seeds with the soil. In the fields, some trenches or furrows are prepared by hoe so that rainwater can easily flow and the soil remains free from water logging. Subsequently the weeds that grow with the crops are removed manually. *Katiamah* is harvested during October-November by uprooting the plants. The methods of threshing and storage of this crop are similar to that of other grain crops.

**Lentil (masur):** The cultivation of lentil is done in two different ways in the valley. Some farmers cultivate lentil directly by sowing seeds in between the rows of the *sali* rice stubbles as soon as the harvesting of rice is over.
In this method of cultivation, the production remains very low. Therefore, farmers usually cultivate lentil by ploughing land seven to eight times until the soil becomes fine. After sowing the seeds, the land is again ploughed to mix the seeds with the soil. Cultivation of lentil is done in the period ranging from the last half of November to the first half of December. Lentil is harvested by uprooting the fully matured plants in the month of March.

**Potato:** A fairly highland composed of sandy alluvial soil is selected for the cultivation of potato. Potato is cultivated in October. It may also be cultivated belatedly in January. Generally two varieties of potato popularly known as *patna* and *khasia* are cultivated in the valley. The land selected for potato cultivation is ploughed and harrowed 8-10 times to make the soil powdery in character. Potato field is ploughed by *saja nangal* to till the soil to a depth of 5-6 inches. Then *kamra moi* is used to remove the weeds and to break the soil clods. When the soil becomes fine, parallel furrows are made with a spacing of 1.5 feet and a depth of about 4 inches. These furrows are usually prepared by using a dwarf plough (*buta nangal*). Potato seeds are placed manually one by one in the furrows. Then soils from either side of the furrows are put to cover the seeds. In the case of *khasia* variety, some farmers cover the furrows with *meteka* (water hyacinth) or rice stubble to enrich the soil and to retain soil moisture. When the plants attain a height of 1-1.5 inch, fine soils are again put to form an elongated heap in order to allow the roots to spread. This process, called *matichapowa*, is repeated two to three times at an interval of 15-20 days. With this process, the weeds that grow between the rows are also removed. Matured potatoes are uprooted in the month of January. After harvesting, potatoes are
dried under the sun at least for a day and then stored in a bamboo container or some other convenient places.

Plate 3.2: Preparation of potato field

A. Putting soils over elongated heaps  B. Removing weeds by iron weeder  C. Potato plants in parallel heaps

**Jute:** Jute is cultivated in the low lands. The land is first ploughed in February to reduce the dampness of the soil and then it is left fallow for 10-15 days. On the day of broadcasting seeds, the land is again ploughed and harrowed 1-2 times. The seeds are sown in March. After broadcasting the seeds, the land is once again ploughed to mix the seeds with the soil. When the plants become 5-6 inches high, the densely grown plants
along with the weeds are removed manually. Weeding for the second time is done when the plants attain a height of around 1 feet.

Plate 3.3: Jute farming

A. A part of a jute field  B. Jute fibres under the sun for drying

The plants are harvested by cutting off at their roots in August. Then these are tied up into bundles and left in the field for 2-3 days to shed the leaves. After that, the bundles are submerged in stagnant water for at least ten to fifteen days. Some pieces of banana tree are piled over the bundles so that the bundles remain submerged. When the plants get decomposed, the fibres are stripped off from the stems. The fibres are then washed in water and dried under sunshine by hanging them in bamboo bars.

Sugarcane: A fairly highland composed of sandy alluvial soil is selected for the cultivation of sugarcane. This crop is propagated from the top of the canes that are cut off at the harvesting time during April-May. These cut-off parts are planted in a shady bed and are covered with rice straw or banana leaves to get rid of sharp sunshine. Required water is sprinkled in the evening time over the bed.
The land selected for planting sugarcane is ploughed and harrowed 6-7 times in February and then left fallow for a few days. This land is again ploughed and harrowed to make some ridges. The ridges having a length of about 8 feet and a breadth of about 3 feet are prepared by a hoe. In the ridges, several trenches are made horizontally with a spacing of 1.5 feet and at a depth of 1 inch using a hook of tree branch. In these trenches, the germinated parts are planted as soon as the pre-monsoon rain occurs in April.

