Rain water harvesting and its diversified uses for sustainable livelihood support in NEH region of India

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Introduction

Water is the most indispensable natural resource available to mankind. Of all the planet's renewable resources, water has a unique place. It is essential for sustaining all forms of life, food production, economic development, and for general well being. It is impossible to substitute for most of its uses, difficult to de-pollute, expensive to transport, and it is truly a unique gift to mankind from nature. Water is also one of the most manageable of the natural resources as it is capable of diversion, transport, storage and recycling. All these properties impart to water its great utility for human beings. Over the years, the need for preserving and maintaining water resources has been made at various scientific events and the subject got main impetus.

The north eastern region comprising the states of Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Sikkim lies between 20 81' and 29 30'N latitudes and 89 40' and 97 50' E longitudes. The region has an area of 26, 2240 Km^2, of which 72.6 per cent is hilly. The region is characterized by diverse agro-climatic and geographical situations. Annual average rainfall of the region is 2450 mm accounting for 10% (42.0 Mha m) of the country's total water of 420 Mha m. In spite of its rich water resources base, the region has not progressed to the expected level. It can till date utilize only less than 1% of water resource (0.88 Mha m of water). Remaining more than 41.0 Mha m water is lost annually due to its major portion being hilly. This also depletes the soil fertility and imbalance the ecology of the region.

The practice of rainwater harvesting in ponds and reusing the stored water for life saving irrigation of crops and also for domestic purpose is prevalent in India since ancient times. One can find efficient management of water in the region in traditional farming systems like 'Zabo system' of Nagaland and Bamboo drip irrigation of Meghalaya and rice + fish farming in Apatani valley of Arunachal Pradesh. Almost all the kingdoms had ponds, lakes etc around their palaces for security, irrigation, fishery as well as for recreation. Its almost a common scene in the states of Tripura, Manipur, Assam, and other states especially in plains that every households have at least one farm pond. Water from such ponds are life line for their day to day activities like domestic uses, cleaning, small scale irrigation some cases even for drinking.

Economy of NE states is mainly rural and agrarian with its about 80% population depend agriculture and allied industries for their livelihood. The agricultural system is predominately traditional and can be broadly classified in two distinct types, viz; settled farming practiced in the plains, valleys, foot hills and terraced slopes, and shifting cultivation practiced in the hill slopes. The nature has been generous in bestowing the region with bounty of water resources in form of rainwater but in the absence of scientific management of this vital resources from rain and consequent surface flow and underground storages, the water resources goes waste and creates havoc downstream. Much of the enormous water resources remain unutilized due to absence of proper water resource planning and scientific management. The efficient utilization and management of available rainwater is the core issue if the cropping intensity and production is to be enhanced. Rainwater harvesting and its recycling through the micro irrigation systems may revolutionize the regions agriculture by enhancing the production, productivity and quality of produce.

Water resources in NE region

Water is one of the key resources of North Eastern region. North East is endowed with bounty of water resources accounting for about 40% of the total water resources in the country. The tentative assessment of this dynamic resource in the North East India is about 60 million hectare-meter. Unfortunately, this vast potential has not been exploited as yet. The region experiences a paradoxical hydro climatic environment and represents a typical hydrological entity in the world atlas. Endowed with huge water resources potential, it has also the worst water resource problems rendering untold sufferings to millions every year. The water budget of the N-E states is given in table 1.

Table 1 Annual Water Budget of North Eastern States

Item		Arunachal	Assam	Manipur	Meghalaya	Mizoram	Nagaland	Tripura	Total
GA (km^2)		83740	78440	22330	22430	21080	16580	10490	255090
Avg. Rainfall	mm	2930	2336	1972	2253	2535	1986	2516	2493
	MCM	245358	183236	44035	50535	53438	32928	26393	635923
E.T. Losses	mm	905 (31%)	873 (37%)	864 (43%)	807 (36%)	976 (39%)	872 (44%)	857 (34%)	883 (35.5%)
	MCM	75785	68478	18891	18101	20574	14458	8990	225267
Recharge to ground water	mm	205 (7%)	234 (10%)	118 (6%)	113 (5%)	128 (5%)	99 (5%)	151 (6%)	183 (7.3%)
	MCM	17168	18355	2635	2535	2698	1641	1584	46716
Surface water runoff	mm	1820 (62%)	1229 (53%)	1008 (51%)	1313 (59%)	1431 (56%)	1015 (51%)	1508 (60%)	1426 (57.2%)
	MCM	152405	96403	22509	29751	30166	16829	15819	363582

GA -Geographical area.

The region experiences excessive rainfall and high floods during monsoon months and also suffer from acute shortage of even drinking, water in many areas due to lack of management. The basic issue under lying the water resources problems, are recurring floods, drainage congestion, soil erosion, human influence on environment and so on and calls for its integrated use for drinking, irrigation, generation of hydropower, navigation, pisciculture, recreation etc. Since most of the areas in the North East region have been declared as restrict area, even the scholars have no access to elementary physiographic or geomorphological datas to make proper inventory. Per capita fresh water availability in the Himalayan Region is evaluated to range from 1757 m^3/yr. in Indus, 1473 m^3/yr. in Ganga, 18417m^3 in Brahmaputra with an all India average of 2214 m^3/yr.

