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STRATEGIES TO MAXIMIZE WATER PRODUCTIVITY IN NORTH EASTERN REGION WITH SPECIAL REFERENCE TO ASSAM

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North Eastern Region (NER) of India comprising eight states- Assam, Arunachal Pradesh, Meghalaya, Manipur, Mizoram, Nagaland, Tripura and Sikkim has a total geographical area of 262.18 lakh hectare (l.ha) out of which the net sown area is about 39.0 l.ha. NER can be broadly divided into four physiographical units – (i) Plateau, (ii) Hill slope, (iii) Foot hills and (iv) Valley. Barring Assam Plain and a small area in Imphal Valley in Manipur , the topography is highly undulating with moderate to steep slope. The climate of the region is mostly subtropical warm humid , though tropical and temperate nature of climate is also prevalent. The average annual rainfall of the region is 1500 – 2900 mm which in terms of quantity, is sufficient to grow any crop. However, most of the rain (about 80%) is received during monsoon period i.e. June to September causing frequent flood specially in many areas of Assam. The cropping intensity of NER is quite low *i.e* 115.7% against the cropping intensity of 142% of Assam and 139% of the country as a whole. Being situated in sub-tropical zone, Assam is characterized by hot and wet summer and dry and cool winter. The average annual rainfall varies from 1500 mm to 3100 mm and the Potential Evapo Transpiration (PET) is less than the precipitation for greater parts of the year which is 995 mm – 1722 mm in the Brahmaputra Valley and 1186 mm in the Barak Valley.

NER is endowed with vast natural resources *viz* land and water with inherent fertile soil . Two important river basins of the region are Brahmaputra and Barak and the annual surface water resources available in these basin are estimated at 58.5 m ha – m. Besides, the region specially Assam has an extensive net work of tributaries, streams and lakes from which water can be lifted for irrigation by appropriate water lifting devices. However, the area under assured irrigation in Assam is only about 20 percent of the net cropped area while the total irrigation potential created is 10.48 l.ha , which is about 37 percent of the net cropped area. The annual replenishable and available ground water for NER are 33.91 and 30.98 BCM/yr respectively, while for Assam, the corresponding figures are 27.23 BCM/yr and 24.89 BCM/yr respectively.

Agriculture being the main consumer of water, the implied increase in food demand to feed the growing population will increase the pressure on the water resources. In India, per capita water availability is continuously declining from 5176 m^3 in 1951 to 1703.6 m^3 in 2005.The only option for addressing the water scarcity and attaining the food self sufficiency is to increase the water productivity and for this certain clear cut management strategies may be adopted .

MANAGEMENT PRACTICES FOR INCREASING WATER PRODUCTIVITY:

Higher water productivity can only be achieved by reducing water loses at any stage of the production system and maximizing yield with minimum water. The traditional practice of continuous submergence of rice field results in wastage of water without increasing crop yield and thereby decreasing water productivity. Research works in recent times have shown that application of 5 cm depth of irrigation 3 days after disappearance of ponded water is optimum for rice (Table -1). Operational research conducted at farmers' fields has also confirmed

Table 1 : Effect of irrigation regimes on grain yield of different categories ofrice.

Irrigation regimes	Mean yield (q/ha)		
	* Direct seeded autumn rice	* Transplanted autumn rice	* * Hybrid rice
5 cm 1 DADPW	16.77	-	43.57
5 cm 3 DADPW	16.39	28.02	43.94
5 cm 5 DADPW	-	21.47	-
7 cm 3 DADPW	-	25.68	-
7 cm 5 DADPW	-	24.82	-
Continuous submergence	-	-	44.42
Rainfed	12.30	-	-

* Mean of 3 years
** Mean of 2 years

this. Under Farmer's Participatory Action Research Programme (FPARP), it has been found that total water requirement for rice with farmer's practice *i.e.* continuous shallow submergence is 1950 mm against 950 mm under improved practice for summer rice while in case of autumn rice, water requirement is 1270 mm with farmers' practice against 670 mm with improved practice (Table 2). The water use efficiency under improved practice could be increased to 70.70 kg/ha-cm with improved practice against the 29.58 kg/ha-cm with farmer's practice in case of summer (*boro*) rice. For autumn rice, water use efficiency under improved practice is 69.22 kg/ha-cm and under farmer's practice is 34.60 kg/ha-cm. The water saving over farmer's practice is 63.30 per cent for summer rice and 60.00 per cent for autumn rice.

