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Rainwater harvesting and integrated development of agri-horti-livestock-cum-pisciculture in high altitudes for livelihood of Tribal farmers

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ABSTRACT

Participatory rainwater harvesting for promoting integrated development of agri-horti-livestock-cum-pisciculture was implemented during 2004-2008 at high altitude (> 1500m MSL) areas of Mawlangkhar village, West Khasi Hills district, Meghalaya in a watershed approach to assess and refine improved package of practices integrating crops, fruits, vegetables, fish and animal production for higher productivity and income. Soil and water conservation measures like construction and renovation of ponds, *jalkund*- a micro rainwater harvesting structure on hilltops, bench and half moon terraces were developed with the active participation of the local peoples. The quantum of water harvested at one point of time during monsoon season through two ponds in community lands (2.69 million litre water), two ponds in individual farmer's land (1.2 million litre water) and 15 *jalkunds* (0.45 million litre) on hill tops estimated to be about 4.3 million litre, was utilized for multiple purposes including irrigation, pisciculture, livestocks and domestic purpose. The cost of water harvesting in community pond was computed at ₹12/1000 litre (L) and for *jalkund* ₹ 82/1000 litre considering the lives of pond and *jalkund* for at least 20 and 3 years, respectively. Impact analysis revealed that the productivity has gone up by 30–40% in potato and 45-50 % in rice with the introduction of improved package of practices for various crops, availability of irrigation water and integration of different components. Farmers are now able to get about ₹ 2 440/month from community dairy unit and the individual farmer's income from piggery unit increased substantially which ranged from ₹ 8 465 to 16 654/year. Besides, farmers are earning a substantial income (₹ 10 000/annum from community pond) from composite pisciculuture. Therefore, integrated watershed programme could be considered as a successful model for high altitude areas of North East India and similar other ecosystems for livelihood improvement of resource poor tribal farmers.

Key words: High altitude, Integrated farming system, Livelihood, Participatory research, Rainwater harvesting, Watershed development

Out of total geographical area of the Northeastern region (26.2 m ha), about 28.3 % has an elevation more than 1200 m above MSL and falls under high altitude category. Net cultivated area is only about 4 m ha, 80 % of which are rainfed. Upgrading of rainfed agriculture requires those technologies which are strongly adapted to local biophysical and socio-cultural conditions coupled with institutional and behavioural changes (Harris *et al.* 1991, Duivenbooden *et al.* 2000). The region is known for its high rainfall (2450 mm/annum), and most of the rainwater goes waste as runoff. Out of 42 m ha-m water received as rainfall, only 0.88 m ha-m is tapped till date. The water availability for domestic use, crop production and animal husbandry is very meagre not only during dry season (November to March) but sometimes, the residents of hillocks suffer from water shortage during rainy season as well. Enormous amount of energy is spent by women and children to collect water from distant places. Efficient rainwater harvesting and recycling may provide new livelihood options for the resource poor hill farmers. Rainwater harvesting and its recycling can increase productivity and diversify agricultural production by growing remunerative agricultural and horticultural crops and it can also be integrated with composite pisciculture and livestock components. Watershed, as an entry point in farming should lead to exploring multiple livelihood interventions (Wani *et al.* 2008). Sustainable rural development through conservation of land and water

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resources gives plausible solution for alleviating rural poverty and improving the livelihoods of rural poor through integrated watershed development approach. In an effective convergence mode for improving the rural livelihoods in the target area with watershed as the operational unit, a holistic integrated systems approach would enable change and improve the livelihoods of the rural poor (Wani *et al.* 2009). A world bank report (World Bank 2005) indicated that agriculture plays a key role for economic development of rural poor and poverty reduction (Irz and Roe 2000) with evidence indicating that every 1% increase in agricultural yields translates to 0.6 to 1.2% decrease in the percentage of absolute poor (Thirtle *et al.* 2002). With this background, a participatory integrated watershed development programme was initiated in the high altitude tribal areas of Mawlangkhar village, West Khasi Hills, Meghalaya, India with the objectives (i) to assess the technology developed by the institute in the farmers' field with respect to productivity and profitability, (ii) to introduce improved package of practices for crops, fruits, vegetables, fish and livestocks for improving livelihood and (iii) to develop technological skills of the local manpower in agriculture in a participatory mode.

