ANALYSIS AND CHARACTERIZATION OF RICE ENVIRONMENT OF ARUNACHAL PRADESH

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INTRODUCTION

Arunachal Pradesh situated between 26°28′ and 29°31′ N latitudes and 91°31′ and 97°31′ E longitude, is a thinly populated hilly tract on the North East extremity of India. Earlier, the area was known as the North East Frontier Agency (NEFA); it became a union territory in January, 1975, and was declared as a full fledged state on 20th February, 1987. The state has an international border with Bhutan in the west, China in the north and Myanmar in the east with interstate borders with Nagaland in south west and Assam in the south. Arunachal Pradesh, endowed with high geographical, socio-economic, cultural and edaphic diversities, is spread over a total geographical area of 83,743 km^2 with a total population of 8,58,392 as per 1991 census. The state comprises of 12 districts, 28 subdivisions and 48 community development blocks, 6 towns, 119 circles, 1,158 gram panchayats and 3,257 villages. It is one of the few backward states in the North East which still uses primitive and obsolete technologies in agriculture. Use of plough and bullocks in certain areas of state is just a recent phenomenon. Cultivators continue to use *dao* (sickle) and dibbling sticks as their agricultural implements for most of their agricultural operations. Use of modern technologies like tractors, power tillers, etc., are limited to few very rich farmers. Due to unavailability of large flat tract this is not feasible too. Owing to the preponderance of forests, barren and uncultivated lands, Per Capita availability of land for cultivation in the hill areas of the state is lowest in India – only 0.12 ha. Cultivation has been extended to marginal lands through extensive deforestation resulting in low productivity and soil erosion. Out of the net cropped area of 1.7 lakh ha, 60% falls under Jhuming (Shifting Cultivation) and rest under upland terraces, wetland terraces, valley lands and plains, etc. Rice accounts for a major share of 62.5% area followed by maize (16.2%) and millets (12.4%). In spite of high work participation (57.65% against 24% national average) of the rural people, average rice yield in the state is only 1.15t/ha, which is very low. Low solar energy interception, high rainfall, unfavourable water regime, undulating land, inadequate irrigation, uncontrolled water, low yielding and less responsive local varieties, low plant density and negligible use of improved tools and implements, fertilizers and plant protection chemicals – are some important causes of low yield and un-sustainability.

PHYSIOGRAPHY

Arunachal Pradesh is the eastern stretch of the Himalayas and all the three sections of the Himalayas are represented here. The Himalayas constitute about 70,000 km^2 out of the total area of the state. The forested Shiwalik hills rise abruptly to 800 m above the Brahmaputra valley. Out of the total area, broad and narrow valley constitute 35 % each, the foot hills and the plain area cover 10% and the snow clad peaks cover about 20% roughly. The whole are may be classified in to four belts from altitudinal point of view, viz., (i) foot hills below 3,000 ft. (ii) Middle belt ranging between 3,000-6,000ft. (iii) High hills ranging between 6,000-11,000 ft. and (iv) Pastoral land and snow clad peaks beyond 11,000 ft. Arunachal Pradesh has two major sections, the Mishmi Hills and Patkai Bum (Range). The former contains the loftiest ranges with many summits rising above 5,000 m. There are several basins too. The largest, Taraoan basin is surrounded by several south flowing tributaries of Tellu river; in this basin the elevation of the hills ranges from 150 m to over 7,300 m. The hill ridges in Arunachal Pradesh are situated in a very haphazard manner. At these intervals, the wide and narrow valleys come in to existence. Because of these ridges and valleys, the surface of Arunachal Pradesh is found varied almost everywhere which also results in to numerous geographical isolations of pockets caused by various rivers and streams traversing the region.

