Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2320-7051.6996

ISSN: 2320 – 7051

Int. J. Pure App. Biosci. **6 (5):** 1326-1334 (2018)

Research Article

International Journal of Pure & Applied Bioscience

OPEN ACCESS

Jalkund: Low Cost Rainwater Harvesting Structure for Sustainable Livelihood of the Chandonpokpi Village, Chandel District, Manipur, India

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Received: 14.09.2018 | Revised: 24.10.2018 | Accepted: 29.10.2018

ABSTRACT

A field experiment was conducted during rabi season of 2015, kharif and rabi season of 2016 and kharif season of 2017 at farmer's field with the objective to ensure sustainable livelihood of the hill farmers of Chandonpokpi Village, Chandel District, Manipur, India The rainwater or run-off can be harvested using eco-friendly low-cost rainwater harvesting structure called Jalkund and used for multiple purposes. A dimension of 5 m x 4 m x 1.5 m has been found optimum for hills. During winter months when there is no rainfall, water conserved in poly-lined ponds (Jalkund) act as a lifeline for the seasonal crops. Life-saving irrigation can be provided from these Jalkund and make the farmers earn an additional extra income through double cropping. Jalkund came as a boon for the farmers of Chandel who could cultivate a variety of vegetable crops in the dry winter months.

Key words: *Sustainable livelihood, Chandonpokpi Village, Rainwater, Jalkund, and Double Cropping*

INTRODUCTION

The overexploitation of natural water resources has already created environmental problems all over the world. In India, conflicts on river water sharing between the states have already started. One of the major solutions to meet ever increasing water demands would be storing the available rainwater through rainwater harvesting techniques (RWH).

Kishore *et al.*[7], report that even when the rainfall shows no decline, there are growing scarcities at many locations, as use is increasingly exceeding the availability. They say that the only recourse in such locations is to close the demand–supply gap by conserving water through rainwater harvesting. This may include building a core wall on the upstream side of ponds to prevent them from pulling out groundwater from upstream lands.

Water is an important input in agricultural production, the availability of which is shrinking over the years. Though the region receives high rainfall, lack of appropriate rainwater management conditions coupled with lack of suitable soil and water conservation measures lead to severe water scarcity, particularly during post-monsoon season and affect crop productivity as well.

Cite this article: Singh, K.S. and Athokpam, H., *Jalkund*: Low Cost Rainwater Harvesting Structure for Sustainable Livelihood of the Chandonpokpi Village, Chandel District, Manipur, India, *Int. J. Pure App. Biosci.* **6(5):** 1326-1334 (2018). doi: http://dx.doi.org/10.18782/2320-7051.6996

In the absence of major and medium irrigation potential/ facilities, the alternative method is to explore minor irrigation potential through effective water-conservation measures. Hill farmers suffer from extreme water scarcity during November to March. Rainwater harvesting has tremendous potential of being an irrigation water resource for domestic use as well as for agricultural purposes for the resource-poor farmers in this vulnerable environment.

Rainwater harvesting is not a new technique to the indigenous people of different parts of the world[9,4], but better management options are needed[16]. With respect to the usefulness of tanks for collecting rainwater, Shah and Raju[14]. who studied the socio-ecology of tanks and water harvesting in Rajasthan report that there are multiple benefits from water harvesting tanks. Tanks lead to substantial rainwater harvesting at the local level, and the associated distribution system leads to water availability in large areas and to larger numbers of farmers. A significant benefit of percolation of rainwater is groundwater recharge and higher water table in the area. Other benefits include low cost flow irrigation, reduction in intensity of flash floods, concentration of silt and minerals to fertilize the soil in the command area, and reduction in soil erosion.

Tilala and Shiyani[15]. undertook a study of the impact of water harvesting structures on the Raj Samadhiyala village of Saurashtra near Rajkot and found that the water harvesting structures had a substantial positive impact on the cropping patterns of farmers (for example, could grow vegetables in summer), crop yields (42 per cent, 45 per cent, and 31 per cent increase for groundnut, cotton and wheat, respectively comparing beneficiary and non-beneficiary farmers) and farmers' incomes (76 per cent, 95 per cent, and 77 per cent higher farm business income for beneficiaries vis-à-vis non-beneficiaries in these crops). They also report benefits of higher water use efficiency, reduction in cost of production, and higher labour productivity.

