Water Resource Development
for Multiple Livelihood Opportunities in Eastern Himalaya

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The authors are hopeful that this documentation of experiences gained under NAIP-III project would encourage the researchers and planners in implementing such projects in remote and difficult areas for water resource development and management and livelihood improvement of rural poor in North-East India.

Authors

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Summary

The North Eastern Region (NER) of India is endowed with enormous water resources potential that accounts for about 34% of the country's total water wealth although the region represents only 7.97 % of the total geographical area of the country. As against an ultimate irrigation potential of about 4.26 million hectares, the area presently under irrigation is only 0.85 million hectares. In spite of the abundant water resources, the ratio of percent irrigated area to net sown area varies from 5 % in Assam to 28 % in Arunachal Pradesh with the average for NE region as a whole at 10.6 %. This is less than one-fourth of the National average of net irrigated area in the country which currently stands at 43.2%. The water scenario in the NER of India suffers from plenty and scanty syndrome. In one hand there is excess water availability during rainy season and on other hand extreme water scarcity during the post – rainy season seriously constraints the farmers access to a reliable water source and to a meaningful economic activity at the farm and extreme hardships for the households. Women and children walk miles to fetch a bucket of water to meet their daily needs. To promote efficient water conservation and its multiple uses, diverse kinds of water harvesting structures were developed as per the location, water source and purpose for which it is to be used. Farm ponds (about 500 m^2) were given preference in South Garo Hills and Dhalai, due to low altitude and availability of valley low lands. Two approaches were adopted for farm pond development, 1. to renovate existing unused and defunct ponds and 2. to develop new ponds for harvesting water for multiple purpose. Jalkund (a micro rain water harvesting structure of 5 m x 4 m x 1.5 m dimension and lined with PVC- agri-film such as silpaulin 250 GSM) and tanks were given preference in hills such as North Sikkim (High altitude) and Saiha. Innovative Thai Jar- a multiple water use scheme (MUS) was popularized by IWMI in hills of North Sikkim and Mon. Roof water harvesting mostly from community structures such as church, schools etc. were developed in mountainous, hilly and inaccessible location of Mon and Saiha. Mini deep tube wells were developed in Dhalai, Tripura to harness ground water sources for creating irrigation facilities to cultivate crops during *rabi* season and provide resilience to rainfed farming. Check dams were developed to harvest water for crop production and improve ground water recharge in Mon and Saiha. A total 438 numbers of various kinds of water resources and structures were created in different clusters by the involvement of consortia partners. Through diverse structures and development of water resources, an approximate amount of 181789 m^3 water harvesting facility was created across 7- clusters. This amount of water is equivalent to 181789,000 litre or 181.8 million litre. About 216 ha area was brought under irrigation through the project. Diversified use of water through integration of crop-livestocks-fishery-vegetables-fruits-multi purpose tree species (MPTs) enhanced crop and water productivity in addition to improvement of farm income and employment in the planning commission identified underdeveloped districts of the region.

1. Introduction

Water is indispensable for virtually all human activities and for sustaining the ecosystems upon which present and future generations depend. There is urgent need for realization that water is finite and vulnerable resource which must be used efficiently, equitably and in ecologically sound manner for present and future generations. Furthermore, a broader view of fresh water encompassing both 'blue water' (i.e., water in aquifers and water courses) and 'green water' (i.e., soil water contributing to biomass production) must be considered in developing a proper water policy. The National Water Resource Council which was set up in 1992 adopted a broad National Water Policy which stresses: "Water is the prime natural resource, a basic human need and a precious national asset. Planning and development of water resources need to be governed by national perspectives". India is blessed with large river basins and possesses about 4% of total mean annual runoff of the rivers of the world. Per capita fresh water availability in the Himalayan region is about 1757 m^3/yr in the Indus, 1473 m^3/yr in the Ganges, 18417 m^3/yr in the Brahmaputra. Water is a shrinking resource and per capita availability of water in our country has shrunk by 53% since independence. Due to highly uneven distribution of water resources, per capita water availability in some of the east flowing rivers of Tamil Nadu is 380 m^3, which is as high as 18400 m^3 in Brahmaputra basin. Per capita availability of water is projected to be 1465 m^3 and 1235 m^3 by the year 2025 and 2050, respectively. As per the United Nations' standard, the countries with annual per capita availability of less than 1700 m^3 are considered as water stressed and those with less than 1000 m^3 as water scarce. India would need 2788 billion cubic meter (bcm) of water annually by 2050 to avoid water stress condition and 1650 bcm to avoid water scarcity situation.

The North Eastern Region of India comprising the states of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Sikkim covers a total area of 26.2 million hectare which accounts for 7.97% of the India's total geographical area. The region is characterized by unique geophysical, socio-cultural and environmental setting. The eastern Himalaya is dominated by an intensely potent monsoon rainfall, a fragile geophysical framework, an active seismicity and a fabulously rich biological and cultural diversity. Because of its immensely rich water resources potential, this region is now linked to a 'Water Tower' and 'Power House' for the country. The North-Eastern region is endowed with an enormous water resource potential that accounts for about 34% of the country's total water wealth and about 37% of its total hydropower potential although the region represents only 7.97% of the total Indian landmass. The per capita and per hectare availability of water in this region is the highest in the country (Goswami, 2002). However, less than 5% of the existing potential of the region has so far been tapped for societal use. As against an ultimate irrigation potential of about 4.26 million hectares, the area presently under irrigation is only 0.85 million hectares. In spite of the abundant water resources, the ratio of percent irrigated area to net sown area varies from 5% in Assam to 28% in Arunachal Pradesh with the average for NE region as 10.6 %. This is less than one-fourth of the National average of net irrigated area which currently stands at 43.2% (Sharma et al., 2010).

The region is very rich in water resources (42 million ha m), receives high rainfall (the long term average rainfall of the NER is about 2000 mm and ranges from 2000 mm in South Garo hills to 3250 mm in North Sikkim) but most of it goes waste as runoff along the steep slopes. Further, erratic distribution of rainfall (both in spatial and temporal dimensions) often leads NER to suffer from severe water scarcity during pre- and post- monsoon months. The monsoon rains from June to September account for more than 70% of the annual rainfall. The unutilized and excessive water supplies during rainy season create devastations almost every year with ravaging floods, landslides, soil erosion and other infrastructural failures. The pre-monsoon rainfall (March to May) accounts for 25% of annual rainfall and the post monsoon and winter rainfall (October to February) are scanty (5%), limiting the agricultural activities during summer and winter season. On the other hand extreme water scarcity during the post – rainy season seriously constraints the farmers' access to a reliable water source and to a meaningful economic activity at the farm leading to extreme hardships for the households. Delay in pre-monsoon showers and onset of monsoon leads to serious dislocation and causes great damages to agriculture (Mishra and Satapathy, 2003). Even drinking water availability is a serious problem especially for the farmers residing on the hills. Women and children walk miles to fetch a bucket of water to meet their daily needs (Saha et al., 2007). The local people in Longwa village, Mon use bamboo vessels to collect water for their daily needs for which they walk long distance (Fig 1). Similar situation is also prevalent in Saiha and to some extent in North Sikkim and Upper Subansiri.

Thus, the water scenario in the region is skewed and is characterized by plenty and scanty syndrome, i.e., excess water during rainy season and severe scarcity during post- and pre- monsoon season. There is wide variation of rainfall in space and time. It is projected that by 2021, an additional 15 million population will be added to the current 45 million in the region (Choudhury et al., 2012).

Fig. 1: Tribal women in her way to collect water from distant source

In Tripura (Dhalai), Meghalaya (Garo Hills) and Manipur (Tamenglong), a large number of farm ponds are available which are mostly small to medium in size with approximate average area of 500 m^2 per pond. Existing water bodies in the clusters were poorly managed, infested with obnoxious aquatic weeds, underutilized and mostly used as dumping ground (Fig 2 & 3). Farm pond needs regular renovation by desilting, repairing dykes, cleaning weeds and scientific management such as liming, proper fish species composition for higher productivity and income. The farmers in different clusters were hardly getting 500-750 kg/ha fish productivity from these ponds. Whereas, the climate of the region is much suitable for aquaculture and multiple use of water for crop-livestock-fish culture and is having very good potential for enhancing water productivity and livelihood improvement.