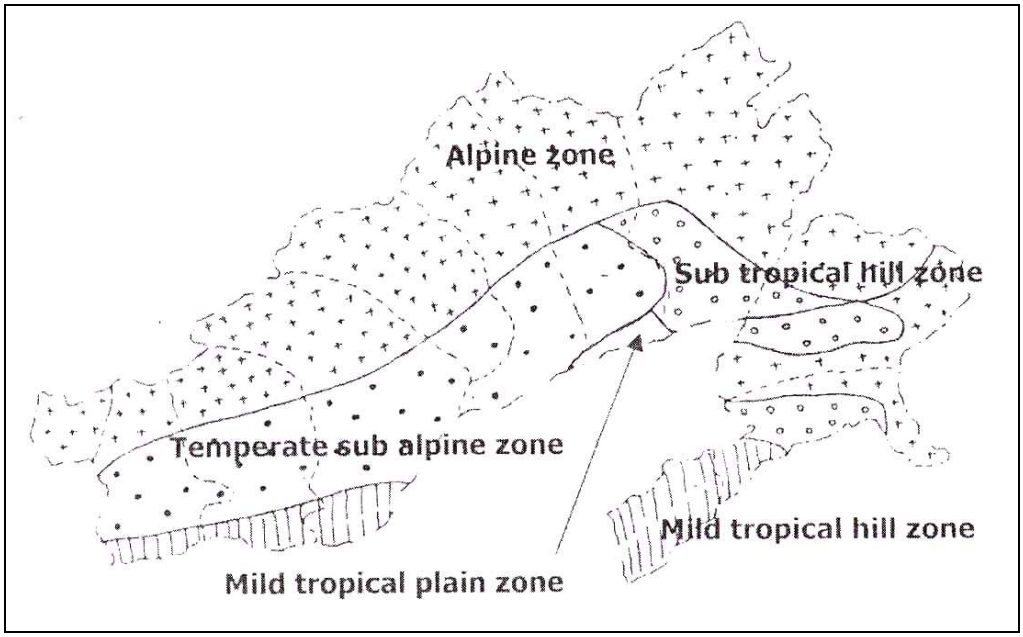

Figure 1. Agro-climatic zone map of Arunachal Pradesh

Climate

The wide altitudinal difference along with physiography contributes to great climatic variations in the state. There are definite pockets representing sub-alpine temperate, subtropical and tropical areas. Such variations are sometimes met with a small area itself, thus making the flora and the agricultural practices very location specific to small units. The Himalayan ranges in Arunachal Pradesh extending 5000 m near Shela Pass and 3000 m at Tawang, both in Kameng district, represent a typical temperate zone covering alpine areas. The climate of the major part of the state falls under humid subtropical with wet summer and winter and other remaining part falls under cold humid with wet summer winter. The average maximum and minimum temperatures in humid subtropical region are 29.47 degrees and 17.70 degrees Celsius and in cold humid region is 21.4 degrees and 2.4 degrees Celsius. The year may be divided in to 4 seasons - January to February is the winter season, which is followed by the pre-monsoon season from March to May, Monsoon from June to September and post monsoon from October to December. The average annual rainfall in the humid subtropical region is about 29972.7 mm and that in the cold humid region is about 2086.9 mm (Bagra and Srivastava, 1992). There have not been much serious attempts at delineation of the entire region in to specific agro-climatic zones. However, some attempts have been made based on altitude, rainfall patterns, temperature variations, topography, soil, etc. According to these criteria five agro-climatic zones (Figure 1) have been identified (Borthakur, 1992) in the state. These are:

i. Alpine Zone: Gorichen, Upper Tawang, Tulungla, Bumla, Shela Pass area of west Kameng district, Jidu and adjoining areas of northern Siang.

ii. Temperate and subalpine zone: Tawang, Dirang, Bomdilla, Shergaon areas of west Kameng district, Dibang valley, northern part of east Siang, Upper Subansiri district, part of west Siang around Anini and north eastrn part of Lohit district.

iii. Subtropical hill zone: Chngyak, Naga and Knonsa area of Tirap district, Basar area of Siang district.

iv. Mid tropical hill zone: Southern part of lower Subansiri district.

v. Mid tropical plain zone: Pasighat area, Siang phow area of Tirap district and lower parts of Lohit district.

Soils

The soils of Arunachal Pradesh have been formed from different type of parent materials. About 50 % of the area has been surveyed by the Geological Survey of India. The dominating parent

material around Bomdilla and Hapoli are found to be gneiss and granite rocks underlined with chlorite quart schist. The soils of the southern portion of Siang district have developed from basaltic rocks phyllitic to slaty rocks, massive quartzite and dolomite (Borthakur, 1993). Soil of Arunachal Pradesh is broadly classified in to two categories viz., soils of the higher region and soils of the lower region (Bagra and Srivastava, 1992).

The soils of higher region are developed from high grade metamorphics comprising of schist, genesis, biotite granite, granodiorite, micaschist, hornblend, sandstone cenglomorates, shales, phyllites, quartzits, etc. Soils are dark brown to dark yellowish brown in colour and are coarse to medium textured. They are coarse loamy sand to sandy loam with loam to clay loam sub-soil, where the depth ranges from 70 to 140 cm or more.

The soils are developed on the alluvium deposited by the rivers and colluvial was gliding down the slope and are carried away by runoff. These soils belong to the orders of Entisols, Inceptisols an Altisols tentatively. Almost entire soils in Arunachal Pradesh are low in available phosphorus and high in organic carbon content. The possible reason for higher organic matter content is due to thick forest vegetation, high rainfall and low decomposition rate. Soils of Kameng and Siang districts are medium in available potassium and that in Subansiri are rated low. The soils of the remaining districts of Arunachal Pradesh are high in Potassium. Practically entire soils of Arunachal Pradesh are deficient in available phosphorous. The reasons of low availability of phosphorus in these soils might be due to strongly acidic soil reaction and presence of considerable amount of exchangeable.

LAND USE PATTERNS AND LAND TENURE SYSTEMS

There is no land use/land cover map existing in Arunachal Pradesh. No exhaustive survey, either ground based or remote sensing is undertaken in this state to assess the pattern of land use or land cover. In many cases, inference is made about the land use pattern on the basis of crude estimation of land cover (Table 1). According to the estimation of the State Forest Department, about 62% of the total geographical area (51,540 km^2 out of 83,743 km^2) is covered with forests.

