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ECONOMIC ANALYSIS OF INTEGRATED FARMING SYSTEM USING JALKUND AND MICRO-IRRIGATION SYSTEM TO HARVEST RAINWATER IN NORTH EAST INDIA

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A B S T R A C T

The North Eastern Hilly (NEH) region of India is characterized by varying topology that is largely affected by high seepage flow and flash runoff. Dual effect of water in the form of heavy rainfall during monsoon and water scarcity during post monsoon is severe in this region. Existing undulated terrain and dual effects of water are the main limiting constrain in storing/ concentration of runoff water and its later use for irrigation purposes in NEH region. There has been an increasing interest in low cost Water Harvesting and Micro-irrigation system for small scale farming practices. Traditional farm ponds practiced by the farmers of NEH region in India are exposed to potential losses like infiltration, percolation, seepage flow and evaporation to great extent. And high monetary requirement for construction/ adoption of concrete pond and optimal irrigation systems make it extremely difficult for the farmers to adopt efficient agricultural techniques/ farming systems. It is essential to identify an economical approach to agricultural techniques so as to uplift the scope for adoption of advance small scale agricultural techniques/ farming systems for the indigenous farmers of NEH region in India. In the present study an approach to economical integrated ways of farming system coupling rainwater harvesting technique, Jalkund and micro-irrigation system using gravity drip/ sprinkler systems was demonstrate to thirty numbers of farming families in Phek District of Nagaland in India. As to assess and monitor the adopted technique, a map showing the beneficiaries was generated using Global Positioning System (GPS) and Geographic Information System (GIS) techniques. The applicability of the proposed approach in the tough terrain of Phek District of Nagaland in NEH region of India was found to be effective and well satisfying.

Keywords: Water Harvesting, Micro-irrigation system, GPS and GIS techniques.

INTRODUCTION:

Water is one of the important natural resource that life on earth has depended on. With ever increasing demand for water caused by growing population, advancement in agricultural practices and rapid urbanization it is essential to focus on efficient utilization and management of the available water resources. In the advancement of agricultural practices sustainable storage and concentration of available water is assumed vital for efficient utilization and management of the available water resources. The North Eastern Hilly (NEH) region of India is characterized by varying topology that is largely affected by high seepage flow and flash runoff. Dual effect of water in the form of heavy rainfall during monsoon and water scarcity during post monsoon is severe in this region. Existing undulated terrain and dual effects of water are the main limiting constrain in storing/ concentration of runoff water and its later use for irrigation purposes in NEH region.

NEH region of India receives heavy rainfall during monsoon and experiences scarcity of water during post monsoon (November to April). During monsoon season, runoff and seepage flow are severe making implement of major irrigation systems difficult. There has been an increasing interest in low cost Water Harvesting and Micro-irrigation system for small scale farming practices. Runoff water can be harvested and used for

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different purposes, which otherwise is lost and causes soil erosion. Water harvesting technology includes inducement and increment of run-off from land surface by using surface treatment, collection and storage of run-off water in suitable reservoir or pond, reducing the seepage and evaporation losses and use of conserved water most efficiently at critical time to provide life saving irrigation to crops (Tiwari & Mal, 2000). Rainwater harvesting can be broadly defined as a collection and concentration of runoff for productive purposes like crop, fodder, pasture or trees production, livestock and domestic water supply (Ngigi, 2003). It has tremendous potential to be adopted as irrigation water source for agricultural purposes as well as for domestic uses in the hilly regions. Desai *et al.* (2007) conducted an impact assessment study of farm-ponds in Dharwad district & reported the average net income generated with farm-pond to be relatively higher than that of the farmers without farm-pond. Various methods of rainwater harvesting are available, through which rainwater is captured, stored and used at times of water scarcity. Traditional farm ponds practiced by the farmers of NEH region in India are exposed to potential losses like infiltration, percolation, seepage flow and evaporation to great extent. And high monetary requirement for construction/ adoption of concrete pond and optimal irrigation systems makes it extremely difficult for the farmers to adopt efficient agricultural techniques/ farming systems. It is essential to identify economical approach to agricultural techniques so as to uplift the scope for adoption of advance small scale agricultural techniques/ farming systems for the indigenous farmers of NEH region in India.