Necessary water is supplied to the planted sugarcanes. The patches of sugarcane cultivation are fenced with bamboo to protect them from cattle and fox. When the plants grow vertically, their roots are hoed and the weeds are removed. The dry leaves of canes are removed at an interval of about 20 days. Soil heaps are raised on the plant roots so that the plants do not fall over the ground. Moreover, to prevent the canes from falling down they are tied up with bamboo bars. Sugarcane is harvested by cutting off at their roots by a large knife (Dao) during January-February.

Traditional agricultural practices

The cropping technologies, local crop varieties, organic manure, herbal pesticides, and traditional belief and knowledge system that have been used in the valley's agriculture are considered as socio-economically acceptable and ecologically adaptive. The farmers have long been operating their agricultural activities on the basis of the locally available resources within the valley's environment. The cropping practice followed by the farmers in the Brahmaputra floodplain has a long evolutionary background reflecting the peculiar natural and human environment of the area.

Except the commercial tea plantation, the agricultural environment of the valley is dominated by peasant agriculture. It is interesting to note that despite the introduction of
modern agricultural tools, many farmers of the Brahmaputra valley still continue to rely on indigenous agricultural tools or equipments either on their own or in combination with modern technologies. The marginal farmers of the valley employ their traditional knowledge of technology in the farming practice. In the context of rapid population growth and scarcity of domestic food products, there is an urgent need to make a sustainable balance between the indigenous technologies with the modern ones. It is now recognized that the modern technologies can only be successful and sustainable only when the knowledge and tradition of the local people and environments attributes are integrated. Most of the modern agricultural inputs and implements are not well suited to valley’s ecological and socio-economic conditions like fragmented landholdings and scattered plots, inadequate and uneven distribution of rainfall, poor soil fertility, unfavorable topography and distance from markets, poor infrastructure and institutions etc. (Deka and Bhagabati, 2010). Besides, the new technologies have led to certain ecological problems that have adverse effects on agroecosystems and human health.

The Brahmaputra valley is characterized by diverse agro-climatic zones which have been cultivated by different ethnic communities. For centuries, farmers of the Brahmaputra valley have been practicing agricultural activities based on their indigenous knowledge, technical know-how and overall understanding of the agroecosystem. The traditional agricultural knowledge systems which have been developed over generations through the processes of man-environmental interaction get expressed in myths, proverbs, rituals, customary laws, way of life, chronicles, songs, agricultural practices, equipments, planted species and animal breeds. Thus, the agroecosystem of the valley is a community based farming system which varies from one agro-climatic zone to the other as well as
from one community to another. The agroecosystem of the Brahmaputra valley, until the advent of agricultural modernization was environmentally benign, ecologically adaptive, socio-culturally acceptable, economically viable and sustainable.

Most of the farmers of the Brahmaputra valley are economically poor and have low level of formal education. The poor and illiterate farmers of the valley have traditionally developed the subsistence agriculture in order to meet their domestic requirements and to dispose of whatever surplus remains in the rural periodic markets.

It is very important to note that the indigenous practices have now been gradually pushed back with the advent of modern agriculture. The haphazard use of modern inputs and implements has adverse impact not only on the agroecosystem but also on the human health and sustainability of the economy. However, even after the gradual influence of agricultural modernization and economic changes, certain traditional agricultural management and knowledge systems are still predominant in the valley.

**Preparation of seed beds**

The seed beds for rice are prepared following the traditional method. Usually a suitable plot of the size 0.5-1.0 *katha* (1 *katha* = 0.026 ha) near the homestead or some water source is selected for preparing the seed beds. The land selected is ploughed about five times and harrowed six times. Generally *saja nangal* (wooden plough that can till deeper) is used for ploughing. Farmers use *kamra moi* (convex side of harrow) for harrowing the land. After supplying required water to the soil, *lota moi* (concave side of harrow) is used to make it smooth. At the time of harrowing, the uprooted weeds are thrown away manually. Then again water is supplied to the plot from nearby *khal* or pond using a *sichani* or *lahati*. The water is distributed all over the plot uniformly with the help
of a sichani. The seed beds are fenced with knitted bamboo sticks to protect them from stray cattle. For one *katha* of land usually 10 kg of rice seeds are required.

![Image of seeds in container, seeds covered with arum leaf, harrowing by kamra moi, broadcasting of seeds, uprooting of seedlings, cutting of the uppermost part of seedlings before carrying them for transplantation.]