Fig. 2: Abandoned pond in Saiha

Fig. 3: A poorly managed pond in Tamenglong

2. Need for Water Harvesting

The farmers in hill and mountain ecosystem are most prone to water scarcity especially during pre- and post-monsoon season. Non-availability of irrigation water, especially during the non-rainy season discourages farmers to go for intensive agricultural activities with higher cropping intensity. Even during rainy season, early withdrawal of rain is very common leading to drought like situations. Droughts of 2006 and 2009 are some of the recent examples which resulted reduction in productivity by 20-30% in the region as a whole (Das et al., 2009). Water poverty mapping based on household surveys in a typical hilly village in the North Eastern region of India (Nagaland) showed that all the households fared very poorly in terms of the most components of water poverty index (WPI); water use (0.15), water resource (0.38), water access (0.40) and capacity (0.40) with an overall value of 0.44 (Sharma et al., 2010). Rain water harvesting has tremendous potential for domestic use as well as for agricultural purposes for the resource-poor farmers in the hill ecosystem. One of the major constraints for water-harvesting structures in the hill region is high seepage loss from storage tanks. Further, seepage losses are quite high as the soil is coarse-textured and lower strata are made of fractured stones. Seepage loss from small tanks has been reported to be in the range of 300–400 l/m^2 wetted area per day (Saha et al., 2007). Gradual siltation and clogging of soil pores has resulted in the development of layers of low hydraulic conductivity on the wetted perimeter. In the North Eastern Region of India, about 56% of the cultivated area is under low altitude (valley), 33% under mid altitude and the rest under high altitude (upland terrace). Collection of run-off water in macro-water harvesting structures (farm ponds, tanks, lakes etc.) having reasonably large catchment area has been proved successful in these valleyes (Das et al., 2013). However, in case of uplands and hills, construction of such structures has not been much successful owing to high seepage loss, porous soil, steep slopes etc. Thus, there is severe water scarcity of water during off-season as most of the rain water goes waste as run-off owing to hilly terrains. Under such situation rain water harvesting in agri-film lined cost-effective micro-rainwater harvesting structure (Fig. 4) is the right option (Ghosh et al., 2009). With some assistance from Government (subsidies, partial support etc.) and effort of subsistent farmers of this region, rain water harvesting in micro-water harvesting structure such as roof water harvesting can be a viable option.

Fig. 4: Rain water harvesting in *jalkund*

3. Project Implementation

The project has been implemented in seven disadvantaged districts of the North Eastern region of India except Assam. The implemented sites are located in the most backward districts (Table 1 and Fig 5) namely Upper Subansiri (Arunachal Pradesh), Tamenglong (Manipur), South Garo Hills (Meghalaya), Saiha (Mizoram), Mon (Nagaland), North Sikkim (Sikkim) and Dhalai (Tripura) with an aim to improve the livelihood of the rural poor by adopting the strategies of sustainable natural resource management, productivity and profitability enhancement, building support systems and institutions. Participatory Rural Appraisal (PRA) was conducted in all sites to understand water scenario of the locality along with other agricultural and socio-economic studies. In some sites water poverty indices were worked out by some of the partners. The water surplus and deficit periods of the years were identified based on the rainfall data and need of farmers. Accordingly, a number of

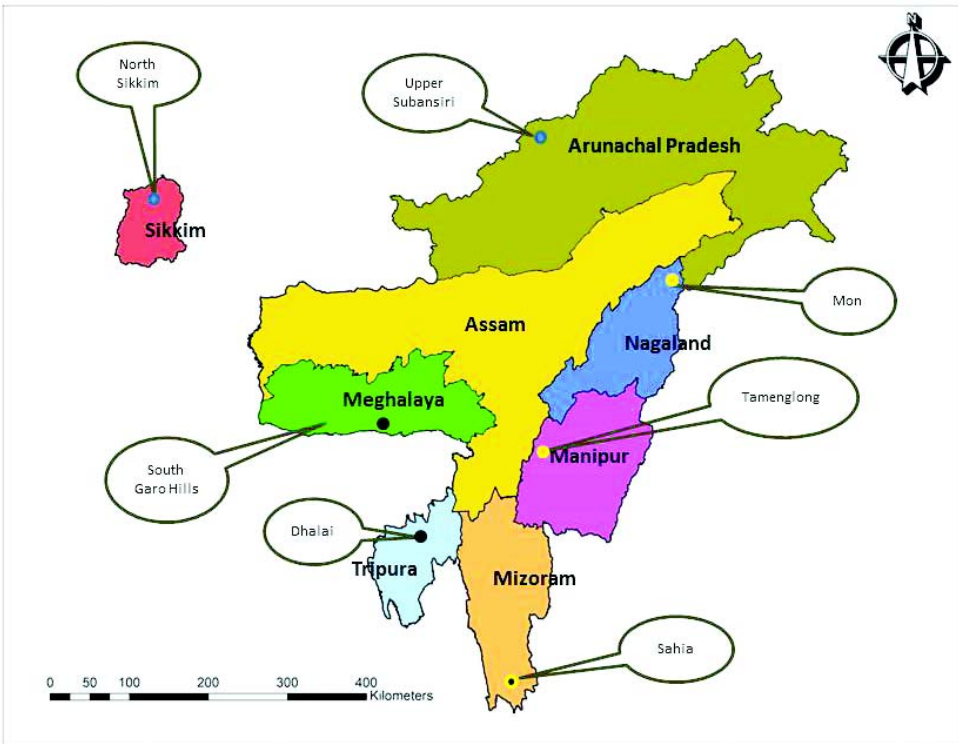


Fig. 5: Operational area of the project in North East India

water harvetsing activities such as farm ponds, jalkunds (a agri-film lined micro rain water harvesting structure), roof water harvesting, tanks, check dams and Multiple Water Use Systems/ Services (MUS), a scheme promoted by IWMI in North Sikkim and Mon to meet the multiple water needs for domestic uses in dwelling units and for small-scale enterprises on the adjoining lands or ‘homesteads’.

Table 1: Operational districts profile

District	**Altitude (m above sea level)**	**Latitude/ Longitude**	**Rainfall (mm)**	**Area (ha)**	**Major crops**	**Nos. of beneficiarie**
Mon	2414	26.00°N/ 94.00°E	2500	1,78,600	Rice, Maize	1206
Dhalai	27	24.60° N/ 92.83° E	2200	255247	Rice, Pineapple	1597
Tamenglong	1330	24.69° N/ 93.55° E	3135	4,39,100	Rice, Maize	1661
Saiha	792	22.48° N/ 92.96° E	2080	196581	Rice, Pineapple	1150
Upper Subansiri	500	27.40-28.42° N/ 93.13-94.36° E	2660	7,03,200	Rice, Maize	1413
North Sikkim	3000-4500	27.66° N/ 88.37° E	3250	4,22,600	Cardamom Rice	1364
South Garo Hills	25	25.72° N/ 90.15° E	2000	188700	Rice, Arecanut	1463
Total			-	640528	-	**9854**

4. Water Resource Development

To promote efficient water conservation and its multiple use, various types of water harvesting structures were developed as per the location, water source and purpose for which it is to be used. Farm ponds (500 m^2) were given preference in South Garo Hills and Dhalai due to low altitude, shallow water table and availability of valley lands. Two approaches were adopted for farm pond development: 1. to renovate existing unused and defunct ponds and 2. to develop new ponds for harvesting water for multiple purpose. Jalkund (a micro rain water harvesting structure of 5 m x 4 m x 1.5 m dimension and lined with PVC- agrifilm such as silpaulin 250 GSM) and tanks were given preference in hills such as North Sikkim (High altitude) (Fig. 6) and Saiha. Innovative Thai Jar, a multiple water use scheme (MUS), was popularized by IWMI in the hills of North Sikkim and Mon. Roof water harvesting mostly on community structures such as church, schools etc. were developed in mountainous, hilly and inaccessible locations of Mon and Saiha. Mini deep tube wells were developed in Dhalai, Tripura to harness ground water sources for creating irrigation facilities to cultivate crops during *rabi* season and provide resilience to rainfed farming. Check dams were developed to harvest water for crop production and improve ground water recharge in Mon and Saiha. A total 438 numbers of various kinds of water resources and structures were created in different clusters by the involvement of 10 consortia partners (Table 2).

