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Dynamics of agroecosystems in the Brahmaputra valley, Assam (India)

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Abstract: Agro ecosystems have been created and modified by the people to satisfy their demand for food, fiber, fuel and other products. The nature and degree of modification, however, vary over space and time depending upon the environment, need and aspirations of the people living in different parts of the world. The changes that take place in the human environment make the associated agroecosystems more dynamic resulting in remarkable transformations in the agricultural landscapes. This work attempts to study the pattern of change in the agroecosystems of the Brahmaputra valley, Assam from geographical perspectives. It focuses on the evolution of agroecosystems and the factors responsible for making them increasingly dynamic in the changing contexts of nature-culture interaction. Special attention has been paid to the dynamics of area and output of rice, which continues to be the dominant crop in the agroecosystems within the valley.
Key words: Dynamics, agroecosystems, Brahmaputra valley, Assam, India.

Introduction

The Brahmaputra valley, a major physiographic unit of Assam, is endowed with rich natural diversity and varied cultural manifestations. The physical and social peculiarities of this river valley have helped development of characteristic agroecosystems within it. The Brahmaputra valley has long been under traditional land use practices dominated by food grain and cash crop farming, fisheries, traditional homestead gardening etc., which make the valley's agroecosystem diverse. The traditional land use practices adopted by the farmers belonging to different communities have their roots in the community cultures in a given ecological setting, which contribute immensely to the sustainability of the valley's agroecosystems. However, during the recent period, the diversity and sustainability of the valley's agroecosystems have been considerably disturbed by the processes of rapid development of the agricultural sector including extension of modern irrigated agriculture, application of chemical fertilizer, High Yielding Variety (HYV) seeds, exploitation of ground water, alteration of land use and cropping pattern and expansion of infrastructural facilities. In addition, the demographic instability, socio-economic changes, changing attitude and perception of the people and farmers, government policies and efforts of the Non Government Organizations (NGOs) have been simultaneously contributing to the dynamism of the valley's agricultural scenario.

The change in the agroecosystems from the traditional to modern may eventually endanger the very sustainability of the long-continued, reliable and, in many cases, eco-friendly agroecosystems of the valley. The present paper is therefore an attempt to investigate the nature and trend of change in the agroecosystems of the valley so as to evolve strategies towards bringing about a positive and sustainable change in the systems.

The Brahmaputra valley covering an area of 56,194 sq. km (72 % of the state's total geographical area) with an east-west span of about 720 km and an average width of 80 km is a unique physiographic entity of the state of Assam **(**Fig. 1**)**. The river Brahmaputra with its 32 major tributaries has been playing a great role on the valley's agroecosystems primarily by supplying huge amount of alluvium to its floodplain. The valley comprises of the elongated north and south bank foothill belts, extensive built-up plains and active floodplains including the most sensitive sandbars (*charlands*). The varied micro-physiographic features and climatic conditions and the rich biological diversity combined with socio-economic multiplicity have contributed remarkably towards variation in the pattern and processes of agricultural land utilization in the Brahmaputra valley (Bhagabati, 1990a; 1990b).

The agroecosystems of the Brahmaputra valley are basically dependent on the seasonal rhythm of monsoonal downpour. The average annual rainfall in the valley is 230 cm, while the Himalayan sector of its catchment records more than 500 cm. The soils of the valley are mainly composed of alluvium and piedmont deposits. The valley has rich diversity of flora and fauna. The total forest area of the valley in 2001-02 was 1.29 million hectares accounting for 23.02 % of the valley's total geographical area.

Human history started in the valley long before the Aryan civilization some five to seven thousand years ago which spread eastward along the Brahmaputra valley (Choudhury, 2004). The Brahmaputra valley has been inhabited by people of diverse ethnic and socio-economic backgrounds. The valley, accounting for 72 % of the state's total area, shares 85**.**00 % of the total population of the state. The density of population in the valley according to 2001 census was 407 persons per sp.km.