**Plate 3.4: Rice farming: from seeds to seedlings**

A. Seeds in container-*Topa*  B. Seeds covered with arum leaf for germination  C. Harrowing by *kamra moi* and supplying water using *lahati*  D. Broadcasting of seeds  E. Uprooting of seedlings  F. Cutting of the uppermost part of seedlings before carrying them for transplantation

Before sowing, the seeds are kept in a *topa* or *thali* and steeped in ponds or *khal* for at least one night and then they are stored in a cool dark place. The seeds are covered with blue arum leaf or banana leaf so that they germinate easily. The germinated seeds
are then broadcast by hand in the land already prepared. When the plants attain a height of 20 – 30 cm after 20-25 days these are carefully uprooted from the nursery bed and carried in bundles to the field prepared for transplantation. If the height of the plants becomes more than 30 cm, their uppermost parts are cut by sickle so that they do not get slanted after transplantation.

Sometimes because of flood, the seedlings may not be transplanted in time. In such a situation, the seedlings are removed from the nursery beds and planted very thickly in larger bunch in another suitable plot. This kind of transplanted rice is said to be unusually strong and more productive (Allen, 1905). There are again uprooted for final transplantation in the prepared fields as soon as the flood water subsides.

Methods of water supply

The farmers still solely depend on the erratic monsoon as most of the areas lack modern irrigation facility. They carry water from the nearby ponds and *khal* to irrigate mainly the vegetables and other horticultural crops. During monsoon (June-August), because of heavy rain the winter rice fields are flooded upto a level of 0.53 meter, while in the autumn rice fields, the flood water attains a height of 0.35 meter. Most of the farmers dig out very small and shallow ponds in the corner of their *sali* fields so as to retain the excessive summer water. When the pond water subsides in late monsoon season, people collect fish from the ponds. Again, to retain the rain water in the fields, farmers prepare dykes around the fields as per the nature of the land. Normally the autumn rice fields are slightly higher than the winter rice fields. Farmers generally make the fields smaller with necessary dykes in the case of autumn rice to retain rain water for a longer period. In an autumn rice field with an area of 1 *bigha* (1 *bigha* = 0.134 ha), for
instance, 5-6 divisions or plots are made with dykes around each plot. In winter rice fields on the other hand, which are usually of smaller size, 3-4 divisions are made. During summer, when the fields get flooded, a very small segment of the dykes is removed in such a way that the released water does not affect the standing rice plants in the successive fields. During the preparation of seedling beds, required water is supplied manually from nearby khal or pond using a sisani or lahati. At the time of ploughing and harrowing, the rain water collected here and there in the fields is distributed equally all over the plot with the help of sisani. Thus, the water in the rice fields is managed traditionally with appreciable co-operation among the farmers sharing a particular field system.

Plate 3.5: Methods of water supply
A. Distributing water in the field by a sichani  B. Supplying water to the field manually  C. supplying water to the baro rice field by machine
Application of fertilizer and crop protection measures

Indigenous farmers have developed various techniques to improve or maintain soil fertility and to resist pest and diseases. Low dependency on external inputs is one of the basic tents of indigenous knowledge and technology. Usually majority of the small farmers do not use chemical fertilizers and pesticides. Some farmers use minimum external inputs as supplement to ensure the production potential. The practice of intercropping, mixed cropping with legumes increases the biological fertility of soils which eventually reduces the dependence of chemical inputs.

The farmers of the Brahmaputra valley earlier applied some indigenously prepared bio-fertilizers and pesticides in their agricultural fields. Farmers used to carry cowdungs from the cowsheds to the agricultural fields all throughout the year. The domesticated animals were also set free from the month of Magh (January) to Chot (March) to graze in the harvested fields and thus the rice fields used to receive enough of dungs and urine. This practice also controlled the growth of weeds in the field. Most of the farmers practiced double and triple cropping particularly in the ahu fields and kitchen gardens in order to get all necessary agricultural commodities. In the acchra ahu fields, the farmers practiced triple cropping. Just after harvesting ahu rice, farmers cultivate sali rice in these fields. Again, when the sali rice plants attain sufficient height and the grounds are dried up during September – November, farmers sow seeds of khesari, black gram and green gram in the rice fields as a practice of intercropping. In the case of kharma ahu fields, after harvesting ahu rice, fields are put to mustard and coriander. Thus the practice of multiple cropping reduce the cost of and time for field preparation, cause effective use of moisture residues in the paddy fields and utilize the prevailing micro-
climate of the standing paddy crops for successful germination of subsequent pulse seeds (Immannuel et al., 2010). Also, these leguminous crops enhance soil fertility by fixing nitrogen in the soil (Sinha, 2004). It is noteworthy that farmers of the valley harvest rice manually, which does not affect the seeds already germinated over the ground. Such a practice of crop rotation, which enhances soil nutrition and reduces attacks of diseases and weeds for the subsequent crop, constitutes an important organic crop management system traditionally pursued by the farmers. The practice of crop rotations preserves larger diversity of species, soil macro and micro fauna and thus sustains ecological balance.

