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ICAR-INDIAN INSTITUTE OF SOIL AND WATER CONSERVATION (IISWC)
Research Centre, Chhalesar, Agra-282 006(U.P)
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PREFACE

Rainfed areas constitute about 57% of the total 141 million hectares cultivated land in the country. Rainfed agriculture is characterised by low levels of productivity and low input usage. Variability in rainfall results in wide variation and instability in yields. A majority of rural population live in the rainfed regions in India. Therefore, Government of India accords highest priority to the holistic and sustainable development of rainfed areas through watershed development approach. To deal with this, the scheme of National Watershed Development Project for Rainfed Areas (NWDPRA) was launched based on twin concepts of integrated watershed management and sustainable farming systems. The main objective of the watershed development program was to improve soil and water conservation, irrigation facilities, and land use pattern leading to increased agricultural productivity in drought prone areas. It is expected that these programmes would led to poverty reduction, improved livelihoods and improved bio-physical and socio-economic conditions leading to sustainable rural development.

A watershed development program under NWDPRA scheme was started in 2008 at Jalalpur watershed in Jagner block of Agra district U.P. that involves multiple stakeholders. An interdisciplinary approach has been followed for this study, given the complex and diverse factors, such as bio-physical, social, ecological, institutional and economic factors, besides the regional variations. The project concentrated on the capacity building of the beneficiaries in conservation and production aspects with improvement in basic livelihood through different livelihood activities that sustain them, especially during drought years by sustainable use of land and water resources.

The study observed improvement in ground water levels, enhanced soil and moisture conservation, development of irrigation facilities, water regeneration capacity, forestry and horticulture development, change in land use pattern and cropping pattern, improvement in animal health, employment and income generation. Some areas need further attention such as, greater involvement of the communities during implementation and post implementation phases, training and capacity building and sustainable income generation. It is observed that farmers need to be trained for carrying out minor maintenance work of the numerous development activities in the watershed.

We are grateful to the Department of Agriculture and cooperation, Ministry of Agriculture, Government of India for sponsorship of the project under NWDPRA scheme. We also gratefully acknowledge the contribution of Director of ICAR-IISWC, Dehradun and Scientists of the institute who directly or indirectly provided their valuable inputs during execution of various activities in the watershed. Thanks are due to all the technical and administrative staff of this centre for their untiring support in the day to day functioning.

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SUMMARY

Watershed management is an approach of enhancing or improving livelihood security through resource conservation and management to serve the socio-economic needs of human society and/or communality concerned. At present this concept has become a key for improving soil and water resources, overall productivity, and ecological restoration of rain-fed areas. This bulletin focuses mostly on the impact of implementation and adoption of different soil and water conservation interventions at the watershed level. To address the overall agricultural constraints mainly water erosion, groundwater depletion, sustainable productivity, and livelihood security in semi-arid tropics of India beset with scanty resources, drought, poor socioeconomics, and lack of education, soil and water conservation technologies were applied in the Jalapur watershed having 697.5 ha area in participatory mode near Jagner block in Agra district (UP). The pre and post-watershed data revealed that the irrigated area enhanced from 381 ha to 515 ha while the rainfed area decreased from 266 to 134 ha which can be attributed to the rise in the average groundwater table from 3.12 to 6.3 meters that led to an increase in the duration of water availability in open-wells/tube-wells from 3-7 to 8-12 month. The count of animals mainly buffalo, cow, goat, and sheep have also been increased by 58.96, 36.30, 43.89 and 28 %, respectively which can be ascribed to more availability of feed and fodder on account of silent increase both in area and productivity of major crops. The rise in area and productivity of wheat and mustard corresponded to 22.5 and 48.6 ha and 4.06 and 2.13 q / ha in, respectively. The increase in area under wheat and mustard was at the cost of decrease in area under lentil and bajra which corresponded to 16.1 and 47.4 ha, respectively. However, the productivity of lentil and bajra enhanced from 7.5 to 8.8 q / ha and from 17.15 to 18.45 q / ha, respectively. Based on the results, it could be concluded that the watershed management interventions proved highly efficient in natural resource conservation in the treated area having fragile agro-ecosystems under semi-arid climatic conditions. The soil and water conservation measures along with improved agronomical practices like availability of more irrigation water, better package of practices, the introduction of high yielding varieties, balanced use of soil nutrients, bio-fertilizers, and the land improvement by mitigation of soil degradation, not only enhanced crop production, productivity, cropping intensity, fodder availability and livestock productivity but also enlarged employment opportunities within the watershed and thus, ensured livelihood security of the watershed dwellers.