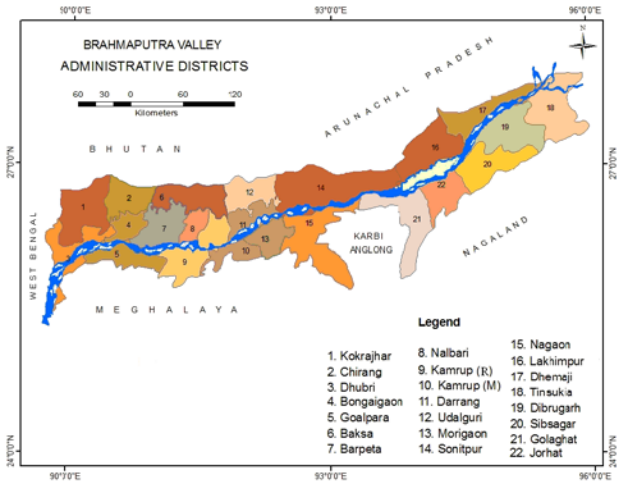

Fig. 1. Brahmaputra Valley Administrative Districts

Materials and Methods

The Brahmaputra valley, which represents a broad agroecosystem zone within the state of Assam, has been selected to investigate the dynamism and sustainability of its diversified agroecosystems. The agroecological

conditions of the valley have been studied on the basis of direct field experiences, surveys through well-designed schedule, secondary data collected, consultation of maps and books and journals. Required base materials for the study have been collected /generated from sources like Survey of India's toposheets with scale 1:50,000, satellite images, revenue maps etc. Relevant literatures were reviewed to develop necessary conceptual framework and appropriate methodology to carry out the work from right perspectives.

Relevant secondary data on agroecosystems of the Brahmaputra valley have been acquired from government sources like the Directorate of Agriculture, Department of Water Resource Development, Meteorological Centre, Directorate of Census, Department of Soil Conservation, Assam Agricultural University etc. Meaningful quantitative and cartographic techniques and soft wares (Arc GIS 9.2, MS Excel, SPSS etc.) are applied to process and represent the data in the form of maps and diagrams. Efforts are made to analyse the problem following certain concepts and models available in the field of agroecosystem studies so that the issues with respect to individual components and the overall agro ecosystems can be understood properly.

Results and Discussion

Evolution of agroecosystem in the Brahmaputra valley: The agroecosystems in the Brahmaputra valley have been evolved since the beginning of human habitation. The state of agriculture in the Brahmaputra valley has been changing from tribalism to feudalism and then from feudalism to the modernism of agriculture (Nath, 2002). The valley was inhabited by the people belonging to indigenous tribal and non-tribal groups like Khasi, Moran, Barahi, Bodo, Karbi, Mishing, Tiwa, Dimasa, Chutia and Bhuyan who entered into the valley through the river valleys and mountain passes from the neighbouring countries and other states of India. Other racial groups like Ahoms and some Tibeto-Burmans and Aryans penetrated into the valley in subsequent periods. These racial groups, with their distinctive cultural backgrounds and traditional knowledge systems gradually started cultivating the land in the Brahmaputra valley (Das, 2004; Choudhury, 1987).

The ancient people, whether following Aryanised or tribals habits, practiced rice cultivation in the valley as rice was their staple food (Barpujari, 2004). The Garo and the Bodo-Kachari tribes in the lower Brahmaputra valley practiced *ahu* and *bao* rice cultivation by using hoe and traditional irrigation system. The Chutiyas, the earliest tribes inhabiting the upper Brahmaputra valley districts, used to practice wet rice cultivation. The Bhuyans reclaimed new lands of the valley and put them under cultivation. The migration of Ahoms into Assam had made significant contribution to the agrarian life and culture of the state during and after the 13th century by introducing new agricultural inputs and implements. The Ahoms acquired ecological and agricultural knowledge and belief systems from the local tribes and castes of the valley such as the Bodos, Kacharis, Chutiyas and the Bhuyans. The Ahoms had brought large areas of the valley under permanent rice fields, gardens and orchards. The Ahom rulers had also given importance to each land cover type like marshy land, forest, *beel* or pond and waste land as potential productive lands.

