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Rain water harvesting and its efficient use in island farming system

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Abstract
Impeded drainage in the low lands and inadequate soil moisture in uplands results in poor land as well as water productivity in Andaman and Nicobar Islands. In order to increase the farm production and water use efficiency, location specific water harvesting and management technologies were demonstrated at 90 selected farmer's field through Farmers Participatory Action Research Programme (FPARP) of Ministry of Water Resources, GOI during 2011-13. Five technologies *viz.*, crop diversification through broad bed and furrow (BBF) system, micro irrigation, plantation and pond based integrated farming system, and moisture management in groundnut under coconut plantation were demonstrated on 0.20 ha covering a total of 18 ha spread over 35 villages across Andaman Islands. BBF recorded a net income of Rs. 1,34,000/ha with water use efficiency (WUE) of Rs. 15/m^3. In pond based integrated faming system Rs. 1,40,000/ha was obtained with a WUE of Rs. 65/m^3. Drip irrigation resulted in 20-30% yield increase and 50-60% water saving at all the locations. Among the technologies, broad bed and furrow system was found to be the best option for crop diversification in water logged areas, while integrated farming system performed better in hilly and undulated terrain areas.

Keywords: BBF, IFS, micro irrigation, WUE

Introduction
Water is the most precious resource in the Andaman and Nicobar Islands despite of being vested with heavy rainfall of 3180mm that is received in about 141 days. The rainfall pattern of Andaman in the past 12 years indicates that 78% of total rainfall is received from South-West and North- East monsoon while the rest from January to May. During the dry period, agriculture suffers badly due to moisture stress. As rainwater is the only source of the water, it's harvesting and management forms the most important strategy for improving water productivity in these islands [1]. Participatory action research (PAR) is more effective and communicative measures in the developmental process [2]. On-farm irrigation management and irrigation service thereby improved by involving farmers in water management practices and introducing acceptable water saving irrigation schedule for growing crops and increasing agricultural production [3]. On-farm participatory field trials brought positive improvements towards better water use efficiency following the recommended methods of water management practices in the farmer's field in Damodar valley corporation command in West Bengal [4].The adoption of rainwater harvesting with existing ponds ensured more water resource availability and utilization in coastal saline region [5]. Location specific water saving technologies will increase farm production and water use efficiency at farmer's field. Under this context, the five improved water management technologies viz., Broad Bed and Furrow (BBF) system, micro irrigation, fresh water and land based Integrated Farming System (IFS), Moisture management in table purpose Groundnut evolved by different scientific organizations and institutes were considered for demonstration in the farmers field of Andaman islands to increase agriculture productivity and profitability at farmer's field through participatory approach. All these technologies have multiple potential benefits to farmers by increasing income through improved water and nutrient use efficiency and productivity.

Materials and Methods
In order to increase the farm production and water use efficiency, location specific water harvesting and management technologies were demonstrated at selected farmers field through Farmers Participatory Action Research Programme (FPARP). Five technologies *viz.*, crop diversification through broad bed and furrow system (25 demonstrations), micro irrigation (10 demonstrations), pond based integrated farming system (15 demonstrations), plantation based

integrated farming system (15 demonstrations) and moisture management in ground nut under coconut plantation (25 demonstrations) were demonstrated on 0.20 ha covering a total of 18 ha spread over 35 villages in different islands of south, north & middle Andaman districts. All the demonstrations were laid out in participatory mode with active participation of the farmers. These technologies have been discussed with each of the selected farmers. Considering their land situation and their priority for technologies, options of interventions have been finalized. Under FPARP, Broad Bed and Furrow System (0.2 ha/demonstration) were demonstrated at 25 farmers field in South Andaman. The inputs like vegetable seeds, fingerlings were distributed to the farmers for integration. The technology involves making of broad bed and furrow alternatively. Broad beds are made in the shape of inverted trapezium by digging soil from either side of the broad bed and putting it in the bed area. Beds of 4-5 m width and furrows of 5-6 m width with 0.75 - 1 m depth are found suitable for the island conditions. The length of beds and furrow can be according to the length of field. The excavated area is used for rice cultivation and the raised bed for cultivating seasonable vegetable. In 1 ha area, 10 beds of 5 m x 100 m x 1 m and 10 furrows of 5 m x 100 m x 1 m can be made. The life span of the system will be more than 5 years. Demonstration of drip irrigation for vegetables (0.20 ha), coconut (0.40 ha), arecanut (0.40 ha) and banana (0.20 ha) has been done at farmer's field to enhance the yield and water use efficiency of vegetables, coconut, arecanut and banana during dry season. Fresh water Integrated Farming System (IFS) which includes household farm pond with scientific fish culture system + poultry + ducks + vegetables + vermicompost models were carried out in 15 farmers field. In this system, poultry sheds (15 m^2) were made in the farmer's field and inputs like poultry chicks (100 no's), goat or pigs (2 no's), fingerlings and vegetables seeds were distributed for integration in the system. Land based Integrated Farming System (IFS) include Coconut/arecanut plantations + poultry+ Goat/pig + vegetable crops. In this model, poultry sheds measuring 5 m x 3 m size were made in the farmer's field and inputs like poultry chicks (100 no's), goat or pigs (2 no's), and vegetables seeds were distributed to the farmers. Moisture management in ground nut under coconut plantation was demonstrated at 25 farmer's field in South and North Andaman districts. Groundnut seeds of *Var. ICGS 76* was purchased from ICRISAT and distributed to farmers. The groundnut crop has been cultivated as inter crop in coconut plantations and seeds produced in the coconut plantations during rainy season (*kharif*) were used for *rabi* cultivation. During the programme implementation period, farmers were motivated through training programmes, scientist-farmer interactions, scientist regularly visited field and finally organized field days for horizontal expansion of technologies.

