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Constraints and opportunities of crop diversification in Assam

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ABSTRACT

Out of the net sown area of 2.83 m lakh ha in Assam, area sown more than once is around 1.24 m ha so cropping intensity stands around 148%. Total flood prone area of the State is 3,41,00 ha out of which 2,50,000 ha is chronically flood prone and 91,000 ha is occasionally flood prone area. Around 4.9 m ha of land which accounts for 62.6% of total geographical area are moderately and slightly acidic in reaction. Average consumption of NPK fertilizers is 51.83 kg/ha which was far below the national average; the crop removal found to be higher than that of added. The period December to February in the state showing very low moisture availability demanding artificial irrigation for better production of different crops. In Assam more than 83% farmers are having either marginal or small holding size. Inclusion of vegetable crops in the system provides better return; pulses and oilseeds may be included in the system under less moisture available condition, fodder crop may be included in the system to meet up the livestock requirement. If irrigated area is expanded and marketing infrastructure develops, then there is tremendous possibility for crop diversification with high profitability in the state. The paper presents the research work carried out by senior author on crop diversification in Assam.

Key word : Agro-climatic zone, Flood prone area, Crop planning, Soil degradation, Moisture Availability Index.

About 89% population of Assam is living in rural areas and 53% of the total workforce is still engaged in agriculture and allied activities. The share of this sector to Net State Domestic Product (NSDP) is 38.72% (Rs 12,282.29 crores) during 2002-03. Out of the total cropped area of 3.994 m ha, net sown area is 2.828 m ha out of which 1.243 m ha is sown more than once and cropping intensity stands around 148%. The state of Assam has six Agro-climatic zones (ACZ) which cover all together 27 districts. The ACZ along with the districts it comprises are mentioned in Table 1. The constraints of farming in Assam includes :

Flood prone area of Assam ('000ha) : Every year, state is experiencing flood once or twice which damages agricultural crops, animals as well as life and property of human beings. The total flood prone area is 3,41,000 ha out of which 2,50,000 ha is chronically flood prone and the rest is occasionally flood prone.

Ground water quality problem : Though there is tremendous scope for utilization of ground water particularly for agricultural purpose, yet some of the districts are facing some problems because of contaminant like Arsenic, Iron etc.

Soil property and fertility status: Soils are acidic in nature (pH 4.5-5.8) in all the zones except Hills Zone (HZ), where it ranges from acidic to neutral (pH 4.5-7.1) (Table 1). The acidic soils have poor base saturation and low exchange capacity. Acidity is more pronounced in orders: Alfisols, Inceptisols and Ultisols of hilly terrain and undulating uplands. The productivity potentials of these soils are limited. Soils in the riverine or *char* areas under the order – Entisols are by and large, neutral in reaction. The percent of neutral soil ranges from 0.6-21.5% in different districts. It is estimated that moderately acidic and slightly acidic soils occupy nearly 4.9 m ha of land, which accounts for 62.6 % of Total Geographical Area (TGA).

Distribution of upland, medium land, lowland as well as marshy land under different zones of the state excluding the tea garden areas and miscellaneous land (isolated hillocks/tillas) are presented in Table 3.

Soil degradation status: Soil physiographic area on which degradation occurs accounts to 37.8% of the TGA. Among different types of degradation, water erosion and loss of top soil constitute the major part. Stable terrain with little or no human induced soil degradation accounts for 15.9% of TGA.

Deterioration of soil physical condition due to tillage practices and under the import of heavy rainfall creates problem for soil preparation for *rabi* crops in most of the areas of the state. Soil structure degrades which ultimately results surface crusting, decreased water entry, formation of pan in the sub soil.