Rainfall Pattern in NE India

The North Eastern Region is the highest rainfall zone of the country and enjoys typical monsoon climate with variants ranging from tropical to temperate conditions. The rapid changes in topography result in climatic changes within short distances. The foothill plains, sheltered valleys and the mountain ranges are however marked with climatic contrasts and as such any generalization regarding the climate of the whole region will be hardly apt for its micro zone. The rains are of long duration and occur mostly between March and October. During March and April the rainfall is sporadic but it is steady and heavy or very heavy during May and October. Annual rainfall in northeastern portion of Arunachal Pradesh, north west of Dihang and north east of Bomdila is about 4000 mm, but gets reduced in southern western district. The rainfall increases in Khasi Jaintia and Garo hills (over 10,000 mm) but drop down in the north of Brahmaputra valley (about 2000 mm). The central parts of Meghalaya are famous for phenomenonaly high rainfall experience there with, average annual rainfall exceeding 2700 mm (Anonymous, 2004). The northern and adjoining central area is in the rain shadow region having rainfall varying 4000 to 2000 mm. The Imphal, Lumding region which partly lies in the rain shadow of the Mikir hill range records lowest rainfall (1000 -2000 mm).

The rainfall is mostly associated with storms and is generally heavy with average number of days having 25 mm or more rainfall are over 100 except southern Meghalaya where there is an average of two days in three. Daily rainfall with a ten year return period ranges from 150 to 225 mm over most of the region and that over 500 mm can be expected once in a year (Sharma 1996). The pre monsoon rainfall (March-May) accounts for 25% of annual rainfall while bulk of the rainfall (67%) occurs during June -Sept which constituted the monsoon season. The monsoon withdraws from the North East almost abruptly in the last week of Sept or first week of Oct. and post monsoon rainfall (Oct -Dec.) and winter monsoonal rainfall are scanty limiting the scope for agricultural activities during the rabi season (Satapathy and Dutta., 2002). The annual variations in rainfall is very wide from one place to another and its duration is most uncertain. The distribution of rainfall in various North Eastern states is given in table 4 and the monthly rainfall pattern in Meghalaya is depicted in Fig.1.

Table 2 Distribution of Monthly Rainfall (mm) in North Eastern Region

Month	**Assam** (Guwahati)	**Arunachal Pradesh** (Basar)	**Manipur** (Imphal)	**Meghalaya** (Barapani)	**Mizoram** (Kolasib)	**Nagaland** (Jharna pani)	**Tripura** **(**Lembu cherra)
Jan	18.4	26.5	9.7	0.0	7.5	24.6	10.0
Feb	38.4	117.5	416.7	16.6	18.5	50.0	51.2
Mar	81.5	139.0	168.8	199.0	65.5	102.0	290.4
Apr	212.6	229.0	213.4	238.0	84.0	119.9	116.3
May	237.6	234.5	268.4	299.8	88.5	117.6	199.0
Jun	484.3	484.0	418.8	193.8	64.0	342.8	192.4
Jul	446.8	336.7	225.3	158.3	441.0	202.3	238.6
Aug	395.9	133.5	297.9	361.0	157.0	143.4	243.8
Sep	317.1	213.0	104.0	356.5	157.0	79.5	84.7
Oct	144.1	181.6	34.8	342.8	55.0	99.2	110.6
Nov	30.8	11.2	13.0	291.2	1.0	13.0	51.2
Dec	8.9	18.5	0.0	0.0	0.0	0.0	0.0
Total	**2416.4**	**2124.5**	**2170.1**	**2459.0**	**1762.0**	**1294.3**	**1588.2**

Based on the Annual Report (1993), I.C.A.R. Research Complex for N.E.H. Region, Umiam.

The figure shows that the rainfall is skewed and ill distributed. Delay in pre monsoon showers and delay in onset of monsoon not only lead to serious dislocations but also cause great damage to the crops. On the other hand, the excessive precipitation causes very rapid runoff on steep slopes resulting heavy soil loss as well as siltation of riverbed and catastrophic flood hazards in plains and also dangerous land slides at excessive leaching of losses causing poor base status and soil acidity leading to detrimental environment for nutrient availability of common agricultural crops.

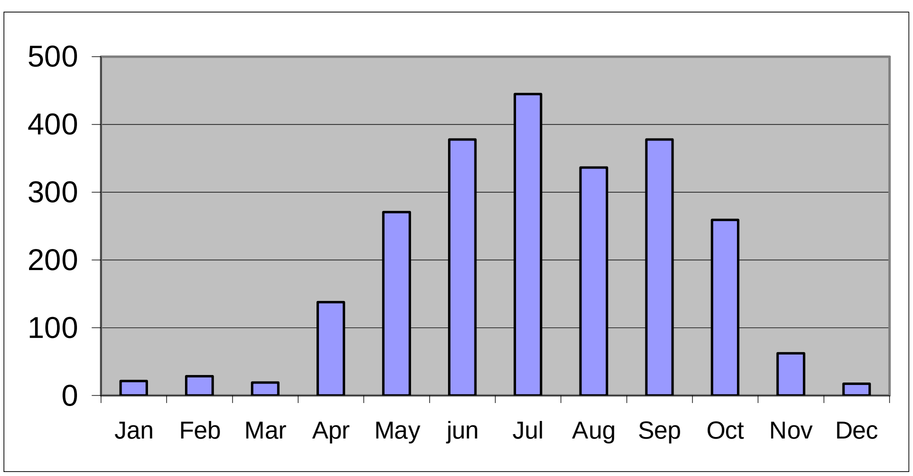


Fig 1 Rainfall pattern in Meghalaya

Water management constraints of the region

The major constraints are undulating topography, highly eroded and degraded soils and inaccessible terrain, land tenurial system, size of land holding and prevalence of shifting cultivation. Infact, there is no water when we really need it, but when we do not need water there is plenty of water.

Monthly rainfall analysis indicates that this region receives more than 84 per cent of annual rainfall during the months of May to October. July is the wettest month with an average of 437.18 mm rainfall. It is also very much clear that the chances of high rainfall during May to October are assured as they have the lowest drought month. Month of December is the driest month with a mean rainfall of 12.15 mm having maximum drought months. It is also having the highest value of co-efficient of variation (152.12), which shows the erratic pattern of rainfall.

