POLICY PAPER 60

Water Use Potential of Flood-affected and Drought-prone Areas of Eastern India

NAAS

NATIONAL ACADEMY OF AGRICULTURAL SCIENCES, NEW DELHI
September 2013

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CITATION : NAAS 2013. Water Use Potential of Flood-affected and Drought-prone Areas of Eastern India. Policy Paper No. 60, National Academy of Agricultural Sciences, New Delhi. 20 p.

Published by Mr H.C. Pathak, Executive Secretary on behalf of
NATIONAL ACADEMY OF AGRICULTURAL SCIENCES
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Preface

The Eastern Region of India is characterized by a paradoxical situation of rich natural resources and cultural heritage on the one hand and poor productivity and low income on the other. The Region is thickly inhabited by resource poor people with small land-human ratio. It has abundant both surface and groundwater resources, however, flood proneness and water logging as well as drought hit the lives and livelihoods of people in myriad ways. Sustainable development and efficient utilization of natural resources should therefore be the highest priority for agricultural development in the Region.

The small and scattered land holdings, very little groundwater utilization and the lack of infrastructure, particularly energy and credit facilities, poor extension mechanism, unavailability of quality seed and planting material, imbalanced use of fertilizer are some of the major constraints preventing enhanced crop production in the Region. These challenge research as well as development functionaries at various levels to capitalize the opportunity of bridging wide productivity gaps by adopting location specific technological interventions and enabling policies for sustained optimum use of the land and water resources in the Region.

A substantial area in the Eastern Region is categorised as water congested or waterlogged where water remains stagnated for a long period. A large portion of the canal commands or lowlands gets seasonally waterlogged and remains poorly utilised. Multiple water uses in waterlogged areas, integrating fish in rice-wheat system, offers vast opportunities for effective utilization of such lands as well as improving the rural livelihood. With increasing competition for available scarce water resources among different sectors, the major challenge of the agriculture sector is to improve water productivity. Likewise, agroforestry, horticulture, apiculture, lac cultivation and integrated farming systems need to be developed and replicated to reduce competition for shrinking water resources, to mitigate environmental degradation and to enhance food security.

In order to critically analyze the water use potential of flood affected and drought prone areas in the Region, the National Academy of Agricultural Sciences organized a brainstorming session to deliberate different issues pertaining to improving water productivity, suitable technologies, and water use potential of flood and drought prone areas on 14th May, 2012 at ICAR Research Complex for Eastern Region, Patna. Over 60 experts participated in the meeting. I would like to express my sincere gratitude to Dr. Peter Kenmore, FAO Representative, Dr. S.A.H. Abidi, Ex. Member, ASRB, Directors of various ICAR Institutes in the Region, officials of Agriculture Department of Bihar Govt. and scientists of ICAR Research Complex for Eastern Region for their participation and deliberations. My most grateful thanks are due to Dr. B.P. Bhatt, Director of the Research Complex for admirably convening the session. Thanks are also due to reviewers and the Editors of this policy paper.

(R.B. Singh)
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Water Use Potential of Flood-affected and Drought-prone Areas of Eastern India

1. INTRODUCTION

Indian agriculture is heavily dependent on the monsoon as a source of water, the failure of which causes water shortage and below-average crop yields. This is particularly true for major drought-prone regions such as southern and eastern Maharashtra, northern Karnataka, Andhra Pradesh, Odisha, Gujarat, southern Bihar, Madhya Pradesh, Chhattisgarh and Rajasthan. Droughts have periodically led to major Indian famines in the past. Similarly, floods are the most common natural disasters in India. The heavy southwest monsoon causes all the rivers to overflow their banks, often flooding surrounding areas. Excessive, erratic, or untimely monsoon rainfall may also wash away the fertile soils including other resources or otherwise ruin crops. In India, about 49.81 million ha (M ha) area has been reported to be flood-prone and on an average, 10-12 M ha is affected every year. Coinciding with rising temperatures, a large part of India is prone to extreme precipitation events causing torrential rains and flash floods. This phenomenon has become increasingly common in eastern and central India over the past several decades.

The Eastern Region, comprising of Assam, Bihar, Chhattisgarh, Eastern Uttar Pradesh, Jharkhand, Odisha and West Bengal, occupies about 21.85 per cent of the national geographical area and supports 34 per cent of human and 31 per cent of livestock population of India. Of the total geographical area of 71.84 M ha in the Region, the net sown area is 31.40 M ha with a cropping intensity of 150 per cent [3]. The major soil types are alluvial, followed by red soils. The region has about 2.73 M ha total area under water constituting reservoirs, ponds, tanks and beels, oxbow lakes, brackish water, etc. besides 15046 km length of rivers and canals. Agriculture is the mainstay of economy in Eastern States since 83 per cent population living in rural areas depends on it for their subsistence. However, high population density (604 persons/sq km compared to 382 persons/sq km at national level), about 116 million BPL (Below Poverty Line) population, the lowest per capita income (Rs. 15,268/- to 34,229/- per annum against the national average of Rs. 38,005/-), and maximum number of economically most backward districts (69 out of 150 at national level) have put tremendous pressure on natural resources. Further, the production levels of agriculture, livestock and fisheries have remained low mainly due to the lack of location-specific production technologies and dissemination of scientific methods of cultivation, frequent natural calamities like floods, water-logging and drought, and social constraints. Farmers mostly depend on unpredictable monsoon for crop production and owing to poor utilization of water resources the cropping intensity is low, particularly in rainfed upland ecosystems. Since water is one of the major resources for agricultural development, deliberation on water use potential of flood-affected and drought-prone areas of eastern India is essentially required.