Nutrient balance : The nutrient removal by various crops has been estimated to the tune of 257, 74 and 268 thousand tonnes of N, P_2O_5 and K_2O annually. The nutrient

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Table 1. Agro-climatic zones and soil characteristics of Assam

Agro-climatic zone	Districts	Soil texture	pH	Organic matter (%)	Available nutrients (kg/ha)		
					N	P_2O_5	K_2O
North Bank Plain Zone (NBPZ)	Dhemaji, Lakhimpur, Sonitpur, Darrang, Chirang and Udalguri	sl-cl	4.5-5.1	0.52-2.2	228-540 (L-M)	10.3-27.7 (L-M)	69.8-209.7 (L-M)
Upper Brahmaputra Valley Zone (UBVZ)	Golaghat, Jorhat, Sibsagar, Dibrugarh and Tinsukia	sl-cl	4.2-5.8	1.5-3.8	243-515 (L-M)	20.5-28.5 (L-M)	115.6-199.7 (L-M)
Central BVZ (CBVZ)	Nagaon and Morigaon	scl-cl	4.9-5.5	0.94-2.5	271-330 (L-M)	26.5-28.4 (M)	104.8-314.5 (L-M)
Lower BVZ (LBVZ)	Kamrup urban, Kamrup rural, Nalbari, Bagsa, Borpeta, Goalpara, Dhubri, Kokrajhar and Bongaigaon	scl-cl	4.8-5.7	0.71-6.3	172-348 (L-M)	17.5-48.5 (L-M)	167.3-297.6 (M)
Hill Zone (HZ)	Karbi Anglong and N.C. Hill	sl-l-cl	4.5-7.1	1.02-2.69	371 (M)	11.3 (L)	67.2 (L)
Barak Valley Zone (BVZ)	Cacher, Hailakandi and Karimganj	sicl-sic	4.9-5.3	2.65-3.15	430 (M)	6.5-56.5 (H)	278-538 (M)

sl: sandy loam; scl: sandy clay loam; sicl: silty clay loam; cl: clay loam; c: clay; sic: silty clay; L: Low; M: medium; H: High

consumption in Assam however, is one of the lowest in the country (Table 3). Nutrient addition is much higher during the *rabi* season than that in the *kharif* season due to the fact that the *rabi* season is relatively risk free period with higher sunshine hours, lesser rainfall and weather aberration and lesser incidence of pests and diseases, resulting in higher crop response to applied nutrients.

Nutrient addition per unit of gross cropped area (GCA) is highest (36.5 kg/ha) in the CBVZ followed by LBVZ (18.1 kg/ha). The highest nutrient addition in CBVZ is due to more area under *rabi* crops viz., vegetables. The least nutrient (1.5 kg/ha) is being added in the Hill Zone of Assam, where shifting cultivation is still prevalent. Nutrient balance (Table 2) shows that all the zones have a negative balance i.e., crop removal being higher than that added.

Fertilizer consumption : Except the Dhubri district (134.27 kg/ha) in all other districts it varies from 1.93 to 80.91 kg/ha.

Rainfed and irrigated area: The district wise net cultivated area, total irrigated area, % irrigated area and rainfed area shows that irrigated area of the state was 15.78%, but practically it is less than 10% because of power shortage and other technological and management problem.

Climatological approach for crop planning: Moisture Availability Index (MAI) may be considered for crop planning at micro-level. The average MAI data from 1975-2006 in four different seasons reveal that winter (December to February) having very low MAI and suggesting artificial irrigation for crop production during these months without which yield of different crops may not be upto the expectation.

The above interpretation is made based on the following classification:

Table 3. Nutrient addition per unit of GCA (kg/ha) and Nutrient balance ('000 t)

Zone	N	P_2O_5	K_2O	Total
UBVZ	7.9	4.1	4.3	16.3
	(37.9)	(9.9)	(47.0)	(94.8)
NBPZ	5.9	2.5	2.9	11.3
	(44.7)	(12.4)	(53.3)	(110.4)
CBVZ	22.2	7.7	6.6	36.5
	(78.3)	(20.6)	(94.5)	(193.4)
LBVZ	9.4	3.8	4.9	18.1
	(24.2)	(5.9)	(42.0)	(72.1)
HZ	0.8	0.4	0.3	1.5
	(15.0)	(4.1)	(17.1)	(36.2)
BVZ	8.9	2.3	6.3	17.5
	(3.7)	(5.8)	(22.6)	(32.1)
Total	55.1	20.8	25.3	101.2
	(203.8)	(58.7)	(276.5)	(539.0)