The **yearly rainfall analysis** indicates that out of the 15 years, the drought, normal and surplus months were 21.67, 70.56 and 7.78 per cent respectively. It implies that in a year, expected number of drought, normal and surplus months is 2.6, 8.5 and 0.9 months respectively. Month of December has the maximum contribution as far as drought months are concerned, accounted for 9 years out of 15 years. Probability distribution of drought, normal and surplus months in a year depicted that the maximum number of drought, normal and surplus months in a year were 5, 11 and 3, respectively. The study also indicates that May to October is the major part of water surplus periods, while November to April is mainly categorized under the water deficit periods. There are strong chances of occurrence of four drought months in a year with 25% probability.

Further, there is paucity of information regarding **appropriate scheduling of irrigation** in the region. The information pertaining to irrigation in relation to fertilizer application for crops and cropping sequence are not known. Above all, it is also essential to know how best the crop could be grown without significant loss in yield by applying irrigation at critical stages of crops and one or two life saving irrigation at critical stages of crops and one or two life saving irrigation in case of limited water supply. There is also problem of growing crops during *rabi*, although the region falls in moisture index zone of 6-8, yet there is acute scarcity of moisture from November to March.

Development of natural water resources, rain and springs, conservation of rain water and its proper use for maximizing crop production are, therefore, the major thrust area of the water management in this region.

Water Demand in North East India

The approximate water demand for water in the region has been estimated to be 7.8 km3, 13.0 km3 and 19.2 km3 in 1995, 2010 and 2025, respectively.. Major quantity of water is required for agriculture and it is expected that the demand for irrigation which is about 64% at present would be around 61.5% in 2012 and 59.9% of the total demand of water by 2025. The other demands for water are for domestic use, energy and industrial use. The present requirement of water for domestic, energy and industrial use is 12.8%, 9.05% and 1.3% of the total demand, which is expected to be 9.2%, 11.5% and 3.8% by 2010 and 8.8% and 4.1% by 2025, respectively.

Water Balance

The region has 46% of the country's valuable surface water resource. The surface water is distributed in important rivers, tributaries and natural reservoirs. The rivers of the region are fed by heavy precipitation and to a lesser extent by snow of Himalayan range. Most of the surface water is confined to the two important river systems- Brahmaputra and Barak. The state wise annual ET loss and surface runoff loss data has been worked out.

Rainwater Harvesting in the Present Context

The region loses the lion share of the rainwater through runoff. It is in this background that the rainwater harvesting assumes significance. It can be implemented as a viable alternative to conventional water supply considering the fact that any land anywhere can be used to harvest rainwater. Rainwater harvesting is in reality extending the fruits of the monsoon based on the principle "Catch the water where it falls. Rainwater harvesting besides helping to meet the ever increasing demand for water, helps to reduce the runoff, which is choking storm drains, avoid flooding of roads, augment the ground water storage and to control decline of water level, reduce groundwater pollution, improve quality of groundwater and reduce soil erosion . This is considered an ideal solution of water problem where there is inadequate groundwater supply or where surface resources are either not available or insufficient. The other advantages are that it helps utilize rainfall runoff, which flows into sewer or storm drains and therefore helps reduce flood hazards. The rainwater is bacteriologically pure and free from organic matter and soft in nature. The structures required for harvesting rainwater are simple, economical and eco-friendly.

Rainwater harvesting is viewed as a water security measure with two broad types of programmes as given in Fig. 2.

Rainwater harvesting, irrespective of the technology used, essentially means harvesting and storing water in days of abundance, for use in lean days. Storing of rainwater can be done in two ways; (i) storing in an artificial storage and (ii) in the soil media as groundwater. The former is more specifically called roof water harvesting and is rather a temporary measure, focusing on human needs providing immediate relief from water scarcity, while the latter has the potential to provide sustainable relief from water scarcity, addressing the needs of all living classes in nature. The rainwater or runoff in the form a spring or stream can be harvested in RCC/ Ferro-cement/Plastic/fibre tanks or various types of low-cost lined ponds for utilizing in lean periods.

Of the above measures, the tendency from the part of implementing agencies is to plan and implement drainage line treatment and ignore the aspects of land improvement as well as the natural groundwater recharge measures. Activities under the sustainable water security measures are locale specific and can be adopted as per demands of the local conditions. Ground Water recharging measures will be taken up at various locations considering its topographical, geographical and climatic peculiarities. Measures under the 'Temporary and immediate water security' can be adopted at any part of the country and should be taken up immediately.

