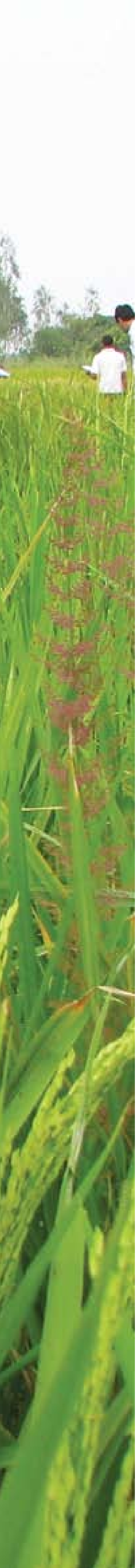
Improving Livelihoods through Water and Agriculture:

A HPPI Compendium of Simple Technologies for the Smallholder Farmers

HUMANA
PEOPLE TO PEOPLE INDIA



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2015

Humana People to People India (HPPI)

New Delhi

Foreword

Poverty is deep, widespread and multi-faceted in rural India as most of the farm families derive their livelihoods from small farms, have little access to water and energy and more importantly to new knowledge and skills for high-value, diversified and sustainable agriculture. With little assets and adaptation skills small scale farmers are also increasingly more vulnerable to the global warming and climate change. At the same time the country has all the resources and skills to provide for a dignified life to all its rural (and urban) masses supported by an excellent network of agricultural universities and Krishi Vigyan Kendras, national and international research institutes and a host of government schemes to improve the rural livelihoods. The challenge is that the rural men and women need to be empowered, to be more capable and skilled and to be better organized and ready to adapt and act. Humana People to People India's mission to *"implement projects that aim at transferring knowledge, skills and capacity to individuals and communities who need assistance to come out of poverty"* works at this interface and has helped thousands of poor women and men farmers and youth inhabiting the most challenging environments to organize in vibrant self-help groups and Farmers Clubs, share skills and knowledge and thus improve management of natural resources and crops in order to increase income and quality of life. Fortunately, most of these technologies and practices were simple and effective with life-changing impact in the project areas and potential for large scale out scaling to similar agro-socio ecologies.

It gives me immense pleasure to present this publication on **"Improving Livelihoods through Water and Agriculture: A HPPI Compendium of Simple Technologies for the Smallholder Farmers"** which is based on experiences and lessons gained through actual implementation of a number of livelihood and environmental projects in the states of Rajasthan, Uttar Pradesh, Uttarakhand, Madhya Pradesh, Odisha and Tamil Nadu over the past 17 years. These simple and low-cost technologies and practices shall help to augment the resources in water scarce regions, use these resources more efficiently for high-value crop, horticulture and medicinal plants; develop small-scale homestead nutrition gardens, enhance agricultural diversification through integration of the livestock and dairy systems, practice biogas-based organic agriculture, conserve wastelands and public spaces through plantation of trees of high economic value, establish effective backward and forward market linkages and above all empower the rural youth, women and men through innovative institutions.

The publication shall be a valuable resource for the development practitioner teams for implementation of the future projects in rural India and elsewhere, to the state governments for improved design and implementation of the agriculture and rural development schemes, to the private companies and foundations for formulation of the meaningful corporate social responsibility programs for the rural poor and value-chain stakeholders and our national and international donors and partners for better appreciation of the needs and conditions and potential solutions for the rural communities in India and beyond.

My sincere appreciations to all project teams of HPPI for their hard work in implementation of these projects and the state governments, corporate houses and foundations, and international agencies for being valuable partners for supporting these projects and interventions.

Finally I would like to express my sincere thanks to Dr. Bharat R Sharma, for developing the compendium together with project leaders and the partnership team.

Dr. A. Padmavati
Chairperson

Preface

This compendium of best technologies and practices for smallholder farmers is based on the experiences and confidence gained through actual field implementation, validation and adaptation to the local conditions of a large number of interventions recommended by the reputed experts and national and international knowledge institutions. Thousands of poor farmers living under the most challenging and water and food-insecure conditions have adopted these interventions mostly using their own resources except for the new knowledge and skills developed through their participation in project activities. These simple technologies and practices helped the women and men farmers to produce more and marketable quality products on their land using environmentally sustainable farming methods and thus had transformative impact on their income and livelihoods. The perspective users of the interventions mentioned in this compendium may kindly consider the following points:

i. Access to a dependable source of water, however small it may be, is the pre-requisite for a resilient, high-value and diversified smallholder agricultural enterprise. Considerable scope exists for development of additional resources and improving the use-efficiency of available resources.
ii. Establishment of productive homestead nutrition gardens even on tiny pieces of land is very helpful in providing food and nutrition security to the rural poor and especially to women, elderly and children. Safe use of wastewater and organics help to boost the year-round productivity.
iii. Integration of trees/shrubs of economic importance and healthy dairy animals in the rural homes provide regular additional incomes for health, education, clothing and housing expenses and better absorb the climatic shocks and weather anomalies.
iv. Establishment of effective backward and forward linkages for purchase of improved inputs, acquisition of new knowledge and sale of produce sufficiently improve the rural household incomes.
v. Individuals and communities are better equipped to address their challenges, resolve the conflicts, share their experiences and expectations, learn new skills and search new livelihood options once they are organized and supported through effective institutions. Crafting and maintaining innovative institutions is the key to establishing vital 'people to people' linkages.
vi. Finally, management of natural resources based small farming units is a much localized expertise. As such all interventions must be need based, economically viable and socially acceptable and contextualized to the local conditions before these are recommended for adoption and out scaling.

Dr. Bharat R Sharma
Scientist Emeritus (Water Resources)

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Introduction

Smallholder farmers, with an increasing share of women farmers form a major share of the Indian rural communities. Their population varies from 60 per cent to as high as 90 percent among different Indian states. Agriculture and farm labor provides the main source of income for this vast population of about 600 million people. Several of these farmers continue to practice subsistence crop- and livestock- based agriculture with low entrepreneurial skills and limited access to affordable technologies and practices for yield enhancement. Additionally, they have poor access to reliable water resources to meet their productive and consumptive water needs. As such yields and incomes are low with limited opportunities for livelihood improvement. At the same time agricultural universities, national and international research institutes, state and central departments, large non-governmental organizations, farmer science centers *(Krishi Vigyan Kendras)* and some champion farmers have developed a number of simple and affordable technologies, practices and products. Large scale adoption of these improved skills shall be possible upon their validation under actual farming conditions and through initial support to the farmers. Continuously addressing the farmers' concerns and queries, improving their capacities and facilitating linkages to the markets and credit and knowledge institutions shall be quite helpful. Designing these interventions with a gender-sensitive approach shall be especially helpful for the women farmers.

Out of several inputs of high yielding seeds and breeds, organic and inorganic fertilizers, and farm machinery and labor; access to a reliable source of water is highly critical for the smallholder farmers. Water is essential for initiating the farm operations for a given crop and meeting the irrigation needs during the crop growth. In fact the decision of cultivation of a particular crop- rice or an upland crop, pulse or oilseed, fodder or a vegetable crop, orchard or tree crops and more importantly irrigated or a rainfed crop, all depend upon the availability and her/his access to a reliable water resource. Diversification of the agricultural enterprise to include livestock and dairy animals, fisheries and aquaculture; and poultry shall also depend to a large extent upon the farmers' assets of water resources. Unfortunately, intensification of water use by agriculture, domestic and industrial sectors has caused exploitation of the water resources more than the natural recharge. The situation is precarious in the northwestern states of Punjab, Haryana, Rajasthan and Uttar Pradesh (except some districts in the east), central state Madya Pradesh and the southern states of Tamil Nadu, Karnataka and Andhra Pradesh. Large parts in these states have witnessed continuous and steady decline of groundwater tables, reduced discharges from open wells and tube wells coupled with degradation of water quality. As an illustrative example the block wise long-term pre- and post-monsoon decadal (1995-2004) declining water table trend of Alwar district of Rajasthan is given below.

Example of depleting ground water resources of Alwar district, Rajasthan: Issues of Concern

Depleting ground water resources and declining water levels are issues of concern for the farmers and general public of Alwar district. The average decline of ground water level (1995-2004) in the district is about 2.90 meters. The maximum depletion was recorded in Neemrana block being 10.65 meters while minimum in Thana Ghazi block being 0.26 meters. The depletion in water table is mainly due to:

- Ground water being the only source to meet the water requirement for various uses
- Significant increase in number of tube wells for irrigation/domestic/industrial purposes
- Increasing population and urbanization
- Increasing industrialization
- Low annual rainfall

It is evident that due to inadequate availability of surface water, there is pressure on the ground water resource to meet the water requirement in the district. State Ground Water Department has carried out the estimation of ground water in association with Central Ground Water Board. Summary of the results is presented in the Table-1.

Table-1: Summary of the Ground Water Resources (million cubic meter = mcm) of the Alwar District, Rajasthan

a. Net annual ground water availability	912.3019 mcm
b. Annual gross draft	1112.0723 mcm
c. Ground water availability for future irrigation development (considering domestic draft for 2025)	(-) 272.1083 mcm
d. Stage of ground water development	121.90 %
Category of blocks – a. Over exploited:	11 (Behror, Bansur, Kathumar, Kishangarh, Kotkasim, Laxmangarh, Mandawar, Neemrana, Rajgarh, Reni, Tijara)
b. Critical	2 (Ramgarh, Umrain)
c. Semi-critical	1 (Thanagazi)
d. Safe	Nil

Source: Environmental Master Plan of Alwar district, 2011. Government of Rajasthan, Jaipur (http://environment.rajasthan.gov.in/Utilites/Upload/Notifications/Environmental_Master_Plan_Alwar.pdf).

The depth of ground water level varies from block to block and in large parts is below 20 meter of ground level. As water tables decline beyond 12.0 meter below ground level, farmers have to depend upon the costly submersible pumps and electric motors for extracting the groundwater and generally this is beyond the capacity of small and marginal farmers. The situation can be improved through suitable interventions for supply augmentation and demand management. Some of the measures like construction of recharge structures to transfer a part of the surplus water in the village ponds to the aquifers and construction of check dams to facilitate recharge through larger and longer surface spread, planting of trees and grasses in the catchments and rooftop rainwater harvesting and recharge from large buildings are best suited for community participation. Other measures like recharge through individual dug wells and hand-pumps, roof top rainwater harvesting and recharge from residential buildings and storage of surplus rainwater in farm ponds, cisterns and tanks may be implemented at individual or farmer-cluster level. Safe and smart use of the harvested water for higher productivity may be achieved through water-efficient farming systems and timely application of limited resource through plastic pipes and taps, drips, micro-sprinklers and sprinklers. Wastewater from households and animal sheds is an important and assured resource for developing kitchen gardens and small family farms.

Smart improvements in the agronomic practices and diversification of the agricultural farms exhibit a large potential of improving the yields and farm incomes. Converting a part of the farm into vegetable gardens; plantation of fruit, timber, aromatic and medicinal trees, shrubs and grasses; adoption of best agronomic practices, conservation agriculture (zero/ minimum tillage and residue management), system(s) of rice and wheat intensification, organic agriculture, value addition of residues and farm manure through vermicomposting and its proper application, and use of soil-test based balanced fertilizers and critical micro-nutrients are all very helpful. Keeping healthy dairy animals provides much resilience and economic security to smallholder farmers, especially the women farmers, through regular cash income, clean cooking gas through *Gobar Gas* (Biogas, cowdung based cooking gas unit) plants, enriched manure for the farms and improved health conditions.

Decade-long and extensive engagement of the field units of HPPI working under diverse socio-economic and agro-ecological environments has shown that knowledge of the farmers, Panchayati Raj Institutions (PRIs) and small NGOs -about these technologies, practices and products is inadequate. Additionally, there is enhanced feminization of Indian agriculture and their knowledge needs, participation patterns and communication products need to be better understood. The rural youth is impatient and always looks for innovative ideas and advise which helps them to meet the resource and infrastructure challenges and provides opportunities to 'convert small farms into smart farms' through linkages of land-labor-technology-niche' markets. HPPI is fully aware of these challenges and emerging opportunities and has formulated its interventions to help small and marginal farmers.