*Value in parentheses indicate negative nutrient balance

Table 2. Cropped areas (in '000 ha) under different land situations

Zone	Upland	Medium land	Low land	Marshy land
UBVZ	97.2	76.3	71.9	3.5
NBPZ	192.3	399.6	141.5	21.3
LBVZ	297.4	445.7	185.0	44.3
CBVZ	92.5	124.9	135.6	1.8
HZ	137.6	4.1	1.9	2.9
BVZ	145.1	24.5	44.4	20.9

Calculated from Soil Resource Map of NBSS & LUP, NER Centre

MAI range	Category
0.0-0.33	Very deficit
0.34-0.67	Moderately Deficit
0.68-1.00	Normal
1.01-1.33	Adequate
>1.33	Excess

Source: Khanikar (2001) Ph.D. Thesis

Characteristics of farmers of Assam

Around 80% of farmers are cultivating crops under rainfed condition i.e. they are always at the mercy of nature. In Assam, marginal holdings with < 1 ha of land accounted for 62.22% and small holdings with size class between 1-2 ha constitute around 20.91%. As in general farmers are marginal and small so they are not financially sound. Investment capacity is not satisfactory in fact they are doing subsistence level of farming just to sustain their livelihood.

Level of adoption of technology by farmers is not satisfactory as majority of the farmers are rainfed they are mostly resource constraint so the technology adoption and in most cases they prefer to go for traditional way; however, improved varieties of rice is accepted by good number of farmers. Under rainfed condition production is very much influenced by nature so it is difficult to ensure definite income, which causes sometimes failure in repaying the credit to the financial institution. Availability of farm power to the farmers was barely 0.3 hp/ha, which has become one of the inhibiting factors towards increasing area under high intensity cropping system.

Contingency plan for 'aberrant weather' condition

The following suggestions may be considered to mitigate draught as well as flood:

The management options include construction of water harvesting structure like community pond may be structured scientifically in the Government land, water distribution to the beneficiaries through water user association. Ponding in the individual land for rearing of fish as well as for irrigation and plantation of horticultural crops in the bank of the pond in the form of integrated farming system. Ponding should be structured in the area where ground water table fluctuate within 2 metre. If the soil remain fallow during summer in that case summer ploughing help in moisture conservation. Siltation tank in the shallow filter point may be suggested with the use of small size gravel for checking silt and iron deposition and green manuring of the soil for organic matter build up.

The crop management for chronically flood affected or drought affected area included : Planting of aged seedlings of long duration photo-insensitive variety like Monohar Sali, Prafulla and slightly sensitive variety *viz*., Gitesh in the following manner :

Variety	Age of seedling	Expected yield
Gitesh	60 days	3 t/ha from all the varieties under late planted condition
Prafulla	80 days (may go upto 90 days but in that case yield will be reduced)	
Monohar Sali	Upto 30th September these varieties can be transplanted	

Direct seeding under puddle condition of the seeds of short duration rice varieties. In case of shortage of seedlings, double transplanting may be advocated and in that case 4 weeks old seedlings are transplanted in a suitable place, then after another 4 weeks splitting of tillers may be done and transplanted on the target area. Community nursery of long duration, medium duration and short duration varieties may be prepared in a suitable place.

A seed rate (kg/ha) of 50-55, 45 and 35-40 may be used in extra early and early duration variety, medium duration variety and long duration varieties of rice.

In the chronically flood affected area perennial grasses may be grown in the high land and stocking and posting of required seeds in different areas to fulfill the farmer's requirement is needed.