2. RATIONALE

The past decade has seen growing recognition of the crisis facing the world's water resources and the need for concerted action to use the available water resources more efficiently. The efficiency of water use (or water productivity) can be increased by producing more output per unit of water used or by reducing water losses, or by a combination of both. A number of options exist for improving the agricultural water productivity through breeding, better management practices and supporting policies and institutions. Producing more crops, livestock, fish and forest products per unit of water used holds the key to both food security and environmental conservation. So far, strategies for increasing water use efficiencies have been limited to increasing crop yield using better water management practices and reducing losses through better irrigation technology and irrigation water management options.

The multiple uses of water, *i.e.*, using the available water sources for more than one use/production system, however, provides opportunity to produce diversified commodities with less water. Water productivity can be increased by integrating fish and other living aquatic resources with existing crops, horticulture and livestock production systems [7, 13]. In Eastern States of India, immense possibilities exist for multiple uses of water. So far, livestock has been considered as a primary producer in Eastern region of India. Its synergistic role in farming systems is yet to be realized since livestock production is an integral part of agriculture and contributes substantially to household nutritional security and poverty alleviation. A vast population of livestock (164.95 million) and birds (176.23 million) thrives in the region and the livestock wastes could be recycled for agricultural production including integrated fish farming [2, 8]. Fish-pig, fish-duck, fish-chicken, fish-cattle and fish-goat are some of the integrations which enhance fish production by 3 to 4-folds compared to fish farming without integration [4, 13]. Other possible integrations could be fish-buffalo since Eastern region has high population of buffalo, particularly in Eastern Uttar Pradesh and parts of Bihar. However, very few systematic studies have been conducted to understand, analyse and enhance productivity of irrigated, rainfed and water logged/floodplain areas through integrated farming system approach [1, 13]. Need of the hour is therefore, standardization of area specific technologies keeping in view the farmers' needs and socio-economic conditions [4].

About 10 M ha area in Eastern region is reported to be affected due to drought. Crop diversification, however, could minimize the risk of drought. Further, horticulture and plantation crops are helpful in minimizing the risk of drought or drought like situations. Restoration of degraded lands through agri-horticulture and other agroforestry interventions is also need of the hour in drought-prone areas. Harvesting and management of rain water following integrated watershed management approach is also the best strategy to capitalise the water potential in rainfed and drought affected areas [3]. Rice fallows, which are predominant in the region, provide another challenging opportunity to exploit their potential. In Eastern region, about 11 M ha of land is mono-cropped with rice, and remain fallow after harvest. A second crop of oilseeds, pulses, vegetables and fodder crops can be raised through effective utilization of residual moisture and appropriate rainwater management/conservation technologies in rice fallow areas.

3. STATUS OF WATER RESOURCES

Although, average annual rainfall in India is slightly higher (~1200 mm) than the world average (~1000 mm), its distribution is temporally and spatially uneven. Entire rainfall in India occurs with fewer rainy days within a time span of few days, in fact within about 300 hrs. The average rainfall in Eastern region varies from 1091 to 2477 mm with a regional average of 1526 mm, which is sufficient and substantial for growing a variety of crops. On an average, Assam receives a mean annual rainfall of 2477 mm which is the highest in the region, followed by West Bengal (1750 mm), Odisha (1451 mm), Chhattisgarh (1430 mm), Jharkhand (1277 mm), Bihar (1204 mm) and Eastern Uttar Pradesh (1091 mm). However, it has erratic annual and spatial distribution with considerable year-to-year variation [3].

The region constitutes about 18 per cent of country's utilizable water resources (10 per cent of surface water and 30 per cent of groundwater). The major river basins of the Eastern region are Ganga-Brahmaputra-Barak, Subarnarekha, Brahmani-Baitarni, and Mahanadi. The average annual potential and utilizable surface water resources from the five river basins have been estimated to be 1218.4 and 349.1 km^3, respectively. The annual per capita availability indices of surface water in Mahanadi, Brahmani-Baitarni, and Subarnarekha basin are estimated as 2067, 2388, and 1982 m^3, respectively. The net annual groundwater availability and annual ground water draft in the region are estimated as 140.5 and 54.4 BCM (Billion Cubic Meter), respectively (Table 1). The stage of ground water development in the region is only 37 per cent as against 61 per cent at the national level. The UIP (Ultimate Irrigation Potential) for the region has been assessed to be 33.65 M ha as compared to 139.89 M ha for the country. However, utilization of the created irrigation potential is only 65.5 per cent in Eastern States compared to 74.0 per cent at national level.

Table 1. Groundwater (BCM) utilization in Eastern States.