1. INTRODUCTION

Preserving the natural resources for safer future of forthcoming generation is the challenge which tops the global agenda as the mankind enters in the third millennium. Situation is far more alarming in Indian context. India is inhabitants of about 18 % of world human population and 15 % livestock on only 2 % of total land resources of world. Considering the expected growth in its population, Indian need to increase grain production by at least 50 % during next 25 years period to maintain self-sufficiency in agricultural production. There is little scope for bringing more area under agriculture. Therefore, needed quantum jump will have to come through the judicious and productive utilization of marginal and degraded lands.

Nearly 57 % (187 mha) of land resource in India is facing physical or chemical degradation. Spread with in 2 km from the riverbanks, ravines are the worst form of terrain deformation. In India about 4 mha land under influence of gully erosion along the various rivers including Beas, Yamuna, Ganga, Chambal, Kalisindh, Mahi, Narmada, Sabarmati and their tributaries. In U.P. out of 1.20 m ha ravine infested area of the state approximately 80 % is along the river Yamuna, Chambal and its tributaries. The networks of gullies are intensifying slowly but steadily engulfing adjoining table lands wherever adequate measures are lacking. For restoring the ravine ecosystems to its optimum production level, IISWC, Research Centre, Agra has developed a technological package applicable on watershed basis.

Farmers as direct beneficiaries of watershed development and management programme have a key role in sustainable management of natural resources. It is with this intention that there has been increased emphasis on farmers participation at all stages of planning and implementation of watershed development project in the recent guidelines issued by the government of India.

A watershed was developed by ICAR- by IISWC, Research Centre Agra at Jagner block of Agra district in Uttar Pradesh to restore the ecological balance in the degraded and fragile rainfed eco-system and to create sustainable employment opportunities for the rural community for livelihood security. This watershed is located at 90 km from Agra city. It is one of the watersheds taken up by IISWC, Dehradun (Uttrakhand) for developing waste lands under the NWDPRA (National Watershed Development Programme for Rainfed Areas) Project funded by Ministry of Agriculture, Government of India. The plan of watershed was prepared and submitted by IISWC, Research Centre, Agra in September, 2008 with the following specific objectives:

Ecological objectives:

- To demonstrate proven techniques for the reclamation of ravines wastelands for adoption by the farmers through a participatory approach.
- To monitor environmental changes due to efficient utilization of soil and water resources in Yamuna ravines.

Socio-economic objectives:

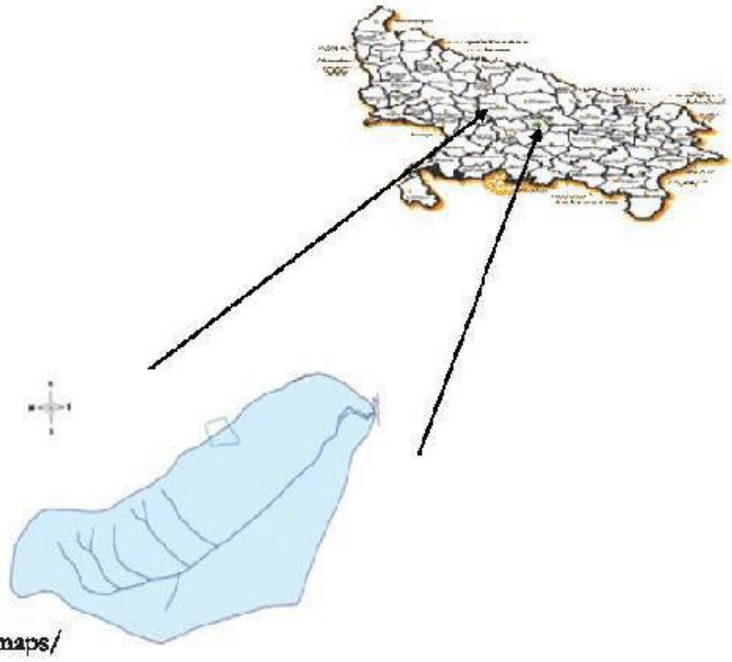
- To generate awareness among the masses about soil erosion problems of the region.
- To increase biomass production in ravine watershed.
- To monitor the impact of ravine reclamation on socio- economic status of the region.