Fig. 6: Jalkund in North Sikkim

Table 2: Clusters and number of structures

Clusters	No of water harvesting structures
Roof water harvesting	
Saiha	1
Mon	3
Total	**4**
Jalkund	
Upper Subansiri	20
South Garo Hills	2
Saiha	50
Mon	2
North Sikkim	88
Total	**162**
New pond	
Tamenlong	8
South Garo Hills	34
Mon	5
North Sikkim	20
Total	**67**
Renovated pond	
Upper Subansiri	1
Tamenlong	10
South Garo Hills	116
Saiha	2
Mon	3
Dhalai	23
Total	**155**
Check dams	
Saiha	4
Mon	1
Total	**5**
Tank and Thai jar	
Saiha	4
Mon	7
North Sikkim	3
Total	**14**
Mini deep tube well	
Dhalai	**10**
Drip and sprinkler irrigation	
Saiha	**21**
Grand Total	**438**

The dimension of the structures varied as per the location, requirement and purpose for which water is required (Table 3).

Table 3: Approximate dimension of various structures developed in different clusters

Dimension in meter (LXBXD)	ICAR-AP	ICAR-MN	KVK, Tura	ICAR-MZ	ICAR-NL	ICAR-SK	ICAR-TR	CAU, Imphal	MZU	SASRD	ICRI	COF, CAU	IWMI
Roof water harvesting	—	—	—	—	20x15 x1.5	8x4x2	—	—	—	20x15 x1.75	—	—	—
Jalkund	6x5 x1.5	—	6x4 x1.5	9x6 x1.2	—	5x4 x1.75	—	—	5x4 x1.5	8x5 x1.65	6x3 x1.8	—	—
New Pond	—	20x10 x1.5	30x20 x1.5	—	20x12 x2	10x10 x1.5	—	—	27x20 x1.5	—	—	—	—
Pond renovation	43x16 x2	20x10 x1.5	30x20 x1.5	—	20x12 x2	—	30x20 x2	—	—	21x18 x2	—	30x21 x1.6	—
Check dams	—	—	—	20x5	—	—	—	—	30x20 x2	—	—	—	—
Thai Jar	—	—	—	—	1.5	—	—	—	—	—	—	—	13m^3
Tank	—	—	—	5x3x 1.2	5x3 x3	7x5 x2.5	—	—	—	—	—	—	—
Terracing for water conservation (ha)	—	—	—	1	70	39	—	—	—	—	—	—	—
Mini deep tube well (water delivery litre/sec)	—	—	—	—	—	—	6	—	—	—	—	—	—
HDPE pipes (m)	—	—	—	—	2600	—	—	—	—	—	200	—	—
Irrigation channel (m)	—	—	—	—	360	—	—	—	—	—	—	—	—
Drip and sprinkler irrigation (ha)	—	—	—	1	—	—	—	—	—	—	0.10	—	0.10

AP- Arunachal Pradesh, MN- Manipur, MZ- Mizoram, NG- Nagaland, TR- Tripura, SK- Sikkim

4.1. *Magnitude of Water Harvested*

Through diverse structures and development of water resources, an approximately 181789 m^3 water potential has been created across 7- clusters. This amount of water is equivalent to 18,17,89,000 litre or 181.8 million litre of water (Table 4). Of the total water resource (excluding deep tube well), South Garo Hills had the maximum volume followed by Dhalai.

Table 4: Cluster wise volume of water harvested/stored for multiple purpose

Clusters	Water volume (m^3)
Upper Subansiri	2276
Tamenlong	5400
South Garo Hills	119892
Saiha	4377
Mon	6029
North Sikkim	6136
Dhalai	37680
Total	181789 m^3 or 181789000 litre or 181.8 million litre

Of the total water harvesting potential, maximum was through renovated pond (986575 m^3) and new farm ponds (136680 m^3). The renovated and new farm ponds together could harvest about 1123255 m^3 water (Fig 7). Of the total water harvested, about 85% was through renovated and 10.4 % through newly created ponds (Fig 8).

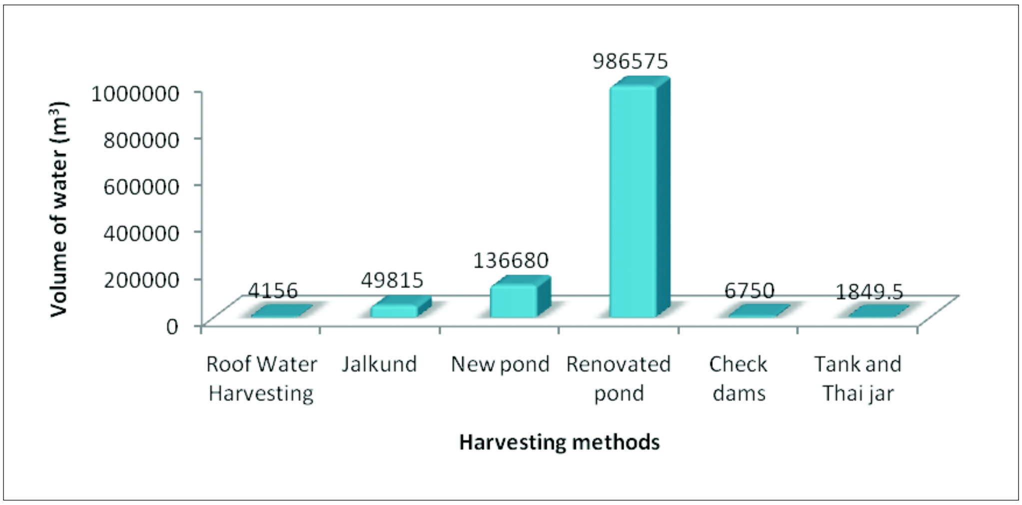


Fig. 7: Total volume of water harvested through different methods

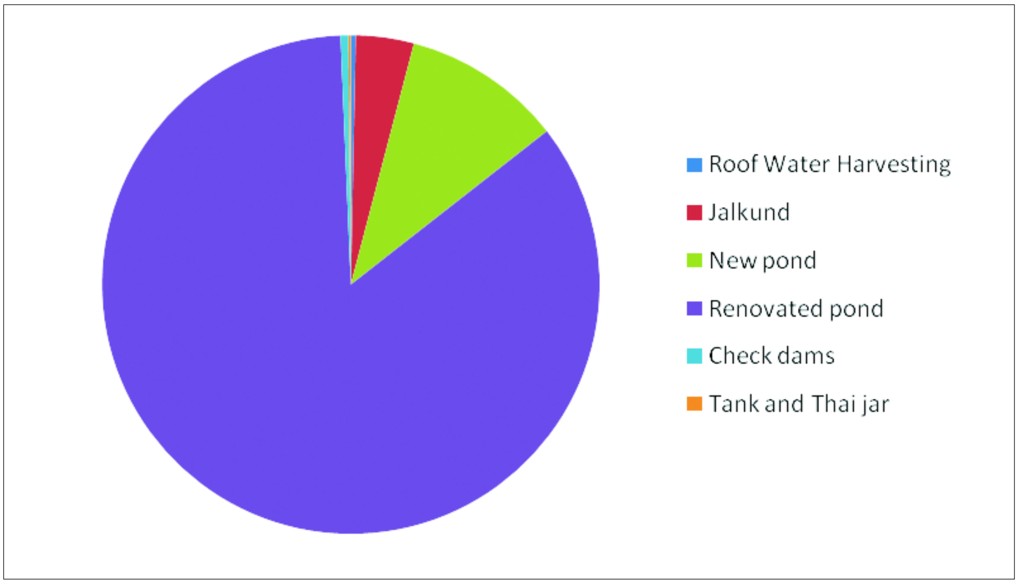


Fig. 8: Share (%) of water harvested through various means across the clusters

4.2. *Irrigation Potential Created*

The survey conducted during baseline data generation revealed that there were no organized irrigation facilities in the cluster villages. Water from ponds, streams, small rivers and rivulets were the source of life saving irrigation. Thus, more than 90% area did not have any irrigation facilities. Due to creation and renovation of water resources, about 216 ha area was brought under complete or partial irrigation in the cluster villages with 97 ha area in Dhalai alone (Fig 9). The more area coverage in Dhalai was due to installation of 10 mini deep tube wells.