Material presented in the following sections draws extensively on the decade long management, community engagement and field implementation of the following rural development projects:

- Selecting and Scaling up Water-Efficient Farming and Groundwater Recharge Systems among 3,000 Small Scale Farmers in Alwar district, Rajasthan
- Groundwater Recharge and Water and Soil Conservation Technology for Poor Farmers in Rajasthan, Dausa District
- Community Development Project, Lakheri, Rajasthan
- Tree Plantation Project: Rajasthan, Haryana and Odisha
- An Initiative for Sustainable Water and Land Resources Management in Neemrana Region, Alwar, Rajasthan
- *Harit Sankalp*/ Green Action Project, Alwar, Rajasthan
- Green Action Project, Neemrana, Alwar, Rajasthan
- Environment and Community Development Project-Nainital district, Uttarakhand
- Diabetes Community Care and Support Project, Jodhpur, Rajasthan
- Climate Adaptation Pilot Project with Farmers in Mallawan Block- Hardoi District (UP)
- Seeds for Life - Action with Farmers in Uttar Pradesh-IGP Region to Enhance Food Security in the context of Climate Change, Badaun and Unnao districts, Uttar Pradesh
- Biogas as Renewable Energy Source in Indian Villages, Dausa District, Rajasthan
- Green Post-Tsunami Action Project, Tamil Nadu, (Villupuram, Kanshipuram, Cuddalore, Tiruvallur districts)
- Community Development Project - Karahal Block, Sheopur District, Madhya Pradesh

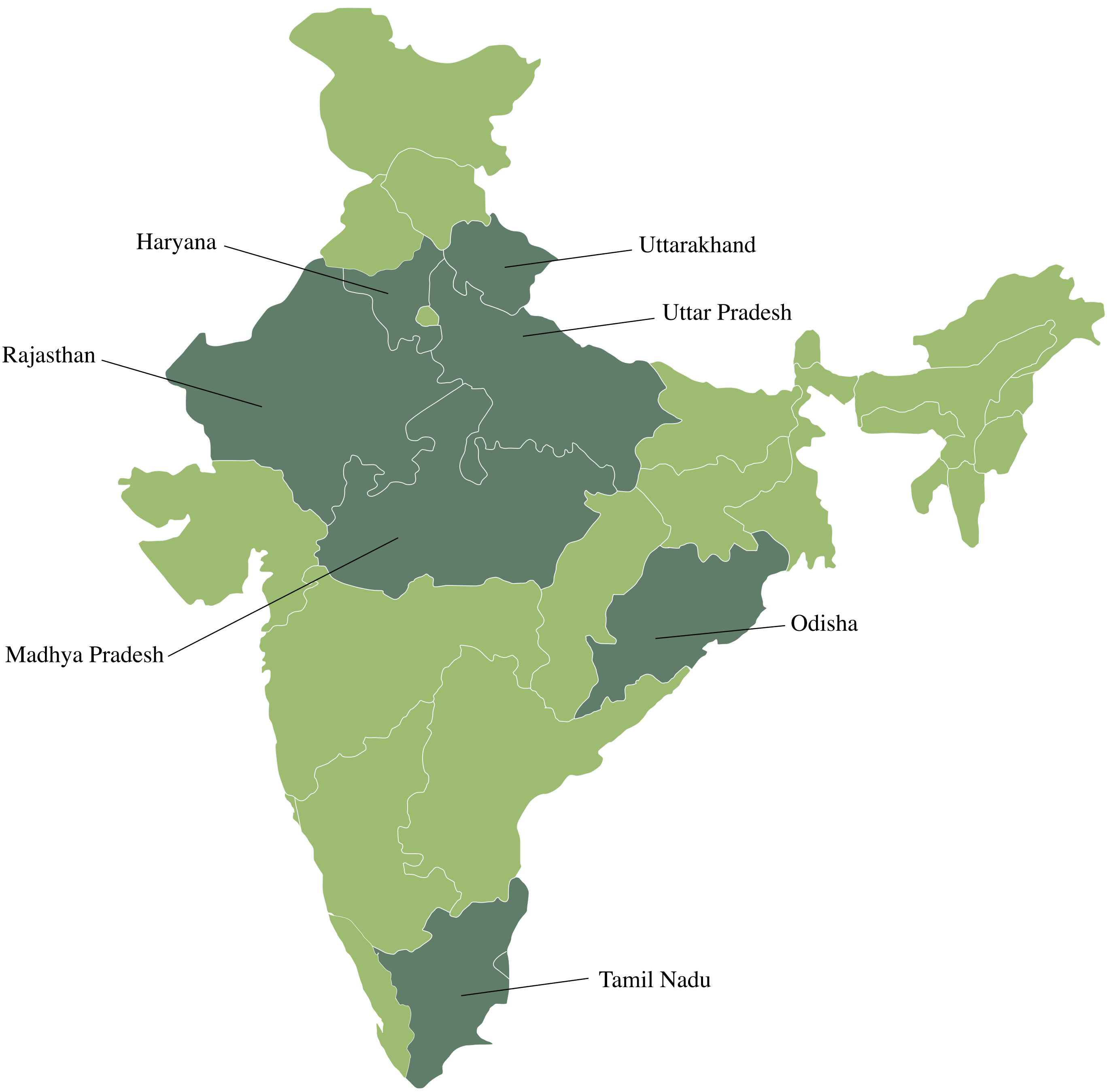


Figure 1: States of India where HPPI has implemented projects

2. Bridging the Demand- Supply Gap: Augmentation of Water Supplies to Meet Production and Consumption Needs

Expansion and intensification of agriculture, cultivation of water-intensive crops in water scarce regions and a significant increase in industrial and domestic water needs in urban areas have caused a large negative water balance between the demand and natural water supplies in large parts of India, - especially in the northwestern arid and semi-arid states of Rajasthan, Punjab, Haryana, western Uttar Pradesh, Gujarat, parts of Madhya Pradesh and southern states of Tamilnadu, Karnataka and Andhra Pradesh. The deficit between total demand and supply for the Rajasthan state was 8 Basin Characterization Model (BCM) in 2005 and is likely to escalate to 9 BCM by 2015. Use of groundwater for irrigation has increased three times during 1984 to 2009. This has caused a secular decline in water tables (Table 2), termed as 'over-exploited' blocks, reduced discharges from the wells and tube wells, including failure and abandoning of wells, and enhanced expenditure on deepening of wells and energy costs. Small and marginal farmers, especially the women farmers, who own small water lifting devices or depend solely upon the informal groundwater markets for purchase of ground water, are seriously affected by these worsening scenarios.

Table 2. Status of ground water recharge and utilization in Rajasthan (BCM)

Year	1984	1990	1995	1998	2001	2004	2009
A. Gross groundwater recharge	16.22	12.71	13.16	12.60	11.16	11.56	11.86
i. Irrigation use	4.93	5.42	9.09	11.04	10.45	11.60	12.86
ii.Domestic and Industrial use	2.11	1.99	0.70	0.98	1.18	1.39	1.65
B. Gross draft (i+ii)	7.04	7.42	9.78	12.02	11.64	12.99	14.52
Groundwater balance (A-B)	9.19	5.29	3.38	0.58	**-0.48**	**-1.43**	**-2.66**
Stage of groundwater development (%)	36	54	59	69	104	125	135

Source: Groundwater Scenario of India, 2010. Central Ground Water Board, MoWR, Faridabad, Haryana

Surplus amount of runoff from the uplands in the village normally gets collected in the village ponds and other depression areas. With the change in lifestyle of the rural population and animal husbandry; the traditional ecosystem services provided by these ponds for satisfying human and animal drinking needs, bathing, washing, worshipping etc. are on the decline and most of these water resources can be efficiently used for recharging the depled aquifers. Construction of check dams at appropriate sites shall help in larger spread of the water resources, reduce the flow velocity and thus provide additional water resource for replenishing the water storage and reduce the negative impacts of soil erosion and crop/ vegetation losses. Large public buildings like schools, community houses and even the individual houses have cemented rooftops and generate sufficient runoff during the rainy season. Simple rooftop rain water harvesting techniques provide a good opportunity to guide this accumulated flow for groundwater recharge. This can be achieved either in a general manner for benefit of the community or targeted directly to individual abandoned wells and near the hand pumps to create the local water table mounds for improved water tables. Groundwater recharge is also a good technique in the coastal areas to arrest the ingress of inward salinity and can be successfully employed to rejuvenate the water resources post major disasters like *tsunami* sea waves and coastal cyclones.

Humana People to People- India (HPPI) successfully employed a number of these techniques under varying socio-economic and agro-hydrological conditions in the water scarce regions of India. A large part of the success of these interventions is attributed to the integration of high class bio-physical technology with an inclusive social engineering of the rural communities. Partnership with global institutions like International Water Management Institute (IWMI) and local agencies like State Ground Water Board, Development Departments, *Krishi Vigyan Kendras*, and village institutions was very helpful in implementation and long-lasting impact. Some salient project interventions are presented below:

2.1. Innovative Techniques for Ground Water Recharge

Behror block in Alwar district Rajasthan represents a typical water deficit region which has a limited rainfall of 666 mm/annum and no perennial river or canal to supply surface water. Groundwater is the only source to satisfy the water requirements for all sectors. Presently, irrigation facility is available to 11,000 hectare or about 40 per cent of the total cultivated area. Tube wells, dug wells and open wells are used for water extraction. With rapid expansion of agricultural, industrial and domestic and livestock water needs, the resource is under severe stress manifested through declining water tables and deteriorating water quality. Behror is one of the most over-exploited blocks with stage of groundwater development estimated at 192.9 percent (Environmental Report of Alwar District, Government of Rajasthan, 2011). This means that extraction of groundwater is twice the amount of natural recharge. Such a grave situation has a serious impact on sustainability of agriculture and acts as a constraint for diversification of agricultural enterprise and the livelihoods.

2.1.1. Recharge through village ponds in Behror Block, Alwar, Rajasthan

Most of the villages in Alwar district have a large pond located on the outskirts, which were traditionally the main source to meet the village water needs. Discussions with the communities in Talwar, Dughera and several other villages indicated that these ponds could be an important source for groundwater recharge. Further interactions revealed that the community shall not allow for using up all the water and a minimum of 25-30 per cent of water may be retained for bathing of buffaloes and general cooling and aesthetic and cultural purposes. Once all the potential benefits were explained in an understandable language, the communities were even enthusiastic to pay for a part of the cost in the form of labor and local materials. The community realized the approaching water crisis and a consensus was reached whereby the community and the local *Panchyat* committed unanimously to participate in the construction of the structure and also to take care of its future maintenance.

The Intervention: After detailed survey of the village pond to map its existing and rainy season water spread an estimation of the surplus water available for recharge was made through depth-capacity curve. A suitable recharge structure in the form of a vertical recharge shaft was constructed at the lowest point of the pond. The construction was completed in the month of May-June when stored water was minimum. The construction site was first evacuated through temporary embankment and pumping. The shaft was dug to a depth of 5 meter with a suitable machinery so as to puncture any impervious layer. It was then filled with porous material in the form of gravel and sand. The inlet in the structure was placed at such a height that a minimum of 25 per cent of the water always remained in the pond to take care of the environmental and cultural services including the birds, which nested in large number on the trees around the pond.

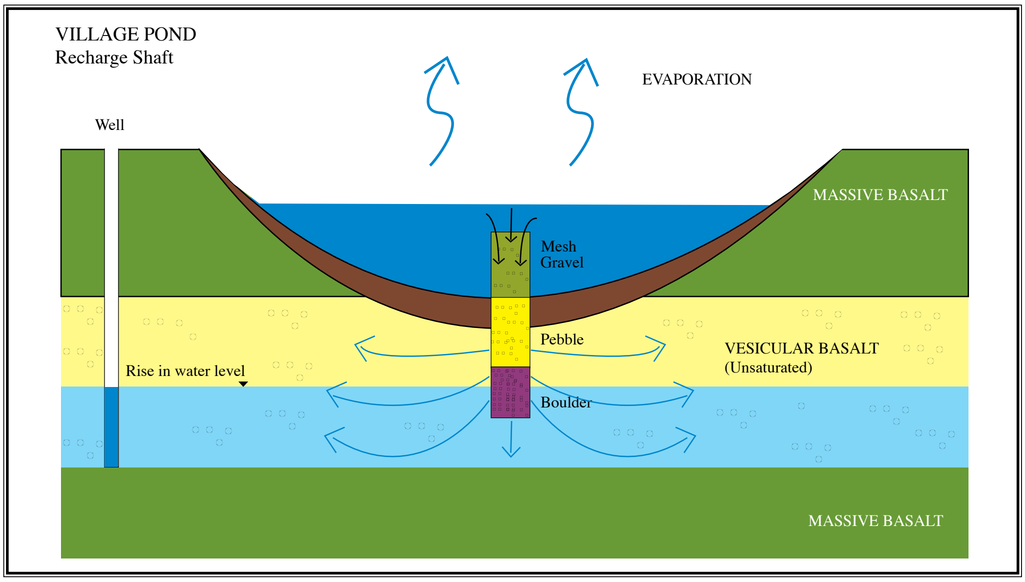


Figure 2: Schematic design of recharge shaft in a village pond (Model Designs for Rainwater Harvesting and Artificial Recharge;
http://wrmin.nic.in/writereaddata/ModelDesignsforRainWaterHarvesting.pdf)

Figure 3: Recharge structure under construction at the project site, Dughera village, Behror block, Rajasthan (June, 2006)

Estimates showed that on an average the village pond was able to provide a surplus water of 10,000 m^3 /season for recharge. Impact of this recharge was measured through change in water levels in the adjoining wells. It was observed that water levels in the wells located within 50 meter's radius from the pond improved by about 2.5 to 3 meter. Water levels in the wells located at 160 meter from the pond were also improved by about 1.0 meter. The villagers were very pleased with this intervention, which resulted in lower energy costs and improved availability besides the satisfaction of a positive contribution to the sustainability of the local resources. The local community greatly valued this intervention and a recent visit (October, 2014) to the structure showed that this was still working satisfactorily and provided the intended benefits. The villagers took great pride in this intervention and were eager to show it and explain the benefits to the visitors. Total cost of the structure was about INR 1,50,000 and 30 per cent of it was shared by the village community.

Figure 4: Village head explaining about the positive benefits of the recharge structure during a recent visit to the site (October, 2014)

Impact and Upscaling: The intervention found much favor with the adjacent villages and was widely covered by the media. The model was appreciated and considered for adoption at other similar sites by the state development departments. Though it may be beyond the capacity of the project to estimate the total benefits which can be attributed to the intervention, but surely it helped in de-escalating the fast pace of declining water tables and improved the groundwater resources in the water scarce regions.

