CHAPTER VI

GENERAL DISCUSSION

The salient characteristics of the soils based on the field study and various geo-environmental features of the older alluvium of Brahmaputra valley of Assam presented in the previous chapters are discussed in this concluding chapter. Effort has also been made to identify potentials and problems of the land of the studied areas and to suggest strategies for better management of land and its resources.

6.1 Soil Characteristics

The soil of the study area is unique in morphological and physicochemical characters and is significantly different from the adjacent soils in the Brahmaputra valley.

6.1.1 Soil morphology

Colour and Mottling: -The hue of the upper horizons of the studied older alluvium soil is 10YR and lower horizons are either 7.5YR or 5YR. The lower horizons are more reddish in colour than the upper horizons. The yellowish and reddish colour indicates the presence of iron oxides. The more intense red colour of the lower horizon is due to older formations and less organic matter content than the upper layers. High chroma colours of the older alluvium soil are due to oxidation of Fe and Mn under unsaturated condition.The colour of the surface horizon is relatively darker than the subsurface horizon due to high organic matter content that impart darkish colouration to the surface horizon. This is in conformity with the observations made by Chakravarty et al (1978), Karmakar (1985), and Poddar et al (1999).

The associated soils have hue of 10YR due to presence of hydrated iron oxides. Mottles are observed in all the horizons in associated soil which may be due to alternate oxidized and reduced condition caused by flooding during summer and drying during winter under imperfect drainage condition.

Texture: - The older alluvium soil profiles are clay loam in surface texture and their sub-soils also have heavy texture which is due to advanced stage in the weathering and translocation of clay to the lower depth. Similar observations have also been made earlier by Chakravarty et.al (1980) and Karmakar (1985).

The texture of the associated soil is found to be lighter which may be due to relatively recent deposits and indicates the fluvial nature of parent materials (Karmakar, 1985).

Consistence: - The older alluvium soil is sticky on wetting and hard when dry. The associated soil is less sticky on wetting and slightly hard when dry. This is due to more clay content of older alluvium soil than the associated soil. Similar soil characteristics were also observed in older alluvium derived soils of Barind tract of Bangladesh.

6.1.2 Physicochemical properties

Particle size distribution: - A perusal of the particle size distribution indicates that clay fraction constitutes major fraction of the soil separates in case of older alluvium and sand fraction dominates clay in associated soil. A highly significant negative correlation(r= -0.67) between sand and clay indicates likely contribution of sand towards the formation of clay in the studied soil. A difference of 0.1 in the ratio of silt/silt+clay in between two adjacent horizons was used as a limit for lithological discontinuity. Based on this criterion, no lithological discontinuity was found to exist in these soils.

Bulk density: - The bulk density of the older alluvium soil profiles ranges from 1.43 to 1.68 g/cm^3. Bulk density increases with increase in depth, which might be due to lower organic matter content of the lower horizons and mechanical compaction by overlying horizons. Associated soil have bulk density in the range of 1.26 to 1.53, relatively lower than older alluvium soil profiles due to less clay content of the soil. Similar observations were also made by Chakravarty et.al. (1978).

Organic Matter: - The organic matter content of the surface horizons of older alluvium soil profiles ranges from 1.2 to 3.6 per cent. The organic matter content gradually decreases with depth. Higher organic matter is found under grass vegetation which may be due to accumulation of more organic matter by decaying grass roots and leaves compared to other vegetations. Decreasing of organic matter with depth may be due to less plant and animal debrises in the lower horizons. These observations are in conformity with observations made by Das et al (1997), Dey and Sehgal (1997) and Dutta et al (1999).

Soil reaction: - The P^H of the soil indicates that older alluvium soil profiles are very strongly to extremely acidic. Surface soil have lower P^H (4.0-4.3) compared to subsurface soil (4.1-4.9). Lower P^H in the surface soils might be due to more biochemical weathering and leaching of exchangeable bases and soluble salts under high rainfall conditions resulting in dominance of exchangeable H^+ and Al^{+++}. Somewhat higher PH of the subsurface soil may be due to absorption of leached down bases in the lower horizons and also due to less intense weathering.

The P^H of the associated old flood plain soils ranges from 5.0-6.0, that indicates that these soils are less acidic than older alluvium soil. This may be due to relatively younger age of the associated soil. The soil P^H value decreases with the increase in age and degree of development of the soil (Chakravarty et.al. 1978).