Evolution of cultivation method and agricultural technology: The technologies used in the agricultural operation in the Brahmaputra valley were of the archaic type. Most of the tribes of the state had traditionally used some sorts of agricultural technology like hoe and stick in the agricultural operation. The Ahoms in the early thirteenth century introduced the advanced plough and other agricultural inputs and implements. They with their skills making earthen bunds raised numerous embankments locally called *mathauri* along the tributaries of the Brahmaputra. Thus, over time the scenario of agroecosystems of the Brahmaputra valley had undergone radical transformation. The traditional agricultural implements used in the medieval period in the valley were wooden plough (*nangal*) with an iron tipped share (*phal*), wooden rakes (*jabaka*) and mallets (*dolimari*), harrow (*mai*), yoke (*juwali*), sickles (*kachi*), bill hooks (*da*), knives (*churi-katari*) and variety of bamboo baskets like *duli*, *mer*, *kharahi*, *pachi*, etc. (Nath, 2002).

It is noteworthy that there has not been any perceptible change in the nature of use of the traditionally developed agricultural implements even during the British period in the early part of the 19th century. The methods of transplanting, ploughing and harrowing, hoeing and sticking, threshing, preserving seeds, applying organic manure and pesticides, making of dykes etc. are carried out even today almost in the same style or with little modification. However, some new dimension have been added to the valley's agricultural landscape with the introduction of modern agricultural inputs and implements like HYV seeds, chemical fertilizers and pesticides, power tillers and threshers, sprayers etc, during and after 1980s (Deka and Bhagabati, 2010).

Nature and pattern of change: The agroecosystem in the Brahmaputra valley has been changing both qualitatively and quantitatively over time and across space due to the nature and degree of modification made by the people. With the rapid growth of population, growing needs for foods and introduction of modern agricultural technologies, the valley's agroecosystem witnessed perceptible changes. The traditional system of farming in the valley is in the process of transformation into the modern phase. The diversity and long-term sustainability of the valley's traditionally developed agroecosystems have been gradually giving ways to the process of modernization. After the introduction of modern agricultural inputs and technologies, the production, yield and the area under crops have been increasing.

Change in area, production and yield of different crops: It has been observed that the crops in the valley have undergone considerable change both in terms of their cultivated area and production due to shrinkage of agricultural lands, transfer of agricultural land to non-agricultural uses, mono-cropping of HYV crops, lack of sufficient irrigation and application of modern inputs and machines. It has been found that the area and production of cereals, oilseeds, pulses and horticultural crops in the

Brahmaputra valley had declined during 2001-2006. The area under pulses registered a decrease by 53.96 % followed by oilseeds (27.15 %), horticultural crops (10.23%) and cereals (10.03%) **(**Table 1 and Fig. 2).

Table 1. Change in area under crops in the Brahmaputra valley, 2001- 2006

Year	Area (in ha) under crops and their % change during 2001-2006			
	Cereals	Oilseeds	Pulses	Horticultural crops
2001-02	2253088	281345	191869	128484
2005-06	2027084	204956	88336	115337
% change during 2001-2006	-10.03	-27.15	-53.96	-10.23

Data source: Directorate of Agriculture, Government of Assam

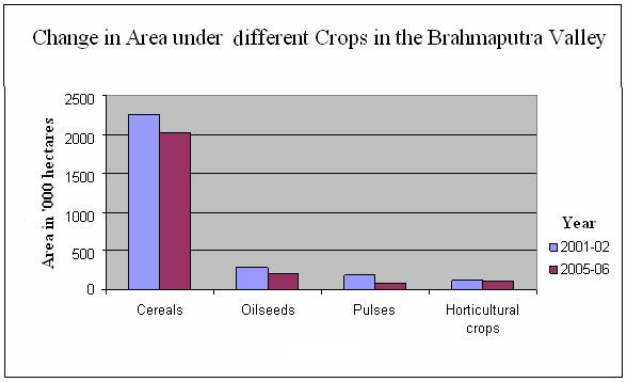

Fig. 2 Change in Area under different Crops in the Brahmaputra valley, 2001-2006

Similarly, with the decrease of area the production of cereals, oilseeds, pulses and horticultural crops in the Brahmaputra valley has also been declining. The decline in the production of these crops may also be ascribed to the traditional mode of cultivation, use of local varieties and erratic nature of rainfall. The production of pulses registered a decline by 55.03 % followed by oilseeds (29.25%), cereals (11.36%) and horticultural crops (9.31%) **(Table 2 and Fig. 3)**.