Most parts of land in Arunachal Pradesh are steep hills deep terrain and thick forests. About 62% of the land covered by forest is supposed to be the biggest endowment of nature. The rest of the land is put to different uses. About 34% of land which probably includes private lands reserved for' hunting and fishing and residential areas, only 4% of land is presently available for agricultural purposes. In 1985-86 about 78% of total cultivable lands were jhum land while the rest were under permanent cultivation. Table 2 shows the proportion of fallow land in jhum areas which shows how a large portion of Jhum land remains unused in any given time (77.60% in average), although it declined from 81.08% in 1970-71 to 77.88% in 1985-86. The Jhum settlement ratio of the land is very important to understand the real nature of land use pattern in Arunachal Pradesh.

Table 1. Area under land cover and land use in Arunachal Pradesh

S. No.	Types	Area (km^2)	Per cent
1.	Built up land	1792.50	2.14
2.	Agriculture land		
	Kharif	1307.09	1.56
	Rabi	17.49	0.02
	Double crop(Kharif and Rabi)	471.79	0.56
	Fallow	45.92	0.05
	Agriculture plantation	25.81	0.03
	Total	**1868.1**	**2.23**
3.	Forest		
	Evergreen/Semigreen	62,923.01	75.14
	Deciduous	252.60	0.30
	Degraded/Scrub land	7600.98	9.07
	Forest blank	29.86	0.04

	Forest plantation	141.55	0.17
	Total	**70948.00**	**84.72**
4.	Wasteland		
	Marshy/Swampy land	131.24	0.16
	Land with or without scrub	3.12	0.004
	Sandy area	14.86	0.02
	Barren rocky/Stony waste/ Sheet rock area	820.42	0.98
	Total	**969.64**	**1.16**
5.	Water bodies		
	River/Stream	620.46	0.74
	Lake/Reservoir/Tank/Canal	29.60	0.04
	Total	**650.06**	**0.78**
6.	Others		
	Shifting cultivation	2613.38	3.12
	Grass land/ Grazing land	5.93	0.007
	Snow covered glacial area	4895.02	5.845
	Total	**7514.33**	**8.97**

Source: Rethy et al., 2003

Table 2. Total area (in ha) under cultivation reported in different agricultural census

Landuse	1970-71	1976-77	1980-81	1985-86	1990-91
(a) Settled	28006	40013	52012	7677759	N/A.
	(5.73)	(10.11)	(15.49)	(22.30)	
(b) Jhum total	461005	355513	283720	267495	N/A.
	(94.27)	(89.89)	(84.51)	(77.70)	
(i) Net area sown	27220	71901	66220	72555	N/A.
(ii) Fallow land	169352	130004	80380	49008	N/A.
(iii) Culturable waste land	148698	84540	47595	44426	N/A.
(iv) Other uncultivated land (other than fallow land)	199164	49850	34888	28655	N/A.
(v) Land not available for cultivation	36571	19218	54637	48129	N/A.
Total area operated	489011	395526	335732	344254	344000

The state is not yet cadastrally surveyed and there is no land record to determine the ownership of land. In absence of any ownership or tenancy legislation and also lack of any land records, the ownership of land is governed by the customs and traditions of various tribes. However, broadly there are three types of ownership: Clan or community ownership, private ownership and mixed type of ownership. The community ownership is the most common type of ownership and is the result of jhum system of cultivation, which warrants frequent collective efforts. In recent years, it is observed that these traditional patterns of ownership are fast changing and giving place to private ownership of land in all areas, owing to a number of factors -the most important being the development of permanent cultivation owing mainly to Government efforts. The table 3 gives an idea of land holding pattern in Arunachal Pradesh. It can be seen that individual holdings are increasing over the years and this increase is mainly due to increase in the number of small and marginal holdings. More than 50% holdings are small holdings of the size of 1 to 4 hectares and size of average holding is gradually decreasing.

Table 3. Pattern of land holdings in the State

Size of Holdings	Numbers of Holdings				
	1970-71	1976-77	1980-81	1990-91	1985-86
Marginal (below 1.00 ha)	6060	6442	12936	14781	16500
	(7.67)	(9.69)	(16.53)	(17.18)	(17.38)

Small (1.00 to 4.00 ha)	29920 (37.88)	30367 (45.67)	38392 (48,89)	43056 (50.05)	48500 (51.05)
Medium (4.00 to10.00 ha)	28750 (36.40)	18169 (27.32)	22073 (28.10)	23237 (27.00)	25800 (27.15)
Large (10.00 ha and above)	14260 (18.05)	11521 (17.32)	5091 (06.48)	4964 (05.77)	4200 (04.42)
Total	78990 (100.00)	66499 (100.00)	78542 (100.00)	86038 (100.00)	95000 (100.00)
Size of average holding	6.19 ha	5.95 ha	4.47 ha	4.00 ha	3.62 ha

Source : Directorate of Agriculture, Government of A.P., 2001 (Figure in bracket indicates %)

The vegetation of Arunachal Pradesh falls under four broad climatic categories and can be classified in five broad forest types with a sixth type of secondary forests. These are tropical forests, subtropical forests, pine forests, temperate forests and alpine forests (Bagra and Srivastava, 1992). The detail classification of forests in Arunachal Pradesh shows that the reserve forests constitute nearly 37.32% of the total forest area of the state which is much less than the all India average of 52.2%. It is important to observe that there is a vast area known as unclassified state forest for which both state and local people claim rights. Arunachal forests are managed by Forest Department with the provision for sharing the net revenue in the ratio of 50:50 with village.