Indian Council of Agricultural Research (ICAR) Barapani, Meghalaya has purposefully developed a low-cost micro rainwater harvesting structure, Jalkund suited for NEH region of India. Adoption of Jalkund for harvesting rainwater and its judicious use in agricultural practices can greatly beneficiate the farmers of NEH region of India. In the present study attempt has been made to demonstrate an economical approach to small scale integrated farming system using Jalkund and micro-irrigation system as to elevate the socio-economic status of the farming families.

Low-cost rainwater harvesting structure, Jalkund: Jalkund, an economical rainwater harvesting structure restricts the potential loses like infiltration, percolation, seepage flow and evaporation to great extent. (Saha *et al*., 2007) ICAR Barapani, Meghalaya has successfully developed Jalkund integrating lining of the inner wall and bed of the pond using Low Density Polyethylene (LDPE) of 250 or 500 micron films. The lining film is a revolutionary concept in water management which dramatically restricts the seepage losses at a reasonable cost. Installation of Jalkund involves excavation of kund (Pond), for a total capacity of 30,000 liters with a dimension of 5m x 4 m x 1.5 m. Once excavation is done plastering of the inner walls of the pond with a mixture of clay and cow dung in the ratio of 5:1 followed by a 3 – 5 cm thick cushioning with dry pine leaf or thatch grass @ 2 to 3 and ultimately laying down of lining material (LDPE black agri-film of 250 or 500 micron). The stored water can be covered with locally available materials like bamboo, grasses, etc. as to avoid the evaporation loss of water particularly during off season (November to March). Adoption and installation of Jalkund is simple. With proper lining and roofing, the potential water losses may be restricted allowing storing of water for later uses. Harvesting of rainwater using Jalkund and integration of micro-irrigation system for irrigating the farmer's farm may uplift the applicability of small scale integrated farming system.

Micro-irrigation system: NEH region of India is associated with highly undulating terrain which may be one of the limiting factors in implementing major irrigation systems. Viewing to this fact alternative method of minor irrigation system potential through effective water-conservation techniques needs to be explored. With regard to agricultural water development, small scale irrigation may be preferred to large scale schemes. The reason for the preference of small-scale irrigation to large scale irrigation includes the high capital requirement for constructing large scale scheme that can only benefit a fortunate few (Turner, 1994). Easy adaptability of small scale irrigation makes it more relevant to large number of farming communities. Undulating topography favoring the gravitational flow of water in NEH region makes it possible to integrate gravity drip irrigation system with Jalkund. Its advantage owing to topography is that, drip pressure can be achieved through gravitational pressure. Therefore, water from pond or tank which is located at higher elevation can be conveyed to the cultivated area located at lower elevation. Use of control drip/micro sprinkler irrigation can increase the water using efficacy and may economize the cost of production.

Treadle Pump: Water lifting from the pond and to the pond manually is tedious and time consuming especially in hilly area. Therefore a manually operated water lifting device may be introduced to overcome time and labour consumptions. Krishak Bandhu (KB) Treadle pump manufacture by International Development Enterprises (IDE) may be useful for lifting water. The pump is positive displacement reciprocating type with two cylinders. Suction head of the pump is 8m and discharge capacity is 4500lit per hour. The cost of pump is approximately Rs. 700/- only. Depending on the conveniences of farmer IDE treadle pump frame may be fabricated using locally available bamboo or timber as to make it either hand operated or foot operated. Installation of the treadle pump is simple and economical and may be efficiently used for lifting water from or to the Jalkund. Integrating rainwater harvesting technique, Jalkund and micro-irrigation system with integrated farming practice, an economical small scale farming system may be achieved for adoption in farmer's farm.

METHODOLOGY

To demonstrate the economical approach to integrated ways of farming system, rainwater harvesting technique, 'Jalkund' and micro-irrigation system using gravity drip/sprinkler irrigation can be coupled. The proposed approach to integrated ways of farming system may be accomplished in two stages. In the first stage, plan a feasible layout of integrated ways of farming system for the farm with respect to its existing topography. Secondly, for the feasible layout prepared accomplish the planned layout using the following steps:

1. Install water harvesting pond with LDPE lining, Jalkund in higher elevation of the farm area for the purpose of irrigation and other domestic use.
2. On the basis of the crop grown install gravity drip or micro sprinkler Irrigation system at the lower elevation of the farmer's farm.
3. Depending on the conveniences of farmer, fabricate IDE treadle pump frame to either hand operated or foot operated using locally available bamboo or timber.
4. Optionally adopt Duckery or fisheries production in small scale to enhance economy and integrated approach.