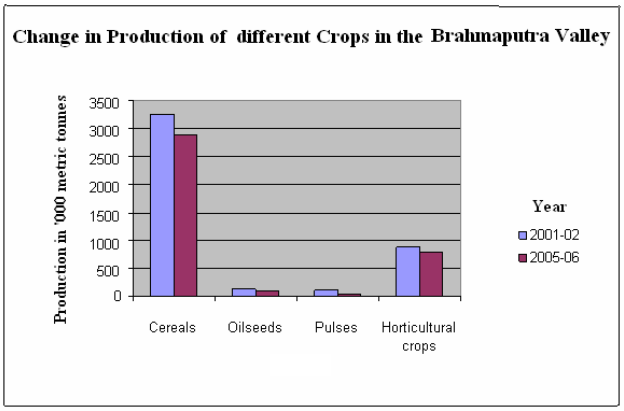

Fig. 3. Change in Production of different Crops in the Brahmaputra valley, 2001-2006

Table 2. Change in production of different crops in the Brahmaputra valley, 2001-2006

Year	Production (in metric tones) of different crops and their % change during 2001-2006			
	Cereals	Oilseeds	Pulses	Horticultural crops
2001-02	3248701	139824	105674	870441
2005-06	2879711	98925	47523	789367
% change during 2001-2006	-11.36	-29.25	-55.03	-9.31

Data source: Directorate of Agriculture, Government of Assam

Table 3. Change in area under different types of rice in the Brahmaputra valley during 1960-2005

Year	Area under rice (in hectare) and percentage change							
	Autumn rice	Change %	Winter rice	Change %	Summer rice	Change %	Total rice	Change %
1960	314577		1092238		2448		1409262	
1965	402149	27.84	1138786	4.26	10709	337.49	1551644	10.10
1970	527880	31.26	1220830	7.20	12360	15.42	1703870	9.81
1975	636800	20.63	1204800	-1.31	25830	108.98	1777490	4.32
1980	606225	-4.80	1245570	3.38	26420	2.28	1788010	0.59
1985	640600	5.67	0	0	31766	20.23	1950914	9.11
1990	608150	-5.07	1374653	0	102866	223.82	2008756	2.96
1995	624761	2.73	1323074	-3.75	140958	37.03	2028731	0.99
2000	539665	-13.62	1344888	1.65	310624	120.37	2134261	5.20
2005	359693	-33.35	1105894	-17.77	260729	-16.06	1671562	-21.68

It has been revealed that the area under rice has been gradually increasing registering a change of + 51.45 % during the period 1960 - 2000 (Table 3). The area under rice after every five years from 1960 to 2000 has shown positive change, except in the year 2005. There was a severe drought in 2005 for which rice area declined. The area under different types of rice (autumn and winter rice) has also witnessed considerable changes (both positive and negative) in the subsequent periods. However, the area under summer rice has been continuously increasing except for the year 2005. It is because of the fact that the farmers of the Brahmaputra valley, especially those from the *char-chapori* areas have opted for cultivating summer rice as an alternative to autumn and winter rice as these are regularly affected by floods and droughts. The area under rice is, however, fluctuating depending mainly on the availability of rainfall and extension of cultivation to some new areas.

The productivity of rice in the valley has also been increasing. The yield as calculated at five years interval from 1960 to 2005 shows positive change except for the year 2005 (Table 4). The productivity of rice during 1960 - 2000 registered a change of + 70.31 %. The production of rice in 1960 was 1.28 million tonnes which increased to 3.99 million tonnes in 2000, registering a change of + 211.72% during the period (Table 5).