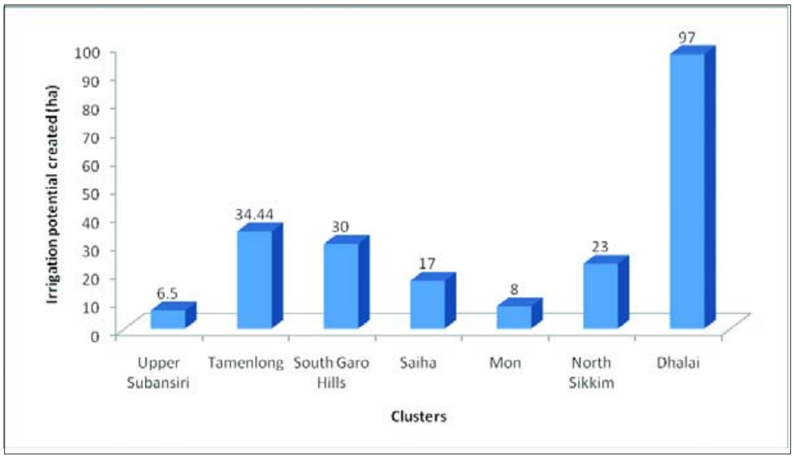


Fig. 9: Irrigation potential created in different clusters

5. Diversified Use of Water

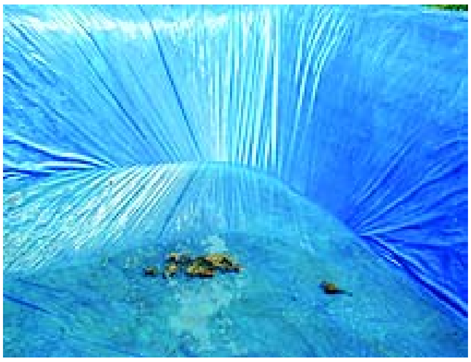
The harvested and stored water is being used by the farmers for multiple livelihood activities. The purpose varied from location to location as per the climate, need of the farmers and water availability (Table 5). Because of availability of water, farmers could cultivate crops in *rabi*/dry season and maintain their livestocks as well. Thus, availability of water diversified farming activities, enhanced productivity and employment of the farmers.

Table 5: Diversified use of harvested water in different clusters

Crops/ Livestock	**Upper Subansiri**	**Tamenlong**	**South Garo Hills**	**Saiha**	**Mon**	**North Sikkim**	**Dhalai**
Roof water harvesting	-	-	-	Tomato, coriander, cole crops, mustard	Beans, tomato, poultry, pig	-	-
Jalkund	Cabbage, cauliflower, tomato, chilli	-	Cabbage, cauliflower, mustard, tomato, chilli, poultry	Strawberry, tomato, grapes, cabbage, broccoli, knolkhol, pig	-	Cabbage, cauliflower, brocolli, potato, cardamom, lettuce	-
Farm ponds	Fish, pig, poultry, vegetables	Fish, cabbage, potato, pig	Fish, cabbage, cauliflower, mustard, tomato, onion, chilli	Fish, pig, mango, papaya maize, mustard, cabbage frenchbean	Fish, pig, vegetables	-	Fish, tomato, cucumber, potato, poultry, goat, mushroom, brinjal, chilli, pig
Check dams	-	-	-	Perennial water supply	Rice, mustard, cabbage, potato, colocasia	-	-
Tank and Thai Jar	-	-	-	-	Rice, maize, cardamom, colocasia	Vegetables, cardamom, potato, fish	-
Mini deep tube well	-	-	-	-	-	-	Mustard, potato, ashguourd, tomato, soybean
Drip irrigation	-	-	-	Strawberry	-	Vegetables	-

6. *Jalkund* - a Micro Rain Water Harvesting Structure for Hills

- Excavation of the *jalkund* or collection tank (5 m x 4 m x 1.5 m) on selected site should be completed before the onset of monsoon.
- The bed and sides of the collection tank was leveled by removing rocks, stones or other projections, which otherwise might have damaged the lining material.
- Spraying of insecticide like endosulphon 35 EC on the surface of the inner walls and the bottom, and application of aluminum phosphide (@ 1 tablet/live whole) around 5 m of the tank is recommended before the lining process to prevent rat or insect damage.
- The inner walls, including the bottom of the tank, was properly smoothened by plastering with a mixture of clay and cow dung in the ratio of 5: 1.
- After clay-plastering, about 3–5 cm thick cushioning may be provided with locally and easily available dry pineleaf or thatch grass (@ 2–3 kg/sq. m) on the walls and bottom, to avoid any kind of damage to the lining material from any sharp or conical gravel, etc.
- This was followed by laying down of 250 micron UV stabilized LDPE agri-film such as silpaulin or other durable materials.
- The agri-film sheet was laid down in the tank in such a way that it touches the bottom and walls loosely and uniformly, and stretches out to a width of about 50 cm all around the length and width of the tanks
- A 25 cm x 25 cm trench may be dug out around the tank and 25 cm outer edge of agri-film should be buried into the soil, so that the film is tightly bound from all around. At the same time, side channels along the periphery of the tank would help to divert the surface run-off and drain out excess rainwater flow. This is to minimize siltation effect in the tank by allowing only direct precipitation.
- *Jalkund* may be covered with thatch (5–8 cm thick) made of locally available bamboo and grasses or other indigenous means such as growing creepers and climber above the *jalkund*.
- A *jalkund* of above dimension can store 30,000 litre water, which can be replenished by seasonal rain whenever water is used for diversified activities by the farmers (Fig 10).



Tura- ICAR

Saiha-ICAR

Upper Subansiri-ICAR

Saiha-ICAR

North Sikkim- ICRI

North Sikkim- ICAR

Fig. 10: *Jalkunds* filled with water in different clusters

7. Farm Pond for Diversified Use

Composite fish farming with the integration of other components such as duck, pig, goat, vermi-composting and agri-horticultural crops has great scope in the cluster area to increase the water productivity/productivity of fish/animal/agricultural crops/horticultural crops etc. thereby increasing the income of the farming community.

Therefore, farm ponds were developed (renovation and construction of new ponds) for promoting multiple use in almost all the clusters with more emphasis in valley lands. Fish culture forms an integral part of the people in the selected clusters of South Garo Hills of Meghalaya, Dhalai of Tripura and Tamenglong of Manipur. It is one of the important sources of income for the farmers in this area. Most of the farmers had small size pond (500 to 600 m^2) where only fish was cultured by conventional method before implementation of the project. The ponds were mostly unutilized/underutilized and infested with aquatic weeds. The farmers were neither maintaining their fish pond scientifically which led to low productivity of fish (500-750 kg/ha) nor they were integrating fish with any other component. Hence, the income from the fish culture was meager.

A total of 155 ponds were renovated and 67 new ponds were developed under the project with active involvement of different consortia partners. Participatory approach was adopted for development of ponds. Following steps were adopted for development of pond based IFS models in cluster villages.

❇ Trainings were conducted on composite fish farming, integrated farming, water harvesting (pond construction, renovation etc.) to develop skill of the farmers.