MATERIALS AND METHODS

Integrated crop-livestock-fishery development programme through watershed approach was undertaken during 2004 - 2008 at Mawlangkhar, West Khasi Hills district (25° 32' 14. 6" N and 910 21' 55.5" E) of Meghalaya, India. Mawlangkhar village is located at about 100 km west of Shillong and 20 km east of Nongstoin city. The project site is characterized by high altitude area with an elevation of above 1500 m above MSL. The climate of West Khasi Hills is temperate sub-alpine type. The watershed covered about 20 hectare area with 50 households. The area receives more than 2500 mm of rainfall annually; even then water availability remained a great problem during the winter months (November to March) due to lack of conservation efforts.

The socio-economic condition and problems related to agriculture were analyzed through participatory rural appraisal (PRA). The multidisciplinary team consisting of experts from natural resource management, plant protection, animal husbandry and social sciences were involved in this programme. The PRA exercise revealed that the agriculture is the main source of livelihood of the people and about 90% population were engaged in agriculture. The farmers are mostly small and marginal and shifting cultivation (jhum) is still prevalent in the area. Monocropping, use of local varieties, negligible use of fertilizer and pesticides, lack of irrigation facilities etc were the major bottlenecks affecting agricultural productivity and farm income. Soil erosion, soil acidity, poor soil fertility and undulating terrains further aggravated the problems.

Pigs were the most common livestock but their productivity was low due to rearing of local breeds. Rice was the most common cereal followed by maize. Rice-potato and maize-potato were the common cropping systems. Average productivity of rice was only about 1.5 tonnes/ha and that of potato 13-15 tonnes/ha. Low temperature, stray animals and lack of irrigation facilities during winter season limited the scope for double cropping. Mixed cropping was followed by the tribal farmers without proper crop geometry and row ratio. The plentiful availability of natural resources, climatic conditions, food habit, etc. offers opportunity for integrated farming systems and organic farming in the area.

The major problems of the village were identified through PRA and the villagers were asked to rank those problems in the scale of 1-10, 1 being the most important problem. Poverty and lack of employment were ranked as number 1 problem. Low productivity and poor soil health were ranked as number 2 and 3, respectively. Since, lack of employment and poverty are directly linked up with socio-economic development and indirectly with the agricultural activities, poor crop productivity and soil health were identified as number one problem. Accordingly, the programmes were undertaken to address these issues.

Systematic efforts for rainwater harvesting, soil conservation measures along with integrated development of agriculture, horticulture, livestock and pisciculture were made for livelihood improvement of the tribal populations. All the activities were undertaken in a participatory mode with the farmers. The men and women including members of youth club from the area actively participated in the watershed development activities. In fact, the seed materials, animal breeds, machineries etc. supplied by the Institute were distributed to the villagers through the *Dorbar Shnong* (Village Panchayat).

Soil samples were collected from different locations of watershed and analyzed (Table 1) at the beginning and end of the programme. The soil was red lateritic and highly leached with low available nitrogen, very low phosphorus and high potassium content. Soil organic carbon and pH were 1.59 % and 4.89, respectively.