Agriculture

Arunachal Pradesh, full of mountains and hills terrains, has very negligible arable flat lands suitable for settled cultivation. Though the state Agriculture Department has estimated the area under the agricultural operation being about 5% of the total geographical area of the state, the 1980-81 agricultural census has found the total land under various agricultural land use category is about 4%, i.e., 3,35,732 hectares. Two distinctly different agricultural practices, viz., Jhum or shifting cultivation and permanent or settled cultivation are found in the state. While the former has been evolved in the long immemorial past in response to the inhospitable nature of the hilly terrain and is practiced almost universally by the local tribes, the settled cultivation is not completely unknown to a few tribal communities, like Apatanis, Khamits and Singphos. It is comparatively a recent phenomenon that makes its way along with the increasing interaction of the isolated tribal communities with the outer world, penetration of modern administration and so on. However, settled cultivation is practiced in the foothills comprising a very insignificant portion of the total land area. The net area sown under permanent cultivation was only 7,6759 hectares in 1985-86 out of total net sown area of 1,49,314 hectares. Paddy maize, wheat, pulses, vegetables and oil seeds are the crops grown in the land depending on the climate and soil. A good number of food crops are grown in the jhum field. The tropical humid forest, high rainfall and low land man ratio are conducive to practice shifting cultivation. Presently, jhuming, which is thought to be uneconomic and undesirable for ecological factors, is increasingly being replaced by permanent or terrace cultivation and a large share of state fund is being directed towards the end.

In Arunachal Pradesh, generally, two types of cropping patterns are prevalent viz. mono cropping and mixed cropping. The former is practiced in settled area where as the latter is practiced both in settled as well as jhum areas. Kharif is the main harvesting season when all the important crops e.g. paddy, maize, millet and wheat are grown all over the state. In course of shifting cultivation different kinds of vegetables are also grown along with the main crops. Though the extent of agricultural activities vary from place to place depending upon the nature and availability of cultivable land and other infrastructure facilities, spatially the cropping pattern remain more or less the same. In some cases, the relative importance of the main crops only varies but that too also not very significant. Important crops of each district arranged in descending order according to the area under each crop are listed in Table 4. Paddy is the principal crop and cultivated allover the state since long historical past. Similarly, maize and millet are produced as traditional substitutes by the different tribes of Arunachal. Production of fruits like apple, pineapple, orange, plume, etc., and vegetable like potato, cabbage, cauliflower, etc., are appeared to have been introduced in the recent past.

Table 4. District-wise cropping pattern in Arunachal Pradesh (With reference to 80's),

S. No	District	Major Crops	Minor Crops
1.	Tawang	Barley, Wheat, Paddy, Millet, Maize, Potato,	Soybean, Buck Wheat, Ginger, Chilies.
2	West Kameng	Maize, Buckwheat, Millet, Paddy, Potato, Pulses, Wheat.	Cabbage, Rajma, Barley, Soybean, Sweet Potato, Chilies, Ginger, Garlic, Mustard, Groundnut, Cauliflower, Radish.
3.	East Kameng	Paddy, Millet, Maize, Fruits, Vegetables, Pulses, Mustard.	Wheat, Potato, Ginger, Sesamum, Groundnut, Chilies, Sugarcane,
4.	Upper Subansiri	Paddy, Maize, Millet,	Barley, Pulses, Oilseeds, Spices
5.	Lower Subansiri	Paddy, Maize, Millet, Pulses, Potato	Ginger, Chilies, Turmeric.
6.	West Siang	Paddy, Maize, Millet, Potato, Sugarcane	Vegetables, Wheat, Oilseeds, Pulses, Ginger, Chilies, Turmeric.
7.	East Siang	Paddy, Maize, Mustard, Millet, Aram, Wheat, Potato	Ginger, Soybean, Blackgram, Jobstear, Chilies.
8.	Dibang Valley	Paddy, Maize, Mustard, Millet, Fruit, Potato.	Wheat, Buckwheat, Pulses, Sugarcane, Chilies, Ginger.
9.	Lohit	Paddy, Oilseeds, Maize, Fruits, Groundnut, Vegetables, Pulses.	Millet, Wheat, Potato, Sugarcane Ginger, Garlic, Turmeric.
10.	Changlang	Paddy, Millet, Maize,	Chilies, Ginger, Potato.
11.	Tirap	Rice, Millet, Maize, Tapioca.	Wheat, Blackgram, groundnut, Potato, Kotchu, Soybean.