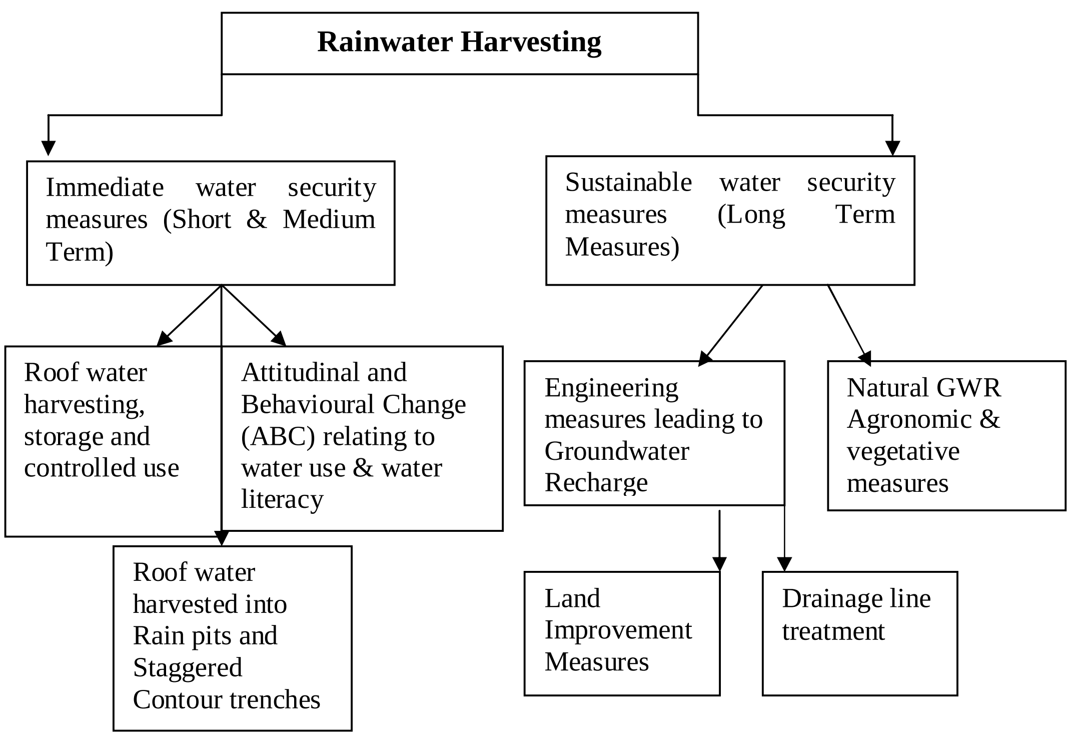


Fig. 2. Two broad areas of Rainwater Harvesting

On going works of research and developments for different modules of water harvesting structures in the Institute are described below:

Module – I

Harvesting of surface runoff water in a pond could be a solution to check frequent occurrence of flood in river basin. Apart from watershed ponds constructed under NWDPRA at Meghalaya, Sikkim and Nagaland the ICAR Research Complex has developed model watersheds in the most backward district of Meghalaya, Nongstoin and also at Nongpoh. The actual need is to implement such watershed management works exhibited in the models in large area in hills with a suitable mechanism through the development departments. There is an exchange of idea among ICAR, State Institute of Rural Development (SIRD), State Soil & Water Conservation Department, State Agriculture Department and other NGOs in the form of training, monitoring and capacity building in the watershed sites. In fact, ICAR has helped in formulating Watershed Project under NWDPRA; one for State Soil and Water Conservation Department and another for Agricultural Department. ICAR also coordinated Installation of Gauging Station for hydrological parameters in Watershed Project area and meteorological station at Cherrapunjee implemented by State Departments.

A) Water harvesting structures under NATP / NWDPRA

Dug out cum embankment type of water harvesting structures are used for creating seasonal and perennial ponds mainly at the foot hills of micro-watersheds. Pond is created by embankment of earth dam with core wall made of either masonry or impervious soil to check seepage in the middle of the designed section and with proper height along with surplusing arrangement by way of constructing masonry spillway etc. Provision of emergency earth spillway to handle peak flow must also be provided against over topping of run off at one end or either end of the dam. Ponds so created have the manifold uses for home use, irrigation, drip and sprinkler irrigations, animal uses, recreation purposes etc. Also integrated fish farming like fishery + piggery, fishery+ duckery and fishery + poultry rearing etc. could be taken up profitably where the animal excreta fed to fishes for early growth and quick income generation.

Many water harvesting ponds in foot hills and valley lands have been created under two projects on NATP and NWDPRA of the ICAR Research complex for NEH Region, Umiam, meghalaya to demonstrate at the farmer's field. Twelve (12 nos.) of ponds of different sizes are created under NATP out of which 10 nos. have been created at Mawpun and 2 nos of ponds at Umroi A total of 9 nos. of water harvesting ponds have been created of minimum sizes 20mx30mx 1.5m of water depth under NWDPRA project out of which 3 ponds at Mawthei, 1 pod at Lumsohlang, 4 nos. at Umdohbyrthih and 1 in Umeit have been demonstrated. Following are the some such ponds shown in the pictures:


B) Ponds created under demonstration of Agro-forestry systems at ICAR Research Complex for NEH Region, Umiam

Six ponds were created of smaller to medium sizes for integration with the Agro-forestry systems at ICAR Research Complex for NEH Region, Umiam (colony site)where the following five Intensive Integrated systems were studied along with one control pond for comparison;

1.Poultry-crop-fish-duck-horticulture along with hedgerow on contour bunds.

2.Crop-fish-poultry-multipurpose trees.

3. Crop-fish-goat- multipurpose trees.

4. Crop-fish-dairy-mushroom-vermicompost-horticulture-hedgerow.

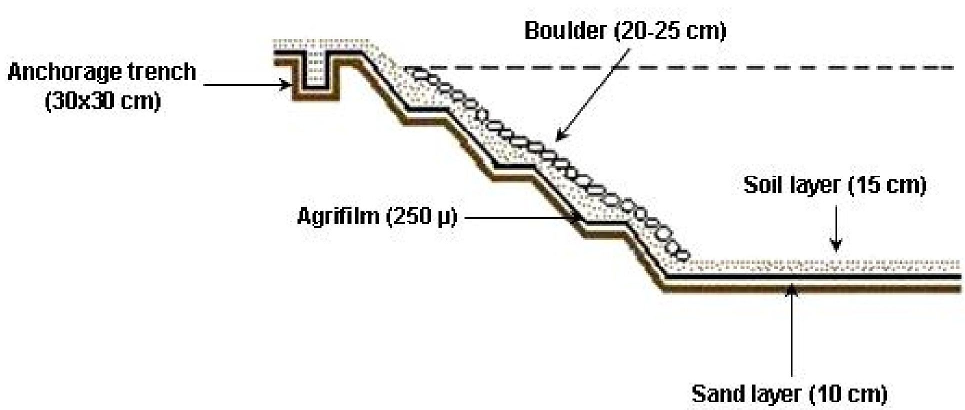
View of ponds of the agro-forestry systems.