Study Area: Demonstration of the proposed economical approach to integrated farming system using Jalkund and micro-irrigation system was adopted in Phek District of Nagaland in India. It lies in the South-East of Nagaland, bounded by Kohima District in the West, Zunheboto and Kiphire Districts in the North, Myanmar in the South East and Manipur State in the South. The name of the district Phek is derived from the word "Phekrekedze" meaning watch tower. The highest hill town of Nagaland i.e. Pfutsero, is also located at Phek district. It is rich in flora and fauna. There are three important rivers namely Tizu, Lanye, and Sedzu and three important lakes called Shilloi, Chidaand and Dzudu. Summer is moderately warm and winter is cold. Monsoon sets in by the last week of May and retreats by the end of September. Agriculture is the main occupation with 80.84 % of the population engaged in agriculture. Terrace Rice Cultivation (TRC) is predominant occupation and practices for the indigenous farming community.

Implementation: Under the sponsorship of NABARD (National Bank for Agriculture and Rural Development), Dimapur, Nagaland the proposed technique was demonstrated to thirty farmers selected from seven different villages of Phek district of Nagaland in India. The farmers were selected after field survey under the umbrella of NABARD, Dimapur on the basis of feasible site location with an objective to develop a model of the proposed technique to the farming community of these seven different villages. Water harvesting pond, Jalkund of cross sectional dimension with side slope was first constructed in the farmer's farm. Construction of Jalkund involves digging of pond, plastering of the inner walls using a mixture of clay and cow dung in the ratio of 5:1 followed by a 3 – 5 cm thick cushioning with dry pine leaf or thatch grass @ 2 to 3 and ultimately laying down of lining material (LDPE black agri-film or SILPAULIN of 250 or 500). Figures 1 – 5 shows the installation of Jalkund on farmer's farm. Table 1shows the cost of construction for the proposed methodology. After Jalkund is constructed, viewing to the conveniences of the individual farmer the treadle pump is assembled and fabricated in either hand operated or foot operated using locally available bamboo or timber. Figure 6 show the fabrication of KB treadle pump.

Thereafter in farmer's field, gravity drip irrigation system were installed for crops like tomato, king chilli, cabbage, etc. And micro-sprinkler irrigation systems were provided especially for nursery raising. Duckery unit and fish farming were introduced along with the Jalkund as to enhance the socio-economic condition of the farming community. Figures 7, 8 and 9 shows the drip, micro-sprinkler and duckery unit installed on farmer's farm.


Figure 1. Smoothening of inner wall of Jalkund.


Figure 2. Plastering of inner walls of Jalkund.


Figure 3. Cushioning of inner walls of Jalkund.


Figure 4. laying of LDPE for Jalkund.

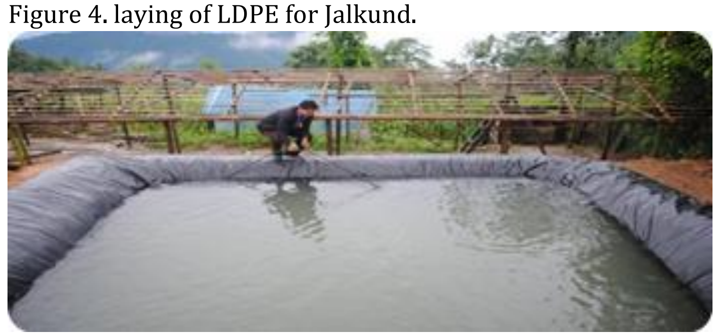
Figure 5. Jalkund on farmer's farm.


Figure 6. Fabrication of frame of Treadle pump and its input to Jalkund.


Figure 7: Gravity drip irrigation system.


Figure 8: Micro-sprinkler system used for nursery raising.

Table 1. Cost of construction.

Sr. No.	Particulars	Rate (Rs.)	Amount (Rs.)
	Construction of Jalkund		
1	Volume of excavation: 16 cumec	50.00/ m3	800.00/-
2	Planking and plastering the sides and bottom with mixture of mud and	150.00	150.00/-
	b. water for smoothening		
3	Cushioning of pond with Pine leaves	150.00	150.00/-
4	Cost of LDPE: Size (8 X 7)m and weight of LDPE = 17.34 kg Thickness = 250 micron (0.025 mm)	273.00/kg.	3822.00/-
5	Labour cost for laying LDPE	Rs. 150/-	150.00/-
	B. Gravity Drip Kit (30 m2) / Sprinkler Kit (30 m2)		1121.00/- (per set)
	C. Treadle Pump		
1	Treadle pump	700.00/-	700.00/-
2	Connecting Pipe (Section Pipe, 100 feet each.)	3000.00/-	3000.00/-
3	One way valve and other accessories for assembling the Pump.	200.00/-	200.00/-
	D. Fisheries / Duckery (optional)		Optional
	Total cost involved		10,093.00/-

Figure 9. Duckery unit constructed on farmer's farm with Jalkund.