Table 2 : Total water use, water use efficiency, water saving of summer (*boro*) rice and autumn rice(ahu) under FPARP .

Crop	Total water used (mm)		Water Use Efficiency (kg/ha-cm)		Water saving ove Farmers' Practice (%)
	Improved practice	Farmers' practice	Improved practice	Farmers' practice	
Summer (*boro*) rice	950	1950	70.70	29.58	63.30
Autumn(*ahu*) rice	670	1270	69.22	34.80	60.00

Likewise for vegetable crops *viz* brinjal, tomato and chilli, about 24 – 41 per cent (Table -3) of water can be saved with improved irrigation practice against the farmer's practice as the farmers often over irrigate these crops, if irrigation water is available. The opportunities to improve water productivity are found in adoption of water management practices like proper scheduling, proper selection of methods of irrigation for specific crops and varieties and also the appropriate depth of irrigation. Drip and Sprinkler irrigation methods are suitable in undulating topography and wide spaced crops with potential to increase irrigation water use efficiency by 90 - 95 percent against the conventional method of irrigation. Bamboo drip irrigation can be made popular utilizing locally available bamboo particularly in the hilly areas

Table 3 : Crop yield, irrigation water use, water use efficiency, yield increase and saving of water of brinjal, tomato and chilli under STW command

Treatments	Crop					
	Brinjal		Tomato		Chilli	
	IP	FP	IP	FP	IP	FP
Crop yield (q/ha)	225.5	283.7	371.4	441.5	28.3	36.1
Total irrigation water use (mm)	270.0	200.0	270.0	160.0	210.0	160.0
Water use efficiency (kg/ha – cm)	835.0	1418.0	1376.0	275.9	134.9	225.6
% increase in yield	-	25.8	-	18.9	-	27.4
% Saving of water	-	26.0	-	41.0	-	24.0

FP : Farmers' Practice
IP : Improved Practice

To improve water productivity, the crop management practices other than water management *viz* choice of crops, variety, fertility management, pest and weed management, timely intercultural operations and crop diversification are also equally important. Selection of low water demanding crops and high value crops may increase water productivity.

Adoption of suitable location specific cropping systems may also play a vital role. Research works have revealed that under irrigated medium land situation, highest system productivity was obtained from the cropping sequence 'winter rice (WR) – onion -cowpea (recording Rs.53,298.00/ha/yr)' which was followed by 'WR - oat - green gram (Rs.32,603/ha/yr)' , fb 'WR- toria - black gram(Rs.28,986/ha/yr)' (Table 4).

Table 4 : Gross return, variable cost, return over variable cost, system productivity and B:C ratio of different sequences under irrigated medium land situation

Cropping sequence	(in Rs/ha/yr)			System productivity (kg/ha/day)	B:C Ratio
	Gross return	Variable cost	Return ove variable cost		
Winter rice- Autumn	40584	21202	19382	17	1.91
Winter -toria	36101	17301	19800	15	2.09
Winter rice-summer rice Autumn rice	56979	32917	24062	24	1.73
Winter rice – lentil Autumn rice	47411	24861	22550	20	1.91
Winter rice – toria –blac gram	51083	22097	28986	22	2.31
Winter rice- oat- gree gram	52889	20286	32603	22	2.61
Winter rice –onion – cov pea (F)	79132	25834	53298	38	3.06
Winter rice-wheat Dhaincha	32398	23863	8715	14	1.37

Strategies for rainfed agriculture.Since almost 90% of the cropped areas of the NER is rainfed and there is sufficient rainfall, the key opportunities for increasing crop yield and water productivity lie on scientific land husbandry, rain water conservation and utilization of zero and minimum tillage, mulching and INM for fertility management. Summer ploughing after the harvest of winter rice may enhance infiltration of rain water by reducing the surface runoff. Sowing of most of the *rab*i crops like potato, rapeseed and mustard, lentil, pea etc.

should be performed as early as possible utilizing the residual soil moisture which will ensure proper germination and growth of the crops.