State	Annual replenishable ground water	Annual ground water availability	Annual ground water draft	Utilization (%)
Assam	30.35	27.81	6.03	22
Bihar	28.63	26.21	11.36	43
Chhattisgarh	12.22	11.58	3.59	31
Eastern Uttar Pradesh	27.64	25.23	16.55	66
Jharkhand	5.96	5.41	1.61	30
Odisha	17.78	16.69	4.36	26
West Bengal	30.50	27.58	10.91	40
India	431.03	396.06	243.31	61

Source: Central Ground Water Board [6]

Water productivity is also very low in Eastern States (0.37 kg/m^3 of water) compared to Punjab (1.01 kg/m^3) and other parts of India. Water productivity ranges from 0.21 to 0.29 kg/m^3 in most of the Eastern States except Bihar, Eastern Uttar Pradesh and West Bengal [16]. This low water productivity in the Eastern States could be attributed to low yield as well as poor on-farm water management practices. However, with various technological interventions, the water productivity in Eastern region could be improved considerably as evident from the data shown in Table 2.

Table 2. Water productivity through technological interventions.

Crop sequence/crop	Water productivity (Kg/m^3 of water)	Water productivity (Rs./m^3 of water)
Betelvine	1.9	155.8
Bitter gourd	6.8	19.3

contd...

Cauliflower	2.2	21.7
Chilli	2.7	107.5
Cucumber	17.2	85.8
Okra	3.2	16.3
Rice-cabbage-cow pea	1.8	17.8
Rice-potato-onion	1.4-1.7	15.7-17.2
Rice-wheat-green gram	0.8-1.2	11.8-12.1

Source: Bhatt *et al.* [5], Khan *et al.* [9], Singh *et al.* [19]

Eastern States also have a total of 4.05 M ha area under wetlands. West Bengal, followed by Assam have comparatively higher wetland area than rest of the States. Efforts are, therefore, required to rehabilitate such areas for agricultural production besides expansion of fishery, Makhana and water chestnut cultivation (Table 3).

Table 3. Wetland area in the Eastern States.

State	Geographical area (M ha)	Total area under wetland (M ha)	Per cent area under wetland
Assam	7.844	0.752	9.59
Bihar	9.416	0.403	4.28
Chhattisgarh	13.519	0.338	2.50
Eastern Uttar Pradesh	8.644	0.586	6.78
Jharkhand	7.972	0.170	2.13
Odisha	15.571	0.691	4.44
West Bengal	8.875	1.108	12.48
Total	71.84	4.048	5.63
India	328.73	15.26	4.60

Source: Space Application Centre [17]

4. WATER USE POTENTIAL IN DROUGHT-PRONE AREAS

Shortage of rainfall coupled with its erratic distribution causes severe water deficit conditions. Twenty districts are known to suffer droughts quite frequently (Table 4). It results in droughts of varying intensities, affecting different human activities and leading to problems like widespread crop failure, un-replenished ground water resources, depletion in lakes / reservoirs, shortage of drinking water, reduced fodder availability etc.

Table 4. Administrative districts chronically affected by droughts.

State	Districts
Bihar	Munger, Nawadah, Rohtas, Bhojpur, Aurangabad, Gaya, Lakhisarai, Jamuai
Chhattisgarh	Khargaon
Eastern Uttar Pradesh	Allahabad, Mirzapur, Varanasi
Jharkhand	Palamau
Odisha	Phulbani, Kalahandi, Bolangir, Kendrapada
West Bengal	Bankura, Midnapore, Purulia

Source: Ministry of Agriculture [12]

Generally, drought results in crop losses of different magnitudes depending on their geographic incidence, intensity and duration. Impact of drought could also be felt as deficit in ground water recharge, non-availability of quality seeds, reduced drought power for agricultural operations due to distress sale of cattle, land degradation, fall in investment capacity of farmers, erratic supply of electricity and costly alternatives. However, impact of drought can be minimized through the development of better water management techniques and efficient water use *viz*. drought proofing through participatory watershed development for vulnerability reduction, best practices for rain water and soil management through linking on-station and on-farm research, weather forecasts, development of early warning and expert systems, contingency crop planning or mid-season corrections, promoting alternate water use efficient cropping systems, water harvesting, *in-situ* conservation of water for maintaining soil moisture and green cover etc. In the drought-prone areas, emphasis could be placed on cultivation of high value and low water requiring crops such as pulses and oilseeds. Rain water harvesting, watershed development and effective and efficient utilization of harvested rain water using micro-irrigation system can help to enhance productivity and income considerably. Water use potential in drought-prone areas is discussed below:

4.1 CROP MANAGEMENT

4.1.1 Rice-based cropping system

The eastern Indo Gangetic plains, has over 20 M ha of rainfed rice area. Drought losses are most severe in the rice bowl States like Chhattisgarh, Madhya Pradesh, Bihar, Jharkhand, Odisha and Uttar Pradesh. Appropriate drought tolerant rice varieties of medium duration like Shahbagi, Vandana, Anjali, CR-Dhan or short duration varieties like Prabhat, Dhanalakshmi and Richaria can be grown in upland areas, where drought is a frequent phenomenon. However, adequate moisture availability needs to be ensured in rice fields for proper panicle exertion and effective filling of grains. There is also a need to popularise SRI (System of Rice Intensification) or DRS (Direct Seeded Rice) along with laser land levelling from water economy point of view. Construction of pond at downstream side of slope can augment water supply during lean period. In case there is no rainfall, ground water need to be used to supplement deficit in rainfall. The other step required is raising bund height to 20-25 cm around rice fields so as to arrest rainwater and utilize in crop production [5, 15]. Conjunctive use of different sources of water should also be followed. Due consideration should be given to promotion of stress-tolerant rice varieties and their management practices. Adoption of deficit irrigation strategies such as irrigation at most critical crop growth stages, low depth at frequent interval, and use of need based and cost effective water saving measures can be followed for efficient use of available water [9].