One of the major constraints for water-harvesting structures in this hilly region is high seepage loss from storage tanks. Further, seepage losses are quite high as the soil is coarse-textured and lower strata are made of fractured stones. Seepage loss from small tanks has been reported to be in the range of 300-400 $1/m^2$ wetted area per day[8]. Gradual station and clogging of soil pores has resulted in the development of layers of low hydraulic conductivity on the wetted perimeter. In this region, around 56% of the area is under low altitude (valley), 33% under mid altitude and the rest under high altitude (upland terrace)[1]. In the valley, collection of run-off water in macro-water harvesting structures (macro ponds) having reasonably large catchment area has been proved successful, provided due attention is given to check seepage loss. However, in case of upland terrace at the hilltop, where land available for constructing a pond is less with limited catchment area and there is severe water scarcity during off-season as most of the rainwater goes waste by run-off through terraced land, construction of cost effective micro-rainwater harvesting structures is the right option.

Rain water harvesting and efficient utilization holds promise for sustainable livelihood in hills. Direct rainfall collection through water catch ponds/pits (*Jalkund*) can be highly beneficial to farmers for providing irrigation to crops during moisture scarcity conditions during dry seasons. Stored water can also be utilized for animal husbandry activities, piggery, poultry and duckery. In the hills, seepage losses could be as high as about 55 $1/m^2$/ day[13]. Owing to the high rate of seepage loss and evaporation, harvested water will be lost within 1-2 months after recession of rain. Therefore, lining of the pond with non-permeable film is essential for retention of harvested water in the pond for the entire dry season, i.e. from November to March. LDPE (low density polyethylene) plastic sheets, popularly known as Agrifilm or silpaulin are found to be a low-cost and durable lining material. The following method can be adopted for lining of the pond with agrifilm or silpaulin

Lack of irrigation facilities has emerged as the major bottleneck in the cultivation of vegetable crops in rabi season. Thus rainwater harvesting remains the only feasible option to meet out the minimal irrigation needs of the crops. And construction of the water harvesting tanks in the fields itself will drastically considerably reduce the drudgery of carrying the irrigation water[6]. If subsistent farmers of this region invest in micro rainwater harvesting structure with suitable lining materials which completely check seepage loss, this can increase productivity and they can diversify their homestead farming by growing highly remunerable crops and rearing of livestock against their conventional practice of remaining idle or workless for want of water during post-rainy season. With this backdrop, a low-cost rainwater harvesting structure called Jalkund for the hilltops has been developed. All aspects, including cost of preparation, size and capacity of *Jalkund*, water loss, longevity of lining material used, water productivity, and diversified use of stored water have been dealt with.

Jalkund- a micro rain water harvesting structure is found suitable for the farmers residing in the hill top for small scale agricultural activities. Farmers may have option for the capacity according to their water requirement for the crop intended to be cultivated and also for diversified use of stored water in various farm activities like crop, livestock and fish production during post-rainy season (stress period). 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 %. Feedback from beneficiaries envisages that 30,000 l of stored water in Jalkund could support 200 tomato plants, rear five piglets or two ducks or 50 poultry birds along with reasonable amount of fish seedling from November to April. Using stored water economically in various farm activities is the most acceptable and profitable one particularly to those in the hilltops, who are the worst sufferers due to water scarcity. This is economically viable and easily adoptable technology needs to be popularized among large sectors of farmers[12].