Table 4. Trend of yield of different types of rice in the Brahmaputra valley during 1960-2005

Year	Rice yield (in tone) per hectare							
	Autumn rice	Change %	Winter rice	Change %	Summer rice	Change %	Total rice yield	Change %
1960	0.6940		1.001		1.102		0.933	
1965	0.7300	5.19	0.977	-2.40	1.119	1.54	0.942	1.03
1970	0.7190	-1.51	1.080	10.54	1.300	16.18	1.033	9.65
1975	0.8040	11.82	1.150	6.48	1.348	3.69	1.101	6.56
1980	0.8020	-0.25	1.171	1.83	1.460	8.31	1.144	3.93
1985	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
1990	0.9030	0.00	1.381	0.00	1.716	0.00	1.333	0.00
1995	0.9200	1.88	1.425	3.19	1.794	4.55	1.380	3.49
2000	1.0540	14.57	1.495	4.91	2.219	23.69	1.589	15.20
2005	1.0110	-4.08	1.436	-3.95	1.925	-13.25	1.457	-8.33

Source: Directorate of Agriculture, Government of Assam

Table 5. Trend of production of different types of rice in the Brahmaputra valleyduring 1960-2005

Year	Production (in tonne) of different types of rice							
	Autumn rice	Change %	Winter rice	Change %	Summer rice	Change %	Total rice	Change %
1960	207367		1073666		2137		1283170	
1965	309429	49.22	1099101	2.37	9803	358.73	1418333	10.53
1970	379573	22.67	1604317	45.97	32539	231.93	2016429	42.17
1975	477633	25.83	1767283	10.16	45506	39.85	2290422	13.59
1980	501692	5.04	1977606	11.90	43499	-4.41	2522797	10.15
1985	507500	1.16	2293700	15.98	45380	4.32	2846580	12.83
1990	522189	2.89	2565423	11.85	182581	302.34	3270193	14.88
1995	516031	-1.18	2622667	2.23	251324	37.65	3390022	3.66
2000	557764	8.09	2759652	5.22	681027	170.98	3998443	17.95
2005	335120	-39.92	2046719	-25.83	530302	-22.13	2912141	-27.17

Source: Directorate of Agriculture, Government of Assam

Change in cropping intensity

The nature of change in cropping intensity in the Brahmaputra valley has been also remarkable. In the traditional subsistence agriculture, usually the cropping intensity remains considerably high. In the limited land resources of the valley, the small and marginal farmers are compelled to cultivate their lands three to four times to raise various crops in order to meet their domestic demand. However, at present, because of the spread of modern mono-cropping, particularly in the case of rice, the paddy lands have been cultivated less intensively.

The cropping intensity in the case of Brahmaputra valley in 1992-93 was 150.31 % which decreased to 144.19 % in 2001-02. A district level observation of the change in cropping intensity over the period **(Table 6 and Fig. 4)** revealed that Darrang district recorded the highest decline (-37.99) in the index of cropping intensity followed by Barpeta (-11.03), Golaghat (-8.36), Nagaon (-6.73), Kokrajhar (-3.94) and Sibsagar (-3.74). However, the intensity of cropping has shown a positive trend in the remaining districts. The highest increase in the intensity was recorded in Dhemaji district (+23.21) and the lowest in the Dibrugarh district (+0.94).

Table 6. Changes in cropping intensity in the Brahmaputra valley, 1992-2002

District	Cropping intensity 1992-93	Cropping intensity 2001-02	Change (%)
Dhubri	151.33	153.29	+1.30
Kokrajhar	166.28	159.73	-3.94
Bongaigaon	156.12	164.79	+5.55
Goalpara	125.64	136.84	+8.91
Barpeta	172.93	153.85	-11.03
Nalbari	133.11	137.46	+3.27
Kamrup	125.28	139.73	+11.53
Darrang	231.4	143.49	-37.99
Sonitpur	136.81	147.12	+7.54
Lakhimpur	163.54	172.05	+5.20
Dhemaji	131.43	161.93	+23.21
Morigaon	131.25	134.55	+2.51
Nagaon	162.13	151.22	-6.73
Golaghat	140	128.3	-8.36
Jorhat	131.2	142.62	8.70
Sibsagar	115.49	111.17	-3.74
Dibrugarh	128	129.22	+0.94
Tinsukia	136.17	141.83	+4.16
Brahmaputra Valley	150.31	144.19	-4.07

Source: Directorate of Agriculture, Government of Assam; Note: Cropping intensity = (Gross cropped area ÷ Net cropped area) × 100