Low productivity in agriculture can be evidenced by the average yield rate of some important crops. The average yield rate of rice, maize, wheat, millet, sugar cane and potato in this state is accounted to 1.13, 1.17, 1.48, 0.54. 19.16, 8.59 tonnes per hectare, respectively. It has been observed that Tawang, Dibang valley, Lohit and West Kameng districts had high cropping intensity. East Siang, West Siang and Changlang districts had moderate whereas Upper Subansiri, East Kameng, Lower Subansiri and Tirap districts had low crop intensity. Though the state has vast potential of irrigation projects, due to the peculiar terrain, only minor irrigation schemes are introduced. However, the state is still lacking in irrigating agricultural sector to a significant level. As per 1990-91 data, only, 31000 hectares of land have been irrigated by the sources other than channels, tube-wells and other wells. The use of fertilizer in Arunachal Pradesh is lowest in whole North -East.

As per 1992-93 data estimated by Planning Commission the consumption of nitrogen in Arunachal Pradesh in both Kharif and Rabi seasons is only 300 tonnes. Similarly, the consumption of phosphate and potash is only 140 tonnes and 50 tonnes, respectively, in the year 1992-93. In Arunachal Pradesh, the consumption of plant nutrients per unit gross cropped is only 1.9 kg/ha. The consumption of pesticides was only 1689 per ha as against 377g at the all India level.

Characteristics of rice cultivation

Paddy by being in the major crop of the farmers in the state is grown over 93.72% of the total operational holdings covering 53.86 % of the total cropped area. The North East region is one of the centers of origin of rice which originated in South East Asia including this region. As such there is large diversity of genetic material in rice including wild varieties of cultivated rice (Tables 5 & 6). In Arunachal Pradesh, 100 strains of upland paddy germplasms were tested for various characteristics and the wide variations in important characteristics are recorded. The studies also indicate that genes are having many desirable characters including resistance to pests and diseases, different plant heights, high protein content, etc. Rice is grown in a wide range of climatic conditions ranging from deep water to high altitudes.

Under the long jhum cycle, cereals constitute the major component of the crop mixture. Sequential harvesting of crops is an effective way of managing up to 35-40 crop species. Successive harvests of cereals create additional space for the remaining perennial crop, which also receive humus and nutrients. Like jhum, valley agriculture is practiced through out the hilly terrain, both at low and high terrain. It is a sedentary form of wet rice cultivation and is a complementary system to jhum. It is

done wherever the terrain permits on flat lands between hill slopes. However, small terraces may also be built by some tribal communities all around the flat valley land extending into the foot of hill slopes. This results in a saucer shaped structure in which rice plots are organised. The soil in valley lands is fertile due to nutrient washout from the hill slopes. Similarly, rice is also grown in different seasons during the year. The rice grown in the region thus can be classified into six classes primarily. These are *Ahu* or autumn rice, *Sailor* Kharif rice also called winter rice, *Boro* or spring/summer rice, *Asra* or shallow water rice, *Bao* or deep water floating rice or hill rice. The hill rice can also be further subdivided into mid altitude rice and high altitude rice. The various classes of rice along with the season of cultivation are indicated in Table 7. However, for uniformity of statistics of the area, production and yield of rice in the region has been classified into three classes viz., autumn rice, winter rice and summer rice depending on the period of harvesting. The area, production and average yield of the three classes of rice are indicated in Table 8. Considerable area under rice is rain fed. The upland rice in the region is almost synonymous with rain fed rice although there are low land as well as midland areas, which are cropped with rice depending on rainfall alone. The upland rice has been particularly classified into two categories mainly shifting cultivation and permanent agriculture. Rice is grown in hill slopes under shifting cultivation. Rain fed permanent areas may be terraced hills and flat lands usually bunded and directly seeded, upland sites are characterized by aerobic soil in which no attempt is made normally to impound water.

Table 5. Variability in rice germplasm collections from N.E. Region

Characters	Range
Plant height (cm)	56 - 220
Flag leaf length	16.8 - 56.0
Flag leaf width (cm)	1.1 - 2.8
Leaf area/plant (cm2)	180 - 6433
Days to flower	94 - 163
No. of ear bearing tillers	2.0 - 20.2
Panicle length (cm)	14.3 - 31.1
Branches / panicle	3 - 99
% of sound grains / panicle	3 - 99
Grains / panicle	31 - 329
Grain density / cm	1.7 - 15.7
1000 grain weight (g)	11.6 - 34.0
Seed yield / plant	0.4 - 24.0

Table 6. Some rice varieties with desirable traits

Trait	Varieties
Higher yield in rainfed upland	Batlong, Lyngsi, Pawnbuh, Bangnapdai, Asienkel
Higher yield in lowland	Ngoba, Khawnowjoma, Chao, Phoonlen Tura - 113
Earliness	Chanmour, Rangegellong, Kangpui, Bethi, Ngoba
Dwarf	Nikhunkatai, Kanchalmang, Khuctio Baophoe, Leitalbubhan
Tolerance to drought	Amiong, Addy, Changpalman, Pyare
Cold tolerance at flowering phase/ diffused light	Pawnbuh, Ngoba, Pangnakla, Mamen
Tolerance to Fe-toxicity	Nemo, Maidangahu, Aamo, Pangnakla, Leitalbuhban
Tolerance to blast	Mirikrak, Pawnbuh
Non-lodging tall	Khonorullo, Ryllored, Aborred B, Fine grain
	Ngoba, Kbathangnew
Glutinous	Changhoesam, Chomju, Kbasawrit
Scent	Pyapon, Horipuri, Moyatsuk