MATERIAL AND METHODS

A field experiment was conducted during rabi season of 2015, kharif and rabi season of 2016 and kharif season of 2017 at farmer's field of Chandonpokpi Village, Chandel District, Manipur, India with the objective to ensure sustainable livelihood of the hill farmers for Chandonpokpi Village, Chandel District, Manipur, India**.** The geographical area of the district is 496 sq. km with 2.22 % of the total geographical area of the state. Shifting cultivation (keeping fallow after certain number of cultivations) is still the main cultivation system in this district due to little external input, small capital, very limited irrigation facility, unavailability of updated technologies, and affinity to age-old primitive option. As a result, the inhabitants often face food insecurity, declining soil fertility and shrinkage of shifting cultivation cycle. Besides, the shifting agriculture has led to soil loss, nutrient loss and indiscriminate destruction of forest for food production causing ecological degradation[3]. The study area is located in the south-eastern part of Manipur and it experiences hot summer and cold winter

Chandonpokpi (24^{o}24.65'N, 94^{o}01.09'E) is a small village located 50 kms away from the state capital Imphal. With a total household of 40, it has a population of 260 of exclusively Chothe tribe. Rice is the main crop grown by the farmers.

As in the rest of the villages of Chandel district, the village is characterized by heavy precipitation. One of the reasons for the poor utilization of rainwater in India is the high concentration of rainfall over a few months. As Table 1 shows, about 74 per cent of the rainfall is received during the south-west monsoon period of June to September. Even this does not fully reveal the concentration of big spells of rains. As a result, the soil saturates, and much of the water flows away if no structures are made to check this flow. The uneven distribution also creates a situation of long dry periods when cropping is difficult if water is not retained or made available in some other way.

Though Chandonpokpi village received more than 1500 mm total rainfall during the year 2017; the rainfall pattern follows erratic distribution with 3 and 2 numbers of long dry spells of 33 days and above during 2016 and 2017 respectively. Thus, even though the village received heavy rainfall, there were more days with no rainfall as compared to rainy days. The number of drought weeks during monsoon months shows an increasing trend in Arunachal Pradesh, parts of Assam, Meghalaya, Mizoram, Tripura and Manipur to the tune of about 25% increase in future[11].

Table 1: Distribution of Annual Rainfall by Seasons in India

Rainfall	*Duration*	*Approx. percentage of annual rainfall*
Pre-monsoon	March–May	10.4
South-west monsoon	June–September	73.7
Post-monsoon	October–December	13.3
Total	Annual	100.0

Source: Meteorological Department of India, Pune, cited in Fertilizer Association of India[5].

Interventions were taken up to popularize low-cost rainwater harvesting structures '*Jalkund'* with silpaulin (5x4x1.5 m) having a storage capacity 30,000 liters, for harvesting rainwater during rainy season and subsequent use during dry periods for life saving irrigation in high value winter vegetables, poultry, fishery, piggery etc

In the present scenario, lack of water supply for crops is the main reason why fields in the village remain fallow and farmers practice mono-cropping. The importance of harvesting of rain water is more critical in places/sites along the hill slopes due to high seepage/infiltration losses. Rain water harvesting has become one of the most important practices and pre-requisite for any successful enterprise of agriculture and allied sectors under such erratic rainfall pattern.

Steps in Preparation of *Jalkund*:

- Excavation of the *kund* on selected site was completed before the onset of monsoon.Soil type, depth, the purpose for which water to be used etc. to be given importance. Hill tops and upper portion of the slopes are preferred to divert water with gravitational flow.
- 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 x 1.5 m and 5 m x 4 m x 1.5 m.
- The bed and sides of the *kund* were levelled by removing rocks, stones or other projections, which otherwise might damage the lining material.
- Spraying of insecticide like Endosulphan 35EC on the surface of the inner walls and the bottom, and application of aluminum phosphide (@ 1 tablet/live hole) around 5 m of the *kund* was done before the lining process.
- 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 µm Silpaulin or LDPE black agri-film. Seepage loss was completely checked throughout the year. The Silpaulin or 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 ' 25 cm trench was dug out all around the *kund* and 25 cm outer edge of Silpaulin or 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.
- *Jalkund* was covered with thatch (5—8 cm thick) made of locally available bamboo and grass. Neem oil (@ 10 ml/sq. m) is also advocated to reduce evaporation during off-season.

RESULTS AND DISCUSSION

Rainwater can be stored directly in the *Jalkunds* during the rainy season which can be utilised to provide protective irrigation to the crops for successful cultivation. Otherwise, it may cause soil erosion and nutrient loss through runoff.