2. PHYSIOGRAPHY AND RESOURCES

The Jalalpur watershed surrounded by Aravalli and Vindhyan hills comprises of three villages namely Jalalpur, Dhanina and Deori, situated in Jagner block of Agra district in Uttar Pradesh. The total area of the watershed is 697.5 ha with undulating to slopping (up to 10%) topography. This watershed is located in the south-west of Agra at 26°49' to 26°51'N latitude and 77° 32' 30" to 77 °35' 30" E longitude (Code No. 2C5A5g1b & 2C5A5l2e) at an altitude from 184 to 217 m above mean sea level (msl) Fig. 1. A nala originating from upper ridge passes through the watershed and form the main drainage line of watershed with a third order drainage pattern with total stream length of 7201 m.

The upper ridges comprise of red sandstone with very shallow soil depth, whereas soil depth increases towards the outlet with soil texture varying from silty clay loam to loamy sand. The middle portion of watershed has heavy textured soils with indurate hard pan in sub surface horizon; whereas lower portion of watershed has coarse texture soil comprising of small network of rill channels and gullied landforms. A sizeable portion of watershed is submerged during the rainy season, which is brought under cultivation during the *Rabi* season by siphoning the stored water.

This excess water stored during the rainy season is the main asset of the watershed provided rationally used. The watershed has arid to semi-arid climate with average annual rainfall < 500 mm in about 35 rainy days. Temperature ranges from as high as 48°C in the May-June to as low as 1°C during December-January. The trend of rainfall is highly erratic and maximum water goes as runoff. The ground water supply is very poor as most of the runoff flows down the slopes in a very short duration thereby limiting ground water recharge.



Source: india.gov.in/maps/

Fig: 1 Location of Jalalpur watershed

2.1: Watershed Features and Existing Natural Resources

Out of total cultivated area of 647 ha during the base year (2009-10), the irrigated area was 381 ha and rainfed area was 266 ha. Agriculture is the main occupation of the farmers in the watershed. The major cultivated crops in the watershed are mustard, lentil, wheat, bajra, and gram. Most of the agricultural land area practiced as fallow during the *Kharif* season, while only near around 25 % area is cropped during *Kharif* season which is used mostly for wheat and gram cultivation in the *Rabi* season. The remaining 75 % of the agricultural land area falls under single crop cultivation and usually practiced as fallow in *Kharif* season while sowing of mustard (25%), lentil (30%), wheat (20%), Gram (10%) and 5% for others crops in *Rabi* season. The watershed has 524 families and a human population of 3049 (male: 853; female: 725 and children: 1471). The general cast dominates in the watershed (52.31 %) followed by scheduled cast (19.15 %), other backward class (10.04 %) and minority and others (18.50 %). Total livestock population in watershed was 782 (cows: 135; buffalos: 424; goats: 180 and sheep's: 43). The watershed is dominated by the marginal and small farmers (< 2 ha) which constitute 84.20 % of total land holdings. The watershed had 19 tractors; 19 trallers; 4 threshers/ cutters; 3 diesel tube wells; 14 submersible pumps and 07 jugars. The present land use of the watershed is shown in Table. 1.

Table 1: Present land use plan of the Jalalpur watershed

S.N.	Land use	Present (ha)
1	Agriculture	
a	Rainfed	380.77
	I Crops	380.77
	II Agro-forestry	Nil
b	Irrigated	118.38
	I Assured	39.46
	II Partial	78.92
2	Waste land	180.95
a	Aforestation	Nil
b	Pasture	Nil
c	Untreatable	40.6
3	Village land	17.4
	Total	697.5

Although abnormal monsoon pattern and severe drought conditions experienced during the project period restricted desired level of project benefits, the basic objectives of the projects were fulfilled with fair degree of success. This bulletin is aimed to document the details on various aspects of project implementation, evaluation of the technological package and over all experiences of watershed developmental team.

2.2: Land Resources

2.2.1: Land holding

Majority of the farmers are in the category of marginal (< 1 ha) and small (1-2 ha) with average land holding of about 2.4 ha. These small land holding are further scattered at different places, which makes cultivation very difficult. Distribution of farm families according to the size of the land holdings are given in the Table 2.

Table 2: Distribution of farm families according to their size of land holdings.