Table 7. Categories of rice growing season

Class	Season of cultivaton	Remark
Ahu	Early : February to May	Transplantedwith irrigation

(Autumn Rice)	Normal : Mar-April to Jun-July Late : May to August	Rainfed-direct sown Transplanted - Rainfed or irrigated.
Sali (kharif) (Winter rice)	Normal:July-Aug. to Nov.-Dec Late : Aug-Sept. to Dec.-Jan	
Boro (spring/summer rice)	Nov.-Dec. to April-May	In water stagnated areas or with irrigation
Asra (Shallow water rice)	Mar.-April to Nov.-Dec.	In 1-2 M deep water
Bao (Deep water/floating rice)	Mar.-April to Nov.-Dec.	In 2-5 M deep water
Hill Rice	Mid Hill April-May -Sept.-Oct. High Hill June-July-Nov.-Dec.	

Table 8. Area and production under rice cultivation

Year	Area	Production	Yield	Area under HYV in NER
80-81	83.4	88.2	1,058.0	N/A
81-82	90.1	94.2	1,046.0	N/A
82-83	93.5	97.4	1,042.0	N/A
83-84	101.0	106.0	1,050.0	N/A
84-85	108.0	117.6	1,088.0	N/A
85-86	108.0	117.6	1,088.0	N/A
86-87	116.0	125.1	1,078.0	6
87-88	116.0	125.1	1,078.0	5
88-89	120.6	135.8	1,126.0	7
89-90	121.3	138.8	1,144.0	12
90-91	121.8	142.5	1,170.0	29
91-92	122.0	143.1	1,173.0	22
92-93	115.3	116.9	1,014.0	26
93-94	122.0	144.0	1,180.0	28

The specific constraints of rice production in the area include (i) soil moisture stress in uplands (ii) excess moisture in rain fed low land on account of ill drained condition and water stagnation (iii) improper crop management leading to inadequate crop stand and suppressed tillering, etc. (iv) leaching loss of nitrogen (v) fixation of phosphorus in acidic soil (vi) iron toxicity and (vii) disease and pest incidence particularly stem borer and blast diseases. In addition to these, lower level of utilization of technology including low use of chemical fertilizer and less spread of improved varieties also hamper production. Further adequate technologies suitable for specific situations have also not been developed. Cold spell during the vegetative growth phase of spring rice and during reproductive growth phase of late planted rice and hill rice, heavy rainfall during harvesting of autumn rice etc. also create problems in productivity.

Rice based farming system of Apatani

Aptani system of farming is an efficient system of hill farming where rice cultivation is integrated with fish culture on terraces and finger millet cropping on risers with an excellence of land, water an nutrient management. The Apatanis have been practicing wet rice cultivation (WRC) and terraces rice cultivation (TRC) with their indigenous irrigation system since time immemorial which solely depends on human labour. The Aptani plateau occupying a stretch of 26 km^2 area in the central core of the lower Subansiri district is inhabited by Apatani tribe of Arunachal Pradesh. The valley lies midway between Panior and Kamala rivers at an altitude of approximately 1554m. Steep mountain tops, with altitude up to 2438 m enclosed the valley on all sides. The valley has been appropriately called "The Rice Bowl" of the Apatanis who practice WRC with expert knowledge of management. Ever since the Apatanis established themselves in their present habitat, rice cultivation on irrigated terrace fields has been the main base of their economy. The energetic early settlers built up dams and dug channels and developed the valley bottom to an unbroken series of rice fields. The streams

originating from the surrounding hills were used to irrigate the terraced rice fields. Every one of the streams rising on the wooded heights that rings the Apatanis country is utilized for irrigation purpose soon after it emerges from the forest and reaches a gully wide enough to accommodate series of terraces. A short distance above the terrace the stream is tapped but here only a small amount of water is deflected and channeled to the highest field (Figure 2). By opening or blocking the connecting ducts any field can be flooded or drained as required. At the head of the valley the terraces are on an average narrow: they are partly carved out of the hill side and partly built up with a difference in level dwindle to a level as half a foot. There are two types of rice fields viz. permanently irrigated and seasonal irrigated. The former is kept under water or at least in a very wet condition throughout the year, and considered more valuable. Late variety of rice, locally called 'Emo' is the principal crop. The other types of field are dried out and hardened soon after the harvest. These are cleared and dug over every time before the cultivation and then water from the channels is allowed to flow over slowly to make the soil loose from puddling. Early variety of rice is grown in these fields. The early variety of rice had higher density but with reduced basal area compared to the late variety. Economic yield per plant and per unit area of the early variety was significantly lower compared to the late variety.