Feeding strategies of livestock in relation to available feed resources:

Forages are cheaper source of nutrients than concentrate feeds. However, the crop residues mainly constitute the major feed material for the animals. This together with tree fodders, weed and pasture grasses provide green forage requirement, so there is a need to find out strategies for the following situation.

Year round forage production: Generally perennial grasses like hybrid-Napier, *Setaria* and guinea gives the higher and assured production throughout the year.

Besides perennial grasses intensive cropping of annual forage through out the year may be pursued. The most feasible cropping sequences are as follows:

Summer	*kharif*	*rabi*
Maize + Cowpea	Maize + Cowpea	Oat + Pea
Maize + Cowpea	Tiosinte + Cowpea	Oat
Teosinte + Cowpea	Teosinte + Cowpea	Oat

Growing of forage crops in the rice – fallow system: Rice–oat; rice–pea/*khesari* (relay) and rice–oat + pea/*khesari* (intercropping) is also advised.

Feeding of animals during flood or drought is a problem so prior planning is a must to feed the animals during that period. Steps should be taken for green forage production involving high yielding perennial forage crops like hybrid Napier and *Seteria* in near by suitable area. Conservation of surplus green forages and crop residue in the form of hay, which can be fed to animal during flood or drought. Selected tree fodder like *Ficus* spp. (fig), Subabul and Jackfruit will provide nutritious green leaf.

Mixing of urea and molasses with rice straw can improve nutritive value of straw. For the purpose of enrichment, the straw should be chaffed and spread in a thin layer. Then urea @ 4kg/100 kg straw is dissolved in 40 litres of water which is then poured and mixed thoroughly in molasses (@ 10 kg/100 kg straw). The urea molasses solution is sprayed or sprinkled on the straw and stirred uniformly. The enriched straw is stored for 28 days, it is exposed to air for 4 days to remove free ammonia, after that treated straw is ready for feeding.

Some promising diversified system:

Some of the findings of All India Co-ordinated Research Project on Cropping System, Assam Agricultural University, Jorhat are mentioned below:

Under rainfed medium land situation of Assam Winter rice-niger, winter rice-wheat, winter rice- *toria*, winter rice- rajmah, winter rice- pea, winter rice- french bean, winter rice- *toria*- green gram and winter rice- *toria*- Autumn rice found to be economically viable (Table 4).

Green gram- *toria*- Lady's finger sequence may suitably be pursued under rainfed upland situation of Jorhat district (Table 5). Improved practices provide better B:C ratio for individual crop as well as a sequence than that of farmers practice (Table 5).

Under rainfed medium land situation of Jorhat, mechanical sowing is found to be economically viable (B:C 3.57) than that of recommended practices (B:C 2.99) with rice- wheat cropping sequence (Table 6).

Incorporation of vegetable crops in the system provides better return under irrigated medium land situation. The sequences Winter rice-tomato-Autumn rice (5.37), Winter rice-brinjal-Autumn rice (3.44), Winter rice-frenchbean-Autumn rice (3.42), Winter rice-rajmah-Autumn rice (3.12) and Winter rice-onion-cow pea (3.06) were found to produce more with better B:C ratio than that of other sequences (Table 7).

Compost + mix culture of *Azotobacter* and *Asozpirillum* + rock phosphate + phosphate solubulizing bacteria (PSB) in Winter rice-potato -lady's finger sequence provide better economic return than that of integrated nutrient management and pure chemical fertilizer use (Table 8).

Inclusion of rice straw at the time of puddling for winter rice can reduce the application of 25% NPK fertilizers of the crop and also reduce the requirement of 25% NPK fertilizers to Autumn rice that follows in Winter rice- Autumn rice sequence; so a total of ¼th of total NPK fertilizers requirement of the system can be curtailed down which also reduces the cost of production of rice (Table 9).