Activities and income generated from a farm area of 0.25 ha of the progressive farmer before & after the intervention of *Jalkund* at Chandonpokpi village, Chandel, Manipur

Table 1: Crop- Based Activity

Activity/ Crop	**Pre-intervention**	**Post-intervention**			
		2015	2016		2017
		Rabi	Kharif	Rabi	Kharif
Vegetables	Mono-cropping was practiced earlier and no crops were grown after harvest of paddy	a) Tomato var Amitabh-004, No. of plants=300, Area=60 sqm., spacing=45X45 cm, Average no. of fruits/plant=33, Fruit weight/plant=2.5 kg, selling price of tomato/kg=Rs. 15	a) Tomato var Amitabh-004, No. of plants=300, Area=60 sqm., spacing=45X45 cm, Average no. of fruits/plants = 24, Fruit weight/plant=2.2 kg, selling price of tomato/kg =Rs. 25	a) Cabbage var. Rareball, No of plants =80, Area=20 sq.m, Spacing =45X45 cm, average weight/plant =2.5 kg, Selling price per kg=Rs. 10/-	a) King chilli, No. of plants= 50, area=10 sq.m, spacing 50X50 cm, average yield=50 nos/plant selling price=Rs. 20/5 fruits
		b) King chilli, No. of plants= 60, area=14 sq.m, spacing 50X50 cm, average yield=50 nos./plant a) Selling price=Rs. 20/5 fruits	b) Turmeric (Lakadong) No of plants= 200 Area=20 sqm. Spacing=30 cmX30 cm Average yield=0.8 kg/plant Selling price=Rs. 20/kg	b) Cabbage var. Rareball, No of plants =85, Area=23 sq.m, Spacing =45X45 cm, average weight/plant =2.5 kg, Selling price per kg=Rs. 10/-	b) Pumpkin var. local, No of plants= 70, average no of fruit/plant=7, Selling price=Rs. 20/fruit
Income generated (Rs)		a) Rs. 11,250/- + b) Rs.12,000/- = Rs.23,250 /	a) Rs. 16,500/- + b) Rs. 3,200/-	a) Rs. 2000/- + b) Rs. 2125/-	a) Rs. 10,000/- + b) Rs. 9800/-
Total Income generated =		Rs.23,250 /-	Rs. 19,700/-	Rs. 4125/-	Rs. 19,800/-
B:C		a) 11250/4000= 2.81 b) 12,000/2800= 4.29	a) 16500/4000=4.12 b) 3,200/1200=2.67	a) 2000/1400=1.43 b) 2125/1500=1.42	a) 10,000/2500=4.00 b) 9800/2260=4.33
NR		a)NR= Rs. 7,250/- b)NR=Rs. 9,200/-	a) NR= Rs.12,500/- b) NR= Rs.2,000/-	a) NR= Rs. 600/- b) NR=Rs. 625/-	a) NR= Rs.7,500/- b) NR= Rs. 7,540/-
Total NR		**NR = Rs. 16,450/-**	**NR= Rs. 14,500/-**	**NR= Rs. 1,225/-**	**NR= Rs. 15,040/-**

The results (Table 1) revealed that BC ratio for tomato and king chilli was recorded 2.81 and 4.29 and the total net return (NR) was recorded Rs. 16,450 during rabi season of 2015.

During kharif season of 2016, the BC ratio for tomato and turmeric was recorded 4.12 and 2.67 and the total net return (NR) was recorded Rs. 14,500.

During rabi season of 2016, the BC ratio for cabbage was recorded 1.43 and 1.42 respectively and the total net return (NR) was recorded Rs. 1,225.

During kharif season of 2017, the BC ratio for King chilli and Pumpkin was recorded 4.00 and 4.33 respectively and the total net return (NR) was recorded Rs 15,040.