RESULTS AND DISCUSSION

Water harvesting ponds

Two ponds were constructed in community land, which remained barren and unutilized. After proper survey, these two ponds [49m (L) × 26m (B) × 1.8m (D) and 20m (L) × 20m (B) × 1.0m (D)] were scientifically constructed during the year 2004-2005. These two ponds together have the water storage capacity of 2.69 million litre of water. These two newly constructed ponds have become a sort of lifeline

Table 1 Soil chemical properties of the project site

Year	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)	Soil organic carbon (%)	pH
2003-04	170–220	1.3–2.6	290–390	1.48–1.70	4.87–4.91
2007-08	185–241	3.1–3.6	295–398	1.51–1.78	4.9–5.1

for the Mawlangkhar village especially during post and pre-monsoon (Nov-April). The ponds are not only utilized for pisiculture but also for irrigation 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. Two old ponds (20m × 20m × 1.5m each) belonging to farmers were also renovated for higher productivity. The two renovated ponds in individual farmers land have the storage capacity of 1.20 million liter (0.60 million litre each). The most significant point in the construction and renovation of the entire watershed pond is that this project created employment to the villagers because they actively participated in the construction and development process. Due to these interventions it was possible to harvest water at high altitude of Mawlangkhar village. Having seen these successful water-harvesting ponds, some farmers in the project area constructed ponds at their own cost for pisiculture.

Jalkund: a micro rainwater harvesting structure

A micro rainwater harvesting structure called *jalkund* suitable for hilltop was introduced in the watershed area in the year 2007-08. The dimensions of jalkunds were 5 m length × 4 m breadth and 1.5m depth which could store about 30 000 litres of water in the hilltop. The inner surface of the *jalkund* was plastered with slurry of clay mud and cow dung and thereafter, cushioned with pine leaf to support the lining material. LDPE agri-film of 250 micron was used for lining the *jalkund.* The water of the *jalkund* was used for domestic purpose, livestock and irrigating important crops. Fifteen numbers of such *jalkunds* were constructed in the watershed area. Farmers of the project area were imparted training regarding construction and multiple use of water from the *jalkund*.

Economics of water harvesting

The two newly constructed ponds together have the water storage capacity of 2.69 million litres. Total expenditure incurred for two ponds was about ₹ 2.2 lakhs. Therefore, in the first year, per litre of harvested water was about ₹ 86 /1000 l. Considering 75% capacity harvesting of water and a minimum life of 20 years for the ponds with a maintenance cost of about 5% per year (₹ 11 700/year), a total of 40 million litre water would be harvested. Therefore, considering 20 years lifespan, the cost of harvested water would only be a negligible amount of ₹ 12/1000 l. The harvested water is now used for dairying, fishery and irrigation (of about 0.5 hectare of high yielding potato, carrot etc.). Thus, increased area under second crop after rice boosted total production of the watershed areas.

Cost involvement for each *jalkund* was ₹ 7 018 and the average cost of harvesting water was computed at ₹ 82/ 1000 l considering the life span of *jalkund* as three years. Feedback from beneficiaries envisaged that stored water in *jalkund* could support 200 tomato plants, five piglets or two ducks or two poultry birds from November to April. Using stored water economically in various farming activities is the most acceptable and profitable one, particularly to those in the hilltops who are the worst sufferer of water scarcity (Saha *et al.* 2007).

Land development

Bench terrace (0.25 ha) and half-moon terraces (0.25 ha) on unutilized hill slopes were developed during 2004 to bring additional area under cultivation. Half-moon terraces were used for growing fruits like peach, pear and plums. Maize, potato and upland rice were grown on the bench terraces. The barren hill slopes were used for cultivating multipurpose trees and bamboo etc. for rehabilitation of degraded lands. Furrow liming 500 kg/ha was advocated for amelioration of acid soils.

Fruits cultivation

Peach and pear plants of the locality were found low yielding and poor in quality. Two peach varieties Shan-e-Punjab and TA 170 were introduced in 2005. The fruit trees were planted on hill slopes above and around the watershed to reduce the runoff of rain and also in backyards of farmers for ensuring house hold nutritional security. One peach variety at farmers' field was already in fruiting stage. The yield and size of fruit was significantly higher than local peach. Feedback indicated that some farmers earned up to ₹ 500 per plant from selling of peach. Two passion fruit varieties (Kaveri hybrid and Meghalaya Local) were also introduced. Kaveri hybrid was liked very much by farmers due to good bearing, big and attractive fruits with more juice content.