It is concluded that though there are several constraints in Assam like flood and intermittent drought, small land holding size, less farm power availability etc. yet crop diversification and intensification possess a tremendous potentiality if it is backed by use of quality seeds of short duration high yielding improved varieties with the application of balanced fertilizer level, enhancing irrigation facilities, mechanization of agriculture, suitable marketing, proper storage facility and agro-based industry and availability of inputs in proper time and place. The acidity of soil can be countered by the application of liming material like dolomite. Infact, presently agriculture in Assam is at subsistence level because of poor resource availability of the farmers. Hence, there is also need to improve upon the role of financial institution, implementing crop insurance programme with true letter and spirit, improving education

Table 4. System productivity and economics (x10^3 Rs/ha) of rice based cropping systems.

Treatment	REY* (t/ha)	Gross return	Total variable cost	Return over variable cost	B:C ratio
Winter rice-niger	6.21	40.38	12.82	27.56	3.15
Winter rice-wheat	4.22	27.43	18.33	9.10	1.50
Winter rice-*toria*	4.74	30.82	13.72	17.10	2.25
Winter rice-rajmah	7.16	46.53	16.79	29.75	2.77
Winter rice-pea	4.70	30.53	14.40	16.13	2.12
Winter rice- french bean	7.60	49.37	17.87	31.50	2.76
Winter rice- *toria*- green gram	14.50	94.19	17.63	76.56	5.34
Winter rice- *toria*- Autumn rice	9.56	62.11	26.48	35.63	2.35

*REY: Rice Equivalent Yield

Table 5. Mean grain yield (kg/ha), and economics (x10^3 Rs/ha) of different crops Greengram-*toria*-lady's finger system

Crop/ Sequence	Yield		Gross return		Variable cost		Net return		B:C ratio	
	FP	IP	FP	IP	FP	IP	FP	IP	FP	IP
Green gram	598	764	20.930	26.74	6.56	8.12	14.57	18.62	3.19	3.29
Toria	515	712	10.300	14.24	7.58	8.95	27.20	5.29	1.36	1.59
Lady's finger	6,224	7,876	37.344	47.26	10.14	11.36	27.21	35.90	3.68	4.16
Green gram	598	764								
Toria	515	712	68.574	88.24	24.28	28.42	44.23	59.81	2.82	3.07
Lady's finger	6,224	7,876								

FP= Farmer's Practice, IP= Improved Practice

Table 6. Effect of various practices on productivity (t/ha) of winter rice - wheat and their economics (x 10^3 Rs/ha) under rainfed condition

Treatments	Productivity		REY (t/ha) of sequence	Gross return	Total variable cost	Net return	B:C ratio
	Rice	Wheat					
Farmer's Practice	5.15	1.39	6.74	43.82	21.19	22.62	2.07
Recommended package of practices	7.03	2.46	10.14	65.88	22.06	43.82	2.99
T_1	6.90	2.15	9.63	62.60	17.82	44.77	3.51
CD (P=0.05)	0.33	0.35					

T_1 : Sowing of seed by Drum seeder in case of winter rice and zero tillage seed cum fertilizer drill in case of wheat.

Table. 7. Comparison of different rice sequences based on rice equivalent yield, REY (t/ha) and their economics (x 10^3 Rs/ha)