Figure 10. Stage provided for measuring the depth of stored water.

RESULTS AND DISCUSSION

In the present study a methodology to economical approach to integrated ways of farming system was successfully demonstrated to thirty numbers of farmers in Phek District of Nagaland in NEH region of India. Implementation of Jalkund is simple and economical with a total capacity of around 30,000 ltrs. Water stored analysis was done in a simple way by providing a stage into the pond and measuring the water loses from pond with Low Density Polyethylene lined and unlined as shown in Figure 10. The water loses from pond was identified by measuring the decrease in depth from bottom. Figure show in graph (Figure 11) indicates the averaged comparative water losses from the farm pond with LDPE linned and unlined pond. The water loses from the LDPE lined pond is treated as evaporation lost. The difference between the water loses from LDPE line and unlined is treated to be seepage losses, assuming that the evaporation loses are same. From the figure it can be noted that water storage depth in unlined pond have sharp decrease from October and fully dried up in the month of March. In the month of December and January the depth of pond varies from 23 cm to 17 cm only. At this time crop failure usually occurs due to less in situ moisture as well as non-availability of irrigation water. The pond gets dried up from the month of February till month May. The major reason for the lost of water was due to seepage and percolation flow in the unlined traditional farm pond. Whereas in the cases of LDPE line pond loses shown in the graph is treated as the lost of water due to evaporation loses. However, in the case of LDPE lined farm pond water was stored successfully during the month of November to March when compared to that of the unlined traditional farm ponds. This stored water in LDPE lined farm pond can be used for irrigating different high value crops during lean season. After initial investment the demonstrated technique can be effectively used for many years thus increasing sustainability of the agricultural practices. Therefore farmer can conserve water every year and can go for cultivation in winter season and uplift the economic life to certain extend. Introduction of the treadle pump was actually planned to save time and labour consumption for lifting of water. Usually people of this place used to fetch water from nearby source. Fetching a bucket of water is very tedious under the undulating terrain of NEH regions of India. Therefore, KB treadle pump was introduced for lifting of water which can be used for various purposes. Comparison of time taken to fetch a bucket (20 liters) from lower elevated source which is located at 30 ft below and water pumped by KB Treadle pump for the same was carried out as to demonstrate its efficiency and applicability. Time taken for collecting 20 ltrs of water was recorded as shown in Table 2. Recorded data shows that under undulating terrain, KB Surface treadle pump can be effectively used for lifting water. Thus it can successfully be integrated with the LDPE lined farm pond for lifting water from the pond to upland agricultural land. Applicability of drip irrigation system was also demonstrated for various crop viz. tomato, cabbage, cauliflower, king chilli etc using the stored water from the jalkund. In the present study with an aim to create a database of the adopted technology GPS and GIS technology was used to generate a map showing the beneficiaries of Phek District in Nagaland, India. Latitude and longitude of the farmer's farm were collected using GPS and were inputted to GIS software, ArcMap to generate the map as shown in Figure 12. The details of the selected beneficiaries are listed in Table. 3. The applicability of the proposed approach in the tough terrain of Phek District of Nagaland in NEH region of India was found to be effective and well satisfying. The demonstrated technology is economical and can uplift the scope for adoption of advance small scale agricultural techniques/ farming systems for the indigenous farmers of NEH region in India.

Table 2. Field capacity of Surface treadle pump.