Water productivity gains could be achieved by rain water harvesting. In Meghalaya , tapping of spring water through bamboo pipes to irrigate plantation crops is widely prevalent in which about 18-20 litres of water entering the bamboo pipe system per minute is transported over several hundred metres. In the plains and valleys, the traditional practice of digging small ponds in low lying rice land could serve farmers for water harvesting and recycling during lean period in addition to fish farming and thereby increase the water productivity in low land situation.

Direct sowing of short duration early *ahu* rice varieties like Luit, Disang, Dikhow and Kalang developed by Assam Agricultural University, Jorhat along with the some popular local varieties like Banglami, Koimurali, Rangadoria in Mid February will enable the farmers to harvest the crops safely before flood and will avoid need for irrigation specially in low lying areas.

In rainfed medium rice land, bund height of about 20-25 cm was found optimum for enhancing water productivity through *in situ* conservation of rain water. On low marshy land situation, alternate raised and sunken bed system of cultivation may be adopted by growing vegetables in the raised beds and aquatic crops in the sunken beds.

In hilly tracts of NER, construction *Jal Kund* with storage capacity of 175 mm water i.e. 1750 m^3 for 1 ha command area has been found successful to conserve rain water to meet the irrigation demand of post monsoon crops. In the plains, a farm pond of 100 sq.m. surface area with 2.5. m depth, a wheat crop of 0.5 ha may be sufficient to store rain water for subsequent minimal irrigation to *rabi* crops.
On medium rainfed lands of Assam, the cropping systems *viz* Winter rice- toria/rajmah/pea/French bean/niger or Winter rice – toria – green gram may be suitably adopted (Table 5).

Table 5 : Gross return, variable cost, return over variable cost and B:C ratio of different cropping sequences under medium rainfed land situation

Cropping sequences	(In Rs./ha/yr)			B:C Ratio
	Gross return	Total variable cost	Return over variable cost	
Winter rice - niger	40380	12820	27560	3.75
Winter rice – toria	30820	13720	17100	2.25
Winter rice – Rajmah	46530	16790	29750	2.77
Winter rice - pea	30530	14400	16130	2.12
Winter rice – French bean	49370	17870	31500	2.76
Winter rice – toria – green gram	94190	17630	76560	5.34

In recent times, a number of HYVs of rice *viz* Ranjit, Bahadur, Maniram, Piyali, Kushal for medium – lowland situation, Satyaranjan and Basundhara for medium upland situation; Lachit, Chilarai, Luit, Disang, Kalang and Dikhow as autumn rice and Kanaklata, Jaymati, Bishnu Prasad, Jyoti Prasad, Dinanath and Swarnabh as summer rice have been found to give high yield in plain areas. Similarly in hilly areas , Inglongkiri, Maizu Bairan may be grown as winter rice. To enhance water productivity in deep water rice situation, high yielding varieties like Padmanath and Panindra are being developed. With these varieties, water productivity of deep water rice can be improved.

Integrated farming of rice-fish culture in medium to low land flood free situation with construction of low height dikes(12.5 cm) has been found to be successful for enhancing water productivity.

Adoption of integrated farming system including crops, animal husbandry, fishery, forestry, sericulture etc. will enhance water productivity. It seems to be the most viable option for sustainable food production and income generation of the small farmers with limited resources.

In conclusion, it may be stated that equitable and sustainable management of water resources in the NER, a holistic approach of Integrated Water Resource Management(IWRM) is required, which may be based on hydrological variations in time and space. Watershed management approach may be a workable and efficient strategy for sustainable utilization and development of land and water resources of the region. However, mass awareness regarding the scientific use of the natural resources among the farmers and their active participation in the programmes like on farm trial, demonstration and production is very much essential.