Pre-*rabi* crops such as *toria* (*Brassica rapa*), pigeon pea varieties Basant, Bahar and Sharada, early potato and cauliflower can be sown during the first week of September in the areas where there is no chance of excess moisture. *Toria* and early potato could be harvested by the end of November to mid-December facilitating cultivation of late sown wheat after these crops. In *Rabi* crop, efficient use of soil moisture is possible through adoption of Zero Tillage in wheat, rapeseed, mustard, lentil and gram. It will save the input cost and result in higher yield.

4.1.2 Crop diversification

Crop diversification by adopting cultivation of maize, groundnut-pigeon pea, sole pigeon pea, black gram, horse gram, green gram, cow pea, and oil seed crops like rapeseed, mustard, niger, sesame, soybean, and safflower can be introduced in rainfed upland conditions. Sorghum, pearl millet, cluster bean (guar), finger millet, barnyard millet, and foxtail millet could also be grown in drought prone areas for grain and fodder production [9]. Govt. of India has also focused on crop diversification in rainfed upland ecosystem of Eastern States under Food Security Mission programme. Out of 181 districts of the region, 158 districts have been identified for pulse production. Average pulse productivity is also higher in Eastern States compared to national average.

There is also a need to introduce various agroforestry systems (AFS) for diversification and risk cover in the area. Cashew cultivation is also suitable for drought prone and coastal areas of Eastern states. In Hill and Plateau regions, agrisilviculture, agropastoral, silvipastoral, agrihorticulture and agrihortisilvipastoral AFS could be adopted for rehabilitation of the degraded / wastelands so as to augment biomass for fuel, fodder, and small timber. The region has 6.16 M ha area under wastelands / degraded lands and it need to be restored through various agroforestry interventions. Lac cultivation should also be sustained for livelihood improvement, particularly in drought-prone areas of Chhattisgarh, Jharkhand and Odisha. The fodder crops like MP Chari, hybrid Napier, maize, Congo, guinea, cowpea and rice bean etc. could be grown during rainy season to sustain livestock and thereby the economy of resource-poor stakeholders [5].

Multi-tier horticulture is another suitable venture for drought-prone areas. Fruit trees with large canopy (mango, litchi, jackfruit, aonla etc.) could be planted at a spacing of 10 x 10 m as main crop, and those with dwarf canopy (guava, custard apple, peach, lime, lemon etc.) at a distance of 5 x 5 m between rows and between plants in the same field as filler crop. During initial phase of establishment of multi-tier system, the interspace could be used to cultivate vegetables and pulses. Once the canopy attains the full height, shade loving crops like turmeric, ginger, and elephant food yam could be cultivated. Black pepper and betel vine can also be grown in such system. The productivity level of 12 to 15 t/ha rice equivalent yield could be obtained in this system compared to 4 t/ha in orchard alone [5].

4.2 ANIMAL HUSBANDRY PRACTICES.

Similar to crops, water productivity of livestock production system in Eastern region is very low. According to one estimate, milk productivity of buffalo in intensified management system in West Bengal has been reported as 0.34 litres per m^3 of water compared to 0.81 litres per m^3 for Hisar and Etawah. During rainy season, the milk yield has been reported as 0.33 and 0.72 litres per m^3 of water, respectively in West Bengal and Hisar [7]. Such data are, however, not available for other category of livestock from Eastern region. Water productivity of crop-livestock production system, therefore, needs to be improved through quality and water efficient feed sources, feed processing, improved livestock management practices and improved genetical potential of livestock.

4.3 Fisheries Development

4.3.1 Integrated Fish Farming

Integrated farming of fish and livestock is vital technological intervention in rainfed ecosystem. The aim of integrated fish farming (IFS) is the recycling of animal wastes to serve as fertilizers, and sometimes as food for fish raised in ponds, enclosures and cages and thereby minimize the cost of cultivation. Grow-out ponds with 1.5- 2.0 m water depth and having good water holding capacity are ideal for IFS. About 8000 to 10000 fish fingerlings could be stocked in 1 ha of pond. However, stocking of yearlings could be preferred to achieve higher growth rate and yield [13]. To fertilize one ha of pond, the stocking density of livestock / birds has been worked out to be 5, 450, 500, 30 and 55 nos. of cattle, poultry, duck, pig and goat, respectively [1, 2].

Adverse impacts of the summer spell / drought on pond productivity can be minimized through adoption of short-term (August/September to February/March) culture of species having rapid initial growth. Medium carps like silver barb (*Puntius gonionotus*), Olive barb (*Puntius sarana*), Bata (*Labeo bata*) and *Labeo fimbriatus* are ideal candidates for summer season mainly due to rapid initial growth and market preference even at smaller size (200-250 g). Culture of the minor carp-*Amblypharyngodon mola* is another summer option for utilizing the small shallow ponds. Though low in production, this fish has the advantage of higher market price, besides ensuring utilization of shallow ponds.