2.1.2. Runoff water harvesting and recharge in Neemrana Block, Alwar, Rajasthan

Neemrana is an ancient historical town in Rajasthan, which is now also a modern industrial hub. The region is dotted with steep hills, rolling lands and flat plains. Presence of large but abandoned step wells in the region indicate that water scarcity was always a concern and population was aware of the benefits of water harvesting. However, the fast pace of agricultural and industrial development has substantially over-exploited the resources. The undulating topography of the region and relatively higher amount of rainfall (700-1135 mm/ annum) provides good opportunities for water harvesting, storage and recharge. Our estimates show that presently 40.6 percent (461.4 mm) of the annual rainfall runs off from the sub-basin. As the temperatures remain very high during the long summer season, a large amount of water (55.9 %) is lost through evaporation and transpiration leaving only a small amount for other uses.

The Intervention: HPPI, Confederation of Indian Industry (CII) and SABMiller India joined hands to scientifically understand the water balance of the sub-basin to ascertain the demand and supply deficit (Table 3) and then design suitable interventions for augmenting the water supplies.

Table 4. Overall water balance of the Neemrana sub-basin, Alwar, Rajasthan*

Particular	Quantity (mm)
Input- Precipitation	1135.0
Input- Groundwater	198.3
Potential run-off from the basin	461.5
Water use-drinking	17.1
Water use-agriculture	173.5
Water use-industrial	7.7
Deep aquifer recharge	42.4
Losses due to evaporation from water bodies and evapotranspiration from the basin	635.0
Balance at the end of the year (summer- pre monsoon)	0.0

**Estimates by experts from CII*

Check-dams in the upper catchments (foothills) and groundwater recharge structures in the flat plains were considered appropriate for harnessing the surplus run-off. In the upper catchments six masonry check-dams of appropriate dimensions sited at the suitable locations for higher impact were constructed with complete participation of the farmers in the upstream and downstream locations. The farmers observed the following main benefits:

- There is a significant increase in the cropped area as the area, which was lying barren due to gullies and crisscrossing small streams, has now been channelized and the entire farm is now under cultivation. At one location in Silarpur village near Neemrana Fort, the increase in high value cropped area was more than 4 hectare.
- The soil profile remains fully recharged after the rainy season and the farmers are harvesting a bumper mustard crop purely on the residual moisture.
- Soil erosion has completely stopped making the soils fertile and responsive to the fertilizers and other agro-inputs including the use of tractors and farm implements.

Figure 5: Levelling of undulating gullies and construction of check dam has enhanced both the cropeed area and the crop productivity in Silarpur, Neemrana block

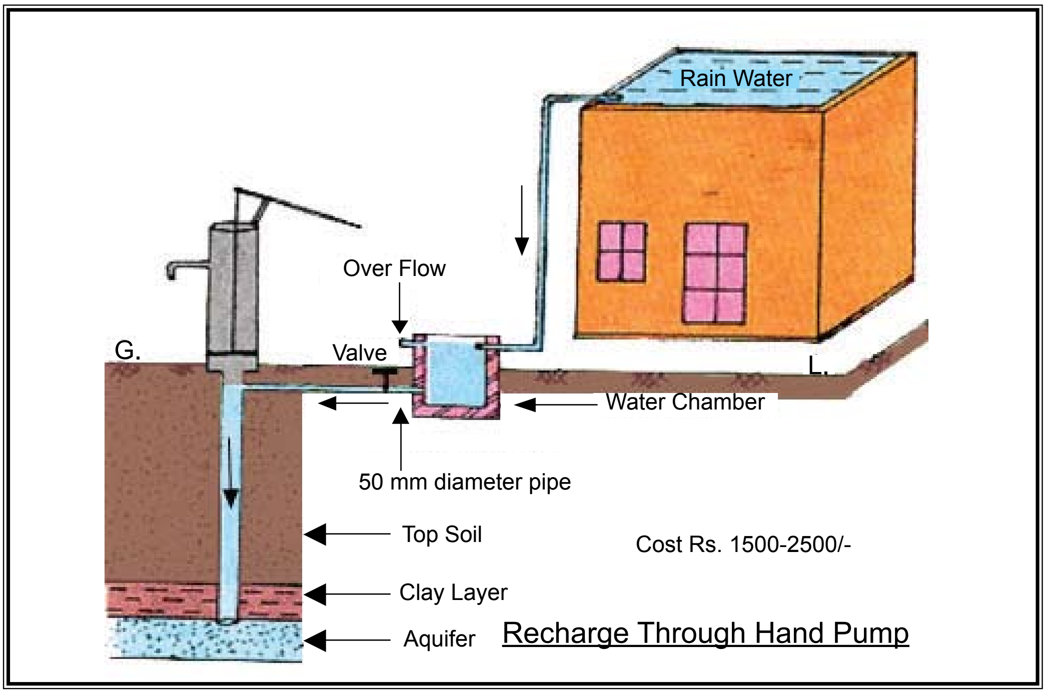
- The discharge from the wells and tube wells has improved with higher and stable water availability at lower energy and pump costs.
- The economic condition of the farmers has significantly improved as several farmers harvested the crop for the first time from new areas, achieved higher yields (> 30% improvement in pearl millet , wheat and mustard yields), improved cropping intensity and diversified the enterprise through inclusion of high value crops (cauliflower seed production, vegetables) and quality dairy animals.
- A significant impact was noticed through interest of rural youth in high value agriculture, improved employment for women and better nutrition for women and children.

Figure 6: Conversion of barren and undulating lands into new and productive farms- a life changing impact for food-insecure farming families

Impact and upscaling: The project has been able to identify 60 sites for such water harvesting structures in the sub-basin, which will have a combined storage capacity of 3.36 million m^3 and a total recharge potential of about 21.8 percent of the total runoff. Scaling up of the intervention shall require an investment of about Rs. 1.74 million and the private companies (as part of Corporate Social Responsibility activities) and District Development Department has shown keen interest in the implementation. The intervention has the potential of bringing lasting smiles on the faces of thousands of farming families and especially the women and children.

2.1.3. Roof-top rain water harvesting and recharge

A number of government schemes to create the public spaces in the form of schools and colleges, dispensaries, community houses and offices; and a large number of private residential houses have cemented roof-tops which generate concentrated run-off during the rainy season. In the urban areas, the government regulation requires all such buildings to construct rainwater harvesting structures. There is no such regulation for the rural areas and presently most of this runoff runs through the streets and open public spaces causing inconvenience and sanitation concerns and is finally lost through evaporation. This resource, when harvested and channelized in a scientific manner, provides good opportunities for augmenting the common pool of groundwater resources or targeted through the individual wells (abandoned or functional) and hand pumps. Such a recharge creates a local groundwater mound for the benefit of individuals and communities. It is recommended that the harvested water may be first passed through a small siltation tank (made of sand and gravel filter material) and then channeled to the recharge structure.



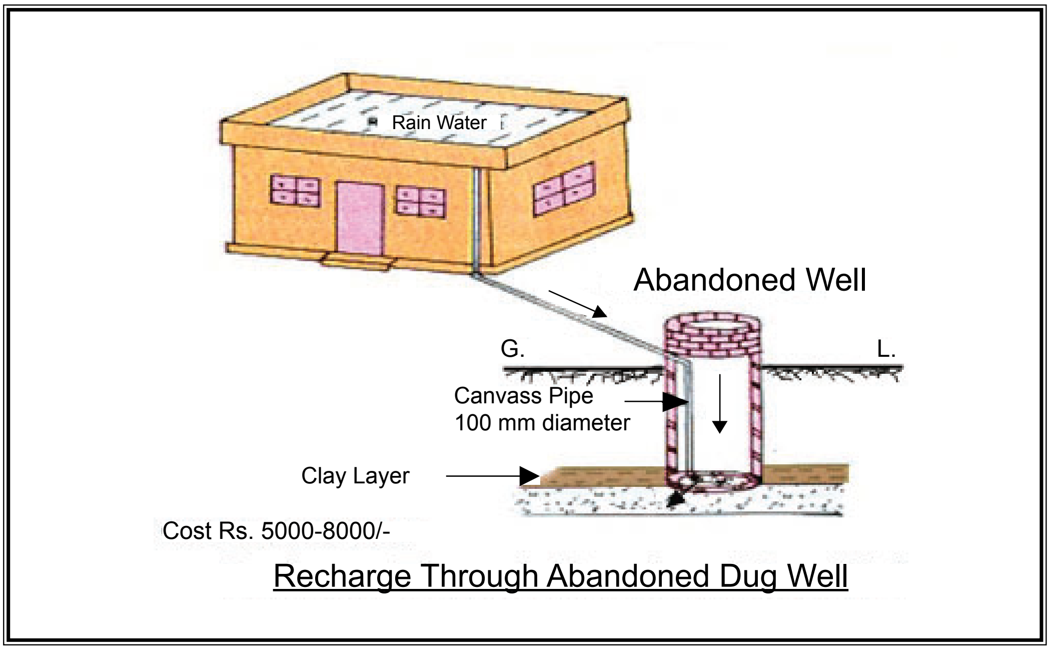


Figure 7: Schematic diagram of rooftop rain water harvesting and recharge through hand pumps and abandoned wells

Some of the successful examples implemented by HPPI and their associated benefits include the following:

- In Behror block in Alwar district, 50 artificial recharge structures were established near the wells where a steep fall in water table was reported by the farmers. The structures were established through consensus with the local communities. The filter media was designed to clean 560 mm of the seasonal rainfall available for recharge. Regular monitoring showed that most of the structures were working satisfactorily and even continuous rain for 3 days (37, 100 and 84 mm) in July caused overflow only in two structures. As such all the rainwater was successfully harvested and used for groundwater recharge.

- In Lakheri, Bundi District, Rajasthan, 10 dry dug-well recharge systems were constructed on 18-21 meter deep dug wells. Three wells were completely filled up with water during the monsoon and water stock in another seven wells was around 50 per cent. The farmers used the additional resource for providing pre-sowing irrigation and cultivation of additional 50 *bigha* (about 8 ha) of land. The water stayed for longer duration in the nearby wells and were further recharged during October rains. The visiting farmers were so happy to see the results that another 10 farmers agreed to contribute Rs.2, 500 each to partially meet the cost of construction. All the 20 dug wells recharged groundwater and are functioning satisfactorily.
- Sixteen rooftop rainwater harvesting and storage structures were constructed at Lakheri during 2010-11. The water storage system preserved rainwater during the monsoon and the associated families looked after their operation and maintenance. Each structure had a storage capacity of 10,000 to 15,000 liters which was sufficient to meet family water requirements for 2 months and partially meet other needs for another 3 to 4 months. In the areas having acute shortage, these tanks could provide drinking water to a family of 5 persons at 6 liters per day for the whole year.
- No overflows were observed in the dry hand pumps and abandoned wells and thus are well suited for recharge. Estimates showed that on an average a rural household rooftop generated a recharge of about 37 m^3 /season (shall vary with size of the roof) and caused a water table improvement of about 3 meter around the pumping structure. The owners also observed an improvement in the taste of water as the general water quality in the region is saline.

Figure 8: Groundwater recharge of (a) small hand pump and (b) rooftop rainwater harvesting in Senior Secondary School in Rewali village, Rajasthan

- Model and large rainwater harvesting structures were constructed at the Girls College in Bhetida village and a Senior Secondary School in Rewali village (Behror block, Alwar). Similarly, four large structures were constructed in the schools at Garampura, Utrana, Shankarpura and Budhel and one at the office of Sub-Divisional Magistrate, Lakheri (Bundi district). Besides the physical benefits, the models served as good demonstration sites for the young students and general public who better appreciated the value of water, the looming crisis of water in scarce regions and an urgent need for conserving it through better practices.

Impact and Upscaling: This is a low cost technology with large benefits at individual and community level. In large metropolitan cities the construction of rooftop rain water harvesting structures has been made mandatory in all large public buildings and constructed at a subsidized cost for the willing individual households. Similarly, farmers may be educated and persuaded to convert their abandoned/ failed open wells and tube well from the dumping sites into functional recharge structures. These structures serve the dual purpose of groundwater recharge and an improved drainage to keep the streets and open spaces free from stagnant cesspools and thus improved sanitation. The only caution is to ensure that effluent from industrial units and wastewater of poor quality may not be used for direct recharge into the ground.