Introduction of high yielding potato

Potato is an important crop for the farmers of the Mawlangkhar village. Potato is cultivated in upland as well as in lowland rice fallow by the farmers. But the productivity was found to be low due to cultivation of low yielding local varieties. Eight hundred kilograms of high yielding varieties of potato (Kufri Jyoti and Kufri Giriraj) were distributed to 25 farmers each year in four consecutive years (2005-2008). On an average the farmers, harvested 30 to 40 % higher yield of potato due to adoption of improved varieties (17-18 tonnes/ha) compared to local varieties (13-15 tonnes/ ha). The farmers of the watershed showed keen interest to grow both the high-yielding potato varieties and saved their own seeds for the next season. The impact was so visible that at present they could manage potato cultivation of their own. Bigger size, uniformity of tubers, good look and high yielding attributes were the main reasons for acceptance by the farmers.

Vegetable cultivation

High-yielding varieties and hybrids of vegetables were introduced in watershed area in the year 2005. Cauliflower (hybrids Mahima and Himani) and cabbage hybrid (Green Empress) were introduced. Two tomato hybrids (Avinash 2 and Rocky) and one variety (Manikhamnu) were also introduced first time. Highest yield was recorded in Avinash

2 (25.0 tonnes/ha) followed by Rocky (21.5 tonnes/ha) and Manikhamnu (18.9 tonnes/ha). The tomato crop took more than 4 months to mature due to prevailing low temperature. In the subsequent year, on-farm trial on sweet potato was conducted with 5 varieties namely, Gouri, Kokrajahr Local, Meghalaya Local, Sree Bhadra and Sonipat. Highest yield was recorded with early maturing variety (4 months) Sree Bhadra (30 tonnes/ha). Farmers were also imparted training on improved nursery management, seed treatment, pest and disease management of vegetables.

Introduction of high yielding rice variueties

The rice yield in the high altitude is low mainly because of low yielding local varieties and poor agronomic practices (high seed rate, random planting, broadcasting, no fertilizer and manure, poor weed management etc.). Eight varieties of rice, viz. Vivek Dhan 82, RCPL 1-10C, RCPL 1-11C, RCPL 1-18C, RCPL 1-62C, RCPL 1-63C, Megha Rice 1, Megha Rice 2 and local rice (*Bahkhawlih*) were introduced during 2005-2008. Transplanting of 25 days seedlings with 3-4 seedlings/hill was advocated as against farmer's practice of random transplanting of older seedlings (30-40 days). Low dose of NPK (40:30:20 kg/ha) along with the farmers' practice of applying FYM 5 tonnes/ha was also advocated. The four years (2005–2008) results indicated that, variety Megha Rice 2 recorded highest grain yield (3.4 tonnes/ha) followed by Megha Rice 1 (3.2 tonnes/ha) and RCPL 1-10C (3.2 tonnes/ha). Local variety *Bahkhawlih* recorded a grain yield of 2.2 tonnes/ha (Table 2). Other varieties were inferior to the local variety. Farmers ultimately have accepted three varieties, viz. Megha Rice 2, Megha Rice 1 and RCPL 1-10C and maintained their seeds. Data in Table 2 showed that the yield enhancement with these varieties over local varieties were 45 to 54%.

Composite fish culture

Composite fish culture involving surface feeder (Catla, silver carp and puntius/java punti), column feeder (Grass carp and rohu), and bottom feeder (mrigal, common carp and gonius) constituting 40, 30 and 30%, respectively were adapted both in community pond and in individual farmer's pond. The stocking density adapted was 1 fingerling/sq. m.