Based on three years of crop based activity at the Chandonpokpi village, the maximum and highest BC ratio was recorded for King chilli (4.29 in Rabi, 2015) and Pumpkin (4.33 in Kharif, 2017) during extreme water scarcity (November to March)

Piggery

Table 2: Pig-Based Activity

Activity/ Crop	**Pre-intervention**	**Post-intervention**		
		Batch A Aug'2015 to May'2016	Batch B May'2016 to Jan'2017	Batch C Jan'2017 to Sept'2018
Piggery	Pig rearing was done only for personal consumption	a) 4 pigs (local breed) (1 male and 3 female) Total weight: 130 kg, Average weight= 32.5 kg/pig, selling price= Rs. 190/kg, Retained=3 piglets on rotation for 6-8 months and excess pigs used for household consumption.	a) 3 pigs (local breed) (1 male and 2 female) Total weight: 97 kg, Average weight= 32.5 kg/pig, selling price= Rs. 190/kg, Retained=3 piglets on rotation for 6-8 months and excess pigs used for household consumption.	a) 3 pigs (local breed) (1 male and 2 female) Ready for sale
Income generated (Rs)	Nil	Rs. 24,700/-	Rs. 18,430/-	Nil
Total Income generated =		**Rs. 43,130/- (No expenditure on feeding as only household leftovers alongwith local wild shrubs were used for feeding)**		
B:C ratio		**24,700/15500=1.59**	**18,430** (no further investment)	

Piggery- 4 piglets @ Rs.3500/- + Transportation cost Rs. 1500/-

The results (Table 2) revealed that the total net return (NR) for pig was recorded Rs 43,130 during Aug'2015 to May'2016 and May'2016 to Jan'2017. No expenditure on feeding as only household leftovers alongwith local wild shrubs were used for feeding.

Table 3: Poultry- Based Activity

Activity/ Crop	**Pre-intervention**	**Post-intervention**		
		Batch A Oct'2015 to Apr'2016	Batch B May'2016 to Nov'2017	Batch C Dec'2017 to Sept'2018
Poultry	Poultry farming was done only for personal consumption	a) 9 birds (local breed) Total weight: 12.6 kg, Average weight= 1.4 kg/bird, selling price= Rs. 240/kg.	a) 16 birds (local breed) Total weight: 14.4 kg, Average weight= 0.9 kg/bird, selling price= Rs. 240/kg.	a) 23 birds (local breed) Total weight: 36.8 kg, Average weight= 1.6 kg/bird, selling price= Rs. 250/kg.
Income generated (Rs)	Nil	Rs. 3,024/-	Rs. 3,456/-	Rs. 9,200/-
Total Income generated (Oct'2015-Sept'2018)		**Rs. 15,680/- (No expenditure on feeding as only household leftovers alongwith local wild shrubs were used for feeding)**		
B:C ratio		**3,024/1200=2.52**	**Rs 3,456 (no further investment)**	**Rs 9,200 (no further investment)**

- **Poultry-9 Adult hens @ Rs. 700**

The results (Table 3) revealed that the total net return (NR) for poultry based activity was recorded Rs 15,680 during Oct'2015 to Apr'2016, May'2016 to Nov'2017 and Dec'2017 to Sept'2018 respectively. No expenditure on feeding as only household leftovers along with local wild shrubs were used for feeding. Fishery

Table 4: Fishery- Based Activity

Activity/ Crop	**Pre-intervention**	**Post-intervention**		
		Batch A Mar'2015 to June'2016	Batch B Jul'2016 to Oct'2017	Batch A Mar'2017 to June'2018
Fishery	Fishery was never done before due to lack of perennial water body	a) 70 fingerlings (catla, common carp & rohu breed) Total no. of fish caught= 60, Average weight/fish: 700 g, selling price= Rs. 200/kg.	a) 60 fingerlings (catla, common carp & rohu breed) Total no. of fish caught= 52, Average weight/fish: 700 g, selling price= Rs. 200/kg.	a) 80 fingerlings (catla, common carp & rohu breed) Total no. of fish caught= 73, Average weight/fish: 700 g, selling price= Rs. 220/kg.
Gross income generated (Rs)	Nil	Rs. 8400/-	Rs. 7280/-	Rs. 11,242/-
Expenditure (Rs.)	Nil	**Rs. 2800/-** (Fish fingerlings @ Rs. 5/, Lime (1 bag @ Rs. 250/-, transportation cost=Rs. 200/-, feed cost Rs. 2000/-)	**Rs. 2550/-** (Fish fingerlings @ Rs. 5/, Lime (1 bag @ Rs. 250/-, transportation cost=Rs. 200/-, feed cost Rs. 1800/-)	**Rs. 2850/-** (Fish fingerlings @ Rs. 5/, Lime (1 bag @ Rs. 250/-, transportation cost=Rs. 200/-, feed cost Rs. 2000/-)
Net Return (Rs.)	Nil	**Rs. 5600/-**	**Rs. 4730/-**	**Rs. 8392/-**
Total Income generated (March'2015-June'2018) =		**Rs. 18,722/-**		
B:C ratio		**8400/2800= 3.00**	**7280/2250=3.23**	**11242/2850= 3.94**