❇ Dug out new ponds (~ 500 m^2) and renovated shallow underutilized ponds scientifically to a depth of ~ 1.5 m.

Constructed low cost pig/goat houses near the pond dykes and duck sheds over the water bodies using locally available materials like bamboo, wooden logs, thatch grass, GI sheet etc.

Distributed 2-3 piglets (Hampshire/Ghungroo), 10 ducks (Sonali), 2 goats (Black Bengal) as per demand of the community restricting to only one livestock components per household.

Duck droppings were allowed directly to fall on pond water to promote phyto-plankton growth to serve as fish feed.

Kitchen wastes, tuber crops, rice bran etc. along with limited quantity of concentrates were used as feed for pigs by the farmers.

Installed low cost vermicomposting unit on the pond dyke and paddy straw, vegetables and other crops waste, mixed weed, etc. were used for vermicomposting.

Planted banana, arecanut, guava, Assam lemon etc. on the pond dyke and on the unused area near the pond.

Vegetables like bottle gourd, lablab bean, laipatta etc. were cultivated in the pond dyke, whereas, crops like tomato, cole crops were cultivated in nearby areas.

Lime was applied based on the pH of the water and the pond was manured before stocking the fish fingerlings.

Fingerlings of catla, rohu, mrigal, silver carp, grass carp and common carp were stocked @ 10000 nos/ha in the ratio of 1.5:1.5:1.5:2:1.5:2

Rice variety Ranjit, Naveen, RC Maniphou 10 were planted under SRI in adjacent fields with 50% recommended fertilizer + pig manure 5t/ha.

During dry season, the water from pond was used for life saving irrigation of crops, vegetables and fruit plants.

7.1. *South Garo Hills, Meghalaya*

The average unit area of integrated farming system model was 1500 m^2 including pond (500 m^2), vegetables in dykes/nearby area (500 m^2), rice in adjacent low land (500 m^2) and fruits in pond dyke. Farmers intensified the utilization of pond dyke by growing vegetables on the lower layer and bottle gourd on the upper layer (bamboo made structure). Farmers net income ranged from Rs. 21, 400 (2009-10) to Rs. 37, 400 (2011-12) with B: C ratio of 2.69 to 2.83 (Table 6). The number of farm families involved in pond based integrated farming system increased consistently from 2009 to 2012 (Fig 11).

Table 6 : Economics (Rs./unit) of pond based farming system

Component	2009-10			2010-11			2011-12		
	GR	NR	B:C	GR	NR	B:C	GR	NR	B:C
Fish	11000	8000	3.66	16250	12200	4.01	17500	13000	4.37
Egg	1250	750	2.50	2260	1700	4.03	2550	1800	3.40
Pig	14000	8400	2.50	22000	12100	2.22	28000	15400	2.22
Vegetables	3950	2000	2.02	3500	2500	3.50	4100	2700	2.92
Fruits	2500	1500	2.50	4900	3500	3.50	5500	3700	3.05
Rice	1750	750	1.75	1900	900	1.90	1800	800	1.80
Total	**34450**	**21400**	**2.69**	**50810**	**32900**	**2.83**	**59450**	**37400**	**2.70**

GR – gross return, NR – net return, B:C– benefit cost ratio.

The interventions have made great impact on farm families and farming communities in terms of higher productivity of fish, pig, duck as well as agri-horticultural crops which led to higher net return and benefit cost ratio in comparison to traditional fish farming only. The livelihood of the farmers improved with the additional income from other components of fish based farming system. The pond dyke utilization component got special attention of farmers in various clusters. Farmers cultivated banana, vegetables on pond embankment and earned a good income besides meeting their own consumption requirement. Mr. Nathan Sangma, Mandangre village sold banana worth Rs.10,000 in a single year from his system

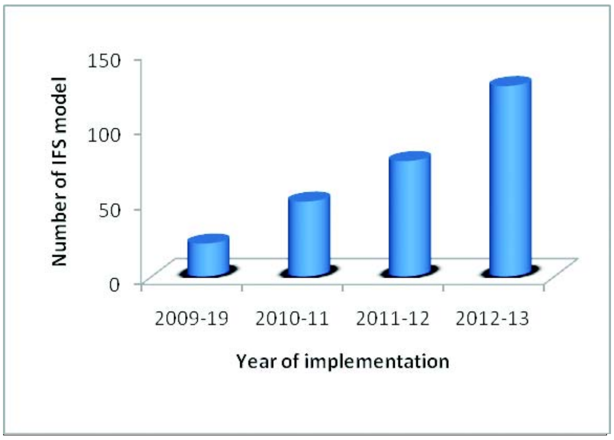


Fig. 11: Growth of IFS model under NAIP-III in Sibbari Cluster

which attracted attention of other farmers. The goat component included in IFS for the farmers (Hajong community) who are not undertaking pig husbandry started generating income. The income and employment of farm families enhanced by about 213 and 130 %, respectively over farmers practice. The people of Sibbari cluster have learned new things with integration of various components (Fig. 12) and doing things differently than they used to do earlier.

Fig. 12: The site before and after development of pond based IFS in South Grao Hills

7.2. *Dhalai, Tripura*

College of Fisheries (COF), Central Agricultural University (CAU) undertook diversified fish based IFS activity for enhancing productivity and livelihood of farmers in Dhalai, Tripura (Table 7). A total of 210 farmers were involved in this activity who were provided with technological backstopping for fish based IFS including renovation and construction of new ponds. About 37 ha area was brought under various fish based IFS by the COF, CAU, Lembucherra, Tripura (Fig 13-15).

ICAR, Tripura Centre also developed fish based IFS models in Tripura with integration of aquaculture, mushroom cultivation and pond dyke utilization mainly for vegetable cultivation. High-tech fish farming concept (use of aerator, improved fishing kits etc.) was introduced for the first time in Dhalai, Tripura by the centre. Renovation of existing underutilized ponds and construction of need based new ponds were undertaken during 2007-09 for developing diversified fish based IFS models. About 13 ha area was covered

Table 7: Diversified fish based IFS with farm pond as central intervention in Dhalai, Tripura (COF, CAU)

Technology intervention	Farmers involved (Numbers)				Area Covered (ha)		
	Balaram	Bagmara	Maracherra	Total	Water	Land	Total
Composite fish culture	50	32	63	145	13.90	7.15	21.05
Fish- horti (veg+ fruit)- farming	10	6	5	21	2.10	4.17	6.27
Fish-rice-veg-fruit farming	9	2	2	13	1.05	2.01	3.06
Fish-goat-fruit farming	5	5	5	15	2.05	1.85	3.90
Fish-mushroom farming	6	5	5	16	1.85	1.04	2.89
Total	80	50	80	210	20.95	16.22	37.17

Fig. 13: A farm pond before and after renovation in Dhalai, Tripura

Fig. 14: Fish +fruit + veg + pig farming

Fig. 15: Fish +rice +fruit farming

with the involvement of 87 farmers (Fig 16). Ponds were dried before the onset of monsoon and all sorts of unwanted fishes were removed. Lime was applied @ 500 kg /ha. After rain water harvest, ponds were fertilized with cattle manure @ 10000 kg/ha, urea @ 12.5 kg/ha and SSP @ 50 kg/ha. After seven days of fertilization, the fingerlings of Indian major carps, rohu (*Labeo rohita*), catla (*Catla catla*) and mrigal (*Cirrhinus mrigala*), procured from the state Govt. farm and *Puntius sophore*, procured from ICAR, Lembucherra were stocked. Pond dykes were utilized for arecanut, ginger, banana and beans, which gave an additional average income of Rs. 1000/farmer. The overall productivity of fish increased by about 67 % over farmers practice with a net income of Rs. 1.78 lakh/ha.