Table 2 Performance of rice varieties in Mawlangkhar Watershed (average of four years)

Varieties	Tillers/ hill	Panicles/ hill	Grains/ panicle	Ripe-ning ratio (%)	Grain yield (tonnes/ ha)	% increase over control
Megha 1	7.6	6.8	144.5	82.4	3.2	45.4
Megha 2	7.4	6.3	140.2	82.0	3.4	54.5
RCPL 1-10C	8.2	7.5	148.2	83.5	3.2	45.2
Sahsarang 1	10.4	5.8	131.6	60.7	2.1	
Local variety (Bahkhawlih)	6.8	5.5	112.5	67.5	2.2	
CD (P= 0.05)	0.82	0.57	10.5	5.6	0.43	

Table 3 Growth analysis of fish species at Mawlangkhar watershed (12 months stocking)

Species	Weight (g/fish)	Growth increment (g/day)	Maximum weight of a single fish (g)
Catla	485 ± 50.6	1.27 ± 0.11	1 350
Silver carp	430 ± 43.2	1.18 ± 0.13	900
Japanese punthi	170 ± 16.7	0.37 ± 0.05	200
Grass carp	510 ± 52.5	1.33 ± 0.17	3 500
Rohu	490 ± 33.7	1.27 ± 0.14	875
Mrigal	282 ± 20.3	0.58 ± 0.06	850
Common carp	445 ± 46.4	1.29 ± 0.15	1 550

Initially, the institute supplied concentrate fish feed and the farmers were trained on improved method of feeding (use of feed tray, quantity of feed and timing of feeding etc.) and other practices for enhancing productivity of fish. Farmers also used locally available materials like cow dung, rice bran, banana leaves etc as the fish feed. Grass carp attained maximum weight (510 g/fish) followed by common carp in one year (Table 3). Common carp was found to be self-breeding and as a result its population increased in the subsequent years and liked by farmers as well because of its good taste. This species was, therefore, found most suitable for the locality. In general, the performance of exotic carp was good especially the grass carp mainly because of availability of grasses to fish from pond banks as well as surrounding areas near pond. Farmers provided grasses; banana leaves etc. as feed for the grass carp. The fish productivity in general was low (1.4 tonnes/ha) mainly due to low water temperature and poor feeding by the villagers. Farmers are now able to get regular fish catch from these ponds. Villagers are selling fish at ₹ 100-120/kg and on an average they are able to earn about ₹ 10 000 net income from the community pond every year.

Pig husbandry

Pig is a household animal in the tribal community. Almost every family maintains 1-2 local breeds of pig. Five unit (Two female and one male constitute one unit) of upgraded pig having 75% Hamshire and 25% Meghalaya Local inheritance were given to the farmers. The farmers made good housing with brick wall and corrugated tin roof with the technical support from the Institute. The farmers were also trained on health care and medication of pigs. The farmers were using kitchen waste, local grasses, vegetables such as carrot, radish, sweet potato, squash etc. grown in their farm and mesh feed made-up of rice bran, rice polish, salt and mineral mixture as pig feed. One farmer in two furrowing got 16 piglets in a year from one sow and sold 3 months old piglet at ₹ 1 400/piglet. In three years, that farmer could get 72 piglets from one unit of piggery (2 sow + 1 boar). However, only 65 piglets survived out of which 61 were sold by the farmer. Contrary to this the local pig in two furrowings delivered only 11 piglets fetching about ₹ 1 200/piglet. The performance of improved

Table 4 List of beneficiaries for piglets and their income (2005-08)

Name of farmers	No. of piglets given	No. of piglets sold in 3 years	Gross income (₹)	Net income (₹/year)
Mr G N S Marthong	One unit (2 female + 1 male)	61**	85 657	16 654
Mr Stonly Sohshong	One unit (2 female + 1 male)	38	970.2	10 373
Mr Stomar Rani	One unit (2 female + 1 male)	42	53 361	11 467
Mr Relshan Nongsiy	One unit (2 female + 1 male)	31	43 532	8 465
Smt Entine Nongsiy	One unit (3* female + 1 male) One female piglet died.			