Cation Exchange capacity (CEC) and Exchangeable cations: - The CEC of the studied old alluvial soils are found to be low (3.5 to 5.6 Cmol (p+) kg^{-1}).The low activity clay with low surface charge in the soil may be the reason for low CEC of these soil. Several workers reported that clay mineralogy of alluvium derived soils of Assam is dominated by Kaolinite and Illite clay minerals (Karmakar, 1985; Chakravarty et al, 1992; Dey and Sehgal, 1997) which might be a cause of low CEC of these soils. The CEC is significantly correlated with clay (r=0.63) and organic matter (r= 0.42) content. Horizons with lower clay and organic matter content generally have lower CEC. The associated soil has rather low CEC (2.1-5.4 Cmol (p+) kg^{-1}), which may be due to low clay content of the soil.

Ca^{++} is the dominant exchangeable bases followed by Mg^{++}in all the soil. There is very low amount of K^+ and Na^+ in the exchange complex. Lower values of K^+ and Na^+ may be due to preferential losses of monovalent ions over divalent ions due to leaching (Jenny, 1931).

Base saturation and Exchange acidity: - The base saturation is found to be less than sixty per cent in all the soil. This may be due to leaching of basic cations resulting in dominance of H^+ and Al^{+++} in the exchange complex. Exchangeable Al^{+++} is dominant over exchangeable H^+ in the studied soil. There is a trend of decreasing of exchange acidity with depth corresponding to increase in P^H of the soil. The associated soil has comparatively lower exchange acidity than older alluvium.

Fertility status: - The surface soils are found to be low to medium in N and medium to high in P_2O_5 and K_2O. The N content decreases with depth which may be due to low organic matter content of the lower horizons. Medium to high amount of P_2O_5 and K_2O may be due to recycling of these nutrients in response to seasonal fluctuation of temperature and moisture regimes. Higher P_2O_5 and K_2O in soil profiles of tea cultivation may also be due to application of chemical fertilizer on tea plants.

6.2 Potentials and Problems of Older alluvium

6.2.1 Potentials

From the soil, climatic and water resource data it is seen that older alluvium of Brahmaputra valley of Assam has huge agricultural and industrial potential. The area is free from flood water, Soil is very deep and well drained, suitable climate for a wide range of crops, good workability of soil and almost free from stoniness. It has got following potentials: -

- The entire land is ideal for raising plantation crops like Tea, Rubber, Coffee etc.

- The land is suitable for development of horticultural crops like areca nut, coconut, mango, litchi, orange, pine apple, lemon etc.
- The land is very good for growing valuable timber trees like Sal, Teak, and Gamari etc. and for Bamboo cultivation.
- Development of Agro-based and Forest- based industries based on Plantation crops, fruits, timber and bamboo.

6.2.2 Problems

- **Soil Problems**

The major soil related problems of the study area are: -

1. High soil acidity: - The P^H of the soil of the study area is in the range of highly to extremely acidic. High proportion of exchangeable hydrogen and aluminium are the main characteristics of the soil of the study area. The adverse effect of acidity on plant growth is mainly related to the presence of aluminium, manganese and iron in toxic concentration, deficiency of basic cations like calcium and magnesium, nutrient imbalance and microbial imbalances. High aluminium concentration inhibits root growth. High iron and manganese concentration in soil leads to the high accumulation of these nutrients in plant tissues and interferes with plant metabolism. High soil acidity leads to high phosphate fixation and make this nutrient unavailable for plant. Soil acidity inhibits biological nitrogen fixation. The population of bacteria and acinomycetes is lower in the acid soil which affects the availability of organically bound nitrogen, phosphorous, sulphur and some micro nutrient elements required for plant growth.

2. Low Cation exchange capacity and low base status of the soil: - The cation exchange capacity of the soil is found to be low. Several workers reported that clay mineralogy of alluvium derived soils of Assam is dominated by Kaolinite and Illite mineral (Chakravarty, 1977; Karmakar, 1985) which might be a cause of low CEC of the soil of the study area. Low CEC indicates a low plant nutrient storage capacity of the soil. Low CEC leads to the low fertilizer efficiency of the soil.

The soil of the study area has low base saturation. The main reason for low base status of the soil is high rainfall which leached down basic cations from the soil solum and the exchange complex of the soil is dominated by aluminium ion. The soil is thus becoming deficient of essential elements for plant growth.

3. Poor soil physical condition for crop growth: - From the observation of soil consistence it is found that the soil is hard when dry and sticky when moist and moderately permeable. The soil is compact compared to other associated soil. Due to hard and compact nature of the soil, aeration of plant root is restricted and thereby plant growth is hampered. Under dry condition growth of shallow rooted plants like vegetables, seasonal flowers etc. faces difficulties due to hardness of the soil. Yield of these crops is low under unirrigated condition compared to flood plain area.