Fig. 16: Hi-tech fish farming in Dhalai

In Fish + Fruit + Rice + MPTs (multipurpsoe tree species) models, teak (*Tectona grandis*) and Gamhar (*Gamelina arborea*), banana, pineapple, mango, arecanut, lemon, improved rice (Naveen, Gomati) plating materails were provided in addition to scientific fish farming. Cabbage, okra, ginger and black pepper were also integrated with the model (Fig 17). These models have completely changed the land use scenario in the locality with year round income and employment to the small and marginal farmers. The agroforestry

Fig. 17: Fish + Fruit + Rice + MPTs in Dhalai, Tripura

based farming system model was introduced to 68 farmers of Dhalai district, Tripura. The net income from crop component was Rs. 14,150 and that of from pig was Rs. 6,200, thereby, giving a total net income of Rs. 20,950 in a single year from a piece of 0.48 ha land area. There was effective utilization of land and various waste materials for maintaining soil health.

Dhalai Zila Parishad, Dhalai demonstrated sucessfuly Agri + Horti + Piggery + Fishery model (Fig 18 and 19). Integrated Farming System on unused *tilla* land (small hillocks with gentle slope and good soil depth) of Dhalai. The *tilla* lands in the selected clusters (Balaram and Maracherra) of Dhalai district of Tripura are suitable for cultivating agricultural as well as horticultural crops. But, they were left fallow by the farmers and the land generally remained infested with weeds and unproductive shrubs. Fish culture is also a common practice among the farmers of Dhalai district of Tripura where they would culture fishes in small size ponds of 500-600 m^2 and most of the ponds are constructed in plain areas, mostly near the paddy fields. But, fish culture is not practiced near *tilla* lands which may be due to scarcity of water or the water source is not available. However, there is ample scope for integrating crops with aquaculture and animal husbandry in these *tilla* lands by conserving rain water during monsoon season and using it for irrigating crops and fish culture.

Fig. 18: IFS site before intervention

Fig. 19: IFS site after intervention

Integrated fish + fruit+ pig + agriculture farming system is a new concept to the farmers in the selected clusters of Dhalai district, hence, steps were taken to create awareness and to promote integrated farming system among the farmers.

- Various training programmes were organized on agri- and horticultural crops cultivation, animal husbandry and composite fish culture.
- High yielding varieties of agri and horti crops were supplied to the farmers.
- Fish fingerlings of Indian Major Carps (IMCs) and exotic carps were distributed to the farmers.
- Arecanut saplings were supplied for planting along the boundary of the land.
- Pig sheds were constructed on the pond dyke and cross bred pigs were opted for rearing.

The gross income of two farmers i.e., Mr. Ramendra Marak and Mr. Durga Marak was Rs. 4,00,235 and Rs. 3,33,625/- from 3 and 2.5 ha land area, respectively. The two farmers are now happy with this IFS and are able to get year round income and employment.

7.3. *Tamenglong, Manipur*

ICAR, Manipur Centre adopted 531 beneficiaries from the four cluster villages and stocked rohu, catla, mrigal, silver carp, common carp and grass carp with a species composition of 1:1:1:2.5:2:2.5 in 900 m^3 pond size. The total water area covered was 15.78 ha. Old ponds were renovated and new ponds were constructed for fishery as well as for water harvesting. Thirteen (13) new ponds were developed with average dimension of 40 x 28 x 1.5 with a total area of about 2.2 ha. Monthly average growth rate of 19.7, 33.9, 34.0, 36.4, 38.4, 118.0 g were attained for rohu, catla, mrigal, silver carp, common carp and grass carp, respectively. Common carp, grass carp and silver carp attained body weight of 812 g ± 10 g and rohu, catla and mrigal also reached a size of 511 ± 10 g, 6 months after stocking. Pig, poultry, rice, fruits and vegetables were integrated with the aquaculture (Fig 20).

Fig. 20: Water harvesting in farm ponds for diversified use at Tamenglong, Manipur

7.4. *Mon, Nagaland*

ICAR Nagaland Centre and SASRD, Medziphema developed 8 farm ponds in two cluster villages and demonstrated diversified fish based farming system comprising piggery, poultry, vegetables, tuber crops etc. Harvested water was used for irrigating the crops particularly during the lean season and for fishery and livestock (pig/poultry) consumption. ICAR Nagaland centre constructed two water harvesting structures (20.0 m x 12.0 m and 20.50 m x 15.80 m) for integrated fish farming in Lampong Sheanghah, Mon (Fig 21)

Fig. 21: Water harvesting ponds for diversified use in Mon, Nagaland

7.5. ***Upper Subansiri, Arunachal Pradesh***

Mrs. Yalom Lida of Lida village in Gusar circle of Daporijo district, Arunachal Pradesh had land area of 1.2 ha under *jhum* and her earnings were just enough to feed her family. Considering the potentiality of fish farming she developed a fish unit on her farm, but the pond remained underutilized.

Under NAIP intervention, it was targeted to convert her *jhum* land to settled cultivation by integrating livestock and crops with fish farming. Before starting the IFS activity, she was provided trainings at ICAR, Basar. After getting her exposure to practical trainings and demonstrations on IFS, she gained confidence and adopted the technology. The pond was renovated during dry season and some terraces were constructed at mid hill slopes, while keeping forest area intact on top of the hills. From the forest area, water was diverted to her field by forming ditches. Low cost pig shed and poultry units were constructed on the pond dyke (Fig 22) and the poultry droppings and pig shed washing were diverted to fish pond to promote growth of zoo plankton and phyto-plankton to serve as fish feed. Additional pig excreta were collected in a nearby pit and composted for manuring vegetables. Similarly, the waste of vegetables was used as feed for the pig. Damaged and low quality maize seeds were used as feed for poultry. Farmers also brought their kitchen waste for feeding pigs and poultry.

The total returns from her traditional way of cultivation before NAIP intervention was Rs. 13,896/- only. However, after integrating the various components she could increase her production and productivity of cereals by 2.71t/ha, vegetables 5.25 t/ha and started earning Rs. 73, 800/- from the above said area and components. She mostly earned the said amount from livestock and fish. By seeing the performance and profit of animal components she is now converting her agricultural land to fish pond.

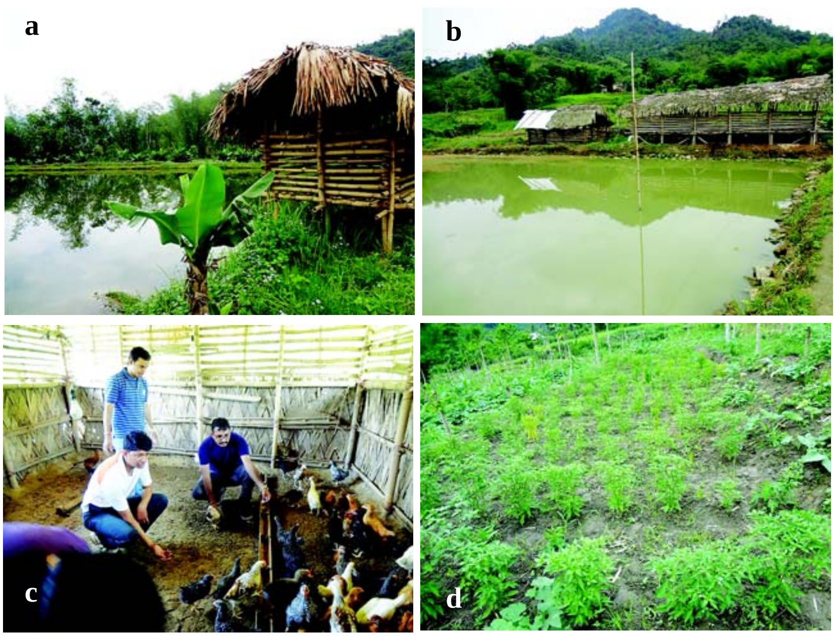


Fig. 22: a.Integration of fruit-fish–pig, b. Integration of fish-pig-poultry, c. Monitoring of poultry unit and d. Integration of crop

8. Rooftop Water Harvesting- a Community Approach

Rooftop rain water harvesting is the technique through which rain water is captured from the roof catchments and stored in reservoirs. Harvested rain water can be stored in a underground reservoir by adopting artificial recharge techniques to meet the household needs. So, a rooftop rainwater harvesting structure was constructed (Fig 23) at the church of the study area (Lampong Sheanghah, Village) which gives benefit to about 50 households under the project. The total water volume available was 926.37 m^3 with investment of about Rs. 8,04,000. Considering lifespan of the structure for about 15 years, the cost of water harvesting works to merely 6 paise/litre water.