4.3.2 Paddy-cum-fish culture

Paddy cum fish culture is an age old tradition in rainfed as well as irrigated ecosystem of Eastern regions. Fishes are cultivated in paddy fields either simultaneously or in rotation. Both freshwater and saline fields can be utilized for the purpose. Common carp (*Cyprinus carpio*) is the most preferred species for paddy-fish culture. However, Catla (*Catla catla*), Rohu (*Labeo rohita*), Mrigal (*Cirrhinus mrigala*), Bata (*Labeo bata*), Java punti (*Puntius javanicus*), Silver carp (*Hypophthalmichthys molitrix*) and giant freshwater prawn (*Macrobrachium rosenbergii*) are some other suitable species for paddy-fish culture. Sea bass (*Lates calcarifer*), Mullets (*Liza parsia, L. tade*, and *Mugil cephalus*), Catfish (*Mystus gulio*) and Tiger prawn (*Penaeus monodon*) could also be reared in fields with saline waters. Fish production @ 500-800 kg/ha from freshwater paddy fields and 400-1500 kg/ha from saline water fields is expected in six months.

4.3.3 Ornamental fish farming

Ornamental fish rearing is yet another suitable option for utilization of shallow ponds during summer months. Ornamental fish species like gold fishes (*Carassius auratus*), koi carps (*Cyprinus carpio* var. koi), guppy (*Peocillia reticulata*), molly (*Mollinesia* sp.), platy and live bearers (*Xiphophorus* sp.) are some of the common and easy-to-bred ornamental fish for rearing in shallow ponds during summer.

5. WATER USE POTENTIAL IN FLOOD-PRONE AREAS

Among Eastern States, Bihar is highly prone to floods (about 70 per cent area is flood affected, particularly north Bihar). West Bengal, a part of Bengal Delta, also has a long recorded history of floods. About 42.3 per cent of total area of the State is susceptible to flood, and spread over 110 blocks in 18 districts. Likewise, Odisha has a history of recurring natural disasters; especially the coastal districts of Odisha are exposed to floods and cyclones. Flood problem is also acute in Brahmaputra and Barak basins and other smaller river sub-basins in the floodplains of Assam.

For effective utilization of lowland eco-systems in Eastern region (popularly known as *Tal, Khal, Jheels, beels*), raised bed-pond system or raised bed-flat bed-pond system of cultivation can successfully alleviate the problem of drainage congestion in monsoon and mitigate water scarcity in dry season where nothing could be grown due to poor drainage, flash flood, occasional flood and land submergence. The land configuration in this system can increase the opportunity of employment as well as supply protein and fat in the diet of marginal and disadvantaged farmers in the Eastern region [5]. For scientific fish cultivation/aquaculture in low lying areas, where water recedes in about 4-6 months (particularly in West & East Champaran and Muzaffarpur), there is need to build check dams and pump ground water into the pond to ensure that level of water in low-lying areas does not decrease and full potential of fish yield can be harvested. There is also vast scope to construct tanks and a canal system in flood-prone areas of Eastern region for commercial fish farming. The following measures could be adopted for increasing water use potential in flood-prone areas:

5.1 Crop Management

5.1.1 Rice-based farming system

In *kharif*, rice as a mixed cropping system could be a better option for flood-prone conditions. Rice is usually broadcast mixed with mungbean, sesame, fodder, sorghum, jute, etc in summer. Mixed cropping induces a fair degree of sustainability in the system even if the rice crop fails. The mixed crops are harvested before the floods in June-July. Yields as high as 4 t/ha could be achieved with rice + mung bean and rice + jute in the Kosi command area of Bihar, where investments are virtually nil.

Flood-tolerant rice varieties like Swarna Sub1, Samba Mashuri Sub1, IR64 Sub1 can be grown in areas which are frequently affected by flash floods causing 10-15 days inundation. Some integrated farming system like rice-fish-azolla, rice-fish-pig, rice-poultry-duck, rice-fish-goat and rice-fish-cattle/buffaloes are also suitable for flood prone areas of Eastern States [5].

In *Rabi*, sowing of wheat or lentil in the low lying areas, may be taken up with the help of Zero Tillage (ZT) machines. The resource conservation technologies (RCTs) have a great significance in order to increase the productivity of rice-wheat cropping system in Eastern region [9]. In uplands with irrigation facilities, crops like winter maize, potato, onion, sweet potato and vegetables can be sown.

5.1.2 Raised and sunken beds

The land is transformed into alternate sunken and raised beds (1:1). Different vegetable / pulse crops of local importance may be grown on the raised beds. Sunken beds could be used for growing lowland rice or other aquatic crops including fish. Paddy and pointed guard yield was recorded to be 4.24 and 4.74 t / ha, respectively, besides 1 t/ha fish yield. Through such interventions, additional income of Rs. 60,500/ ha / yr can be realised with cost of cultivation of Rs. 45,000 / ha [5].

5.1.3 Sub-surface water harvesting (SSWH)

This technology is applicable for coastal waterlogged areas. The fresh water, which floats in coastal water logged areas, could be tapped through subsurface water-harvesting structures to meet the *Rabi* crop irrigation requirement as well as pisciculture. To extract water from these structures, pump sets upto 2 hp is suitable to avoid saline water ingression into fresh water layer. The depth of structure should be restricted within sandy zone below ground up to 5 m. According to one estimate, the average water productivity of SSWH involving pisciculture and *Rabi* vegetables is Rs. 36 / m^3 with a unit cost of Rs. 14 / m^3. It results in higher area of irrigation including higher cropping intensity and crop productivity [15]. The average benefit : cost ratio of SSWH was reported to be 1.55 in the first year of construction itself. The participatory approach of implementing SSWH could improve the economic status of resource-poor farmers of the area.