- **Land erosion and degradation**

The older alluvium of the Brahmaputra valley comprises uplands having undulating topography. The land is facing both natural geologic erosion and accelerated soil erosion due to disturbance by man. Due to uneven land surfaces the land is continually eroded by running water. As the area is facing high rainfall water erosion is a dominant problem.

In addition to natural erosion various anthropogenic activities such as deforestation, cultivation without proper land conservation measures etc. lead to massive soil erosion of the area. It is seen that forest cover of the investigated area is found to be only twelve per cent. There is continuous pressure on land which leads to deforestation and that accelerates soil erosion process.Soil erodibility was found to be alarming in many areas of the valley(Sen et al, 2001).The soil erosion in turn reduced agricultural productivity in the area and it leads to social insecurity.

- **Water stress during dry period**

The study area is free from flood water. The depth of ground water table in pre and post- monsoon period is generally three to ten meters below ground level. Dry period prevails in winter months when rainfall is scanty. All these leads to water stress condition of the area during dry period. Under water stress condition soil moisture also reduces to considerable level and thereby affects crop growth. In some locations of older alluvium area of the valley people faces scarcity of drinking water due to drying up of wells as the ground water table rests at a very lower depth during winter months.

- **Low to moderate ground water prospects and lack of irrigation facility**

From the ground water prospects study, it is found that most of the study areas have low to moderate ground water prospect. Only shallow tube wells and ring wells may be developed in the study area for moderate quantity of water. However due to very small size of operational holdings installation of tube wells is a very difficult and uneconomic for individual farmers. Therefore only six per cent of the total cultivated area is irrigated.

Except for big farm house like tea cultivator and cooperatives of association of farmers, irrigation in farm land is only a dream for most of the farmers. Another big problem being faced by the tube well owner farmers is lack of electric supply or diesel outlets.

6.3 Strategy for better management of land and its resources

For rational and sustainable land use of the study area the following strategy can be adopted.

6.3.1 Land Management

The major problems of the land resources of the study area are discussed in foregoing pages. Systematic strategies to combat these problems are required to be chalked out with location specific approach.

1. Conserve soil quality through green manuring: Green manuring is the practice in which leguminous plants particularly Sunhemp and Dhaincha are grown in monsoon before sowing crops and succulent tender plants are ploughed in to the soil and allowed to decompose in situ under favourable soil moisture condition. In this process some organic matter and nitrogen are added to the soil. This practice is followed mostly before tea cultivation and that can be extended to other non-tea growing areas for growing other crops. Green manure not only adds nutrient and organic matter but also improves soil physical condition and soil productivity.

2. Use of Farmyard manure and compost: Farm yard manure is prepared from a combination of cattle dung and urine and little amount of waste feed and fodder, where as Compost is decomposed organic residues. Both the manures when applied add nutrients, particularly Nitrogen, Phosphorous and Potash in the soil. In addition to this it improves physical condition of the soil. Since the soil of the study area is clayey in texture and have problems of aeration and permeability, these manures will improve the condition of the soil and make it more favourable for plant growth.

3. Afforestation: Since the forest tree conserves soil moisture and increases organic matter and nutrient through decomposition of roots and leaves and reduces soil erosion, the forest of the study area should be conserved and new trees should be planted wherever feasible to manage eco system. A no. of reserve forest falls under the study area like Guma Reserve Forest of Kokrajhar district, upper dihing and Burhi dihing reserve forest of Tinsukia district. A considerable area of these forests is almost open. Gap afforestration within the reserve forest boundaries should be developed by growing by growing valuable trees like Sal, Segun, Makai etc.

4. Soil conservation: Considering the vulnerability of the land resources to erosion and degradation, the important strategy is to use scientific soil conservation measures. Both agronomic and engineering practices can be adopted in the study area. Establishment of permanent vegetation like forest trees, fruit trees, plantation crops etc. are effective means in protecting the soil erosion and increasing productivity. Orchard terrace and contour trenching and mulching can be adopted for growing horticultural and plantation crops. Soil and water conservation measures on water-shed basis at the farmer's level are also feasible.

5. Soil acidity management: Soil acidity can be managed in two ways, viz. either by growing crops suitable for acidic condition or by ameliorating the soil through the application of lime which will counteract soil acidity. Since some crops like Tea, Rubber, Rice and some forest and horticultural plants grow well under acidic environment, these crops can be cultivated without any measures to combat acidity.

The soil of the study area can be made more suitable for agricultural use by liming which raises the soil P^H. Liming increases crop growth by affecting solubility and availability of most of the plant nutrients and raising the level of exchangeable base status. Farmers may be trained for using liming materials and encourage growing wheat, maize and vegetables in the study area.