In addition to these, most of the farmers of the valley leave the residues of certain crops in the fields after harvesting. The use of compost, cowdung, oil cakes, twigs of crops etc in the field has been an age-old practice in the valley for enhancing soil fertility. This practice helps conserve the soil moisture and improves structure and fertility status of soil through decomposition of mulches during rainy season. During the recent period, some farmers started practicing HYV crops, chemical fertilizer and pesticides in order to increase the yield level of the crops.
So far the protection of crops from insects and pests is concerned, farmers applied some age-old practices and organic substances. Farmers used wood-ash on foliage of crops like chili, onion, potato, bringal, lady’s finger, cucumber, etc. Wood-ash particles act as a mechanical hindrance to insects and may also destroy the fungal spores and insect’s eggs (Sinha, 2004). The ash coat mixing with dew slows down the aggression of pest and pathogens. Another common practice for controlling diseases and insects was to apply the leaves or branches of certain medicinal plants such as *pasatia* (*Vitex negundo*) and *mahaneem* (*Azadirachta Indica*) in the paddy fields. Some farmers also throw pieces of citrus fruits, fresh cow dung, oilcake, lime etc. on the crop foliage. Fish and meat wash water were also applied in some crops like gourd, water melon, pumkin, lemon, brinjal, onion etc as a mild deterrent in keeping away of pest due to unpleasant environment for
the proliferation of pest and pathogens. To use as a good deterrent for rats or rodents and insects, farmers left dead snakes in the fields to decompose. Farmers also used to hang rotten crabs (*kekora*) in the paddy fields so that its smell could attract insects and deviate them from the targeted crops. In addition, some farmers put lamps in the fields at night to attract and kill insects. In order to drive away the rodents from the field, farmers identified the rat holes and chunk them except the one through which they would pour water. The rats inside thus get suffocated and die. Again, for driving away the birds and rodents from the fields some farmers even to-day tie some colorful ribbons and polythene strips around and across the fields. When the ribbons oscillate in the air making some sound, the birds get scared and keep themselves away from the fields. Another means to drive away birds from the crops is by placing a false human figure made of rice straw and dressed with tattered cloths and painted eyes, nose and mouth in the field to give an absurd look.
Plate 3.7: Traditional crop protection measures
A. Rotten crabs hanged in the paddy fields  B. False human figure placed in the field  C. Branches of *pasatia* tree (*Vitex negundo*) put in rice field to protect it from insects  D. Fencing the paddy field to protect from domesticated animals.

Method of harvesting, threshing and storage

The method of harvesting rice followed by the farmers is really interesting to note. It continues to remain traditional inspite of remarkable changes in this sector of economy. When rice becomes mature, the farmers make necessary preparation for harvesting. They cut the rice plants off at about 20 cm from the top. One or two plant strings are used to tie up the reaped rice plants and then left the bundles to dry over the stiff stubble for one or two days. During harvesting, especially in the case of *ahu* rice, if the fields are inundated by rain water, the bundles are kept hanging over bamboo bars in the field itself for drying. When the grains dry up, the bundles (*muthi*) are put together to
form a dangori (bigger bundle). A dangori contains a few japs (six smaller bundles form a jap). And two such dangoris form a bhar. Two dangoris of equal size are connected by a strong bamboo bar called hulabari to put it over the shoulder and then the pair of load is carried home. In this way harvested rice is brought home manually from the fields located sometimes at a distance of more than a kilometer. This system of harvesting deviates, to a certain extent, from area o area within the valley.