5.1.4 Deep waterlogged areas

In some parts of the region, prolonged waterlogging (> 1m) during rainy season reduces tillering and growth of normal rice varieties. Sometimes flash flood inundates the standing crop at any stage of growth for 8-10 days at a stretch, resulting in heavy mortality. The crop is damaged completely if this situation occurs at early vegetative stage. Hence, proper establishment of crops before onset of flooding and adoption of deep waterlogging-tolerant rice varieties (Hangseswari, Saraswati, Ambika, and Sabita) are of paramount importance to realize net return from the crop. These varieties could produce 2.4-2.5 t/ha yield in *Kharif* season with cost of cultivation of Rs. 10,000 / ha [5].

Due to poor drainage, saucer shaped topography and high monsoon rainfall, some parts of eastern India remain waterlogged (> 1m surface water logging) and unproductive. To stabilize and enhance net income from such areas, pond based farming technology (deep water rice in *Kharif* + vegetables like watermelon, ladies finger, spinach, chili in winter + fruits + fish) could be adopted. An additional income of Rs. 25,000/ha/annum with water productivity of Rs. 7.2/m^3 could be realized adopting the technology [14].

5.1.5 In-situ rainwater conservation for multiple use

In 8-10 per cent of the total rice field, small dugout ponds of 1.0 m depth and 1:1 side slope at downstream or at the middle can be made. The small water harvesting structures could be used for short-duration aquaculture during monsoon and its embankment is used for growing horticultural crops. The conserved rainwater could also be used for supplementary irrigation to *Kharif* paddy and also to *Rabi* crops. The *Kharif* paddy yield increase from 1.8 to 2.6 t / ha and fish yield of 1.4 t / ha has been reported using this technology [14].

5.2 Integrated Farming Systems (IFS)

Integrated farming system (IFS) is a viable option to achieve food and nutritional security at household level and even at individual level. Such land use system could provide round the year employment to the farming family. A two-acre IFS model has been developed for marginal farmers, inhabiting in lowland and midland irrigated ecosystems of Bihar. Crop-livestock-fishery was integrated with allied enterprises like duck, vermicomposting, bee keeping, mushroom cultivation, and cereal crops (*Kharif* rice, followed by *Rabi* wheat, maize, lentil, mustard), fruits and vegetables. The net monetary gain from the model has been estimated to be Rs. 1,80,500/- per yr. Likewise, one acre model has been developed for small holders of midland situation. Agri-horti crops, goat, poultry with allied enterprises like vegetables, mushroom and vermicomposting have been integrated and the net monetary gain from such model was accounted for Rs. 99,500/- per yr [11].

Cultivation of Makhana (*Euryale ferox*) with fish and water chestnut is another IFS model, suitable for waterlogged districts of Bihar. It include cleaning of pond before emergence of Makhana seedlings, removal of carnivorous fishes by application of mahua oil cake @ 2.5 t/ha, transplanting and gap filling of Makhana, making refuge area of 10 per cent of total water body area and integration of different carp fingerlings. Water chestnut is cultivated as a tertiary crop. Net monetary returns for such system has been estimated to be Rs. 89,000/- per ha [10]. The technology has a potential for adoption in 1.10 M ha of non-arable waterlogged areas in the country [18].

5.3 Restoration of Waterlogged/marshy Areas through Agroforestry Interventions

Agroforestry land use is very vital for rehabilitating waterlogged/marshy and degraded lands. Raised bed method could be adopted in marshy areas for planting of saplings. Species like *Anthocephalus chinensis*, *Casuarina equisitifolia*, *Dalbergia sissoo*, *Eucalyptus* spp., *Ficus* spp., *Mangifera indica*, *Melia azadirachta*, *Moringa* sp., *Morus* sp., *Musa paradisiaca*, *Populus deltoides*, *Salix* spp., *Syzygium cumini*, *Terminalia arjuna*, *T. bellirica*, *T. tomentosa* and *Vitex nogundo* etc have been found suitable for cultivation in such areas besides various bamboo species. Such lands could also be rehabilitated with land configuration and adopting pisciculture and agroforestry together.

5.4 Makhana Cultivation in Cropping System Mode

In seasonally water-logged areas, Makhana could be cultivated in a cropping system mode (water depth- up to 0.60 m). While 4-5 months are sufficient for Makhana cultivation, other crops could be cultivated successfully from the same piece of land. Makhana yield in cropping system mode has been recorded as 2.8 t/ha compared to 1.6 t/ha in perennial/seasonal water bodies. Field method of cultivation requires less water. Makhana could be transplanted in the second week of April and harvested by the second week of August. Short duration varieties of rice could succeed thereafter. Fodder crops could be sown by mid-December and harvested by the second week of April. Hence, cultivation of three crops per year is possible in such areas, particularly in Darbhanga, Madhubani, Samastipur, Sitamarhi, Araria, Saharsa, Madhepura, Supol, Purnea, Katihar districts of Bihar [10].

5.5 Fish Development

5.5.1 Air-breathing fish culture in marshy or swampy areas

Air breathing fish culture (freshwater catfish) of magur (*Clarias batrachus*), singhi

(*Heteropneustus fossilis*) and climbing perch (*Anabas testudineus*) is a suitable technology for restoration of marshy/swampy areas. These fish could be grown in shallow ponds as they are sturdy and tolerate higher water temperature and even withstand dry summer spell [5].