*Piglets of Ms. Entine Nongsiy did not perform well and no data was available for analysis.
**₹1 400/piglets

Table 5 Economic analysis of improved piggery (pig lets) in Mawlangkhar (three years average)

Particulars	Quantity	Rate (₹)	Total amount/ month (₹)	Cost per piglet (₹)
Concentrate	0.4 kg/day	12/kg	144	432
Roughage	1.5 kg/day	1/kg	45	135
Labour	2 hours/day	100/md	800	300
Cost of production for 3 months/ piglets				867 (Approx)*

*Since the farmers mostly used the family labors and locally available feed materials, the profit was actually much more than calculated. Considering this, the cost of production of one piglet would be only about ₹ 567/piglet

Table 6 Economic analysis of dairying in Mawlangkhar watershed

Particulars	Quantity /month	Rate/unit (₹)	Expenditure/ income (₹/month)
Expenditure			
Broken rice	60 kg	15/kg	900
Rice bran	60 kg	10/kg	600
Oil cake	30 kg	20/kg	600
Roughage	600 kg	1/kg	600
Labour	90 hours (11 md)	100/md	1 100
Total (A)			3 800
Gross income			
Milk	270 L	22/L	5 940
Cow dung	600 kg		300
Total (B)			6 240
Net income (B-A)			2 440
B: C ratio			1.64

breed of pigs was highly remunerative. About ₹ 8 465 to 16 654/ year were earned from piggery unit by the farmers (Table 4). The cost of production per piglet up to marketing age was estimated at about ₹ 567/piglet, excluding the cost of family labour (Table 5). The suitable composition for pig feed considering the ingredient available at farmhouse was suggested. For making 10 kg feed the suggested composition were maize/rice bran (4 kg), rice polish (3 kg), mustard oil cake (1.5 kg), groundnut cake (1.2 kg), vitamin and mineral mixture (vitamin-D3 & E12 mineral - Ca, Mg, etc (0.25kg) and common salt (0.05 g). Three litres of water was recommended for adult and 1 litre for piglets at a time totaling 9 and 3 l water for adult and young one per day, respectively. Better performance of upgraded pig breed under hill conditions compared to local breed (Khasi Local) was also reported by Bujarbaruah *et al.* (2006).

Integration with dairy component

A dairy unit (one improved crossbred Jersey milch cow with a calf) was maintained in the watershed to serve the dual purpose of milk and supplying manure for fish pond and crops. The cowshed on the bank of the main water harvesting pond in community land has been designed in such a way that the washings of the cow unit is diverted to the fish pond that helped in growth of phytoplankton and zooplankton which served as feed for the fish. The ultimate aim was to introduce the concept of integrated farming system in the watershed so that the resources are effectively utilized and cost of cultivation is reduced. The dairy component would also generate additional employment to the farmers and improve the farm income. Improved feeding practice involving concentrates, roughage and use of locally available materials were suggested for better productivity. The villagers were getting about 8-10 l of milk daily. On an average about ₹ 208/day and more than ₹ 2 440/month was earned as net profit from dairy unit (Table 6). Vermi-compost and FYM were prepared adjacent to the cow shed using cow dung, straw, weed biomass etc. and applied to crops and vegetables. Thus, there was an effective recycling of biomass/nutrients in the system.

Rabbits

Two units of New Zealand White rabbit (Two female and one male rabbit in each unit) were distributed to two farmers in the project area. Subsequently, more numbers of rabbit units was established in the village due to returning back of young one by the previous farmers to other farmers. The farmers in the project area were selling rabbits at ₹ 120 each and there was good demand locally. The farmers made the housing for rabbits with locally available materials with the technical support of the Institute. Rabbit growth was found to be about 14g/day. In four kindling, litter size at birth and at weaning was 6.50 and 6.0, respectively.

Indigenous technical knowledge (ITKs)

The people of the Mawlangkhar were using some ITKs for conservation of natural resources and other agricultural practices. Some of the important ITKs identified were mentioned below.