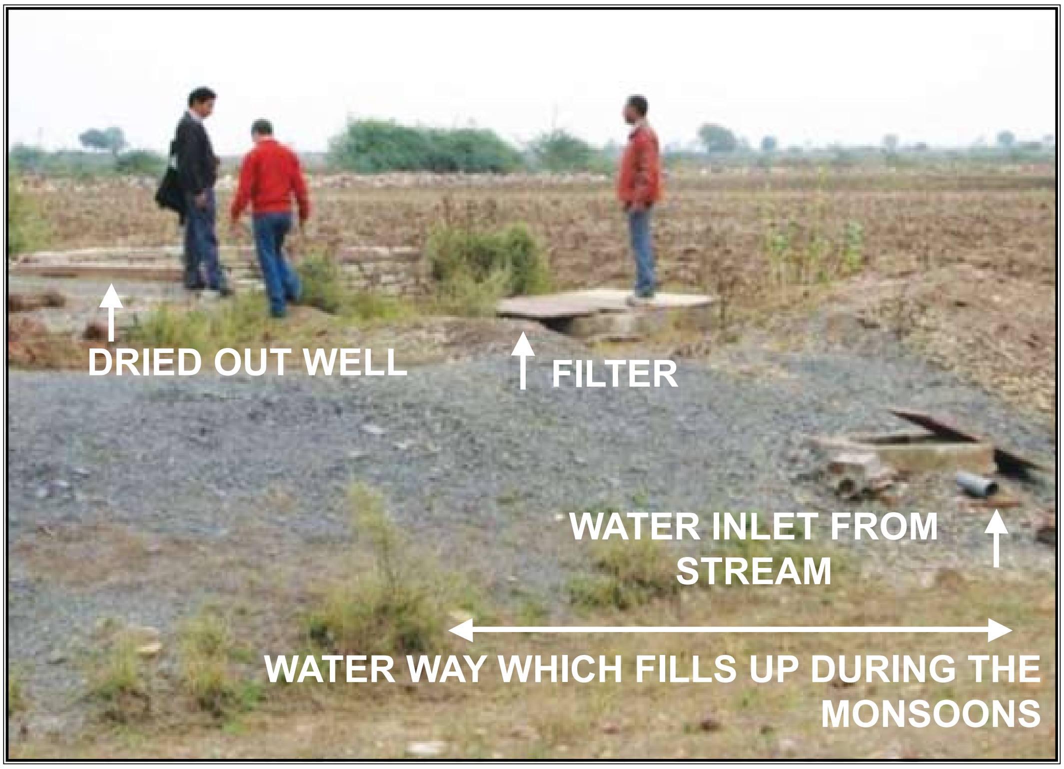


Figure 9: Abandoned and failed wells are successfully retrofitted as rainwater recharge and storage units- highly useful in water scarce regions

3. Water Saving Irrigation Methods

Water is a prime natural resource, a basic human need and a precious national asset, and more so in the water scarce arid and semi-arid regions of India. With more than 80 per cent of the developed water resources being used in agriculture, it is imperative to use it with utmost efficiency. While it is important to reduce the water deficits through water conservation and groundwater recharge it is even more important to use these resources prudently. Best practices need to be adopted to produce *'more crop per drop'* or *'more value per drop.'* Unscientific and indiscriminate use of water leads to undesirable consequences and lower productivity and services. The basic knowledge of large section of the farmers on 'how to irrigate, when to irrigate, and how much to irrigate' is insufficient. Water, as a critical input to crop production, needs to be applied at the right time, in the right amount and through the right method. Most studies and demonstrations have conclusively shown that even small amounts of water applied at critical stages of crop growth has the potential of improving the crop yields by 30 to 100 percent. In the time of abundance or when the water resource has low marginal productivity, farmers have the tendency to apply the water inefficiently through flood irrigation on the imperfectly levelled large basins. Unfortunately, the same tendency continues even when the resources are limited and costly and the farmer is practicing high-value agriculture.

A smart and efficient irrigation method applied at the appropriate stage produces large benefits and more importantly, it creates:

- Higher productivity of field crops, fruits and vegetables and other economic plants.
- Improved benefits from the applied inputs- improved seeds, fertilizers and manures, tillage and agro-chemicals.
- Opportunities for increasing the extent of irrigated farms from the same resource.
- Opportunities for diversified and high value agriculture through inclusion of vegetables and fruits, flowers and medicinal plants and dairy, poultry and fisheries. And of course, improved quality and timing of the produce.
- Resilience towards droughts, frosts, heat waves and other impacts of climate change.
- Economic opportunities for small farmers through intensification of agriculture, and better targeting of local and niche markets.

HPPI through its implementation of a number of projects in the water scarce regions of Rajasthan, Uttar Pradesh, Madhya Pradesh and Tamil Nadu helped the rural communities to realize these benefits through adoption of a number of efficient irrigation methods and practices. These included the adoption of furrow irrigated raised beds (FIRBS); smaller/ optimum size of the check basins; use of plastic pipes for water conveyance; irrigation at critical stages of crop growth; aerobic rice cultivation; and use of drips, micro-sprinklers and sprinklers for precision water application. The following interventions were highly appreciated and adopted by the farmers:

3.1. Furrow Irrigated Raised Beds (FIRBS)

This innovative system of crop planting has been perfected with years of extensive and participatory research and demonstrations at the farmers' fields and now constitutes an important component of the conservation agriculture. Most of the upland crops have been successfully planted in the furrow irrigated raised beds with major gains for vegetable and horticultural crops, wheat and sugarcane and for all crops when the fields are saline and waterlogged. The bed widths can be adjusted as per the nature of the crop and normally two rows of plants on 65-75 cm beds were suitable. Salient benefits of Furrow Irrigated Raised Beds include the following:

- Fifty per cent savings in the cost of quality/ hybrid seeds, seedlings and planting materials.
- Thirty-forty per cent savings in amount and cost of water and its application.
- Higher crop yields (10-30%) with improved product quality.
- Reduction in farm drudgery, especially for women farmers.
- Opportunity for applying small and targeted amounts of water and fertilizers at all stages of crop growth.
- Avoids temporary waterlogging, promotes better rooting and anchorage of healthy plants.
- Facilitates mechanical weeding, allows sub-surface basal and top-dressing of costly fertilizers and reduces nutrient (nitrogen) losses.
- Promotes rainwater conservation (up to 100% in low rainfall areas) without any adverse effects on crop growth.

Figure 10: Wheat planted on Furrow Irrigated Raised Beds (FIRBS) in HPPI model fields at the farmers' fields in Kankerchajja village, Dausa District, Rajasthan

The Intervention: In the semi-arid areas of Rajasthan and neighboring states (Haryana, Gujarat), farmers face the problem of yield losses due to crop lodging caused by high velocity hot winds at the time of maturity of wheat. The losses can be as high as 25-40 per cent depending upon crop variety and stage of crop growth. FIRB technology does not allow the plant to come in direct contact with standing irrigation water and maintains a strong anchorage. As a modification, three rows of wheat were planted on a raised bed followed by a furrow for irrigation. The fields were perfectly levelled and in case fields have some slopes, the furrows were made across the slope to ensure uniform moisture level for different parts of the field resulting in uniform growth. The furrows also helped in better intercultural operations and the uprooted weeds were used as mulch to reduce evaporation losses. The crop on FIRB required smaller irrigations as compared to conventional flood irrigations. Though 25 percent of the land was occupied by furrows, there was no reduction in crop yield due to better growth and bolder grains. In fact the farmers' average expenses on irrigation were Rs. 3,516/ha under FIRB as compared to Rs. 6,884/ha with flood irrigation due to reduced pumping hours (88 hours of irrigation/ ha under FIRB and 172 hours of irrigation/ha under the conventional flood irrigation).

Farmers were of the view that FIRB technology was also better suited to cope with erratic power supply and they were able to significantly reduce the area under irrigation without actually over-exploitation of the groundwater. The method was also recommended for farmers who prefer to raise a seed crop as the grains were bold and healthy. Some of the additional details are provided in the Table 4 below:

Table 4. Comparative analysis of Furrow Irrigated Raised Beds and flood irrigation in wheat in Behror block, Rajasthan (2006-2007)

Components	Average of FIRB model fields	Normal check basins
Total number of irrigations	7	6
Total irrigation hours required to mature the crop	**87.9**	172.1
Average grain yield, t/ha	3.3	3.4
Total expense on irrigation, INR/ha	3,516	6,884
Returns from the sale of grains, INR/ha	28,882	29,206
Returns after accounting for irrigation expenses, INR/ha	**25,366**	22,322
Total water pumped to mature the crop, m^3/ha	**1,638**	3,205
Water savings, % (as compared to normal basins)	**48.9**	---

3.2. Optimum size of the check-basins

Uniformity and efficiency of water application in the field largely depends upon the levelling conditions, discharge of the pump and size of the check basin. Farmers generally have small size water pumps and little control over the discharge. With the use of small tractors and implements and small window available for farm operations after the *kharif* crop harvest, the field levelling conditions are at best satisfactory but may generally be 'imperfectly levelled'. Farmers in the states of Punjab and Haryana have started preparing their fields with the use of precise laser land levelers but the same are still not in use in most of the other states. Most farmers tend to have one acre field plots for wheat and other field crops and as such end up losing more water and nutrients (especially nitrogen) in the head reaches and several patches at little higher level remain under-/un-irrigated. Such a situation also leads to uneven crop growth, lower yields and uneven ripening of the produce.

Figure 11: Farmer irrigating a small check basin for vegetable planting, Gunti Village, Behror

Smaller check basins is a non-monetary practice, which divides the field into smaller units for improved application of water and achieving higher water application efficiency. Demonstrations with improved practice and its comparison with normal check basins showed a number of benefits:

- Spread of water and thus the nutrients was more uniform in smaller check basins as compared to large fields. Crops in smaller basins were also less susceptible to lodging at maturity.
- Irrigations of smaller check basins saved on irrigations hours/unit land: on an average one hectare of smaller basins was irrigated in 132.9 hours as compared to 172.0 hours for large basins. Number of irrigations (6) was same for small check basins and the large fields.
- Keeping all other factors comparable, irrigation expenses for one hectare of smaller check basins was Rs. 5,316 as compared to Rs. 6, 884 for the traditional large fields- making a financial saving of about 23 per cent.
- Additionally, there was an increase in grain yield in small check basins making an additional benefit of Rs. 5,467/ ha (13.34 % increase over the control).

Construction of small check-basins is an easy and non-monetary intervention and farmers were quick to understand its benefits even during the initial sensitization meetings. However, the farmers got fully convinced during visits to the demonstration and personal discussions with the adoption farmers. The good and lasting behavior demonstrated by the famers and keen interest exhibited by the visiting farmers makes this intervention suitable for upscaling. The intervention is suitable for most irrigated field crops namely wheat, mustard, gram, other oilseeds and all the vegetable and floriculture fields.

3.3. Smart Sprinkler System

Sprinkler irrigation is widely used in Rajasthan, Haryana, Madhya Pradesh and other states, especially in areas where the soils are sandy (high infiltration capacity), topography is undulating and the water availability is limited. Wheat and several other crops are irrigated with sprinklers. Sprinkler irrigation has several benefits:

- It enables farmers to irrigate more area with same amount of water supply- sometimes as high as 80 per cent as compared to surface flooding.
- It helps to apply small amounts of water more frequently which is good for crop growth as the plants are never under stress, the micro-environment in and around the fields is also improved.
- It also increases the cropped area of the farm as field channels do not occupy any space.
- Nutrient use efficiency of applied major and micro-nutrients is improved due to reduced leaching and improved uptake by the plants.
- Sprinkler irrigation helps farmers to harvest higher yields of up to 25 per cent and a better quality of the produce as compared to surface irrigation.

For vegetables and other low height crops, micro sprinklers can be used as these sprinkle water around the root zone under low pressure.

The Intervention: Initial technical surveys by HPPI teams showed that though farmers spend good amount of money in installing the sprinklers and also operated them correctly, they had little knowledge about the irrigation schedules and the amount of water to be applied. In most cases the farmers operated the sprinklers for long and un-necessary durations and under windy conditions and were applying water amounts equivalent to the flood irrigation. Similar observations were also made by researchers at Tamil Nadu Agricultural University, and International Water Management Institute (2011) while making large field surveys with the sprinkler irrigated farms in a number of districts in Tamil Nadu. As such the farmers did not make significant water savings, lost nitrogen fertilizers through leaching, incurred higher energy/ pumping costs and also covered smaller areas per day of sprinkler irrigation.

Under the 'Smart Sprinkler System' the farmers were educated about the correct method and duration of the sprinkler operation through improved knowledge about the rooting patterns of crops and the need to keep only the upper soil profile wet as to connect it with moisture available in the lower layers. As a thumb rule, the farmers were advised to ensure that moisture is available to the root zone, i.e. up to 10 cm of soil depth. The farmer verifies this by digging the soil to this depth after the irrigation and irrigation is terminated when the required moisture depth is attained. The progress was well monitored during the season to respond to any queries by the participating and other farmers. Irrigations were small and frequent (15 days interval) under the 'Smart Sprinkler System' as compared to normal practice (20 days interval, heavy irrigation). The water savings were significant as the model fields required only 92 irrigation hours/ha as compared to 138.3 irrigation hours for crop maturity under the normal practice and comparable conditions. As a result the seasonal irrigation expenses for 'Smart Sprinkler System' were Rs. 3680/ha and Rs. 5540/ha under normal practice of the farmers. Additional water saving in the model field was 34 per cent when compared to the conventional sprinkler irrigation method.

Figure 12: A wheat field under irrigation with 'Smart Sprinkler System' in Lakheri, Bundi District, Rajasthan

Smaller hours and erratic power supply further acted as drivers for the farmers to adopt 'Smart Sprinkler System' as they were able to cover large areas through precision application, which also reduced leaching of nutrients below the root zone under the sandy soil conditions of the region. This method is recommended to farmers even where the lands are imperfectly levelled and where other methods like small check basins and FIRB method cannot be implemented due to uneven topography and high infiltration sandy soil conditions.