5.5.2 Fishery in flood plains

The floodplain lakes (*Chaurs*), saucer shaped water filled depressions having 50 to 400 cm water depth, are predominantly found in north Bihar, West Bengal, Eastern Uttar Pradesh and Assam. Fish inhabiting these water bodies are magur, singhi, kabai or koi, garai and other economically unimportant weed fish. These floodplain lakes are almost unutilized. The fishermen around the *chaurs* are mostly engaged in capture fishery activity. The fish productivity is approximately 15 kg/ha/yr. However, flood plains have the potential to yield 2.0 to 2.5 t/ha/yr of fish in semi-intensive culture system with suitable technological interventions. *Chaurs* can be stocked with naturally collected or hatchery reared fingerlings of IMC (Indian Major Carps). Air breathing fish can also be reared in *chaurs* [13].

The ox-bow lake, popularly known as *maun* (defunct loops of rivers cut off from the main rivers), are also predominant, particularly in Bihar, West Bengal and Assam. During floods in river, they receive water. Fish production in *mauns* ranges from 60-150 kg/ha/yr. However, *mauns* have the potential to give fish production up to 1.5 t/ha/yr with cage and pen culture practices, and selective stocking of IMC [5].

5.5.3 Pen culture of fish and prawn in derelict water bodies/lagoons/lakes/ floodplain wetlands

Shallow areas of derelict water bodies/lagoons/lakes/floodplain wetlands could be utilized for raising table size fish and prawns in enclosure (pens). After assessing water depth, duration of water availability and seed availability, pens of suitable size (0.1 to 0.2 ha) and shape could be erected, depending on the capacity of water bodies and topography of the area. The selected water bodies should have at least 1 m water depth for a period of 3-4 months. Indian major carps, *viz.*, Catla (*Catla catla*), Rohu (*Labeo rohita*), Mrigal (*Cirrhinus mrigala*) and giant freshwater prawn (*Macrobrachium rosenbergii*) are ideal for rearing in pens [5].

6. RECOMMENDATIONS

1. Geographical Information System (GIS) signatures for the identification of suitable farming systems for different agro-ecologies and land types (*e.g.* valley land, low

land, sloping land, waterlogged lands etc.) may be deployed for enhancing land and water productivity and for crop diversification.

2. Water productivity data for different crops should be gathered through using standardized methodologies so as to enable proper comparison. Region-specific water production functions for different crops and their varieties and different water application technologies are needed. Database of soil hydraulic properties also needs to be developed for water balance modelling, proper irrigation scheduling and irrigation water management. Hydro-meteorological database alongwith near real-time flood/drought forecasting/warning tools are required for disaster risk management.

3. Appropriate policy interventions may be instituted for exploiting participatory irrigation management (PIM) in the conjunctive use of rain, canal and ground water. Considering the poor facility of electricity in most of the Eastern States, attractive schemes are necessary to promote low energy low lift pumps to tap shallow water table as supplemental irrigation during critical growth stages.

4. Integrated farming system models in irrigated and rain-fed ecosystems incorporating location-specific climate-resilient features must be scaled up in order to achieve food and nutritional security, and also to mitigate adverse climate change impacts.

5. About 10 M ha area in the Eastern Region is reported to be affected due to drought. Crop diversification (including horticulture and plantation crops) could minimize the risk of drought. Water-harvesting in drought affected areas should be given emphasis with field bunding, dug-out ponds, Mahaband, recharging ponds and other water harvesting structures.

6. In flood-prone areas, drainage development, link and secondary drainage system in low lands, peripheral embankment, land configuration according to need, and renovation of village and other ponds should be given due consideration. Production of specialty corn in these lands could become a major economic option.

7. Availability of large wetland area (4.05 M ha) in the Region offers unique opportunities for agricultural development and employment generation by veritable technological interventions such as cultivation of *Makhana*, water chestnut, fish and lotus and adoption of various combinations of integrated crop-forestry-fish-animal farming systems. Importantly, the wetlands must be protected for biodiversity conservation.

8. There is a vast scope for increasing the production and productivity of rice-wheat cropping system through better management of water resources. Interventions

like System of Rice Intensification (SRI) and Direct Seeded Rice (DSR) provide opportunities to enhance rice productivity, minimize water and other inputs uses and benefit environment, but their efficacies should be assessed rigorously.

9. About 11 M ha of land is mono-cropped with rice, and remain fallow after harvest. A second crop of oilseeds, pulses, vegetables and fodder crops can be raised through effective utilization of residual moisture and appropriate rainwater management/conservation technologies in rice fallow areas.

10. Large scale demonstration of scientific 'rice-fish cultivation' is also required. Further, fish hatchery should be given due consideration (as a commercial venture for supply of fish seed) so that the appropriate fish seed can be available at farmers' door steps.

11. Use of micro-irrigation system (particularly drip irrigation for horticultural crops) can be popularized in the Eastern Region through demonstration and financial support for installation of the system.

12. Livelihood augmentation through animal husbandry is a viable option in drought-prone areas for marginal farmers in general and landless in particular. Goat husbandry, particularly Black Bengal X, backyard poultry and swine husbandry are some of the options.

13. Vast scope exists in aquaculture. Application of GIS-based Decision Support System (DSS) should be encouraged for assessing site suitability for aquaculture which can enhance fish production in the Region. Efforts may be made to increase the fish productivity extending the innovative scientific tools primed by policy support.