Rice is threshed systematically after they are carried home. Threshing is generally done by pairs of the bullocks making them walk over the heaps of rice bundles kept on the courtyard. This practice is called marana mara. The sheaves of rice are spread in a circular manner over the courtyard. Usually ten to fifteen sheaves are taken together for threshing at a time. Tightened parallelly 3 to 4 bullocks are driven over the heaps of rice for several rounds until the seeds get completely separated from the stalk. While taking the bullocks over the heap, a bamboo hook (okhon) is frequently used to mix the grain bundles. When the grains get separated from the stalk, these are then collected by a wooden shovel (raina) and by broom (bahrani). The grains are then passed through a sieve and jerked in the air by a flat bamboo tray (kula) so as to remove the chaff from the grains. The grains and seeds before storing are completely dried in the sunshine.

The grains are then stored in a granary (bharal ghar) or in a huge container (duli or pasi). The bharal ghar, duli and pasi are made of split bamboo plastered with a mixture of mud, fresh cow dung, mustard oil cakes and rice husk. Over the stored grain, a layer of blighted grain or ash or neem leaves are put to protect the grains from pests and insects. Smooth plastering of bamboo crevices hinders the entry of pest and pathogen. Oil cakes release unfavorable odour to pest and diseases. The seeds, which are preserved for
subsequent sowing, are kept in loosely plaited bamboo baskets (*topa*) wrapped around with rice straw. This is the way the farmers traditionally protect the seeds from all probable damages.

Plate 3.8: Traditional methods of harvesting and threshing
A. Harvesting rice by sickle  B. Bundles of rice plants left to dry  C. *Dangoris* with bamboo bar (*hulabari*) being carried home  D. Threshing of rice on the court-yard using bullocks  E. Grains are being separated from stalk using bamboo hook (*okhon*)  F. Removing chaffs from the grains.
Traditional soil conservation techniques

The soils of the Brahmaputra valley have been conservatively maintained by its indigenous people. An impressive array of soil management techniques employed by the indigenous farmers are crop residue mulching, summer ploughing followed by leaf litter mulching, growing vegetative barriers, crop rotation and relay cropping. The fertility of soil is conserved or improved by applying animal and green manures, usually produced within the households and farm area. Cowdung is most popular animal manure applied in the agricultural fields.

The tilling of lands by indigenous plough and harrow has many good effects on the soil. This increases the rate of absorption of precipitation, reduces surface and sub-surface heat, controls weeds and pests, and improves root and rhizome of plants.

Plate 3.9: Indigenous soil conservation techniques
A. Superficial ploughing by buta nangal in the muddy field to check soil erosion
B. Harrowing by lota moi to level the field to check velocity of surface run-off
C. Dry ploughing (Morachah) to conserve soil moisture before the arrival of summer monsoon
D. The roots and lower parts of the rice plants are left in the field after harvest as organic matter to check soil erosion
Diverse agroecosystems of the Brahmaputra valley

The traditional Agroecosystems of the Brahmaputra valley represent biophysically diverse situations. They comprise numerous varieties of domesticated and wild plants and animals. The diverse physical and cultural conditions of the valley make its agroecosystem diverse. Besides, providing food and fodder for man and livestock, the plant species also serve different purposes of man by providing fuel, fibre, manure, timber and medicines. The rural land use for agriculture, grazing, fisheries and forestry forms the basis for the sustainable livelihood of traditional societies in the valley. The raising of home gardens, wet rice cultivation, rotational fallowing and the traditional horticulture and cash crop farming systems contribute to the rich crop biodiversity in the valley.

The perception of ‘sacred grove’, sacred tree species, sacred lands maintained by the traditional societies of the Brahmaputra valley as in some other parts of India indicates the traditional cultural values which contribute to conservation of biodiversity in the region.

In the case of the Brahmaputra valley, where population is more and land resource and capital are scare, the polyculture system can be regarded as an efficient economic system of resource use to meet the growing needs. The traditional practice of crop rotation such as cultivation of some pulses after the rice plants attain a considerable height also contribute significantly towards sustainability of the agroecosystems as these practices minimize tillage, facilitate the use of legumes and green manures to maintain natural fertility of soil, prevent pest and disease outbreaks, and provide different types of food and income sources for livelihood. Mixed cropping is a common practice in the
Brahmaputra valley which also helps in reducing soil erosion and increasing the total biomass output, yield stability and food security.