3.4. Drip Irrigation Method

Drip or trickle irrigation is the slow application of water on, above or beneath the soil surface near or into the plant's root zone by surface or sub-surface drippers. It is one of the new commercially available irrigation application equipment that uses a network of main and branch pipelines to convey water to laterals that are fitted with drippers for precise application of water as continuous drops directly into or near the root zone of plants. Various forms of drip irrigation are now widely recommended in water scarce and other regions where farmers decide to cultivate high value row crops of improved quality. Studies and demonstrations have shown that drip irrigation is highly suitable for a number of vegetable crops, fruit orchards, plantation crops, medicinal and aromatic plants, and sugarcane, and cotton. Drip systems can be costly with standard fittings; but drum kit based low- cost systems for small farmers and vegetable plots, drip taps etc. are affordable. There are a number of government schemes available for installation of the drip irrigation systems, which provide the equipment and fittings at subsidized cost to the farmers (sometimes up to 80 per cent of the cost for small and marginal farmers). The main advantages of the drip system include the following:

- Drip systems always maintain an optimal water and nutrient regime around the plant root system through small and frequent applications.
- It helps in savings of a large amount of irrigation water, in most cases drip irrigation saves about 40-60 per cent of irrigation water.
- Drip systems also achieve higher fertilizer use efficiency.
- Drip irrigation provides ease in inter-cultural operations, has reduced weed growth, and lower levels of pest and disease attacks.
- Above all, the crops grown under drip irrigation produce higher yields of uniform and high quality. This leads to higher market value and total income for the farmers. On an average an increase of 25-50 per cent of produce has been achieved under varying crops and climatic conditions.

The Intervention: HPPI helped the farmers to install and operate efficient drip irrigation systems. Under the ACC Limited supported Community Development Project (2010-2012) at Lakheri, Rajasthan seven drip irrigation systems were installed to demonstrate production of vegetables and other crops with much less amount of water. The farmers were educated about the advantages of drip irrigation including improved yields, early and uniform maturity, reduced weeds and pest infestation and large water savings. Farmers showed keen interest in this intervention but small farmers found it cost and management intensive. Targeted support for small farmers shall accelerate the pace of adoption of drip irrigation.

Figure 13: Many farmers got subsidized drip irrigation systems installed with help from the projects

3.5. A comparative analysis of improved irrigation methods

Through the improved irrigation systems for wheat (and other field crops), a total water saving of up to 50 per cent was demonstrated in the Project villages. It was observed that on an average, 23 per cent of water is saved by adoption of small check-basins, 49 per cent by using FIRB method and 52 per cent by intelligent operation of the 'Smart Sprinkler System'. Table 5 presents a comparative analysis of the main parameters. Additionally, the net profit was always higher in the model fields as compared to the existing farmers' practices under comparable conditions.

Table 5. Comparative analysis of water savings and economic benefits under improved irrigation methods for wheat in Rajasthan

Components	Conven-tional	Small Check basins	Sprinkler-conventional	Smart Sprinkler System	FIRB Method
Total no. of irrigations	6	6	6	7	7
Total irrigation-hours to mature the crop, hour	172.1	132.9	138.3	92.0	87.9
Average grain production, t/ha	3.4	3.7	3.5	3.6	3.3
Cost of irrigation, INR*/ha	6,884	5,316	5,540	3,680	3,516
Returns from sale of grains, INR/ha	29,206	33,105	29,597	30,855	28,882
Returns after deduction of irrigation expenses, INR/ha	22,322	27,789	24,057	27,175	25,366
Total water pumped for crop maturity, m^3/ha	3,205	2,475	2,300	1,529	1,638
Savings of water as compared to conventional flood method, m3/ha	---	730	905	1,676	1,567
Savings of water as compared to normal basin irrigation, %	---	**23.0**	**28.0**	**52.0**	**49.0**

**INR = Indian Rupee*

Impact and upscaling: Improved irrigation methods hold good promise of higher returns and savings in water use. Concerns of the participating and other observer/ visiting farmers regarding failure or low yields of crops due to smaller irrigations or reduction in total cropped under FIRBS were properly addressed through continuous interactions and proper monitoring of the fields. As a result large number of farmers (tenfold increase) signed up to participate in these interventions and acquired the required knowledge indicating a good success of the interventions. The objective of saving water for the future and averting the water crisis can be achieved as result of this innovative movement initiated by the farmers of this water deficit region of Rajasthan.

4. Improved Cultivation Practices

There is no substitute for improved agronomic practices for obtaining higher and sustainable yields at affordable costs. Most farmers in India are small and marginal (about 80-85% of total holdings) cultivating less than 1.0 hectare and in large cases less than 1.0 acre (~0.4 ha). Traditionally, the farmers have been practicing subsistence agriculture to eke out a living in the rural areas and also meet, at least partially, the family food requirements. However, with smaller farm holding size and rising input and labor cost, this has become a major challenge.

On the positive side the vast national and state agricultural research and extension system, have developed a vast pool of actionable technologies and practices with a potential of significantly improving the agricultural yields. The improved interventions aim at intensifying the agricultural systems to produce more value from small farms, make the farms resilient to weather aberrations and long-term climatic changes, diversify the agricultural enterprise and link the farmers to the markets. Unfortunately, such an information and knowledge targeted to small and marginal farmers, landless labor and more importantly for the women farmers, is not easily available. It is at this interface that HPPI field teams with a mission to *"unite with people in India to create development through the implementation of projects that aim at transferring knowledge, skills and capacity to individuals and communities who need assistance"* has been very helpful. HPPI experts, innovators and farm functionaries identify and prioritize the most significant agronomic practices and organize large number of participatory demonstrations and hands-on practice for the farming community. This helps the farmers to evaluate the intervention both in terms of labor and input costs and potential benefits; and its suitability under their specific farming conditions and thus take an informed decision about the adoption. The following improved cultivation techniques and practices have been widely appreciated:

4.1. System of Rice Intensification (SRI)

Rice is a staple food for large part of the world and Indian population. Traditional rice cultivation methods are water, fertilizer and labor intensive and in the upland regions water scarcity is becoming a real threat for rice cultivation. Another challenge is deterioration of soil health due to imbalance in use of fertilizers. Small and poor farmers cannot afford the use of heavy tractors for puddling etc. on their small and fragmented fields. System of Rice Intensification has emerged as a potential alternative to traditional way of flooded rice cultivation and has shown good promise of saving water, seeds, fertilizers and pesticides and produce more or comparable yields.

The Intervention: The main components of SRI include raising nursery on raised beds (commonly 1.25m x 8 m). The nursery bed is prepared with application of farm yard manure (FYM) and soil alternately in 4 layers so that the young seedling has a good rooting system. One kilogram of seed is enough for 2 nursery beds and 5 kg seed is required to transplant 1hectare of land. The seeds should not be crowded at few places and covered with FYM or paddy straw. Depending upon the requirement, the beds may be watered lightly twice daily. Preparation of the main field in SRI is same as in conventional transplanting except that there should not be any standing water in the field. In the SRI method 8-12 days old seedlings are widely spaced (25cm x 25cm) and only one seedling per hill is transplanted. Uniform spacing is the essence of SRI transplanting and for convenience of weeding with cono weeder. The seedlings may be uprooted very carefully to keep the fine roots intact. Single seedlings with seed and attached soil are transplanted shallow by using index finger and thumb. Light irrigation may be given on the next day of transplanting. A thin layer of water may be maintained during panicle initiation and grain filling stage. The irrigation is given just to keep the soil saturated with water (no flooding). Regular wetting and drying of soil results in increased microbial activity and ease in availability of nutrients. Weeds are managed with the help of hand operated cono weeder. SRI places major emphasis on the use of FYM (up to 10 t/ha) and chemical fertilizers may be used only to make up for the deficit. Use of natural bio-pesticides is recommended whenever necessary to keep pests under control.

Figure 14: Field preparation and nursery transplantation under System of Rice Intensification (SRI) technique

Main advantages of SRI include water savings (35-45% as compared to field submergence), seed saving, enhanced root growth, profuse tillering of the plant, more grain filling and less lodging, and thus increased productivity. Similar advantages for wheat cultivation have also been observed by following system of wheat intensification.
The farmers were keen to adopt SRI in larger fields. One hundred and twenty farmers were provided with intensive training and interaction with the experts on SRI.
In Badaunn and Unnao districts, Uttar Pradesh, from 2012-14 under the 'Seeds for Life' project 48 demonstrations of SRI were laid and the farmers were keen to adopt SRI in their fields. In average more than 43 percent of the farmers who participated in the project adopted SRI, and many of them were approached by their neighbors, asking for instruction and access to SRI tools.

4.2. Vermicomposting

Vermicomposting is a method of preparing enriched compost with the use of earthworms. It is one of the easiest methods to recycle agricultural wastes and to produce quality compost. Earthworms consume biomass and excrete it in digested form called worm casts, which are rich in nutrients, growth promoting substances, beneficial soil micro flora and having properties of inhibiting pathogenic microbes. Vermicompost is stable, fine granular organic manure, which enriches soil quality by improving its physicochemical and biological properties. It is highly useful in raising seedlings and for crop production. Vermicompost is also becoming popular as a major component of organic farming system. Vermicompost benefits soil by:

- Improving physical structure of the soil and its water holding capacity.
- Enriching soil in micro-organisms, adding plant hormones such as auxins and gibberellic acid, and adding enzymes such as phosphatase and cellulose.
- Attracting deep-burrowing earthworms which are already present in soil.
- Improving root growth and root structures.
- Enhancing germination, plant growth and crop yield.

There are different species of earthworms but *Eisenia foetida (Red earthworm)* is preferred because of its high multiplication rate and efficiency in converting the organic matter into vermicompost within 45-50 days. Since it is a surface feeder it converts organic materials into vermicompost from top to bottom. Vermicomposting is done by various methods, among them bed and pit methods are common.

The Intervention: HPPI field units understood the potential of vermicomposting early on and included this intervention under a number of projects, especially for the young and women farmers who own small parcels of land and are eager to learn and thus diversify the small farms with vegetables and fruit plants. The technique has been standardized by including cow dung, kitchen waste, farm residues and forest litter as the organic base material. It was further noticed that mixture of leguminous and non-leguminous crop residues enriches the quality of vermicompost. Farmers were informed of the following steps to prepare a good and quick vermicompost:

- Vermicomposting unit should be in a cool, moist and shady place preferably close to animal sheds or under homestead groves.
- Cow / buffalo dung (or slurry from biogas plants) and chopped and dried leafy materials are mixed in the proportion of 3:1 and are partially decomposed. A layer of 15-20 cm chopped and dried leaves/grasses may be kept as bedding material at the bottom.
- Beds of this partially decomposed material of sizes 6x2x2 feet should be made and each bed may contain 150-200 kg of raw material and number of beds shall depend upon the availability of material and the field requirements.
- Live and healthy Red earthworms (~1500-2000) should be released in the upper layer of each bed and water should be sprinkled with a can immediately after release of the worms.

- Beds should always be kept moist by sprinkling of water (daily) and by covering the bed with gunny bags/ polythene.
- Beds should be turned once after 30 days for aeration and for proper decomposition. Vermicompost gets ready in 45-50 days and the final product is about dark brown/black in color and granular. It is about three-fourth of the raw material.
- For harvesting, the compost should be kept over a fresh heap of partially decomposed cow dung so that earthworms could migrate and after two days the compost can be sieved for use.

Figure 15: Preparation of Vermicompost pits with the active support of HPPI farm advisors

A typical vermicompost shall contain 20.5 per cent organic matter, 1.02 per cent nitrogen, 0.3 per cent available phosphorus, 0.24 percent available potash and 0.17 per cent calcium besides a number of beneficial growth promoting substances. The doses of vermicompost application depend upon the type of crop grown in the field or nursery. Vermicompost should be used as a component of integrated nutrient supply system with a dose of about (5t/ha) for field crops, 3-5kg/plant for fruit crops and 200 g for each of well-spaced vegetable seedlings.

Upscaling and Impact: Most farmers reported positive benefits for the application of vermicompost for their high value crops and the homestead gardens. As use of cow dung as a source of domestic fuel is on decline in most rural households (use of LPG gas, biogas units, fuel wood etc.) and raising of few dairy animals is very popular with smallholder farmers, availability of animal waste is assured. Vermicomposting has demonstrated a good potential with proper capacity building on the technique and initial supply of quality earthworms.

4.3. Mixed-cropping, intercropping and crop diversification

Farmers in the water scarce regions having little or no access to critical irrigation cultivate drought tolerant crops of pearl millet, sorghum, guar (cluster bean) and few other minor crops. These crops have both low yields (poor Harvest Index) and low economic value but provide resilience against weather aberrations (long dry spells) and ensuing climate change. Mixed-cropping of a number of crops in random proportions; intercropping of cereals and legumes or using the wide open spaces during the initial stages of orchard plantation and crop diversification through inclusion of some high value crops like vegetables, aromatic and medicinal plants, fruit crops in a part or the whole farm helps the farmers to harvest a variety of crops throughout the season/ year and also achieve higher economic value for the harvested commodities as compared to sole cereal crops. More enterprising farmers with some access to institutional or local credit diversify their farm enterprise by including poultry, small (goat, sheep) or large (cow, buffalo) dairy animals; agro-forestry or tree culture and similar other ventures suitable for smallholder farmers. Access to an assured water supply source is generally a pre-requisite for crop and farm-enterprise diversification. Some of the successful interventions demonstrated by HPPI and adopted by the farmers include:

4.3.1. Dhaincha (*Sesbania*- Green manure)- Mustard cropping system

In the arid and semi-arid areas of Rajasthan, low organic matter (< 0.2%, normal soils-0.5%) was found to be a critical factor for low fertility and water holding capacity. Several farmers in Alwar and adjoining districts keep part of the land fallow during rainy season for a good post-monsoon mustard crop as the rains are sufficient to support only one crop. This prompted the HPPI field staff to experiment with the use of fallow land for a green manure crop to create improved water relations and soil fertility. The farmers were advised benefits of improved organic content through cultivation of short duration green manure crop locally called *dhaincha (Sesbania grandiflora)*. Twenty-seven progressive farmers from operational area in Behror block agreed to participate in the intervention.