Success stories surface water harvesting ponds with integration different farming systems at farmers field are given at Annexure –I & II.

Module – II

Agri-film lined (LDPE) and UV resistant plastic (silpaulin) ponds had been established in the institute as part of research studies and the results were quite encouraging. A study of storage behaviour of the pond revealed that seepage loss from agri-film lined pond was reduced from 55 to 2.9 l/m2/day i.e. by 94.7%. In a similar manner, it was found that the percolation rate through the silpaulin-lined pond is nearly zero and the storage hydrographs of the unlined pond and lined pond clearly showed the increase in water saving efficiency of the pond after lining in terms of both quantity and duration of storage. Furthermore, the input/output statement of Farming System Research Project taken up by the ICAR Complex, Barapani revealed that the Agri-horti-silvi-pastoral system and dairy farming becomes profitable due to the integration of silpaulin lined water harvesting structure. These technologies have been popularized among the farmers of the hilly regions through NWDPRA, NAIP, KVK and other extension programmes.

Schematic diagram of Agri-film lining of water harvesting pond is given below:



According to a study at ICAR Research Complex for NEH Region, Barapani, seepage losses could be as high as about 55 $l/m^2/day$. Owing to the high rate of seepage loss, harvested water will be lost within 1-2 months of recession of rain. Therefore, lining of pond with low density polythene (LDPE) agrifilm is very much essential for retention of harvested water in the pond for the entire dry season i.e. from November to March.

Method adopted for lining of the pond with agrifilm

After the pond was dug as per the design, pond bed and sides was made weed and stone free. Steps at 50 cm vertical interval were made on sides of the pond to hold the agrifilm at its place. On top of the sides, continuous trench of 50x50 cm was dug for the purpose of anchoring the agrifilm to prevent it from sliding down. Pre-emergence herbicide was also sprayed on sides and bed to arrest the weed growth. After the sides and bed were dressed properly, 10cm thick layer of sieved sand was spread uniformly on bed and sides to provide cushion to the agrifilm. After that, agrifim was laid properly in the pond. LDPE agrifilm of 250 µ was used for lining. Utmost care was taken in joining the agrifilm to suit the shape and size of the pond. For joining, bitumen of 85/127 and 80/100 grade in the ratio of 2:1 was used. While laying too much stretching or tightness of the agrifilm was avoided, particularly on sides. Over agrifilm, soil cover of 30 cm was provided. Then stone pitching was done on sides only to safeguard the sides of the pond against erosion and any other external forces. Study of storage behaviour of the pond revealed that seepage loss from agrifilm lined pond was reduced from 55 to 2.9 l/m^2/day i.e. by 94.7%.

Advantages of lined ponds

It is observed that the construction of a dugout pond and lining it with strong and durable plastic sheets for harvesting rain and spring water has the following advantages:

- (i) Effective storage of harvested water by hindering seepage losses,
- (ii) Low capital investment per litre of collected water,
- (iii) Multiple use of harvested water.

The performances of Agri-film lined (LDPE) pond at farmers level yet to be assessed as only one farmer at Umroi area of Ribhoi Distt tried this particular technology recently.

Module – III

The Northeastern region of India is characterized as the highest rainfall zone of the country. However, the water availability for domestic use, animal and crop production is negligible not only during the off-season but to some extent also during the rainy season particularly for families residing on hillocks.

The Institute has developed the low cost, simple, polythene based micro rain water harvesting structure for hill top and it was demonstrated in the fields of 111 farmers in four NE states (71 units through Farmers Participating Action Research Programme (Ministry of Water Resources) and 40 units through NABARD). The capacity of a Jalkund is 30,000 litres at Rs. 6055. Each Jalkund can harvest approximately one and half times its original capacity considering replenishment of the pond by intermittent rains and consequent evaporation loss of about 10%. Hence, the total water harvested per annum through the applied research programme of ICAR Complex is almost 5 million litres (5,000 cubic metres) which otherwise goes as runoff and might create flood problems in the downstream areas. The water harvested in 111 Jalkunds can irrigate 35-40 ha under high value crop through drip irrigation. These activities are likely to increase the additional income to around Rs. 3.77 lakhs at the regional level. Subsistent farmer investing in micro water harvesting structure like Jalkund and its recycling can increase productivity and diversify their homestead farming to growing remunerable crops and rearing cattle, pigs, poultry, etc. From each Jalkund, the farmer can grow 250 tomato plants with 18,000 litres water and the remaining 12,000 litres can be used for rearing 3 piglets or 10 ducks and 100 fish or 50 poultry birds.

ICAR Research Complex for NEH Region, Umiam is implementing a pilot project on "Scaling up of Water Productivity in Agriculture for Livelihood through Training and Demonstration" since

2007. Under this programme, it is intended to impart training, upscale knowledge and upgrade skills of the farmers and trainers from the entire NEH Region. During 2007-09, a total of 37 farmers training were conducted in Meghalaya and other NEH states where about 1850 farmers qwere trained in various aspects of water management and sustainable farming practices.

Jalkund* construction mechanism*:

· Excavation of the *kund* on selected site was completed before the onset of monsoon.

· The bed and sides of the *kund* were levelled by removing rocks, stones or other projections, which otherwise might damage the lining material.

· The inner walls, including the bottom of the *kund*, were 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 was done with locally and easily available dry pine leaf (@ 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 mm LDPE black agri-film. Seepage loss was completely checked throughout the year. The agri-film sheet was laid down in the *kund* 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 *kund*. A 25 x 25 cm trench was dug out all around the *kund* and 25 cm outer edge of agri-film was buried in the soil, so that the film was tightly bound from all around. At the same time, side channels all along the periphery of the *kund*, helps to divert the surface run-off and drain out excess rainwater flow. This is to minimize siltation effect in the *kund* by allowing only direct precipitation. Silpaulin sheet 250 GSM can be also used for longer duration in place of LDPE black agri-film.