Plate 3.10 Agroecosystem diversity
A. A tree in the rice field  B. Kitchen garden with trees around  C. Cultivation of pea (*motor mah*) in the harvested rice field  D. Mix cropping  E. Kitchen gardening  F. Creepers of white guard (*komora*) over the thatched roof.
Integrated agroecosystems

In the case of integrated farming system, the wastes of various farming activities are reused and thereby overall economic and ecological efficiency is enhanced. In a mixed cropping system where farms provide food year-round and even in adverse weather conditions. The correct spatial and temporal assemblage of crops, trees, animals, fish, soil, and so forth enhances the interaction which provides sustainable yields and enhances biological pest control depending on internal resources and recycling of nutrients and organic matter and on trophic relationships among plants, insects, or pathogens (Altieri and Nicholls, 2000).

In the Brahmaputra valley, there is a long tradition of managing the agricultural systems in an integrated way. The integrated crop-livestock-fish farming system, traditionally practiced in the valley is so important that it can contribute to the sustainability of the agroecosystems. There are many combinations of integrated farming practices operated by the farmers in the Brahmaputra valley. The rural people of the Brahmaputra valley, who have limited access to farm lands, have traditionally developed such farming systems which generate income and food in an efficient, reliable and sustainable manner. Among the most important integrated farming systems, the rice-fish integrated system adopted by farmers has enabled to increase rice yield as well as fish output for both sale and domestic consumption. The practice of aquaculture, i.e raising of ponds, and management of other natural water bodies, has played an important role in uplifting the living standard, especially for the rural poor. Ponds located near the residences can provide a range of domestic services. Ponds located within or near vegetable gardens provide scope for irrigation when needed. Different types of off-
seasonal vegetables can be grown using pond water to counter seasonal rainfall shortages. Ponds contribute to maintaining the stability of the small scale farms with the provision of water for irrigation as well as fish and other aquatic resources. Many small farmers of the valley create very small and shallow ponds in the corner of their paddy field. These small ponds provide habitat to different varieties of small fish to survive during the winter season. The fish population get their food in the rice field during summer months. Thus, these ponds help the farmers in compensating their losses in adverse climatic conditions. Small-scale rice-fish integrated farming systems are more efficient in converting feeds into fish and produce fewer negative environmental impacts (Brummett, 2002). In addition to these, various kinds of fruits and wood trees planted on the banks of the ponds give extra income and resources to the small holders.

In the rural areas of the Brahmaputra valley, the traditional farming systems are associated with livestock and poultry rearing. It is a traditional practice indispensable from agriculture and rural culture in the Brahmaputra valley. Among the livestock and poultry, cow, bullock, goat, buffalo, pig, sheep, duck, pigeon, chicken are important. It is reported that there are 7.29 million cows, 0.43 million buffalos, 0.12 million sheeps, 2.59 million goats, 1.34 million pigs, 0.011 million horses, 14.95 million fowls and 5.95 million ducks in the Brahmaputra valley (Table 3.3). The farmers usually domesticate local breeds of animals as they are well adapted to the local environment, cope with lesser amount and low quality feed and highly resistant to diseases compared to the cross breeds. In traditional farming, the farm animals perform an important role in recycling soil nutrients from the farm wastes like the crop residues. Besides, livestocks are an integral part of the livelihood systems of the rural people of the valley.
The livestocks perform a number functions by providing cash (planned sale) or serving as liquid assets (emergency sale); contributing inputs to crop production; minimizing farmer’s risks by acting as a buffer to poor crop yields, being a source of food; acting as a means to derive benefits by the poor from land owned by others; and cultural value (Conroy, 2008). In this system, the manure derived from livestock is used to fertilize the fields, the duck or chickens eat insects which attack the fruits, the farm animals release urine and stool as bio-fertilizers, they consume the weeds, and their eggs and meat can be consumed or sold.

Many domesticated animals use of a wide range of feedstuffs. However they can convert plant food energy and protein into animal protein in the form of meat, milk, eggs or breeding stock (Tivy, 1990). Integration of animals into farming systems in addition to providing service in ploughing and harrowing, milk and meat adds another tropic level to the system, making it even more complex (Gliessman, 2004).
Table 3.3: Number of livestock and poultry in the Brahmaputra valley, 2003

<table>
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<tr>
<th>District</th>
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Data source: *Statistical Hand Book, Government of Assam*

The people of the valley have an emotional attachment with their livestock. While the male farmers take care of cows and buffalos, the woman folk look after the goats and poultry. The rural people are very much careful in selling their livestock for earning income.