After the first monsoon showers the fields were sown with *dhaincha* seeds (60 kg/ha) and allowed to grow up to 40 days. At this stage this succulent green crop was ploughed with soil turning plough and left until sowing of mustard crop. This improved the water holding capacity of the fields by 27 per cent. Further studies showed that it was possible to raise a good mustard crop with just one irrigation (640 m^3 /ha) or two irrigations (1117 m^3 /ha) as compared to normal practice of three irrigations (1487 m^3 / ha) resulting in a savings of 57 percent and 25percent, respectively. The incidence of white rust disease declined by about 30 percent in the model fields. Keeping in mind that this region is under dark zone for ground water availability, raising a good mustard crop with green manuring and one irrigation at critical stage is recommended.

4.3.2. Integrated crop management in cotton by introduction of okra (ladies finger) as a trap crop

Sucking pests attack leaves and apical buds of cotton giving yellowish color and inverted cup shape to the leaves. This is mistaken by the farmers as a symptom of water stress and application of unnecessary irrigations and thus affecting crop growth. Even the local extensions workers were not successful to dissuade the farmers from this practice. HPPI field teams decided to develop something innovative.

Okra crop attracts pests similar to cotton crop sometimes in larger magnitude. Five lines of okra plants were planted as trap crop around the cotton fields. This provided farmers with additional income and reduced their expenses for purchase of costly pesticides to control sucking pests and bollworms of the cotton crop. As most of the pests are attracted by the okra crop pesticides were sprayed only on the five lines of the trap crop. As there were no signs of apparent wilting, the farmers did not apply unnecessary irrigations.

The Intervention: Twenty-seven demonstration plots were cultivated with this okra trap intervention during *kharif* season of 2007.

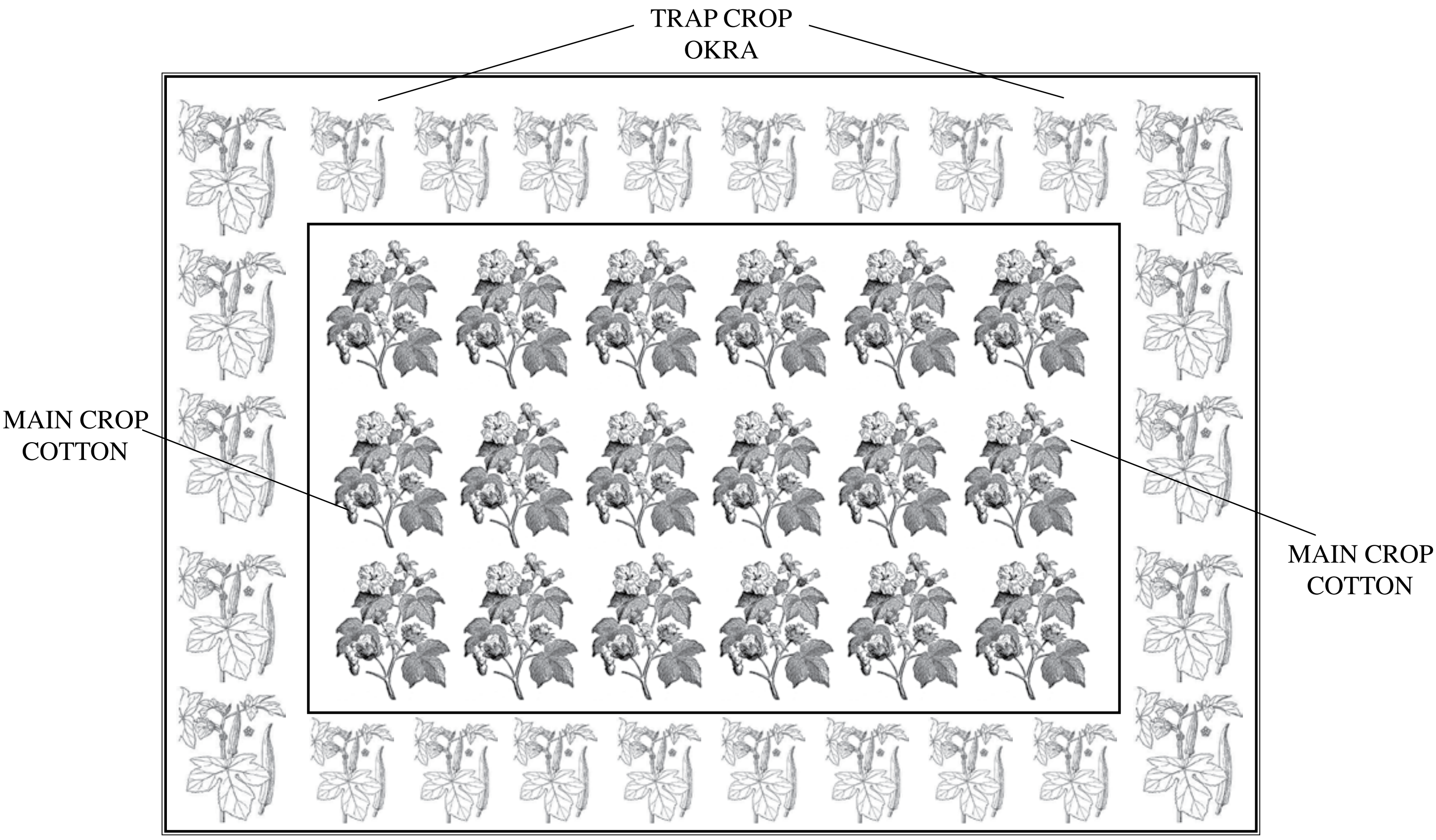


Figure 16: Use of okra as a trap crop around cotton fields to reduce the pest attack and pesticide use in the main crop

Attack of the sucking pests was more in control fields as compared to the fields with trap crop of okra. The plots with proposed intervention also fared better on net returns (58% higher) and water savings (40.9%, average of 27 model fields).

Upscaling and impact: This eco-friendly intervention of using okra as a trap crop around the cotton fields has the triple benefits of very low use of pesticides, water savings and higher net returns as compared to solo cotton cultivation. This simple practice has a good potential for upscaling for the small-scale cotton cultivators.

4.3.3 Inter-cropping of cotton and arhar main crops with mung pulse crop

Mung as an intercrop for the widely spaced cotton and arhar main crop attracts defender pests like spiders which feed on sucking pests like jassids, boll borers and white flies of the main crop. During the early stages the intercrop serves as green mulch and later on as a dried mulch to reduce evaporation losses; its nodules fix nitrogen to save on the fertilizers and the extra yield of mung improves the economic returns from the main crop.

The Intervention: In the widely spaced rows of arhar and cotton fields, the interspaces were planted with rows of short duration mung crop. No additional inputs in terms of water and fertilizers were made to these fields. Mung crop is generally available for harvest in about 60 days and the main crop does not face any competition. HPPI demonstration plots with this intervention showed good advantages in the form of reduction in use of pesticides, savings on irrigation water use (~ 41 %) and higher net returns (> 60 %)for both the cotton and arhar fields. Additional mung crop was also appreciated by the women farmers as it helped in family food and nutrition.

Upscaling and impact: The intervention is highly suitable for widely spaced crops cultivated during the hot summer season in the irrigated but water scarce regions. The intervention helps in reducing the use of pesticides and thus saves on costs and saves the environment, the intercrop acts both as a green and dry mulch during early and late stages of the main crop which saves on water and improves the micro-climate; the leguminous intercrop saves on nitrogen through its nodulation and the residues improve the soil fertility, the pulse crop adds to family food security and nutrition and finally it helps to achieve improved economic returns from a given unit of land through better use of the land and energy resources.

4.4. Soil and water testing for optimal fertilizer application

Each soil type is unique in terms of its physico-chemical and biological characteristics and cropping history and is endowed with only a limited number and amount of major, secondary and micronutrients. At the same time each crop/ cropping system has specific nutrition requirements for good crop growth and higher yields. Deficiency of essential nutrients seriously impacts the crop growth and yield and the net returns. Most farmers and especially the small and marginal farmers have limited knowledge about the nutrient status of their fields and the fertilizer requirements of the specific crops. As such fertilizers are applied on adhoc basis leading to unnecessary and wasteful expenditures or under-fertilization of the fields leading to sub-optimal yields. Soil and water testing and the test-based fertilizer recommendations is a very simple method of applying the right quantities of all the required major and micronutrients. HPPI field teams realized the importance of this intervention and included it under a number of projects for the benefit of rural communities.

The Intervention: Farmers were sensitized to the importance of proper understanding of the soil and water testing of their fields, and tube wells and drinking water sources. The benefits of proper and balanced fertilization including the application of micronutrients for improved yields were also explained. They were encouraged to get their soils and water sources tested on regular basis. Demonstrations were held on the proper method of collection of soil sample and it's labeling and information on the nearest soil testing laboratory was provided. Initially, the samples were collected from the project villages and the results obtained on behalf of the farmers. Most important part was the assistance provided to the farmers in proper understanding and appreciation of the soil and water test results and making informed decisions about the application of the right amount of the fertilizers for a given crop. Farmers greatly appreciated this advice as the yields improved along with the savings on the purchase of the fertilizers. On several occasions, small doses of critical micronutrients made large differences in crop growth and yields. Some of the successful examples include the following:

- During 2010-11, a total of 175 soil samples from 10 villages in Lakheri block were analyzed for major and micronutrients through Soil Testing Laboratory, Bundi district and the results were explained to individual farmer. The adjoining farmers were also invited to such meetings to generate further interest and adopt this important practice.
- In the same block, random samples from water sources were also collected and analyzed for water quality parameters.
- Soils of 575 fields, including 135 model fields, were tested for micronutrients from 68 villages in Neemrana and Behror block during 2012-13 and the farmers advised on the critical deficiencies.
- In Nainital district (Uttarakhand), 75 soil samples from 25 villages were tested for nutrient composition. Drinking water samples were also analyzed and high levels of fluoride was reported. Water filters were provided to 310 affected families.

Upscaling and Impact: Creation of awareness and proper guidance on collection of soil samples, submission to the testing laboratories and understanding of the soil test results for informed decision is very important for the farmers. This simple practice shall help in maintaining good soil health, harvest higher yields and reduce unnecessary application of costly fertilizers. Recently, the central and state governments have also launched major programs on soil health.

Figure 17: Proper collection and labelling of the soil samples and field testing for critical nutrients

5. Promoting Homestead Gardens

Homestead garden is a small scale production system supplying plant and animal consumption and utilitarian items either not obtainable, affordable, or readily available through real markets, field cultivation, and wage earning. There are five intrinsic characteristics of home gardens: i) are located near the residence, ii) contain a high diversity of plants, iii) production is supplemental rather than a main source of family consumption and income, iv) occupy a small area, and v) are a production system that small farmers can enter at some level. Important benefits of homestead gardens include improvement of food, nutritional security and health conditions, uplifting the status of rural women, and the economic and environmental benefits. However, most families fail to establish a healthy and productive home garden due to a number of constraints including lack of suitable piece of land and an assured water resource, capital or credit, suitable seeds and planting material, weak extension and advisory services and access to markets. Per capita consumption of vegetables in India is only about 86 g/day, compared with FAO's recommendation of 200 g/day. Consumption of fruits is also very low and this becomes all the more important as a large section of the society is vegetarian by choice and depends mainly on fruits and vegetables to meet their daily nutrition requirements. To improve the nutrition of rural families, vegetable and fruit production must be increased and better integrated into the predominantly cereal-based farming systems. At the same time, the increasing demand for food from the urban poor living in megacities needs to be satisfied. To mark its global importance the United Nations declared 2014 as "International Year of the Family Farming".

Depending on the need of the rural communities HPPI field units have included various forms or components of homestead gardens:

- Model gardens in the crop fields
- Homestead gardens
- Small vegetable plots
- Inclusion of fruit trees, medicinal herbs and other high value crops in the fields.

The main objective is to provide nutrition to the family especially young children, empowerment of women and good use of the wastewater from the kitchen and animal sheds. In other cases, these interventions improved the crop diversity, generated additional income through sale of the surplus production and improved land use of the small, unused pieces of the land.

Under a specific project, the homestead gardens were targeted to poor rural families of Jodhpur district of Rajasthan having a member diagnosed with diabetes as the consumption of the vegetables helped in better management of the blood sugar levels.

Experience shows that initially the family requires support and guidance for establishing and managing a good homestead garden and HPPI field teams were forthcoming in providing:

- Sensitization to the concept and benefits of "Homestead gardens and associated interventions" during regular meetings of the women self-help groups, young farmer clubs, meetings with the school children, and interactions with the farming communities.
- Guided visits to the successful homestead gardens in the adjoining/ same village and to the large farmer fairs; display of posters, pamphlets and other extension material.