· *Jalkund* was covered with thatch (5-8cm thick) made of locally available bamboo and grass. Neem oil (10ml/sq.m.) is also advocated to reduce evaporation in off season.

Jalkund with silapaulin lining

Silapaulin lined Jalkund filled with rain water

Benefits/advantages from *Jalkund*

It has been recommended to construct the *Jalkund* at high ridges of crop catchments areas so that water could be recycled through gravitational force without any extra energy application. About 44% area is under high and medium altitudinal condition. Hence, farmers residing at the hilltop are considered to be the beneficiaries of this technology.

1. Water loss

a. Seepage: There was no seepage loss of water from poly-lined *Jalkund*.

b. Evaporation: The evaporation rate of water was maximum in February (9.2 mm/day) and minimum (1.8 mm/day) in October in the control *Jalkund*. Use of neem oil as anti-evaporate on the water surface and *Jalkund* covered with thatch were found effective to minimize evaporation. It was recorded that use of thatch reduced up to 80% in comparison to the control (no thatched).

2. Low preparation and maintenance cost

The cost/l-harvested water, which was calculated on the basis of aging, duration of lined agri-film/silpaulin total expenditure under different materials and capacity of *Jalkund*. Total cost of a unit of *Jalkund* of size 4mx5mx1.5m is Rs. 6,000/- approximately.

3. Capacity

Farmers have the option to go in for size and capacity of the *Jalkund* according to the water requirement for crops intended to be cultivated. Preparation cost is reflected accordingly. However, considering the seepage loss of water, the size was restricted from 6000 to 30,000 l with respective dimensions of 3 m x 2 m x 1 m, 3 m x 2 m x 1.5 m, 4 m x 3 m x 1 m, 4 m x 3 m x1.5 m and 5 m x 4m x1.5 m. The size of lining material of the corresponding dimension was 6 m X4 m, 7 m x6 m, 7 mx 6 m, 8 m x 7 m and 9 m x 8 m respectively.

Use of stored water

The water stored in Jalkund can be used for many purposes. The vital necessity of the stored water is for irrigating plants. It can also be used for rearing ducks and for domestic uses. The few below are a description of its uses:

Crop production

Farmers grow tomato, capsicum, cabbage, strawberry, cauliflower, carrot, medicinal plants (*Alpina galanga*, local name Kulanjan) all along the periphery of the *Jalkund* to increase farm income as a whole.

Livestock and fish production

The stored water in the *Jalkund* could partly be used for crop production and partly for livestock or fish production or integration of both livestock and fish. Use of stored water for the dual purpose of crop production and livestock/ fish production was a complementary system, where none of the enterprise was practised at the cost of the other as far as water use was concerned. Various options of farmers' choice were tested for diversification and economic use of stored water in the *Jalkund*. Farmers can opt for these farming systems according to resources available with them.

Pig-based activity: Per unit water requirement of *rabi* crop and piglet has been standardized, which envisaged thatm30,000 l of stored water could support 200 tomato plants in 250 sq. m area and five piglets for 200 days during dry spell periods (November to April) of the year.

Poultry-based activity: Based on per unit water requirement, 30,000 of stored water can support 200 tomato plants in 250 sq. m area along with 50 poultry birds for 200 days during water-stress periods (November to April) of the year.

Fish and duck-based activity: The stored water in the *Jalkund* could be partly used for crop production and partly for integration of fish-cum-duck culture, where Azolla is used as feed for fish production. In duck–fish integration, the duck variety selected was the Indian runner, which was found to survive well in the mid-hill conditions. Excreta of duck reared in the *Jalkund* were also used as fish feed. The water was used for vegetable production during December to February, and fish and duck lived together in the *Jalkund* during the whole post-rainy season without affecting water supply to the vegetable crops. The fish culture was with grass carp, *Ctenopharyngodon idella* and golden hybrid tilapia. These two species were selected considering their compatibility in the culture system, utilization of unwanted weeds and Azolla for raising grass carp and the effective utilization of decomposed feed nmaterials and faecal matter of grass carp by golden hybrid tilapia. Grass carp was stocked @ no./sq. m and golden hybrid tilapia @ 3 nos/sq. m. Golden hybrid tilapia being a natural breeder, bred in the pond during the culture period and the young ones were allowed to grow even after the harvest of main stock (table-size fish) in November. The study revealed that apart from meeting water requirement of *rabi* crops, 30,000 of water could also support 1000 fish seedling of one month age, 25 fish of five months age and two ducks. By doing so, the water quality of stored water not only improved, but also farm income had increased.

Field demonstration on *Jalkund* in participatory mode

The tangible benefits accrued from implementation of *Jalkund* in NEH Region is reflected as per following table 3 & 4.

Table 3: Tangible benefits accrued from implementation of *Jalkund* in NEH Region

Sl. No	State	District	No. of Jalkund constructed	Crops/activities Undertaken	Net return from/*Jalkund* (Rs)
1	Meghalaya	East Khasi Hills	21	Tomato	3404
		West Khasi Hills	15	Strawberry	6650
		Ri-Bhoi	30	Piggery	3500
		Jaintia Hills	10	Duckery	3450
		West Garo Hills	5	Fishery	3520
2	Manipur	Churachandpur	3	Capsicum	3350
		Imphal West	4	Cabbage	3300
		Chandael	3	Cauliflower	3400
3.	Tripura	West Tripura	10	Cabbage	3500
4.	Nagaland	Dimapur	5	Maize	3495
		Wokha	5	Maize	3200
	NEH Region		111		

Table 4. Implementation of *Jalkund* under different projects by Water Management Division, I.C.A.R. Research Complex for NEH Region, Umiam, Meghalaya

Project	**Sponsors**	**No. of Jalkunds**				**Type of polythene**
		Ri-bhoi	East khasi hills	Jainita Hills	West khasi* Hills	
FPARP	Ministry of water resources	25	21	10	15	LDPE
Rural innovative fund	NABARD	5				LDPE
SWPAL	Ministry of Agriculture	7	-	2	4	Silpaulin

* Five unit is also given to Tura at Garu Hills.