Dimensions of the Church

Length	=	28.2	m
Breadth	=	14.6	m
Rainfall	=	2.5	m
Runoff Coefficient	=	0.9	
Water volume available	=	926.37	m^3
(in litre)		926370	L

Design (Inside) Dimensions of Tank

Design volume	=	204	m^3
Design length	=	17.0	m
Design width	=	4.0	m
Design Height	=	3.0	m
Height underground	=	2.0	m
Wall thickness	=	12.5	cm
Material loss (10%)	=	0.1	

Dimensions of Excavation

Length	=	17.5	m
Width	=	4.5	m
Height	=	2.5	m

Fig. 23: Roof water harvesting on church building at Mon

9. Modified Thai Jar- an Innovative Approach

A low cost modified Thai Jar (MTJ) was constructed at the project site with a capacity of 1570.38 litres. Modified Thai Jars (Fig 24) are usually available in three different sizes, *viz.*, 1000, 1500, and 3000 litres capacities, which are cheaper than the commercial plastic and masonry tanks and easy to construct. It is sturdy, easy to maintain and can withstand heat stress and takes only 3-5 days to construct by a local trained mason.

Fig. 24: Modified Tahai-Jar installed at Mon, Nagaland

However, these capacities can be altered by modifying the design of the frame. The design details of these MTJ structures are provided by Adhikary (2009). The construction details of this structure are given as below:

i. A stone masonry platform (Fig 25) is constructed on a leveled land of the hill terrace.
ii. The frame of the MTJ is covered tightly with wet jute bags on which 17 mm plastering is done with 1:3 cement and sand mix.
iii. Above this plaster, the 8# gabion wires are fixed.
iv. The chicken wire mesh is covered on the gabion wire which is tied with the binding wire.
v. Then, another 17 mm plastering is done on the chicken wire mesh with 1:3 cement and sand mix.
vi. On the plaster, a ferro-cement (white cement) coating is made on the surface by means of a painting brush. A similar white cement washing is also done on the inner surface of the jar after removing the frame. Note that water is applied on this structure for 10-15 days to keep the plaster moist to avoid any heat stress.
vii. A proper hole size (25 – 32 mm diameter depending on the capacity of the tank) is kept at the bottom of the structure for pipe fittings.
viii. The top opening of the MTJ can be covered with a plate made up of reinforced cement concrete (RCC).

Construction cost of modified Thai jar (MTJ) is illustrated in Table 8.

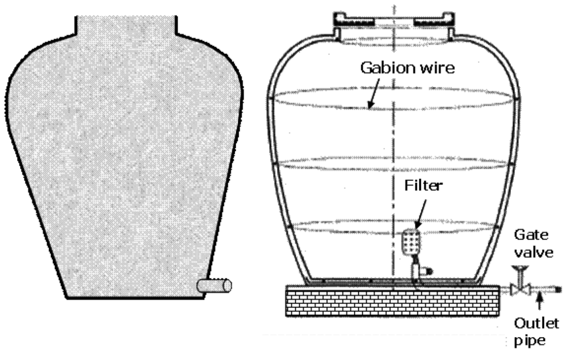


Fig. 23: Modified Thai jar (adopted from Adhikary, 2009)

Table 8: Details of the construction cost of modified Thai jar

Material	Unit	Rate* (Rs.)	Modified Thai Jar capacity (Litres)					
			1000		1500		3000	
			Quantity	Amount (Rs.)	Quantity	Amount (Rs.)	Quantity	Amount (Rs.)
Portland Cement	(50 kg) bag	350	2	700	4.00	1400	6	2100
Ferro-cement	kg	25	2	50	3.00	75	4	100
7 mm steel rod	kg	43	2	86	3.00	129	5	215
8# Gabion wire	Kg	80	1.5	120	2.00	160	4	320
Chicken wire mesh	m^2	160	1	160	2.00	320	4	640
Binding wire	kg	65	1.5	98	2.50	163	4	260
Pipe fittings	Set	650	1	650	1	650	1	650
Filter	No.	500	1	500	1	500	1	500
Plastic / Polyethylene sheet	m^2	20	0.35	7	0.55	11	1	20
Jute bag	m^2	30	2	60	3.00	90	5.5	165
Stone	ft^3	7	2	14	3.00	21	4	28
Sand	ft^3	35	14	490	15.00	525	20	700
Gravel	ft^3	35	3	105	4.00	140	6	210
Mason wage	Man day	300	3	900	4	1200	7	2100
Unskilled labour	Man-day	150	4	600	4	600	9	1350
Supporting tools	Lump sum	-	-	500	-	500	-	500
Miscellaneous	Lump sum	-	-	500	-	500	-	500
Total				**5540**		**6984**		**10358**

* The rates are as per the local market rates at *Dimapur* (Nagaland) in 2009. Source: Adhikary (2009).

Considering the life span of the system as 15 years, calculated system capacity for storing water for lean period is 82.35 thousand liters and average unit cost of water harvesting is Rs 0.47/litre. MTJ is demonstrated by IWMI in collaboration with ICAR at Mon, Nagaland.

10. Multiple-use Water Schemes

In the northeastern hilly region of India and Nepal, women are among the main beneficaries of Multiple-Use water Schemes (MUS). The technology is being promoted by IWMI in collaboration with ICAR mainly in North Sikkim and Mon in Nagaland.

The MUS are providing more controlled and reliable water supplies for household needs and more productive agricultural activities in the northeastern hilly regions of India and Nepal. In this region, only 5% of the existing water resources are used for economic activities. A surfeit of water wreaks havoc in the rainy season, while households suffer acute water shortages in the dry season. The impact of MUS on household income and the status of women have been significant.

10.1. *Management innovation*

Farmers would like to grow more vegetables and fruit trees but changing farming practices requires reliable supplies of water. What smallholder farmers need is a water supply system that provides water for both domestic needs and high-value agricultural crop production, including livestock. Such a system needs to be flexible so that householders can switch from domestic to productive use to match seasonal demands. It has to be simple with low maintenance costs and it must ensure equitable access. Such systems are called MUS (Fig 26).

Fig. 26: Meeting domestic water needs is the first priority of MUS

10.2. *Matching MUS design with user needs*

The basic designs for MUS are based on: ground water/lake water lifting and distribution; rainwater collection and distribution; spring water distributed by gravity system; and stream/river water supply after treatment (Fig 27). Most MUS are designed to cover 10 to 40 households. In some cases, up to 80 households have been provided service from MUS. Design of an MUS accords first priority to drinking water and domestic use. This is in line with the government's policy on water resources development. The design criteria assume 45 liters per person per day for domestic use and 400-600 liters per household for productive use. The final design is decided by technicians in consultation with community users based on their local knowledge and stated needs.

Working with local authorities, researchers from the International Water Management Institute (IWMI) and International Development Enterprises (IDE) installed MUS in the hilly regions of Nepal and organized cross-learning programs between the Indian and Nepalese researchers, policymakers and farmers. A water-poverty mapping technique helped identify the best areas to target in the study villages in Nagaland and Sikkim states of India.

Fig. 27: Jars and ferro-cement lined tanks for intermediate water storage, and is an important element of MUS

An evaluation of the schemes installed showed that they met the key criteria with the added benefit of low initial investment costs (approximately USD 200 per household) and short cost-recovery periods. With MUS, households can earn an additional annual income of about USD 190 through the sale of surplus produce, which means that the system has a payback period of only one year. The MUS system installed in Mon gave benefit to community for irrigation to crops and other multiple uses (Fig 28).