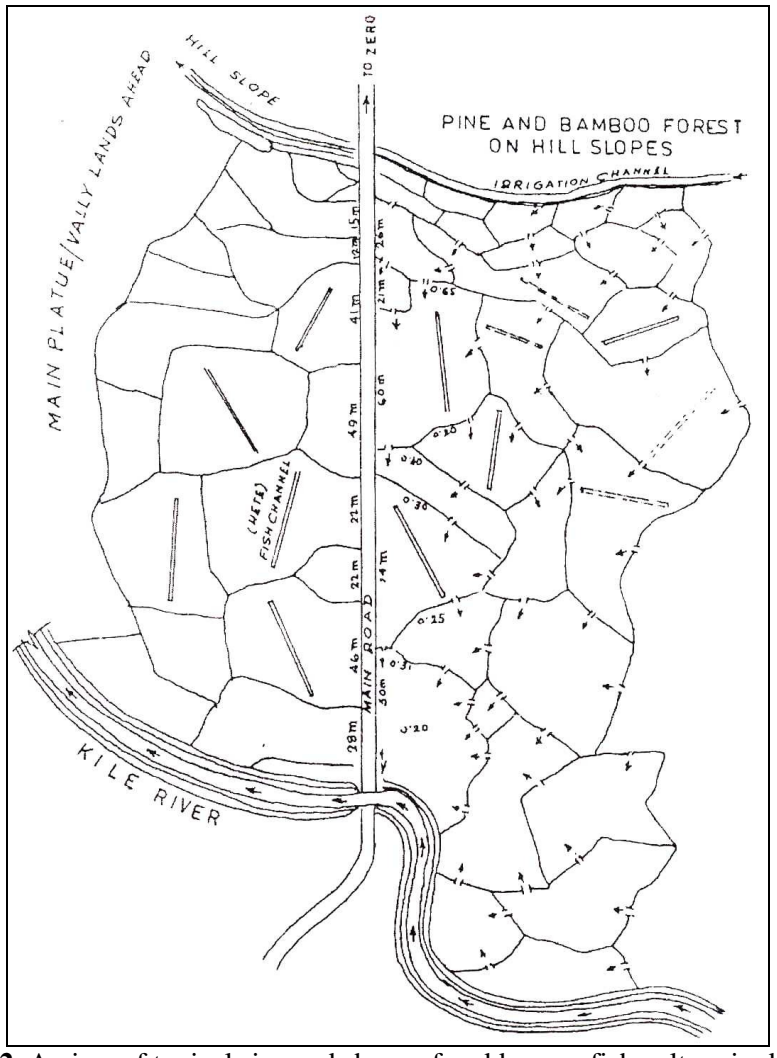

Figure 2. A view of typical size and shape of paddy-cum-fish culture in diffusion

The valley having cultivated area of 2,703.91 ha is exclusively covered under local rice variety where "Emo" occupies maximum area of 60% followed by Pysping (15%) and Pyat (10%) giving an average yield of 5.2, 4.0 and 3.2 t/ha, respectively. These indigenous rice varieties have very long duration of 190-278 days with and average of 220 days. Preparation of rice seedlings is taken up after the celebration of Myoko festival in March. Nursery duration range 60-80 days. In the middle of April, most of the fields are ready for transplantation. Each of the terraced plots is puddled

for 2 or 3 times with an interval of 3 to 4 days and properly irrigated. Single rice seedling transplanting at a spacing of 20-24 cm is practised. Normally, by mid of May transplantation is over through out the valley. The weeding of the fields is taken up thereafter and this is done with great thoroughness. Each plot is weeded for 2 or 3 times but there are instances of weeding for five or more times. In the mid of June, dry crops like early millet (Mipe) are planted mainly along with the bunds of rice fields and in garden plots too. The late variety millet (Sarse) is cultivated on high land garden plots. Maize is, however, sown exclusively in garden along with other vegetables. Millet cultivation through transplanted seedlings on terrace risers gives 8.2-120 q / ha yield. Harvesting of early varieties of rice begins in later part of August. The main harvesting is done in mid of October and continues for 2-3 weeks depending on the land holdings and availability of the workers. The harvesting pattern of two varieties of grains are stripped from the ear by hand, and in other varieties the straws are cut with either sickles or knives, tied into shears. The seeds are then thrashed out in the spot by beating against a slanting wooden board. The seeds are stored in carrying baskets which are latter shifted to the owners grainnery. Paddy cum fish culture is a vital component of the system where mainly common carp followed by grass carp and silver carp are grown at a stocking density of 17,52,500 Nos./ha with an average of 1750 finger lings/ha gaining weight from 130-400 g/fish in 4 months. Fish culture done synchronizes well with late ripping variety and production is also substantial.