Module – IV

Model demonstration unit on roof water harvesting mechanism is made at research farm for studying storage behavior in silpaulin based storage tank both during wet and dry seasons (winter rains) and its effectiveness to meet out water requirement of crops grown during dry season. There is a scope to popularize the technology in other locations.


Roof water harvesting in silpaulin lined pond at ICAR, Umiam, Meghalaya..

Water Harvesting Activities in Farmers Field

Water harvesting ponds at Nongpoh model watershed

In view of taping of one of the perennial spring water resources at Mazerallo Orphanage Society land near Nongpoh, Ri-Bhoi District, Meghalaya two dug out cm embankment type of water harvesting storage tanks have been created under Intensive Integrated farming systems project of the Institute to create models in 2003-04. Two successive earth dams with stone lining across the valley by digging waste land/ paddy field to fill the embankment with additional earth cutting from the near by hills. A masonry core wall is constructed longitudinally for the 1st embankment for seepage control whereas mud core wall has been provided to the 2nd embankments.

Major components of Integrated farming systems introduced in an area of 10.0 ha land are like Integrated fish farming using these two ponds (Fish cum pig - 0.36 ha and Fish cum duck - 0.16 ha), Low land paddy - 2.50 ha, Backyard poultry (Vanaraja), Dairy, Rabbit rearing, Goat rearing, Multistoried AFS (3.6 ha), Area under Horti-pasture (3.38 ha) etc . Conservation measures like bunding, are done and Water harvesting ponds (2nos.) with surplusing arrangement of spillways are constructed. Pine apples (Kew Queen) are grown on slopes successfully (Plate 29 to 32).Initial Trend of Production recorded were - Fish- 34.5 q/ha, Pig (12 nos.)- 9.60 q, Duck (120 nos.)-2.00 q, Milk - 2.0 lit/day, Poultry (48 nos.)-1.44 q, Paddy-35.50 q/ha and French bean-65.5 q/ha.

It is reported that the society has generated income from fish rearing for Rs. 42,000/- in the 1st harvest, Rs.38,000/- in the 2nd harvest from these two ponds and more income is continuing to generate in the subsequent years. Due to this encouragement the society has expanded creating more water body in a another area of about 1.2 ha m harvesting both rain and spring water for fish production.

Apart from fish the society earned income about Rs.78,000/- from selling of pigs from the project which was integrated with the ponds started with 10 pig lets. Further, they got extra income from pineapple about Rs.51, 000/- as reported which was grown by the side of the pond with 10000 suckers at starting time. Details of all other components are awaited.

Goats at Model watershed, Nongpoh

Pigs at Model watershed, Nongpoh

Impact

Mazerallo Orphanage Society is devoted to socio-economic upliftment of the rural folk of Ri-Bhoi District. Earlier, the society was developing Human Resource only through the vocational training on education and health. Now, they are disseminating the technology of Integrated Farming System to the rural people on behalf of the Institute. Almost every day, people of the surrounding area, NGO's, Village Headman, Govt. Officials and other dignitaries visit this farm, as it is located on the side of national highway. This farm is giving a positive impact regarding the technology dissemination.

Water harvesting ponds at Mawlangkhar Watershed

Mawlangkhar Watershed is located near Nongstoin, Meghalaya. To introduce Integrated farming systems ICAR has created 2 (two) Water Harvesting Ponds demonstrated scientific method of integration of fish with other crops like potato and vegetable cultivations in the model watershed.

A participatory Integrated watershed development programme was undertaken during 2004 - 2008 at Mawlangkhar, Nongstoin, West Khasi Hills (25^0 32' 14. 6" N & 910 21' 55.5" E) 100 km west of Shillong and 20 km east of Nongstoin, situated on both sides of Shillong- Nongstoin main road. The project site is characterized by high altitude area with an elevation of more than 1500 m from mean sea level. The watershed covered about 20 hectare of area with 50 households. The area receives more than 2500 mm of rainfall, even then drinking water availability is a great problem during winter months (November to March).

Two ponds Mawlangkhar Watershed near Nongstoin, Meghalaya

Systematic efforts for soil and water conservation along with integrated development of agriculture, horticulture, livestock and pisciculture were made for improvement of the livelihood of the tribal populations. All the activities were undertaken in a participatory mode with the farmers. The man and woman from the watershed actively participated in the activities of the watershed. The local youth club also engaged themselves in watershed activities. Headman and Secretary of each village also took part in this programme. In fact, the seed materials, animal breeds, machineries etc. supplied by the Institute were distributed to the villagers by the *Dorbar Shnong*. In this way the scientists built a good rapport with the villagers.

Water harvesting ponds

Two new ponds were constructed in community land, which remained barren and unutilized and could not hold rainwater during off-season prior to undertaking the project activity. After proper survey, these two ponds [49m (L) x 26m (B) x 1.8m (D), 20m (L) x 20m (B) x 1.0m (D)] were scientifically constructed during the year 2004-2005. These two ponds together have the water storage capacity of 26.93 lakhs litres of water.

These two newly constructed ponds have become a sort of lifeline for the Mawlangkhar village for which only Rs. 2 lakh was incurred. These ponds are not only utilized for pisiculture but also have become a source of irrigation water during lean period (November – March) for potato and carrot cultivation in the village. In time of need, farmers of the village are also using the pond water for drinking purpose. Apart from new ponds constructed by the ICAR Research Complex for NEH

Region, Umiam, two old ponds (20m x 20m x 1.5m each) were also renovated in farmers field for higher productivity. The major success was that water was flowing through the spillway even in winter months.