6.3.2 Water resource management

The study area experiences high rainfall, a number of rivers flow through these areas, there is moderate ground water prospects and availability at a shallow depth, but the area still faces water scarcity both for irrigation as well as drinking water. Despite having high potential only a little of water resource has been developed. Strategy should be made to manage the water resources for efficient utilization and development of the area.

1. Rain water harvesting: Harvesting of rain water as runoff from small watersheds can be done by storing in small reservoirs. The stored water can be profitably used in providing irrigation to plants during moisture stress period. Construction of small earthen dams for water storage and silt retention at lower reaches and the stored water can be utilized for fish production and to recycle the water for live saving irrigation.

2. Excavation of Tanks and ponds: To augment surface water, tanks and ponds at suitable places should be excavated in the farmer's field to conserve water. The stored water should be used for irrigation during dry period. Along with irrigation the canals and ponds can be used for pisciculture and make additional earning by farmers.

3. Development of Shallow tube wells: Since the older alluvium area is favourable for shallow tube well development, the same should be developed on priority basis through government assistance. The water from shallow tube wells can be used for both irrigation and as drinking water.

4. Excavation of Canals: -Irrigation canals should be excavated in selected locations and water should be distributed through small drains to the farmer's field. Instead of big canals, small canals to be excavated to have minimum impact on environment.

5. Development of ring wells: - The study area has potentiality of development of ring wells mostly for drinking water. Government agency should make necessary help to poor and distressed persons in development of ring wells for drinking water.

6. 3.3 Land Use planning

The last step of the present study is selection and adoption of land-use options which are most beneficial to land users without degrading the resources or the environment. Land use planning here should be made at local level with proper participation of land users and with due consideration of the land holding and financial condition of the land users. At present 7 percent (24635ha) of the total geographical area of the older alluvium is cultivable waste, only nearly 9 per cent of the cultivated area is irrigated and remaining 91 per cent is unirrigated land. Considering all these, the following land use options have been suggested.

- **Growing of Plantation crops**

From the suitability evaluation of the study area it is found that the entire study area is suitable for growing tea (Camellia sinensis) and rubber (Hevea sp.). Tea is traditionally cultivated in the upper, central and north bank plains of the valley. Rubber cultivation is getting momentum in recent days mostly in lower Brahmaputra valley. More than fifty per cent of the cultivated area under older alluvium in Tinsukia and Sonitpur districts is covered by tea cultivation. Cultivation of both the cash crops can be extended to the entire study area. However, economic return from these crops takes time. Therefore only big and medium farmers having substantial land holdings can afford these plantations. Before cultivation of tea and rubber marketing facilities of selling green tea leaves and rubber latex should be assessed. It is better to develop small tea gardens in the cultivable waste lands of nearby big tea estates for easy marketing of green tea leaves.

- **Mixed Homestead garden and raising of horticultural crops**

Since most of the farmers of the study area are small and marginal having small land holdings, instead of going for plantation crops they can raise horticultural crops. Citrus (Citrus sp.) is an important horticultural crop and grows well on well drained, deep soil free from flooding which suits the soil and climatic condition of the study area. Citrus crops like mandarin orange, orange and lemon along with traditional plants like Pine apple, black pepper, betel vine, areca nut, banana, jack fruit etc can be raised successfully which have very good economic return. Ginger and turmeric can be grown in between the rows of fruit trees. High density multitier cropping system including most of the aforesaid crops can be grown to utilize vertical and horizontal space properly. These crops meet a range of needs from food to shelter and the surplus sold in local market.

- **Raising of timber trees and other economic plantation**

The older alluvium area of the Brahmaputra valley is traditionally having very good timber production. Valuable trees like Sal (Shorea robusta), Teak (Tectona grandis), Tita chapa (Michelea champesa), Gamari (Gmelina arborea) grows mostly in areas covered in the Goalpara, Dhubri, Kokrajhar and Tinsukia district of Assam. These areas receive comparatively higher rainfall than the other areas of the valley. The land can be profitably utilized for growing these trees. These trees give very good economic return without much cultural practice. However they have long gestation period. Cultivable waste lands can be utilized for growing these trees. Bamboo (Bambosa sp.) grows well under acidic condition and requires well drained soil and heavy rainfall. Bamboo is very high value potential crop for agro forestry with short gestation and recurring return. Bamboo, which has high industrial value and acts as raw material for paper industry, can be cultivated extensively in the study area.

Proper implementation of above suggestions will definitely reach agricultural sustainability and raise the economic condition of the people and uplift the socioeconomic structure of the region. However participation and coordination of land users, planners and decision makers are prerequisite conditions for such transformations.