LOW ELEVATION WET RICE AGRO ECOSYSTEM – A CASE STUDY

At Balijan (Arunachal Pradesh), the local Nishi tribe coexists with the immigrants tribals of the nearby plains of Assam and Bangladesh, such as the Karbis, the Kachharis and the Chakmas. The Nishis, the Chakmas and the Karbis alone do valley cultivation, the former raising one crop of rice annually, the latter raising two crops. Cropping of rice is done by transplanting seedlings between July-November. The second cropping done by the Karbis alone is a mixture of rice and maize raised between February-June, but the seeds are broadcast. Bullock power is used for ploughing. The Nishis and the Chakmas had similar yield pattern for their valley agroecosystem (Table 9), with labour as the chief input, the energy yield under the valley system was equal to the yield under a 5 year jhum cycle as done by the Nishis, but the total of two croppings done by the Karbis exceeded the yield under a 10 year jhum cycle of the Nishi. From a monetary view point, one cropping under valley as done by the Nishis and the Chakmas was comparable to the output under a 60 year jhum cycle. Thus wide varieties in yield pattern are evident from these comparative studies (Ramakrishnan, 1993).

Table 9. Energy output/input (mj ha-1 yr-1) under valley compared with mustard cultivation done by the Nishis and the Karbis of Balijan in the State.

Production measure	Valley cultivation		Mustard	Cultivation
	1st crop	2nd crop	Flatland	Kitchen garden
	Nishis & Karbis)	(Karbis)	(Nishis & Karbis)	(Karbis)
Input Total				
Energy	2286	2458	720	450
Monetary	1583+72	1154+52	1070+40	558+81
Output Total				
Energy	3777491	12791	10237	4535
Monetary	4940+169	2351+101	2017+40	1042+48
Output/ Input				
Energy	16.4	5.2	14.2	9.9
Monetary	3.1	2.0	1.9	1.9

Nishis take only one crop from valley land.

Source: Maikhuri and Ramakrishnan, 1991

Values in Parentheses are for monetary output/input pattern (RS HA^{-1} YR^{-1}) + S.E.

Constraints and Problems

The constraints for agricultural production in the region can be grouped under five broad heads: i) Climatic constraints ii) Infrastructure constraints iii) Biophysical constraints iv) Constraints of management and v) Socio-economic constraints.

Constraints of climatic include the high rainfall and humidity low temperature during winter, low light intensity and radiation flood as well as drought conditions in certain seasons. The high rainfall and humidity not only create favourable environment for the prevalence of wide range of pests, diseases and weeds but also create problems in drying, storage and hay making, etc. The high rainfall and cloudy sky again reduce the total sunshine hours so essential for food production. The low temperature prevailing for a considerable period during winter particularly in hilly region, limits the total period of time available during a year for crop production, thus limiting multiple cropping. The rugged terrain, high rainfall, steep slope and narrow valleys, etc., cause the problem of soil erosion in the form of – sheet, gully and bank erosion. Heavy silt load carried with free flow of high rainfall water through hill slopes cause choking of river beds making flood water spreading over vast adjoining areas causing extensive damage. Valley plain are degraded by the deposition of debris from upper hill slopes carried by high rainfall water. Scouring action of torrents are very common in the state. Landslides and land slips pose heavy threat to road/highways, villages and agricultural lands. Swampy/Marshy land and problems of water logging in the foothill areas are also not uncommon. Due to shifting cultivation and large scale deforestation there had been a continuous degradation of the land leading to ecological imbalance as well as disturbance in the soil and water balance.

The infrastructure constraints include the lack of road, transport and communication facilities, inadequacy of irrigated areas and lack of post harvest facilities and marketing, etc. Many areas particularly the inferior areas, are practically inaccessible in the hilly region. This creates problems of extension and supply of inputs in times besides the problems connected with transportation and market. The undulating topography, hill slopes and varied altitudes also create various problems of agriculture.

The agricultural production in the region can still be described as production under low level of technology. Situation specific varieties are not available; rate of application of fertilizer per hectare is low; appropriate tools and implements are also not available. There are also a large number of problems connected with management of agricultural production. Some of the important ones are the gap in extension, poor motivation and awareness, inadequacy of training, lack of incentive for the farmers due to weakness of procurement and non assurance of minimum price noon availability of inputs in time, the lack of credit facilities and market, dearth of qualified manpower in many cases, weak linkages between research and development and ineffective coordination between various departments connected with agricultural development.

There are number of socio-economic problems in the region inhabited by a large number of ethnic groups living in isolation in most cases. Some of the important socio-economic constraints are the ignorance of the people, the varied nature of village leadership lack of risk taking capacity of the poor farmers. Large scale fragmentation of holding leading to more poor and marginal farmers, prevalence of large number of traditions among the people which are linked up with agricultural programmes, the land ownership pattern particularly in the hilly areas, and presence of absentee land lords in other cases as well as lack of involvement of the farmers in the development programmes (Borthakur, 1992).

SUMMARY AND CONCLUSIONS

From the above discussion it can be concluded that despite a large number of constraints in production of rice in Arunachal Pradesh only two favourable parameters viz., high availability of water during rice growing season and highly productive and fertile land resources if exploited scientifically can not only result in enough production for the state but also boost the rice trade across the state boundaries. Therefore, the concentration of the planners should be on scientifically harnessing the natural resources, systematically exploiting the strengths and opportunities of the rice environment of the state of Arunachal Pradesh to become self reliant in rice production, which is not a unreachable goal.

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