14. Developing adequate infrastructure for productive systems and strengthening of supply chain from farm to market are essential for increasing the rural economy of Eastern India.

REFERENCES

1. Bhatt, B.P. and Bujarbaruah, K.M. 2011. Eco-energetic analysis of integrated agro-aquaculture models, North Eastern Himalayan region, India. *J. Sustainable Agriculture*, **35**: 493-510.

2. Bhatt, B.P., Bujarbaruah, K.M. and Vinod, K. 2006. *Integrated Fish Farming in Eastern Himalayas*. Technical Bulletin No. 47, ICAR Research Complex for NEH Region, Meghalaya, 34 p.

3. Bhatt, B.P., Haris, A.A., Islam, A., Dey, A., Mukherjee, J., Barari, S.K., Das, B. and Kaushal, D.K. 2011. *Agriculture in Eastern States: Opportunities and Challenges*. Technical Bulletin No. R-31/PAT-20, ICAR Research Complex for Eastern region, Patna, 78 p.

4. Bhatt, B.P., Bujarbaruah, K.M., Vinod, K. and Karunakaran, M. 2011. Integrated fish farming for nutritional security in Eastern Himalayas, India. *J. Applied Aquaculture*, **23**: 157-165.

5. Bhatt, B.P., Haris, A.A., Dey, A. and Singh, K.M. 2012. *Technological Options for Agricultural Transformation in Eastern Region*. Bulletin No. R-35/PAT-23, ICAR Research Complex for Eastern region, Patna, 99 p.

6. Central Ground Water Board. 2011. Dynamic Ground Water Resources of India (as on 31st March, 2009). Central Ground Water Board, Ministry of Water Resources, Govt. of India, Faridabad, 243 p.

7. Clement, F., Ishaq, S., Samad, M., Acharya, S.A., Venkata Radha, A., Haileslassie, A., Blummel, M., Dey, A., Khan, M.A., Shindey, D. and Mit, R. 2010. *Improving Water Productivity, Reducing Poverty and Enhancing Equity in Mixed Crop-Livestock Systems in Indo Gangetic Basin*. Project Report, Challenge Programme for Water and Food (CPWF), CGIAR, Srilanka.

8. Edwards, P., Kaewpaitoon, K., McCoy, E.W. and Chantachaeng, C. 1986. *Pilot Small-Scale Crop/Livestock/Fish Integrated Farm*. AIT Res. Report, 184, Bangkok, Thailand, 131 p.

9. Khan, A.R., Bhatt, B.P. and Singh, A.K. 2011. *Resource Conserving Technologies for Sustainable Food Production System: Some Experiences from Eastern Region of India*. Technical Bulletin No. R-33/PAT-22, ICAR Research Complex for Eastern region, Patna, 62 p.

10. Kumar, L., Gupta, V.K., Jha, B.K., Singh, I.S., Bhatt, B.P. and Singh, A.K. 2011. *Status of Makhana (Euryale ferox Salisb.) Cultivation in India*. Technical Bulletin No. R-32/PAT-21, ICAR Research Complex for Eastern region, Patna, 31 p.

11. Kumar, S., Subhash, N., Shivani, Singh, S.S. and Dey, A. 2012. Evaluation of different components of small and marginal farmers under semi humid climatic environment. *Experimental Agriculture*, **48**(3): 399-413.

12. Ministry of Agriculture. 2009. *Manual for Drought Management*. Department of Agriculture and Cooperation, Ministry of Agriculture, New Delhi, 192 p.

13. Samra, J.S., Sahoo, N., Roy Chowdhury, S., Mohanty, R.K., Jena, S.K. and Verma, H.N. 2003. *Sustainable Integrated Farming System for Waterlogged Areas of Eastern India*. Technical Bulletin No. 14, Directorate of Water Management, Chandrasekhapur, Bhubaneswar, 24 p.

14. Sikka, A.K., Bhatnagar, P.R., Haris, A.A., Kaushal, D.K., Prasad, L.K., Dey, A., Reddy, A.R. and Kumar, U. 2010. *Productive Utilization of Waterlogged Areas Through Multiple Water Use Systems in Eastern India*. Technical Bulletin No. R-24/PAT-14, ICAR Research Complex for Eastern region, Patna, 1-21 p.

15. Singh, R., Kundu, D.K., Ghosh, S., Chaudhari, S.K., and Kumar, A. 2009. Natural resources and social capabilities of eastern India: An analysis of opportunities and constraints for efficient management of water. In: Rattan, R.K., Sarkar, A.K. and Singh, A.K. (eds.). *Soil and Water Management for Agricultural Transformation in Eastern India*. ISSS Bulletin No. 26, Indian Society of Soil Science, New Delhi, 1-22 p.

16. Singh, R.D., Dey, A. and Singh, A.K. 2011. *Vision 2030*. ICAR Research Complex for Eastern region, Patna, 26 p.

17. Space Applications Centre. 2011. *National Wetland Atlas*, SAC/EPSA/ ABHG/ NWIA/ATLAS/34/2011, Space Applications Centre (ISRO), Ahmedabad, India, 310 p.

18. Verma, A.K., Banerji, B.K., Chakraborty, D. and Dutta, S.K. 2010. Studies on Makhana (*Euryale ferox* Salisb.). *Current Sci.* **99**(6): 795-800.

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