Fig. 28: A simple, low-cost drip system in Mon, Nagaland

11. Tank for Harvesting Water from Perennial Streams

Seven numbers of water harvesting tanks (Fig 29) were constructed at the project site in Mon district (Lampong Sheanghah village) to collect base flow of a perennial stream. During the survey, it was observed that the village had two perennial streams. Hence, a thought was given to capitalize on the water resource in order to improve upon the livelihood of the stakeholders. Two hillocks were selected for implementation of the activity in three-tier system. For restoration of the water source, agroforestry block was established on both the hill tops followed by horticulture in the middle of the hillock and terracing in the lower part of the hillocks. Water was diverted from the stream through irrigation channel, pipes and conserved in six nos. of water harvesting tanks (size of each tank = 5.0 m × 3.0 m × 3.0 m) which was used for irrigating the crops particularly during the lean season and for fishery and livestock consumption. This small intervention had helped to maintain the perennial flow of water. The stored water in these 6 tanks is used for facilitating lifesaving irrigation to the crops during lean period and to increase the cropping intensity of the village, thus leading to sustainable agricultural development of this village.

Four more numbers of such tanks were constructed at Saiha, Mizoram for creation of irrigation facilities.

Fig. 29: Water harvesting tanks in seires at Mon, Nagaland

12. Check Dam

Check dam measuring 28.5 x 4.5 x 6.5 meter = 833.625 m^3 with boulders pitching was constructed on Tuimei Village, Mon (Fig 30) by ICAR observing the fact that most of the water was flowing through a nalah (gutter) into a tributary as making it inaccessible for the cultivation. Through this check dam construction the farmers are ensured with irrigation facilities even during lean period for growing high value vegetable crops like strawberry, cabbage, cauliflower, knol-khol, potato etc. Four check dam were also developed in Saiha, Mizoram by the ICAR, Mizoram Centre.

Fig. 30 : Check dam developed in Mon, Nagaland

13. Mini Deep Tube well

To create irrigation facilities for cultivation of rabi crops and irrigation during drought conditions for climate resilience, deep tubewells were installed (Fig 31) in Dhalai, Tripura. The delivery capacity of mini tube wells are estimated at about 6 litre/second. The water is being used for cultivation of vegetables, rabi crops, lentil, toria etc. in Dhalai district, Tripura.

Fig. 31: Mini deep tubewell in operation in farmers field, Dhalai, Tripura

14. Efficient Water Conveyance

In rainfed agriculture rain water is the ultimate source of water for multiple purposes. Thus, harvested water should be economically used to enhance water use efficiency. The conveyance losses should be minimized to get more water for productive purposes. Low cost drip irrigation and RCC (pucca) irrigation channels were promoted for efficient utilization of scarce natural resource.

14.1. *Low-cost drip irrigation system*

The conventional drip systems are suitable for most vegetable, horticultural and other high value crops but generally are costly and technology intensive and do not find favour with small-holder farmers who have tiny plot sizes located in remote areas. Gravity based low cost drip irrigation kits are appropriate for small land holdings and financially affordable. The main components of the system include: head tank, outlet set, mainline set, drip-pipe set and the filters.

It is recommended to put up a fence around the crop field to prevent damage and theft and keep away the stray animals. Irrigation requirements shall vary with the season and crop. It is recommended to irrigate daily in the first month of the growing season and may be extended to up to 3 days at later stages. For closely spaced crops, low cost mini-/ micro-sprinklers are available in a pre-assembled form with mainline sub-set and a riser sub-set. A low cost gravity fed drip irrigation unit have been installed (Fig. 32) by the ICAR, Sikkim Centre in North Sikkim for irrigation of cardamom and vegetable crops. Rain water harvested in *jalkunds* is used for feeding the drip system.

Fig. 32: Low cost drip irrigation system installed in North Sikkim, Sikkim

14.2. *Irrigation channel*

Two numbers of irrigation channels (180 m length) have been constructed (Fig 33) to divert water from the perennial hill spring for terraced wet rice cultivation (*Panikheti*). Soil moisture stress in the post-rainy season is the main constraint for winter cultivation at the project site. To ensure water availability during the lean season, action had been taken to harvest rainwater as well as surface runoff from hill slopes through construction of two water harvesting structures of 20.0 m × 120.0 m and 20.50 m × 15.80 m size and it has been integrated with fish farming.

Fig. 33: Irrigation channels developed in Mon, Nagaland

15. Economics of Water Harvesting

Unit cost of harvested water under different interventions as estimated for Nagaland conditions has been presented in Table 9. Considering the life span of the system as 15 yrs, calculated system capacity for storing water for lean period is 105.75 thousand litre and average unit cost of water harvesting is Rs. 0.47/litre. Total area of fish ponds for fish culture is 858.4 m^2 and capacity of fish ponds to conserve water is 1244 thousand litre. Average unit cost of water harvesting in fish ponds was calculated as Rs. 0.01/litre.

Table 9: Cost of water harvesting- comparative studies in Mon

Structure	Dimension			Effective volume of water stored (m^3)	System cost (Rs. /m^3)	Unit cost (Rs./litre)
	L (m)	B (m)	H (m)			
Rooftop water harvesting	8.5	3.5	2.2	65.45	4.29	0.44
Spring water harvesting-1	3.6	2.5	1.7	15.30	1.36	0.59
Spring water harvesting-2	4.00	3.00	1.20	14.40		
Spring water harvesting-3	3.00	2.00	1.00	6.00		
Spring water harvesting-4	2.00	1.50	1.00	3.00		
Modified Thai Jar	*	*	*	1.60	0.09	0.38
Total				**105.75**	**5.74**	**0.47**
Fish pond-1 (constructed)	23.00	7.50	1.80	310.50	0.56	0.01
Fish pond-2 (constructed)	20.00	12.00	1.30	312.00	0.77	0.00
Fish pond-3 (constructed)	20.50	15.80	1.20	388.68		
Fish pond-4 (renovated)	12.00	6.00	2.40	172.80	0.08	0.00
Fish pond-5 (renovated)	10.00	5.00	1.20	60.00	0.15	0.02
Total	1243.98	1.545	0.01			

The cost of water harvesting and structure development taking averages of all the sites ranges from Rs. 10,000/Thai-Jar to as high as Rs. 20,00,00 for check dam. The unit cost of mini deep tube well was Rs. 1,50,000 (Table 10).

Table 10: Average cost involved per unit in construction of different water storage structures (across clusters)

Structures	Avg. cost/unit (Rs)
Roof Water Harvesting	84,929
Jalkund	17,500
New pond	62,000
Renovated pond	10,610
Check dams	2,00,000
Tank	2,46,023
Thai jar	10,000
HDPE pipes	16,608
Mini deep tube well	1,50,000

16. Innovations

i) Renovations and construction of a total of 222 ponds were undertaken in a participatory mode involving mostly local people for development of water resource within cluster villages.

ii) Innovative Modified Thai Jar concept was introduced for the first time in the region through the project.

iii) Community facilities such as Church roof was used for harvesting water for the community to meet domestic and multiple needs.

iv) Terracing for wet rice cultivation (*Panikheti*) was introduced in the cluster village in Mon and 210 nos. of terraces were made covering an area of 7.5 ha with a net cultivable area of 5.73 ha resulted sustainable increase in yield of paddy and other crop.

v) Mini deep tube wells were installed for harnessing ground water resource to increase irrigated area, cropping intensity and provide resilience against climatic aberrations.

vi) About 181789 m^3 or 181.8 million litre water was harvested through various means and 216 ha area was brought under complete or partial irrigation.

vii) Multiple use of harvested and stored water was promoted through site specific integration of crop-livestocks-fishery-vegetables-fruits-MPTs for enhancing crop and water productivity.

viii) For the first time, Research Institute, Universities, Panchayat, NGOs including international organizations (IWMI, ILRI) worked together for a common goal of improving livelihood of small and marginal farmers through location specific interventions such as water resource development and management.

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