The main pond of the watershed has the following components: (i). Dyke made of stones and soil. (ii) Stone pitching on the dyke slopes from inside to stabilize the dyke, (iii) Retaining wall / toe wall made of stone, cement and sand to hold the pressure of the dyke soil and stones in inner side of the dyke. (iv) Pitching the top of the dyke with grass blocks, (v) The most significant point in the construction and renovation of the entire watershed pond is that this project created employment generation to the villagers because they were actively participated in the construction and development process. (vi) Polythene lining along with wooden plank packing was done to control seepage. (vii) A drainage pipe with valve in the dyke bottom to drain water with gravitational flow for irrigation, fishing etc. (viii) A spillway to drain excess water (0.9 m x 1.0 m), (ix) An emergency spill way in both the sides to drain water during flooding. (x) Two diversion channels in both sides of the pond to reduce excess pressure of water load to pond during heavy rain.

After successful implementation of the programme and at end of project activity in 2008, villagers realized the importance of water harvesting in that area. Having seen this successful water-harvesting pond, some farmers in the project area constructed pond at their own for pisiculture. A spring source of water was also identified in the upper ridges of the watershed, which is being utilized as drinking water during lean season.

The two ponds together have the water storage capacity of 2.69 million litres (L). Total expenditure incurred was Rs. 2 lakh. Therefore, in the first year, per liter of harvested water costs about Rs. 0.074/l. However, considering a minimum life of 20 years for the ponds, and only maintenance cost of about 5 % per year (Rs. 10,000/year), total 40 million litre water would be harvested considering at least 75 % capacity harvesting of water. Therefore, after 20 years per litre harvested water would costs only a negligible amount of about Rs. 01/L. The harvested water is now used for dairying, fishery, irrigation (of about 0.5 hectare of high yielding potato). The motivated farmers are planning to increase area under vegetable cultivation after paddy harvest.

Jalkund

A micro rainwater harvesting structure called *jalkund* suitable for hilltop was introduced in the watershed area in the year 2007-08. The dimension of *jalkund* was 5m L x 4m B and 1.5m D which could store about 30,000 L water in the hilltop. The inner surface of the *jalkund* was plastered with slurry of clay mud and cow dung and there after cushioned with pine leaf to support the lining material. LDPE agri-film of 250 micron was used to line the *jalkund*. Recent study revealed that silpaulin was found better over LDPE film in-terms of cost effectiveness and durability. The water of the *jalkund* can be used for small scale domestic use, for livestock and important crops. Fifteen numbers of such *jalkunds* were constructed in and around the watershed area with the fund from Ministry of Water Resources, Govt. of India. Each *jalkund* costs about Rs. 6,000. Farmers of the project area were imparted training regarding construction and use of water from the *jalkund*. The average cost of storing per litre water in *jalkund* was computed at Rs. 0.07/litre considering the life span of three years. Feedback from beneficiaries envisaged that 30, 000L stored water in *jalkund* could support 200 tomato plants, rear five piglets or two ducks or two poultry birds from November to April. Farmers in Mawlangkhar are using stored water for vegetables, chilies, sweet potato, cucurbits and for rearing pigs. Using stored water economically in various farm activities is the most acceptable and profitable one particularly to those in the hilltops who are worst sufferer due to water scarcity.

Jalkund at Umroi Madan (Farmers field)

A strawberry farmer of Umroi Madan village of Ribhoi District could earn more than Rs.70,000/- in a year using water from *Jalkund*

***Jalkund* filled with rain water**

Strawberry cultivation in Umroi Madan

Issues of Rain Water Management

Some of the important aspects of rainwater management and the major scope for enhancing irrigation facilities in the terrain can be envisaged as follows:

- Management of runoff on slopping land use and in-*situ* retention of rainfall by adoption of appropriate soil conservation measures and land use practices.
- Ensuring safe disposal of surplus water from higher to lower level.
- Increased utilization of stream flow through diversion works at feasible locations.
- Storing surplus water at appropriate locations by constructing small reservoirs and recycling it in the same area.
- Stream flow lift irrigation.
- Conjunctive use of surface and ground water on rotational basis.
- Adoption of scientific on farm water use and management technology.
- Drainage of high water table areas.
- Tackling flood and irrigation an integrated manner.
- Proper harvesting and recyling of spring water

Conclusion

The locally adoptable low-cost technologies for rainwater harvesting can be implemented as a viable alternative to conventional irrigation and drinking water supply schemes considering the fact that any land anywhere can be used to harvest rainwater. The Government and local communities has to identify it as an effective measure to combat the problem of finding a workable technology option for mitigation of droughts, preserving the ground water reserves, hinder soil erosion, preventing saline intrusion and providing a dependable source of drinking as well as irrigation water. Rainwater harvesting, irrespective of the technology used, essentially means harvesting and storing water in days of abundance, for use in lean days. Storing of rainwater can be done in two ways; (i) storing in an artificial storage and (ii) in the soil media as groundwater. The former is rather a temporary measure, focusing on human or small scale irrigation needs, providing immediate relief from water scarcity. The rainwater or runoff in the form a spring or stream can be harvested in RCC/ Ferro-cement/Plastic tanks or various types of low-cost lined ponds for utilizing in lean periods. The studies suggested that these technologies are sustainable, locally adoptable, cost-effective and affordable to the farmers.

The rainwater harvesting and groundwater recharge initiatives will bring together the experiences and energies of a wide spectrum of stakeholders in mitigating the ill effects of drought and providing security against future droughts. It requires equitable involvement of local people to analyze localized problems and to arrive at the best possible solutions regarding natural resources management activities in the corresponding watershed area.