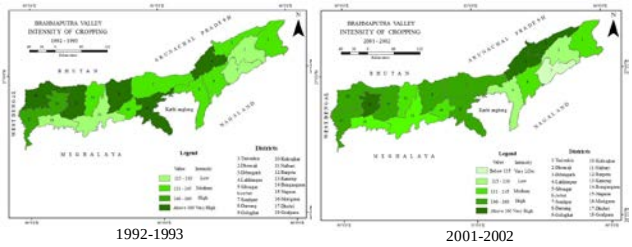

Fig. 4. Brahmaputra Valley Intensity of Cropping 1992-1993 and 2001-2002

Change in physiological density: There has also been seen a change in the physiological density of population in the Brahmaputra valley. It has already been mentioned that the Brahmaputra valley, with extensive uninhabited and uncultivated fertile lands attracted immigrants from East Pakistan (Bangladesh) and Nepal, especially after 1950s. The immigrants along with the growing indigenous population exerted immense pressure on the valley's limited agricultural lands.

It has been observed that the physiological density in the valley in 1991 was 798 persons per sq km which increased to 947 persons in 2001, registering a change of +19 % during the decade (Table 7).

Table 7. Change in physiological density in the Brahmaputra valley, 1991- 2001

District	Physiological density, 1991	Physiological density, 2001	Change (%) 1991-2001
Dhubri	888	1139	+28
Kokrajhar	931	1067	+15
Bongaigaon	824	953	+16
Goalpara	857	1037	+21
Barpeta	766	915	+19
Nalbari	687	748	+9
Kamrup	1124	1402	+25
Darrang	627	733	+17
Sonitpur	874	1014	+16
Lakhimpur	783	890	+14
Dhemaji	684	907	+33
Morigaon	666	840	+26
Nagaon	806	986	+22
Golaghat	662	806	+22
Jorhat	697	833	+20
Sibsagar	639	764	+20
Dibrugarh	834	859	+3
Tinsukia	1024	1156	+13
Brahmaputra Valley	798	947	+19

Data source: Statistical Hand Book, Government of Assam, Note: Physiological density denotes persons per sq km of arable land.

Causes of change: The changes in agroecosystem of the Brahmaputra valley are caused by a number of physical and cultural factors. Among the physical factors spatial distribution and seasonal variation of rainfall, humidity and temperature, floods and erosion, deterioration of soil quality and degradation of wetlands are mainly responsible. Since rice is cultivated extensively in the monsoon season, floods cause great loss to the paddy cultivation in the valley. The area and production of rice in major flood years (1988, 1998, 2004 etc.) were found to be less than normal (Fig. 5 and 6).

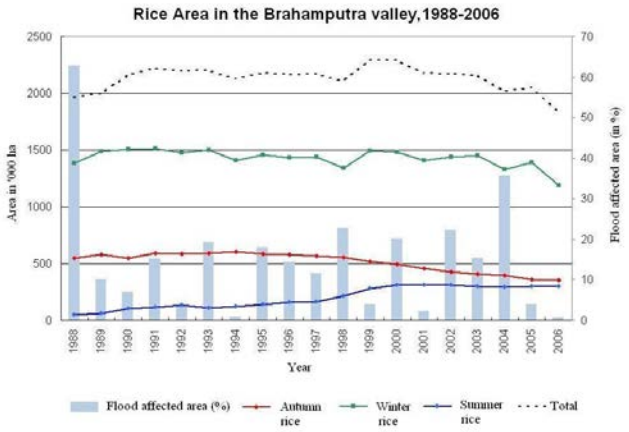

Fig. 5. Rice Area in the Brahmaputra valley 1988-2006

Again, the rapid population growth, occupational shift, modernization in agricultural and allied sectors, change in food and dress habit and housing, impact of globalization and government policies are some of the important socio-economic factors that contribute to the change in nature and functions of the agroecosystems in the valley. The rapid rise of population and limited supply of land resources in the Brahmaputra valley have adversely affected the valley's agroecosystem. It is already mentioned that the density of population in the valley has been rising fast from 225 in 1971 to 342 in 1991 and 406 persons per sq km in 2001. The agricultural density in the Brahmaputra valley which was 707 persons per sq km of agricultural land in 1991 increased to 824 persons in 2001 registering a change of + 17% during the period.