Sr. No.	Quantity	Time Taken by Treadle Pump (Sec)	Time taken to fetch the same amount of water manually (Sec)
1.	20 lit (one bucket)	20	137
2.	20 lit (one bucket)	25	132
3.	20 lit (one bucket)	25	150
4.	20 lit (one bucket)	23	155
5.	20 lit (one bucket)	20	136

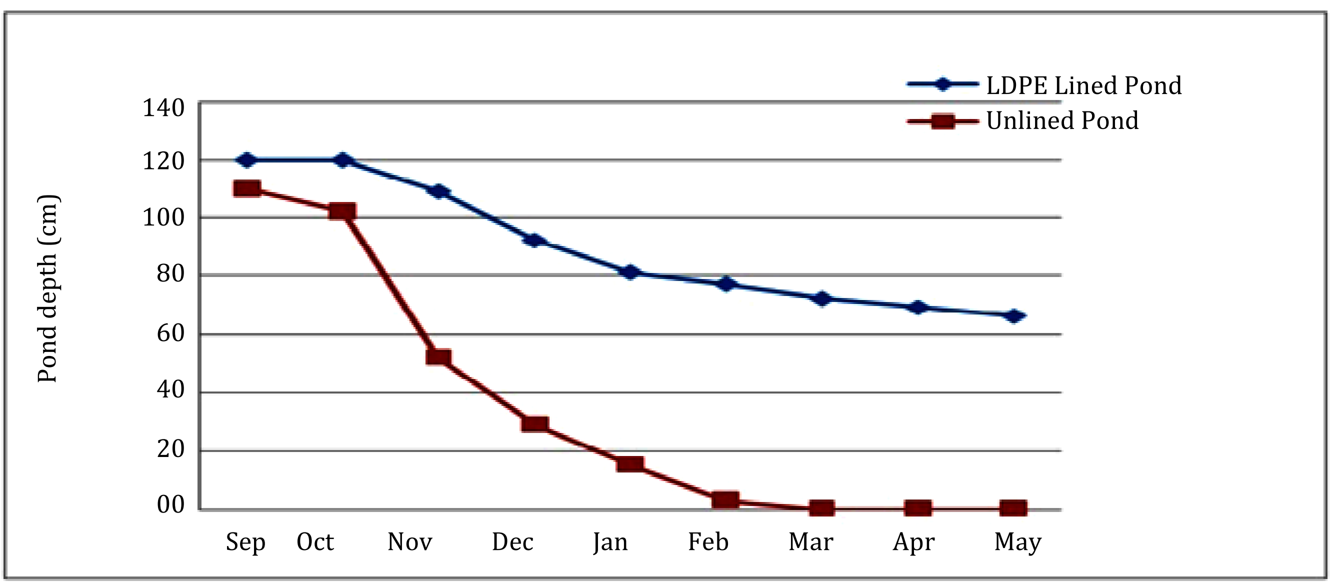

Figure 11. Water loses chart per different months of the year.

Table 3. List of beneficiaries with location (Latitude and Longitude).

Sr.	Name of Beneficiaries	latitude (n) degree decimal	longitude (e) degree decimal	Sr..	Name of Beneficiaries	latitude (N) degree decimal	Longitude (E) degree decimal
1	Ame	25.6162	94.3386	16	Sevohu	25.6266	94.2791
2	Avi Sakhamo	25.6167	94.3194	17	Tazuhu Puro	25.6184	94.3297
3	Cekrosa	25.6502	94.2912	18	Thipunipra	25.5772	94.2378
4	D. Kenye	25.5784	94.3005	19	Vecusuyi	25.628	94.2767
5	Dipelhi Kaffo	25.5681	94.2674	20	Veduhu Akulu	25.6577	94.2913
6	Khaloii Dienu	25.5677	94.2644	21	Vesorayi	25.6245	94.2651
7	Khrunuhu	25.6572	94.2921	22	Vetsucho Puro	25.5623	94.2922
8	Kropeii Ritse	25.568	94.2881	23	Veveto Puro	25.6177	94.3197
9	Kuvelu Puro	25.6159	94.3384	24	Vezosa	25.654	94.261
10	Molhinei	25.5683	94.287	25	Zachirayi	25.569	94.3173
11	Luno Puro Edekhoi	25.5967	94.2195	26	Zasheyi	25.6209	94.32782
12	Neipelo Kafpo	25.5675	94.2663	27	Zhiengulo Mero	25.5658	94.2855
13	Nielelo-ii Puro	25.5664	94.2965	28	Zhoshehu	25.5809	94.3131
14	Pukrotso	25.6189	94.3284	29	Zhovehu	25.6262	94.2792
15	Razuseyo	25.5951	94.219	30	Ziitsoloii Mero	25.561	94.2851