Results and Discussion

Five technologies *viz.* crop diversification through broad bed and furrow system, micro irrigation, pond based integrated farming system, plantation based integrated farming and moisture management in ground nut under coconut plantation have been implemented in 90 farmer's field. Impact assessment of these technologies at the farmer's field has been taken up using the prescribed format. The impacts of these technologies on yield and water use efficiency were discussed hereunder.

Broad bed and furrow system has sound economic impact in the low land rice ecosystem. It offers scope for growing of high value vegetables during the monsoon season. Besides that BBF is expected to increase the cropping intensity from 100 – 125% in the traditional system to 300% in the beds and 200% in the furrows. Under Broad Bed and Furrow System, net income of Rs. 1,34,000/ha was obtained from broad bed and furrow system with water use efficiency of Rs. 15/m^3. This is mainly due to cultivation of different vegetables in the beds and fish in the furrows of BBF [6]. Under island condition, BBF system could harvest and store 4476 m^3 ha^{-1} of rainwater and increase the cropping intensity (220%) and water productivity (47.36 Rs/m^3) [7].

Integration of fish, vegetables, goat and poultry in pond based integrated faming system (IFS), gave higher net return of Rs. 1,40,000/ha as compared to conventional method (fish culture alone) with higher water use efficiency (WUE) of Rs. 65/m^3. The produce and residue from one component is used as input for the other component. Besides that it gave some additional employment opportunity in pond based integrated faming system [8]. Similarly, under plantation based integrated farming system, net income of Rs. 1,10,000/ha was obtained from coconut based integrated faming system and Rs. 2,50,000/ha was obtained from arecanut based integrated faming system with water use efficiency of Rs. 85/m^{-3} whereas, coconut and arecanut sole crops could able to record a net return of Rs. 50,000/ha and Rs. 2,00,000/ha, respectively under island ecosystem. Integrated faming system has increased farm income and employment through vegetable production and poultry farming in tribal areas of Nicobar [9].

Lack of irrigation facilities is a major constraint in intensification of island agriculture. Hence, drip irrigation was evaluated in coconut, arecanut, banana and vegetables at different locations of South Andaman. Drip irrigation resulted in 20-30% yield increase and 50-60% water saving at all the locations as compared rain fed cultivation with water use efficiency of Rs. 75-85/m^3. Drip irrigation is the most effective way to supply water and nutrients to the plant, which not only saves water but also increases yield of crops. Drip irrigation has proved its superiority over other conventional method of irrigation, especially in the cultivation of fruits and vegetables due to precise and direct application of water in root zone. A considerably saving in water, increased growth, development and yield of vegetables under drip irrigation has been reported [10]. Groundnut cultivation under coconut plantations gave lesser net income of Rs. 53,000/ha with WUE of Rs 40/m^3 as compared to other technologies. The technologies *viz.*, broad bed and furrow system, Pond based integrated farming system (IFS), Tank-well system and micro irrigation demonstrated in the farmer's field of South Andaman gave higher yield, net return and water use efficiency over the conventional method [10]. Household livelihood security is easily achieved by these technologies as these increase the farm income, provide more employment opportunities and nutritional security.

Table 1: Impact of broad bed and furrow system on yield and water use efficiency

S. No	Items (with units)	Conventional Method	Using Technologies	Benefits
1.	Water use (m^3/ha)/ water use efficiency (Rs./m^3)	WUE in rain fed rice –fallow: Rs 1.2/ m^3	WUE in BBF : Rs. 4/m^3 in Kharif Rs.75-95 / m^3 in Rabi	In situ rain water harvesting and increased cropping intensity
2	Yield	Paddy: 2 t/ha	Okra: 1200 kg Brinjal: 1600 kg Cow pea: 800 kg Bitter gourd: 600 kg Bottle gourd: 1400 kg Rice: 400 kg, Fish:150 kg	Vegetable crop cultivation during monsoon
3.	Increase in income /monetary benefits from agriculture, fisheries & livestock etc.	Rs. 12,000/ha	Rs. 1,34,000/ha	Enhanced income from high value vegetables and fish.