Treatment	REY (t/ha)	Gross return	Total Variable Cost	Return Over Variable Cost	B:C ratio
Winter rice-autumn rice	6.24	40.58	21.20	19.38	1.91
Winter rice-toria	5.54	36.10	19.30	19.80	2.21
Winter rice-autumn rice- summer rice	8.77	56.98	32.92	24.06	1.73
Winter rice-tomato- autumn rice	26.48	158.85	29.60	129.25	5.37
Winter rice-brinjal- autumn rice	19.48	116.87	33.95	82.93	3.44
Winter rice- french bean- autumn rice	12.70	76.21	22.27	53.94	3.42
Winter rice- rajmah- autumn rice	11.53	74.96	24.02	50.94	3.12
Winter rice- onion- cowpea	12.17	79.13	25.83	53.30	3.06
Winter rice-toria- autumn rice	8.93	58.07	21.63	36.44	2.69
Winter rice- oat- green gram	8.13	52.89	20.29	32.60	2.61
Winter rice- pea- autumn rice	8.54	55.49	21.78	33.71	2.55
Winter rice- toria- black gram	7.86	51.08	22.10	28.99	2.31
Winter rice- potato- autumn rice	14.04	91.27	49.45	45.81	2.01
Winter rice-lentil- autumn rice	7.29	47.41	24.86	22.55	1.91
Winter rice- wheat- dhaincha	5.07	32.40	23.68	87.15	1.37

Table 8. Economic (x 10^3 Rs/ha) comparison of different treatments

Treatment	REY (t/ha)	Gross return	Total variable cost	Return over variable cost	B:C ratio
T_1	8.92	66.91	30.98	35.93	2.16
T_2	7.01	52.56	13.81	32.83	2.65
T_3	6.86	51.42	32.67	18.74	1.57

T_1 : 50% N as urea+ 50% N as compost (+ recommended P anf K) + Inorganic sources of micronutrients as per soil test value;T_2 : ½ N as Compost + Mix culture of *Azotobacter* and *Azospirillum* + recommended level of P as Rock phosphate + PSB; T_3 : Recommended level of NPK fertilizer + Secondary and micro-nutrient as per soil test value

level of farmers, providing better transport and communication networks and connecting Assam through alternative route by surface, water and air which looks to be pre-requisite to provide agriculture a commercial status in the state.

The policy makers, planners and researchers for development of agricultural sector in the state should take steps to : (i) Consolidation of fragmented land holding with cooperative system; (ii) Afforestation in the hills of Assam and neighbouring state to stop siltation of Brahmaputra and its tributaries and consideration of desiltation programme of these rivers along with formation of micro-watershed may be considered. All these may yield a good effect in re-

Table 9. Productivity and economics (x10^3 Rs/ha) of different nutrition treatmentsin winter-autumn rice.

Winter-autumn rice fertilizer	Grain yield (t/ha)	Straw yield (t/ha)	Gross return	Total variable cost	Return over variable cost	Benefit cost ratio	Cost of production (x 10^3Rs/t)
33.75 - 22.5 - 30 kg NPK/ha+1.24 t rice straw							
33.75-22.5-30 kg NPK/ha	7.53	10.78	51.07	20.45	30.61	2.50	2.718
100% RDF (45-30-40 kg NPK) to both crops	6.88	10.30	46.69	21.58	25.18	2.16	3.130
Farmers practice: (11.25 kgN-11.25 kg N+1t FYM)	4.50	6.49	30.55	18.66	11.89	1.64	4.147

ducing flood havoc in Assam; (iii) Refinement of land tenure system; (v) Expansion of irrigation facilities; (iv) Purification of water from excess iron, arsenic etc.; (vi) Value addition of agricultural products and utilization of by-products; (vii) Strengthening of input supply system for availability of quality inputs in proper time and place; (viii) Rain water harvesting on community basis and distribution through water users association; (ix) Formation of small holder estates for location specific profitable commodities; (x) Decreasing grazing land causes poor animal health for which fodder crops may be considered as part of the cropping system or plantation of perennial fodder in the homestead; (xi) Awareness of rigorous standards of cultivation required for organic products, certification standards, certification procedures etc.; and (xii) Group certification or individual certification cost needs to be subsidized or borne by the Govt. initially for the production of organic produce with proper Markey support system; (xiii) Establishment of market–risk–stabilization fund jointly by central and state government, and other financial institutions to protect farmers during period of violent fluctuation of prices; and (xiv) Agricultural Insurance Policy needs to be implemented in true letter and spirit; may also look in to the possibility of covering health of the farmer.

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