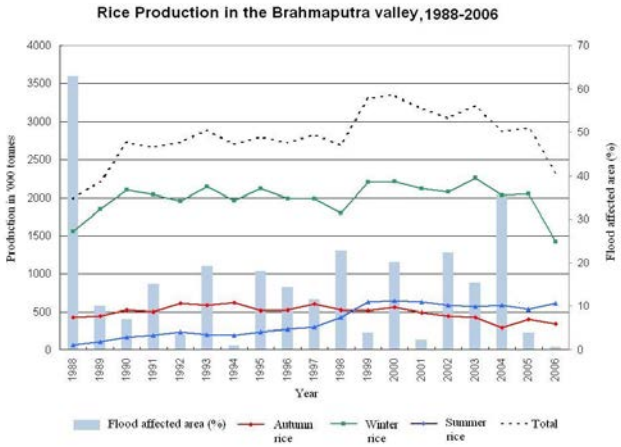

Fig. 6. Rice Production in the Brahmaputra valley 1988-2006

After independence, more particularly after 1980s, efforts have been made to use modern inputs and equipment in the agricultural fields which has brought about change in the land use pattern, methods of water supply, cropping pattern, crop-combination, productivity and the overall character of the agroecosystems of the Brahmaputra valley.

Consequences of change: The changes in agroecosystem for the purpose of modernization have generated lot of changes in the culture, economy and livelihoods of the people of the valley. With the introduction of modern inputs and implements the diverse and mixed cropping systems in the valley tended to be mono-cropping. Many traditional crop varieties that adapted to the site-specific conditions and practices now tend to disappear. With the disappearance of certain local crop varieties as well as indigenous agricultural tools, there has been a parallel disappearance of some agriculture-related customs and festivals, traditional house type, food and dress habits. These have slowly led to the withdrawal of the emotional attachment of the people with their agriculture. Earlier, people used to have a biasness for their own agricultural produces.

There has been a growing social negligence to the farming community and the traditional farming activities. As a result, the percentage of workers engaged in agricultural activities has significantly decreased. All these factors have, however, compelled at least some of the farmers to gradually opt for mechanized farming. Growing dependence on mechanization has ultimately displaced farmers and farm workers from the agriculture to other secondary and tertiary sectors of the economy. The cumulative effects of all these have rendered the agroecosystems gradually unsustainable causing poverty and marginality among the small farmers in the valley.

Moreover, the low return of agriculture, general negligence to the farming community, lack of irrigation facility, gradual change in food habit, adoption of HYV and related farming packages are held responsible for the declining trend of cropping intensity during the recent years. Again, there has also developed a psychological reluctance among the aged group of farmers towards the use of modern farm technology due to lack of training and orientation (Deka and Bhagabati, 2010). Further more, the rapidly growing population due primarily to immigration from the erstwhile East Pakistan during and after 1950s and the consequent rise in demand for food, fibre and fuel on the one hand and the rich-biased development programmes implemented by the government agencies and the changing socio-political situations on the other, have weakened the traditional organic agroecosystems that dominated the valley's agricultural scenario till recently.

The agroecosystems of the Brahmaputra valley, Assam have been evolved by the people of different ethnic groups sharing different ecological settings. During the early pre-Ahom period, the valley's agroecosystem was primitive in nature. The indigenous tribal people living in the highlands have developed agroecosystems following the shifting (*jhum*) system. The Ahom, who came to Assam during early 13th century are said to have introduced the wet rice cultivation and some other crops using tools like wooden plough, harrow etc. During the British colonization in Assam in the 19th and first half of 20th century, the land revenue system, land reclamation etc were introduced and thus provided a new configuration to the valley's agricultural systems. Again, after independence, due to high growth of population and resultant demand for food, and advancement of modern agricultural technologies, the highly diverse and traditionally evolved agroecosystems of the valley has been in the process of transformation. Thus, the agricultural ecosystems in the valley are no doubt in a state of transformation from traditional to a modern one. However, some elements of primitive and traditional society and culture are still found to characterize the basic tenets of the valley's agroecosystems.

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