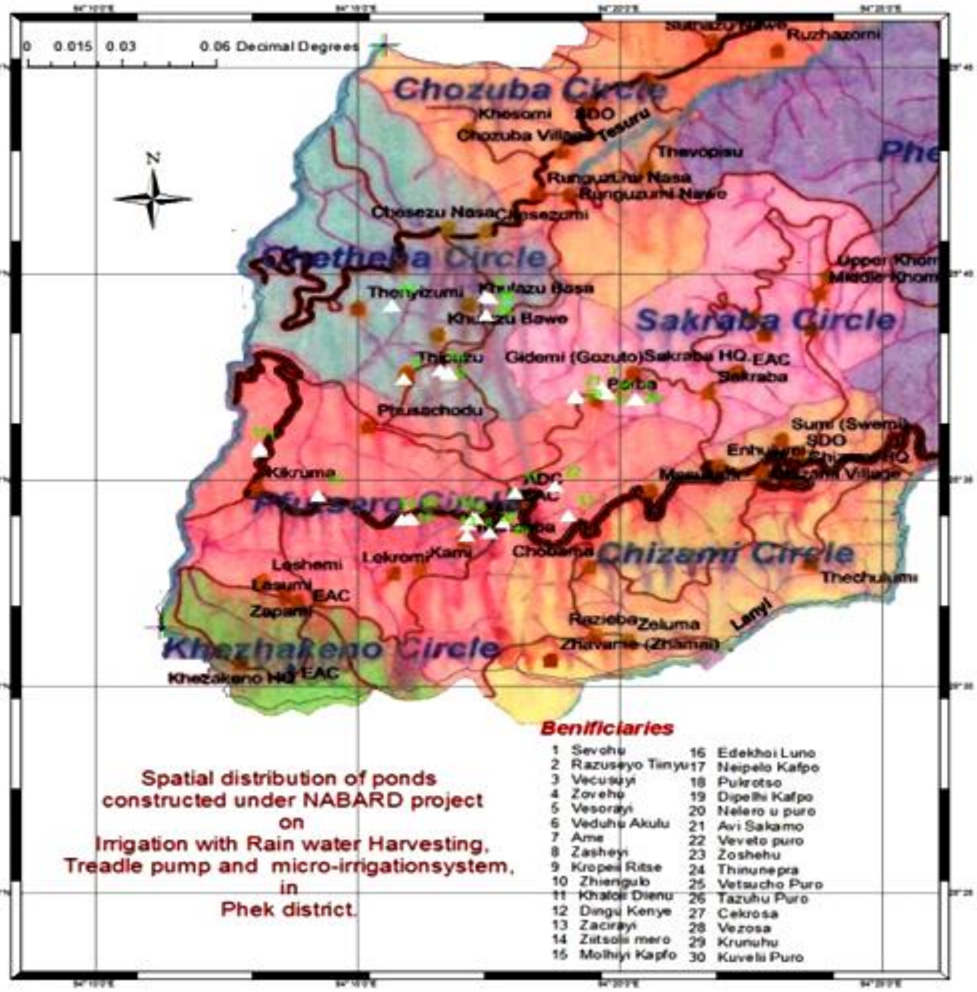

Figure 12. Map showing the beneficiaries.

CONCLUSION AND RECOMMENDATION

The proposed technique was found to be effective and well satisfying in the tough terrain of Phek District of Nagaland in NEH region of India. It is simple, economical and can uplift the scope for adoption of advance small scale agricultural techniques/ farming systems for the indigenous farmers of NEH region in India. Farmers' feedback have revealed that the propose technology is found to be very useful and can be utilized for cultivation during winter season. Mrs. D Kenyi, from pfutsero commented "I have never got succeeded planting cabbage in my farm during winter due to less water and plant gets wilted. But this time, after KVK installed a plastic pond, I used this water for irrigation during the winter season; it was really surprise that the entire cabbage crop were growing properly. One cabbage weight comes around 0.8 t0 1.5 kg. I sold them at pfutsero market and earn around 8000/-". Mr Sevohu, Rihuva village said "your introduction of drip irrigation save my Raja Mircha, water in drip system is very efficient and I was able to manage the water requirement during non-rainy season". Mr pukroto quote "I can even pump water in my rice field by pumping water easily using your KB pump from the lower terrace to upper terrace". However limiting constrain in accomplishing the technique are need for suitable site selection, non-availability of LDPE, KB treadle pump in Nagaland. Procurement of these raw materials takes longer time prior to its fluctuation of material cost. To the effort of identifying an economical approach to integrated ways of farming system for the indigenous farmers of Phek District of Nagaland in India, coupling rainwater harvesting technique, Jalkund and micro-irrigation system using gravity drip/ sprinkler systems is found to be effective and useful.

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