Table 2: Impact of micro irrigation on yield and water use efficiency

S. No	Items (with units)	Conventional Method	Using Technologies	Benefits
1.	Water use (m^3/ha)/ water use efficiency (Rs./m^3)	Rainfed	WUE: Rabi : Rs. 75-85/m^3	40-50% water saving
2	Yield	Pre-project Coconut:6000 nuts/ha Arecanut: 2000 Banana: 15 t/ha Vegetables: 2000 kg/ha	Post – project Coconut: 6500 kg/ha + Pepper: 50 kg/ha Arecanut:2400 kg/ha + Pepper: 50 kg/ha Sole Banana: 16 t/ha Vegetables: 3200 kg/ha	20 -30% increase in yield + additional yield from black pepper
3.	Increase in income /monetary benefits from agriculture, fisheries & livestock etc.	Coconut: Rs.45000/ha Arecanut: Rs.2,00,000/ha Banana: Rs.1,70,000/ha Vegetables: Rs.40,000/ha	Coconut: + Pepper: Rs. 1,15,000 Arecanut + Pepper: Rs. 2,50,000/ha Banana alone: Rs.2,20,000/ha Vegetables: Rs. 64,000/ha	Additional income from black pepper and vegetables due to drip irrigation

Table 3: Impact of pond based integrated farming system on yield and water use efficiency

S. No	Items (with units)	Conventional Method	Using Technologies	Benefits
1	Water use (m^3/ha)/ water use efficiency (Rs./m^3)	WUE in mono culture (Fish) : Rs. 20/m^3	WUE in IFS): *Kharif* : Rs. 10-20/m^3 Rabi : Rs. 35-40/m^3	Multiple use of water for crop/animal and fish
2	Yield (kg/ha)	Pre-project Fish: 900 kg	Post – project Fish: 900 kg Vegetables: 2500 kg Poultry: 300 kg meat Goats: 50 kg meat	20-30% increase in arecanut yield +additional income from black pepper
3	Increase in income /monetary benefits from agriculture & livestock	Rs. 60,000/ha	Rs. 1,40,000/ha	Enhanced farm income from different sources

Table 4: Impact of plantation (land) based integrated frming system

S. No	Items (with units)	Conventional Method	Using Technologies	Benefits
1.	Water use (m^3/ha)/ water use efficiency (Rs./m^3)	Kharif : Rs. 10-20/m^3 *Rabi* : Rs. 20-40/m^3	*Kharif* : Rs. 20-30/m^3 Rabi : Rs. 50-60/m^3	Multiple use of water for crop/animal
2.	Yield (kg/ha)	Coconut; 6000 nuts/ha or Arecanut: 2000 kg/ha	Coconut: 6500 nuts/ha Or arecanut: 2200 kg/ha + Vegetables: 2300 kg Poultry: 300 kg meat Goat: 50 kg meat	20% increase in arecanut and coconut yield +additional income from Vegetables, poultry and goat/pig
3.	Increase in income /monetary benefits from agriculture, fisheries & livestock etc.	Pre-project Coconut: Rs.45000/ha Arecanut: Rs.2,00,000	Post – project Coconut based IFS: Rs. 1,10,000/ha Arecanut based IFS: Rs. 2,50,000/ha	Enhanced farm income from different farm enterprises

Table 5: Impact of moisture management for table purpose groundnut under coconut plantation

S. No	Items (with units)	Conventional Method	Using Technologies	Benefits
1.	Water use (m^3/ha)/ water use efficiency (Rs./m^3)	No crop	WUE of groundnut during Rabi Rs. 40/m^3	Efficient utilization of soil moisture
2.	Yield (kg/ha)	No groundnut crop in coconut plantation	Groundnut: Kharif: 600 kg pods/ha Rabi: 1700 kg pods/ha	Additional income from ground nut
3.	Increase in income /monetary benefits from agriculture, fisheries & livestock etc.	Coconut: Rs.45000/ha	Coconut: Rs. 45,000/ha +Ground nut: Rs. 8000/ha	Additional income from ground nut

Conclusion

From the results of two years study, it can be concluded that broad bed and furrow system was found to be the best option for crop diversification, higher income and water use efficiency in water logged areas, while integrated farming performed better in hilly and undulated terrain. Implementation of these technologies through participatory mode was proved to be highly successful and beneficial to farmers by enhancing the farm income and water use efficiency besides meeting their nutritional security.

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