- Capacity building sessions on designs of homestead gardens, allocation of land to different crops, cropping calendars and response to individual queries.
- Best practices for cultivation of important vegetables and fruit plants, use of water and wastewater, manure/vermicompost and fertilizer management, insect-pest and disease control and harvest/ post-harvest techniques.
- Supply of improved seed kits, young nursery/ planting material and guidance on nursery raising and transplanting.
- Low cost drip irrigation systems (Drum or bucket kits) for small plots and assistance in their procurement, installation and management.
- Harvesting schedules, post-harvest value addition, aggregation of surplus production and linkages to markets for good prices.

Figure 18: HPPI staff provides guidance on the layout design and management of the various types of homestead gardens in the project villages

The salient achievements in the establishment and management of homestead gardens included the following:

- Under the "Diabetes Community Care and Support Project" (2013 - 15) in Mandore block of Jodhpur 118,000 people were tested for blood sugar levels and more than 4,500 people were referred to hospitals for 2nd blood test and eventual diabetes treatment. Two hundred and forty four of the diabetes patients agreed to establish kitchen gardens close to their premises. Field staff encouraged people living with diabetes to better manage the problem with higher intake of fresh vegetables and greens. This helped the diabetic patients maintain a balanced, healthy diet and also save money. Special training program was organized with the technical support from Central Arid Zone Research Institute, Jodhpur. More than 500 homestead gardens have been established in the project implementation area as a result of promotion and good role models.
- More than 4,000 families in Badaun and Unnao districts in UP state have planted Moringa trees within their household premises as an intervention under the Seeds for Life project (2012-14).
- Seventy homestead gardens were established among the women groups during 2012-13 in the Neemrana block of Rajasthan. About half of these homestead gardens are irrigated with wastewater from the kitchens. Under another project on Women Empowerment, vegetable cultivation was introduced to 20 women farmers with a mixed use of organic inputs with 4 demonstration plots of 1200 m^2 size and 16 smaller plots of 300-400 m^2 size. Based on this success, massive 716 women farmers have established homestead gardens close to their premises. Women are very happy with the availability of fresh vegetables for the family which adds nutrition and diversity to the food.
- Under the 'Community Development Project, Lakheri, Rajasthan" (2010-2012), 41 homestead gardens were established in all the project villages to promote cultivation of vegetables like coriander, radish, bottle gourd, carrots, spinach, tomatoes and cabbage for domestic consumption and livelihoods. Fifteen demonstration farms each of 0.25 hectare size were established with farmers having roadside plots and planted with fruit plants, vegetables, pulses and cereal crops. All farmers were provided with quality seeds and planting material and linked to the markets.
- Under the Tree Plantation Project in Gurgaon, about 4,000 fruit trees were planted with different families during 2010-2012 and most of these have survived.
- In Mallawan block of Hardoi district, Uttar Pradesh (2010-2011), four nurseries were established for distribution of healthy vegetable seedlings of crops and 13 pilot homestead gardens were established for demonstration and the intervention had a large scaling-out impact.
- *"Harit Sankalp*- Green Action Project" in Behror block of Rajasthan (2005-2007) motivated 672 families to establish and maintain homestead gardens for vegetable production. Out of this 161 (24%) of the families also installed low cost drip/micro-sprinkler systems in the kitchen gardens. 1,330 families planted at least 5 trees in the households and took good care of the trees. Additionally, 477 families established model fields of 0.25 hectare each for sustainable farming following best practices.
- In the water scarce Behror block of Rajasthan, 50 model gardens were established (2006-2007) through the introduction of perennial fruit plants like Belpatra (Stone fruit), Lesva (Gum plant) and papaya in the vegetable fields. Economic returns improved by more than 25 percent with the introduction of papaya in the vegetable fields cultivating fenugreek and ladies finger.
- Environment and Community Development Project in Nainital district, Uttarakhand established 31 nurseries for horticultural plants (apricots, peach), distributed 44,000 plants/ cuttings of rosemary and 302 seed kits of vegetables (potatoes, peas, cabbage, capsicum) for planting. The project also established 25 nurseries for promotion of aromatic and medicinal plants (rosemary, lemon grass and local herbs).
- To rehabilitate the *tsunami* affected coastal districts of Tamil Nadu, floriculture (Jasmine, marigold) was introduced in the 45 affected fields. This has turned out to be a profitable

business for the marooned families. In the same villages, 74 families were helped with establishment of vegetable and horticulture gardens using drip irrigation systems. Moringa, mango and coconut plants were successfully established.

Upscaling and Impact: Consistent improvements in rural and urban economy provide good opportunity for the populations to diversify their diet patterns and include higher amounts of fruits and vegetables in the daily intake. This has led to a higher demand and prices for these commodities and presented an opportunity for the small holders to diversify their enterprises. Additionally, the homestead gardens make good use of the waste water which otherwise poses a health hazard and poor aesthetics. Actually small holder farmers, especially the women farmers, are better suited to such an intensive year round cultivation practice. The practice is also helpful to the rural families to improve their own consumption patterns and avoid the prevalent malnutrition. The recommendation of establishing homestead gardens is viable and has great potential in the rural and peri-urban landscape and may be adopted under all agricultural, livelihood improvement and corporate social responsibility programs.

Figure 19: In 2013 - 14 more than 4000 moringa trees were planted for supply of highly nutritious green leaves

6. Enhancing Agricultural Diversity

While specialized farms (potato, maize, soybeans, grapes, dairy, meat, etc.) dominate the developed world, the small farms in the developing countries like India rely on a number of crops or enterprises to be resilient against the weather aberrations and meet the subsistence needs of the farming family. Diversification of agricultural enterprise through creation of a balanced and demand-based mix of crops, vegetables and fruits, trees and shrubs, mushrooms, honeybees, livestock and dairy, poultry and fishery and other specialized enterprises has several benefits as compared to single crop cultivation. Some of the specific benefits include:

- Better use of small pieces of land, family labour and small capital.
- Less risk to crop failure and market price fluctuation of the product.
- By-products of this farm can be utilized properly as cattle, poultry, birds, etc. are reared along with crop production.
- Regular and quicker return is obtained from various enterprises.
- Soil fertility can be better managed as land is kept under diversified cultivation throughout the year.

Continued interactions with farming families revealed that they were quite interested to diversify their farming enterprise, learn techniques for testing of the new varieties to ascertain suitability to their regions, establish small gene banks to preserve the local varieties, produce their own seeds and its safe storage, experiment with new crops like medicinal and aromatic plants and inclusion of dairy and livestock in the enterprise. Several of these interventions were quite successful:

- **Introduction of medicinal and aromatic plants –** Under the "Women Empowerment Project" (2012) master farmers were provided advanced training at Indian Institute of Integrative Medicine, Jammu in the cultivation of Lemon grass and received the planting material. This was introduced by the women in small farms and proved successful.

- **Dairy and livestock husbandry as a livelihood option –** Based on the constraint analysis for adoption of animal husbandry among the women farmers of Behror and Neemrana blocks, the small farmers were trained on the basics of animal rearing and timely treatment and prevention of common animal diseases. The treatment of diseases like mastitis and oestrus at sub-clinical level is important for higher productivity. Similarly, the root cause affecting dairy production was mineral deficiency in the animal diets which also leads to silent heat and anoestrus. Infertility among the animals was common and the farmers lacked the basic knowledge of artificial insemination. Once knowledge on these aspects was made available to the women farmers their confidence level and willingness to adopt the animal husbandry as a livelihood option improved. A total of 16 trainings on veterinary care and breed management were organised for 100 Women Livelihood Groups (WLGs). Through access to the funds from savings of the WLGs and bank loans, most of the 1,050 member women farmers have now adopted animal husbandry as an integral part of the farming. Creation of this milk catchment attracted the vendors and created a healthy market with a win-win situation for the producers and the value chain. Additionally, a part of the nutritious milk was also available for the children, old parents, pregnant women and other family members leading to overall nutrition security. Women farmers also well understood the importance of separating the animal shelters from residential premises and more than 900 families adopted this system in project villages in Behror block.

In another example in the most disadvantaged area of Karahal block in Sheopur district, Madhya Pradesh facing acute water scarcity, the Community Development Project (2013) constructed 23 animal troughs in 18 villages creating separate drinking water facility for the cattle. Approximately 10,000 animals of more than 6,000 families benefitted from these simple structures thus reducing the animal and human diseases and improved productivity. In another project on Community Development (2010-2012) in Lakheri, (Rajasthan), 31 feeding mangers were constructed to demonstrate the importance of proper management of feeding of farm animals and avoid contamination and wastage of fodder. Three trainings on goat rearing were organised for 119 women SHG members of Bundi district of Rajasthan. Trainings on livestock and dairy management were also well received by the farmers.

- **Production of high quality seeds –** Non-availability of high quality seeds in the remote areas is a serious constraint for higher productivity. This can be resolved to a large extent by training farmers in basics of seed production and its cultivation in the village itself. Under Green Action Program, 10 seed production training and demonstrations were organised during 2014. Another 10 demonstrations of seed production fields were organised under the Initiative for Augmentation and Sustainable Management of Water Resources in Alwar district.

  Under the "Seeds for Life" Project (2012-2014) seven seed banks were established by the farmers in Badaun and Unnao districts of Uttar Pradesh. The rural Seed Bank is an innovative concept where farmers evaluate and conserve their indigenous and improved crop varieties as per the local climatic conditions. The results are shared among the community members and the seeds of the important varieties are multiplied to meet the needs of the farm families. Farmers stored and distributed seeds of a number of improved varieties of wheat, paddy, pulses, vegetables and spices. Seed banks were established in the designated rooms of the Community Centres or the rooms made available by the volunteer farmers. Under the project 450 SHG members and 150 additional farmers were trained in seed selection and

Figure 20: Varietal testing of wheat crop at the farmers' fields in Uttar Pradesh

conservation. Fifteen special trainings were organised to demonstrate the importance and characteristics of good seeds, improving seed quality and importance of seed selection in conserving indigenous plant varieties. Farmers also conducted rice and wheat varietal trials on their fields to understand the importance of improved varieties. In total 2315 rice and wheat trials were conducted by the farmers, through which they got access to new crop varieties, which was a great benefit compared to the low yielding varieties available in the area.

Having access to 30 good varieties of rice and 26 good varieties of wheat, combined with knowledge and skills in seed selection, seed production, and seed conservation has greatly enhanced the possibility for the farmers to increase their production and thereby also income. As a result, more than 1700 farmers included more varieties of rice, and more than 1130 included new varieties of wheat in their cultivation.

In Mallawan block of Hardoi district (UP), 73 farmers cultivating low yielding rice varieties adopted new seeds of improved varieties and large scaling-out impacts were noticed. In other locations, the local level institutions helped in collating the seed requirements of a particular crop(s) variety(ies), arranged for the funds and procured the bulk quantity of quality seeds from public or private agencies at competitive rates. These were then distributed to the individual indenting members which saved considerable time, efforts, costs and assured timely supply of quality seeds.

7. Tree Plantation

There are many benefits of tree planting and other greening projects for the individual, community and the environment and especially for the young school children and rural masses. As a direct benefit trees combat the greenhouse effect, mediate climate change impacts, clean the air and provide oxygen, cool and regulate the micro-climate of the surroundings; trees conserve water, control soil erosion and prevent water pollution; trees provide food, wood and several other economic benefits, enhance aesthetics and provide community spaces, trees add canopy and habitat for birds and other organisms, trees provide valuable biomass, stop desertification and help recreation and rejuvenation. Studies by Forestry Commission, UK show that as a rough estimate each tree is locking 0.546 kg of carbon per year- equivalent of 2 kg of CO_2. As long as right trees are planted at right place, planting more trees can be an attractive way of removing CO_2 from the atmosphere and thus mitigate the impacts of climate change. When used in the form of campaigns, rallies and special events, tree plantation programs create mass awareness for the communities, and especially help the young school children to become environment-sensitive and responsible citizens.

Humana People to People places great significance on the persistence and endurance of the grasses and trees under adverse conditions and this philosophy forms the bedrock of the Charter of the organisation. Trees significantly improve the rural and urban environment. Therefore, tree Plantation has been the *'signature intervention'* of HPPI and forms an important part of most of the projects. There have been several projects specifically aimed at planting of thousands of trees on community spaces, school grounds, premises of government offices, roadsides, along the water bodies and on individual homesteads and farm lands. HPPI worked with the remote, rural and disadvantaged communities of Rajasthan, Haryana, Madhya Pradesh, Odisha, parts of Uttar Pradesh and tsunami affected coasts of Tamilnadu and created location-specific models for successful tree plantation, enhanced their survival rate and ensured long term growth and upkeep. Some of the common features of these models include:

- Setting up of local tree nurseries and training of local resource persons in selection of appropriate tree species, procurement of seeds or cuttings, preparation of nursery beds and the individual tree bags and care of young seedlings.
- Creating mass awareness through targeted programs for school children and school management.
- Organising rallies and campaigns to ensure effective participation of all sections of the rural communities especially women, herdsmen and landless labourers.
- Specific programs for the village commons like the community buildings, places of worship, village ponds and water bodies, playgrounds and other wastelands.
- Involvement of the government officers through plantations at dispensaries (Primary Health Centres), veterinary centres, *Anganwadis*, Block offices, bank branches, check posts etc.
- Encourage women farmers to use the homesteads and animal sheds for plantation of minimum of five high economic-value trees for each household. Use of farm boundaries and other less productive plots for block plantation of economic trees.
- Organise special tree plantation campaigns during the rainy season, invite dignitaries and village peers for higher impact and participation and include tree plantation as an integral component under the corporate social responsibility (CSR) sponsored projects.
- Ensure ownership of the planted trees by village elders and community members, women and school children. Conduct regular monitoring, fill up the gaps and achieve high survival rates. Set up Eco Clubs, Women Livelihood Groups, Self Help Groups and student groups for skill

development, and avail benefits under the "National Horticulture Mission" through plantation of fruit trees and other government schemes.