Grass block pitching: Farmers' practice of grass block pitching on pond embankments and terrace risers to stabilize and also for erecting earthen bunds are the glaring examples of indigenous soil and water conservation measures. The cubes of grass blocks were artistically arranged in layers similar to that of masonary works.

Thonglong or soil piling: In lowland rice fields, crop residues and weed biomass are placed in a heap and covered by slicing the topsoil from the surrounding area and left for 3-4 weeks as such. Thereafter, the soil is spread uniformly over the field and rice is cultivated. It allows better decomposition of organic matter and improves soil physical parameters due to exposure to sun. It also reduces the problems of pest and disease in rice.

Indigenous fodder species: Locally available two non-traditional fodder for feeding cattle, pig and rabbits were identified as *Chloris barbata* (DM: 66.25%, CP: 14.07%, CF: 23.20%, EE: 9.93%, TA: 7.35% and NEE: 45.45%) and *Erianthus rufipilus* (DM: 41.16%, CP: 10.49%, CF: 33.38%, EE: 1.77%, TA: 10.37% and NEE: 43.99%).

Roof top water harvesting: Almost all the family collect roof top water through indigenous means for domestic purposes. Farmers use bamboo or tin sheets for diverting roof water to a tank or drum from where water is used for domestic purposes. This is especially good for Mawlangkhar farmers as most of them are residing in hilltop with steep slopes.

Vegetative barriers: Farmers of the locality use vegetative barriers (biofencing) and earthen bunds (beautifully place grass blocks one above another) for controlling soil erosion. This also reduces the runoff velocity and thereby reduces soil loss.

Capacity building

A stakeholder's meet involving experts from Agriculture, Horticulture, Veterinary and Soil Conservation Department were arranged to interact with the farmers on various aspects of agriculture. A five days training programme on "Entrepreneurship development in crop and livestock production" was also arranged for the farmers (30 farmers) of watershed to improve their skill in Agriculture. Farmers were also taken to agricultural fairs like North East Agriculture fair at Umiam, Meghalaya. An awareness-cum-training programme on rainwater management was also arranged.

Ensuring people participation

The significant aspect of the watershed development programme was the active involvement and participation of the local peoples including women at all the stages of the programme. The community participation since inception of the project was ensured through involvement of local *Dorbar Shnong* (village panchayat) and Youth Clubs besides direct interaction and visits to individual farmers. After construction and complete development, the water resources, terraces and cattle units etc were handed over to the *Dorbar Shnong*. The *jalkunds*, i e micro rainwater harvesting structures constructed mainly on hilltops were handed over to the respective farmers. Such type of creation of common resources and people's participation was identified as the key factors for success of watershed projects in Haryana (Arya and Sharma 2001) and Himachal Pradesh (Yadav *et al.* 2006). Community watershed development programmes are used as growth engines for sustainable development of rainfed area (Wani *et al.* 2008). However, the major challenges are scaling-up of such programmes to large areas as successful watershed remained few and unreplicated (Kerr *et al.* 2002). Most of the farming problems require the participatory approach of those practising farmers closely involved in technology development, testing and dissemination. The adoption of this new paradigm in rainfed agriculture has shown that with proper management of natural resources the system productivity can be enhanced and poverty can be reduced without causing further degradation of natural resource base (Wani *et al.* 2008). At the end of the project, the soil fertility status was improved substantially due to adoption of soil and moisture conservation practices and better nutrient management involving fertilizer and organic manures.

The Mawlangkhar village has become a successful model village for agricultural development in the most backward district of Meghalaya. As a part of disseminating the improved technology, the villagers are selling the piglets, rabbits, milk etc. at 10-20 % lower than the market rate to the neighbouring farmers. The productivity of crops especially rice, potato, maize and vegetables were increased substantially and farm income in general has gone up by at least 25 % in the adopted village. The villagers are now aware of the new agricultural technologies and their self-confidence has gone up as well. The water-harvesting ponds and jalkunds stored significant quantity of water and became an asset for the villager. For overall development more number of such activities needs to be taken up in the various identified pockets of the NEH states.

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