The age-old practice of agroforestry, i.e. integrating trees into the farming systems is one of the most important characteristics of the agroecosystems of the Brahmaputra valley. The agroforestry of the valley comprises both wild and planted trees which are distributed in different micro-agroecological niches such as residential land, home garden, grazing land, small patches of forest, wetland and cropland. The traditional wisdom of tree growing in the valley in both natural and cultural lands has given rise to
most diverse agro-forestry and ethno-forestry landscapes which have immense contribution to the local ecology and economy (Deka et al, 2011). Agroforestry offers multiple benefits to the farming families as well as to the environment by enhancing sustainability of agroecosystem, crop yields and food security, conserving soil moisture and nutrients reducing poverty and protecting biodiversity (Sanchez, 2002).

Plate 3.11: Integrated agroecosystem
A. Fishery close to a rice field around a homestead  B. Grazing land in between residential area and the rice fields  C. Betel nut trees with betel leaf in a home garden  D. Preparation for potato cultivation in a rice field  E and F. Traditional fishing near rice field
The trees in the agricultural landscape provide habitats for birds and honeybees. The birds help in biological control of insects and the honeybees act as natural pollinators and improve the seed set of cultivated crops (Immanuel, et al., 2009). In addition to these, among the farmers of the valley, there has been a significant traditional method of erecting vegetative barrier around the farmlands. The vegetative fencing consisting of some tree and shrub species like *bhotora, kohimolla, posatia* acts as a protective barrier against animals and even wind. This method of fencing is eco-friendly and very cheap and easy for the poor and marginal farmers to maintain.

### Land tenure systems

Land tenure is a characteristic feature of land ownership and farm management systems in the Brahmaputra valley. The ownership of land and occupational pattern among the people have traditionally developed some kind of land tenure systems through which the small farmers and even the landless farmers can sustain their livelihoods through farming practices (Deka, et al., 2011). The peculiar land tenure systems followed by the people have great significance in the sustainability of the livelihoods of the rural people. However, the recent modernization in the agricultural sector has gradually altered some of the land tenure systems followed in the villages of the valley.

There are four kinds of land tenure systems in the valley: mortgaging (*bandhaki*), share-cropping (*adhia*), leasing (*ehukti*) and sharing of plough (*morogia*). The marginal and landless farmers can have the opportunity of cultivating crops following certain terms and conditions laid down in these systems.
(i) **Share-cropping (adhia):** In the share cropping system, the tenant has to pay half of the produce to the land owner. Usually the service holders and businessmen, who do not cultivate their lands themselves, offer their lands to the farmers under the share-cropping system. In this system, farmers themselves bear all sorts of expenditure involved in the agricultural operation. However, at present, the land owners also bear some expenditure, particularly for ploughing by power tiller and purchasing fertilizers and other inputs so as to encourage the tenant to continue the share-cropping process profitably for a long period without creating any trouble in between.

(ii) **Mortgaging (bandhaki):** In mortgage system, generally the poor farmers, when face some problem and need money urgently, prefer to mortgage a part of their land to some relatively well-off people known to them. Under this system, a legal agreement is made between the landowner and the tenant. The tenant has to pay a certain amount of money in advance to the land owner as agreed upon to get temporary ownership of the land. The tenant holds the right to use the land until the landowner returns the entire amount to the tenant. In this system, many poor farmers are ultimately compelled to sell their land to the tenant as they are unable to return the money.

(iii) **Leasing (chukti):** In the lease system, the tenant and the landowner make a legal agreement in such a way that the tenant has to pay the rent for the land in kind or cash in advance to the landowner for a fixed period. The rent varies depending upon the farm size, type of land, productivity of land etc. Generally, the leasing out system is followed
by those farmers who are not capable to cultivate their land because of shortage of draught animals, labour and necessary input for agricultural operation.

(iv) Sharing of plough (*morogia*): This is a peculiar cropping system, popularly known as *morogia* prevalent in the village. In this system, a verbal agreement is made between the landowner and the farmer who takes land for cultivation. The farmer ploughs the land by using the pair of bullocks of the landowner for which he gets the advantage of ploughing his own land using the same bullocks. Some landowner let the farmer cultivate 2 bighas of his land for the farmer’s sustenance free of any rent. In this system, the landowner does not pay anything to the farmer. Usually, the marginal farmers, who have limited agricultural land and do not have draught animals prefer this system.