The salient achievements include the following:

- Under a special project on tree plantation on public spaces in Rajasthan (Bundi, Khetri, Neemrana) and Haryana (Gurgaon) about 39,000 trees were planted during 2011 through involvement of school children, government offices including the police and CISF stations, hospitals, school and college hostels, tehsil and block offices, temples and mosques, railway stations and bus stops, industrial plants and water supply units. Involvement of panchayat members, school staff, government officials, retired army personnel and other senior citizens proved very helpful.
- HPPI has implemented *"Harit Sankalp* (Green Action)" Project in Rajasthan during 2005-2007 where tree cover under 10 selected villages was significantly improved, common areas were beautified, 50 hectare catchment area was conserved, groundwater recharge was improved, a Children's Forest with 10,000 trees was developed and the villages were made CO_2 emission neutral.
- More than 3,000 small farming families in Behror block were encouraged to plant and maintain a minimum of 5 plants of economic value (Amla, Lesava, Ber, Guava, Citrus, Papaya, etc.) at their homesteads and plant additional trees at field boundaries.
- More than 200,000 saplings of vetiver grass; 112,570 saplings of tropical evergreen forest species *(Terminalia, Hopea, Drypetes* etc.), about 20,000 fruit trees and 1,100 mangroves were planted for stabilisation of sand dunes and improvement of degraded farm lands in four *tsunami* affected coastal district of Tamilnadu under "Green Post-Tsunami Action" project.
- More than 5,000 trees were planted in 15 model villages through the help of students, youth club members, village development committee members in the remote Karahal block, Sheopur in Madhya Pradesh.
- Twenty model gardens with Indian gooseberry, lemon and papaya plantations were established in 10 villages of Mahwa block of Dausa district in Rajasthan. Through establishment of model nurseries by the Farmer Youth Clubs more than 100,000 saplings of economic trees and vegetables were distributed to the project farmers during 2006-2009. A recent visit (November, 2014) showed that most of the trees have survived, started bearing fruits and are improving the livelihoods and the environment.
- Under a special drive in the rainy seasons of 2014, more than 800,000 trees have been planted across 50 projects in six states of India.

Figure 21: *Greening the public spaces with trees of high economic value*

8. Establishment of Effective Backward and Forward Linkages for the Rural Families

Out of several factors responsible for poor productivity and low incomes of the small, marginal and women farmers' inadequate knowledge and emphasis on the weak backward and forward linkages for the agricultural enterprise is an important constraint. Backward linkages include the purchase of inputs and include seeds/planting material, fertilisers and pesticides, machinery and farm energy, dairy and livestock animals, labour and most importantly the knowledge and information about improved practices for higher productivity. Forward linkages include how a farmer or a group of farmers sells its produce, products, or supplies to an agent or a market. Theoretically, backward linkages exist when investments in the farm profit from inputs and forward linkages exist when investments in produce profit from outputs. Generally, these linkages are very imperfect for smallholder semi-literate farmers located in remote areas. At production level they face poor and delayed access to quality inputs and pay high prices., and above all have insufficient access to extension services, capacity building programs, demonstrations and visits and support by the experts which all lead to low productivity and non-demand linked production systems. At supply level the lack of storage, aggregation and transportation facilities, high wastage of perishable commodities, multiple intermediaries and limited knowledge of price fluctuations lead to lower returns.

HPPI with its basic philosophy of 'People to People' has been active creating awareness about the importance of these linkages and helping farmers through improved access to new knowledge, market information and linkages, group knowledge sharing and master farmers, and provision of critical inputs generally unavailable in the local markets. The following interventions were quite successful and appreciated by the farmers:

- Provision of vegetable, flower and tree nurseries and seeds of newly introduced improved crop varieties at the village level and its proper distribution especially among the smallholder and women farmers.
- Training the farmers on successful production of their own seeds and direct linkages to the government departments and companies providing timely and high quality seeds. Generally demands are aggregated at the group/village level for better price negotiation and timely supplies.
- Proper advice on the use of fertilisers and other agro-chemicals. In fact farmers are made self-reliant and encouraged to use local organic resources through enhanced use of vermicompost, properly decomposed slurry from the biogas plants, use of dhaincha and other legume crops as green manure, introduction of trap crops to reduce the use of pesticides.
- Special training programs on improved and sustainable farming practices and innovative interventions like SRI, resource conservation technologies, use of sprinkler and drip irrigation, improved irrigation practices, groundwater recharge, diversification, livestock and dairy management – all geared towards higher productivity at lower costs.
- Develop, train and sustain Farmer Groups and Women Livelihood Groups to create opportunities and platforms for knowledge and experience sharing, commodity aggregation and transportation for higher prices and reduced wastage.

- Create and train village/group leaders for improved access to market information and price fluctuations, information on minimum support prices and bonuses announced by the governments, advance knowledge on the nearby market demands especially for the high-value crops.
- Special emphasis on dairy value chain through help in purchase of high quality livestock, veterinary services for disease and fertility management, feed and fodder managements to take care of deficiencies, artificial insemination, and finally collection and linkages to the competitive markets for higher prices for milk.
- Training on proper storage of produce and the seeds, cleaning and grading, primary value addition and processing for improved benefits and product safety.

Figure 22: Produce aggregation at the village level for better marketing and better price

9. Empowerment through Farmer Organisations

Poor and smallholder farmers receive less benefits from new technology, seeds, products and services offered by the state and private agencies. Experience shows that they can be best served by effective grass root organisation in which the farmers have strong involvement. Several extension roles can be conceptualised to help rural communities, especially women and youth, to get organised and improve community organisation and empowerment, capacity building and resolve the problems and conflicts.

Figure 23: An active Women's Self Help Group in Behror block, Rajasthan

HPPI Experience in Crafting Innovative Organisations

Humana People to People India has always paid special emphasis on empowering the communities through organisation, skill development, education, action research, problem solving and experiential learning. Besides the in-house dedicated faculty and community mobilisers, HPPI invites the experts to impart specific knowledge and address specific issues. Women, youth, adolescent girls, school children, sick persons and poor rural farmers have always received special attention for their inclusion in projects and crafting and nurturing special institutions to empower them and address the concerns. The following institutional models have worked quite well under specific situations:

- Women Self Help Groups
- Women Livelihood Groups
- Farmer Clubs
- Youth Clubs (Rural)
- Water User Groups/ Committees

- Village Action Groups/Committees
- Village Sports Clubs
- Eco Clubs
- Village Water and Sanitation Committees
- Champion Farmers
- *Grameen Aajeevika Pathshala* (Rural Livelihood Schools)
- Farmers' Field Schools
- Village Development Committees
- Village Diabetic Forums

Figure 24: Members of a Youth Club receiving special training on effective marketing and banking services

Each of the above model of farmer organisation had a specific role to perform and were created as per profile and needs of the village community, project objectives and target groups and available time to complete the project. Project staff designed several innovative platforms to ensure inclusive and highly participative meetings and general interactions. These meetings employed a number of modes to achieve the desired outputs and outcomes: sensitisation meetings, awareness campaigns, school/ college rallies, exposure visits, capacity building programs, skill development and training programs, *"Ratri Choupals"*(Late evening 'Open Town Hall' type Meetings with village Panchyat and rural community to ensure larger participation), open forums, stakeholder meetings, farmers' days, demonstration tours, meetings with the experts; visits/addresses by high ranking government officers, community leaders and national/international experts and donors. Hallmark of all these meetings was the openness and transparency, encouraging each member of the community (especially women and poor who initially are less forthcoming) to convey her/his concerns, needs and experiences and ensure that specific, valuable and high quality knowledge was transferred from *'people to people'* which is vital for empowering the communities.

10. Future Perspectives

Humana People to People India is a member of the Federation for Associations connected to the International Humana People to People Movement which counts 31 national member organisations implementing development projects in 45 countries and reaching out to more than 12 million people on an annual basis. The organisations in the Federation works with the basic philosophy of sharing everything *'from the haves to have-nots'* and *'Man standing shoulder to shoulder with all mankind'*. Humana People to People India has been striving to improve the pace of development and sustainable livelihood options for the smallholder farmers especially in the water insecure states of Rajasthan, Madhya Pradesh, Haryana, and parts of Uttar Pradesh and coastal districts of Tamilnadu. It has acted as a dependable partner for several thousands of the farming families and especially encouraged the women, youth and school children to improve their skills, access the information on the best practices; get themselves organised in Self Help Groups for mutual support, in livelihood groups for experiential learning, in youth and farmer clubs for acquiring new skills and openly express their concerns and suggestions through the farmer forums, *ratri choupals* and village action groups. Meetings with the experts, peers and departmental officers and exposure visits to advanced centres of learning, farms of the champion farmers and farmer' fairs opened new avenues for change and mainstreamed the marginal and remote sections of the rural communities.

Simple but innovative interventions presented in this compendium have largely been successful as these are validated by rigorous research, recommended by the institutes of advanced learning and state schemes and contextualised to the local situations through participatory action programs. These interventions have been helpful in achieving multifaceted benefits:

- Improved the crop and agricultural productivity.
- Secured higher economic returns from small farms.
- Improved resilience to the climate change and seasonal weather aberrations through smart farm practices.
- Diversified the agricultural enterprise for round- the-year employment and income generation opportunities.
- Reduced the negative impacts of agriculture through adoption of organic agriculture, vermicompost, trap crops, *gobar gas* (Biogas) slurry, and green manure crops and mixed cropping.
- Improved water security and supplies through local rain water harvesting, augmentation of groundwater recharge, efficient irrigation practices and safe use of the waste water resources.
- Improved women, child and family health and nutrition through targeted emphasis on homestead gardens, fruit and medicinal trees and dairy animals.
- Empowered the women and rural youth through skill improvement, micro-credits, and innovative and inclusive local institutions and enhanced people-to-people interactions.
- Enhanced the knowledge of and access to government development programs, create efficient backward and forward linkages to address input purchase and output sale constraints and effective extension linkages.
- Guiding and partnering with the large industrial corporations and foundations in design and implementation of meaningful corporate social responsibility programs.

HPPI shall continue to expand its areas of operation, diversify the development portfolio and engage with enhanced number of collaborative partners and donor agencies. The innovative and simple interventions validated through working with thousands of farming communities shall be further refined and extended to other rural poor for improving the livelihood options and creating healthy habitats and communities to live in.

Our strength lies in demystifying the complex knowledge, break the barriers to transfer the knowledge to the last person waiting to be heard and empowered; and crafting innovative institutions for inclusive development of all sections of the rural community, especially women and rural youth. Commitment of HPPI to create a cleaner and safer rural environment, reduce pollution loads to soil and water bodies, produce safer and healthier foods for improved nutrition and lower disease risks shall be pursued with enhanced vigour and dynamism. HPPI envisions the following improvements in its strategy and program implementation:

- Sustainable and responsible farm practices for improved productivity and incomes of the small farms.
- Diversification of the agricultural enterprises to be climate resilient and develop smart rural communities.
- Ensure the programs to be gender-sensitive and channelize the energy and imagination of the youth through inclusion and skill development.
- Act as a responsible partner and facilitator for the large corporations and foundations for design and implementation of the corporate social responsibility programs which genuinely address the concerns and empower the communities.
- Actively support the national and state government departments, academic and research institutions, and international development and donor agencies for successful implementation of the plans and projects and create long lasting impacts and outcomes.

You are welcome to be a partner in this journey of thousand smiles.......

Annexure-I

HPPI Partners in Development and Empowerment of Rural Communities

1. Challenge Program on Water and Food, CGIAR International Water Management Institute (IWMI), Colombo, Sri Lanka
2. Bioversity International, CGIAR International Institute for Plant Genetic Resources, Rome, Italy
3. Food and Agriculture Organisation of the United Nations, Rome, Italy (the Benefit Sharing Fund of the International Treaty on Plant Genetic Resources for Food and Agriculture)
4. The European Union
5. Ministry for Foreign Affairs, Government of Finland
6. Letz Dream Foundation, New Delhi, India
7. Audemars Piguet Foundation, Switzerland
8. World Wide Fund for Nature (WWF), India
9. DuPont Limited, India
10. Toyota Environmental Activities Grant Program of Toyota Motor Corporation
11. SABMiller (South Africa Breweries) India, Neemrana, Rajasthan
12. Nokia India Private Limited
13. The GAIA-Movement Trust Living Earth, Green World Action
14. Bristol-Myers Squibb Foundation
15. ACC Limited (Associated Cement Company), Lakehri, Rajasthan
16. Confederation of Indian Industry (CII), New Delhi, India
17. NABARD – National Bank for Agriculture and Rural Development, India

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Registered under Section 25 of the Companies Act, 1956

Registration No. 55-93972; FCRA Registration No. 231660194

Tax exemption under Section 80 G of the Income Tax Act, 1961

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