The results (Table 4) revealed that the total net return (NR) for fishery based activity was recorded Rs. 18,722 during Mar'2015 to June'2016, Jul'2016 to Oct'2017 and Mar'2017 to June'2018 respectively.

Stored water can also be utilised for the vegetable, horticultural crops and rearing of livestock, piggery, poultry and duckery. Fish rearing can also be taken up in the harvested water.

CONCLUSIONS

It can be concluded that the adoption of rainwater harvesting technologies increases agricultural production, improves the farmers' standard of living and reduces environmental degradation. In most cases, marginal farmers are constrained by inadequate capital, therefore rainwater harvesting enables farmers to break out of the cycle of poverty, and enable to purchase equipment and improve their livelihoods[10]. Similarly, rainwater harvesting is ideal for farmers in areas where irrigation is difficult or impossible to establish. Nevertheless, the technologies need to be properly tailored to the socio-economic and physical conditions of the locality where they are being promoted. There is therefore the need to make people conscious of the different technologies and their benefits, then mobilise and train the communities so that they can appreciate rainwater harvesting and adopt these techniques to improve their livelihoods. By and large, development that empowers local communities has a greater chance of achieving sustainable resource management as the communities take direct ownership of the developments. Furthermore, the adoption of the rainwater harvesting technologies has led to changes in cropping patterns such as the introduction of new crops, improved tillage methods and the growing of two or more crops during the same season including winter cropping.

It is found that silpaulin-lined ponds are more stable and have a longer and useful life. It can be made in any size and is also suitable for multiple uses of harvested water. The water harvested in lined ponds can be utilized for multiple uses, such as irrigation, drinking water for cattle and other livestock, fishery, piggery, duckery etc. thereby increasing its use efficiency. A dimenstion of 5 m x 4 m x 1.5 m has been found optimum for hills. Before the intervention of rainwater harvesting structure, the local farmers practiced monocropping. After the intervention of rain water harvesting structure-*Jalkund*, the water productivity (WP) and water use efficiency (WUE) of crop increased significantly. The benefit-cost ratio of crops also increased remarkably. After the construction of low cost rainwater harvesting structure- *Jalkund*, multiple uses such as irrigation, drinking water for cattle and other crops, livestock, fishery, piggery, duckery etc are taken up in the Chandonpokpi Village. This villager has increased their income and improve the livelihood of the local hill people. Hence, silpaulin-lined rainwater harvesting structure-*Jalkund* is recommended for *Jhum* improvement in the hilly region of the Chandonpokpi village, Chandel.

Usually at the hilltop, area available with farmers for cultivation is limited and their homes are situated within the cultivated field. Therefore, to store water in a *Jalkund* for longer periods during off-season, roof water collection may be linked up wherever possible. 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. Hence, farmers residing at the hilltop are considered to be the beneficiaries of this technology. During winter months when there is no rainfall, water conserved in poly-lined ponds (*Jalkund*) act as a lifeline for the seasonal crops. Life-saving irrigation can be provided from these *Jalkund* and make the farmers earn an additional income through double cropping. *Jalkund* came as a boon for the farmers of Chandel who could cultivate a variety of vegetable crops in the dry winter months.

Acknowledgement

We thank the ICAR, ATARI Zone-VII, Barapani. Meghalaya for their support and encouragements.

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