Land holding	Village name			Total	Percentage
	Deori	Jalalpur	Dhanina		
Marginal (< 1ha)	-	17	70	87	29.79
Small (1-2 ha)	4	15	98	117	40.07
Medium (2-4 ha)	-	7	50	57	19.52
Large (> 4 ha)	-	4	27	31	10.62
Total	4	43	245	292	100

2.2.2: Soils

The entire watershed is topographically divided into three major landforms. Accordingly, the soils of watershed were grouped into following three major categories:-

i) Hill terrain,
ii) Plain land and
iii) Ravinous land

i) Hill terrain-Red soils

The topmost portion (Western & North-West part) of the watershed is hilly terrain with occasional depressions of flat land interlocked between the hillocks. These soils are derived from the solid rocky terrain and are located at a height of around 600 feet. They have developed from various formations of the Vindhyan sandstones of Central India hills of Bharatpur and Dholpur.

The soils of the hilly terrain are loamy sand to sand with occasional thin layers of silt in small patches. At great group level, these soils are grouped in Psamments. Near the hills, the soils are coarse and underlying with hard rocky fragments of sandstones. The soils of the hilly terrain and very nearby adjoining areas are loamy sand to sand in texture.

Depth is the major limitations of these soil groups. As we move away from hills, the soil depth gradually increases along with clay content thereby improving the fertility status. The soils are red in colour with ferruginous concretions with slightly acidic to neutral in reaction.

ii) Fine textured alluvial soils

These soils are the most extensive soil group found in the Jalalpur watershed. The middle portion of watershed is relatively flat land with fine soil texture. These soils are black in colour and are inherently high in fertility status. These black soils are calcareous and develop numerous cracks and fissures on drying. Soil texture is silty clay loam particularly in depressions and loam in the elevated portion.

The soils of the lower horizon are invariably heavier than the surface, being a zone of compaction and invariably a zone of calcium carbonate accumulation in the form of *Kankar* nodules. A subsurface indurate pan of *Kankar* or clay or mixtures of both locally called as Potni soils are prevalent, which impede the downward movement of water thereby creating problems of high runoff.

iii) Coarse textured alluvial soils

These soils are lying mostly near the adjoining areas of Kawat River near the outlet and around the lower portion of foot hill of watershed. These soils are coarser in texture and are relatively poor in fertility status. The soils are loamy sand in texture.

These soils also occupy significant area of the watershed. The soils are derived from the alluvial deposit and also from residual soils of the hill region. Rill and gully formation in some parts particularly near the outlet of watershed can be seen.

2.3: Available Water Resources

The watershed has arid to semi-arid climate with average annual rainfall < 500 mm in about 35 rainy days. The middle portion of watershed has heavy textured soils with in durate hard pan in sub surface horizon; whereas lower portion of watershed has coarse texture soil comprising of small network of rill channels and gullied landforms. A sizeable portion of watershed is submerged during the rainy season, which is brought under cultivation during the *Rabi* season by siphoning the stored water. This excess water stored during the rainy season is the main asset of the watershed provided rationally used.

The Jabalpur watershed is having four seasonal water bodies on private as well as on community land. Management and maintenance of these water bodies is still in the hand of minor irrigation department. During good rainfall year, these water bodies having full of water during the *Kharif* season. Before sowing of *Rabi* season crops water from these water bodies is either used for supplementary irrigation for *Kharif* crops or irrigating fields for *Rabi* sowing or allowed to go as waste. After releasing water from water bodies, submergence area also put under cultivation for *Rabi* crops.

Two Bundhi 1980 ha-cm
Village Talab 640 ha-cm
Kachcha Talab 600 ha-cm
Calkhat Talab 98 ha-cm

3. MAJOR LIVELIHOOD PRODUCTION SYSTEMS

3.1: Agriculture, Horticulture and Agro–Forestry

The agriculture land use constitutes about 57% of the total watershed area. Both rain-fed and irrigated agriculture are practiced in the watershed. Mono cropping is dominant in the rainfed production system while double cropping is limited to the irrigated lands, which constitutes about 30% of the total area under agriculture. Rainfed agriculture is mostly mono cropping with invariably low productivity. These areas constitute about 70% of total agriculture area. The food and livelihood security is primarily driven by the natural weather factors of rain and its distribution specifically across the cropping season. Only about 37% area under agriculture is cropped during *Kharif* season in the watershed. Among various crops, bajra shares maximum area (20%), followed by sesame (10%), jowar (5%) and pulses *i.e.* black gram and green gram (2%). Farmers use high yielding varieties of bajra (JK, Pioneer, Aarti, Boss, PAC 9444, Mahyco Bajra) and sesame (Nitya) which are mostly truthfully labeled seed from private seed companies.

The productivity of *Kharif* crops is low and fluctuates depending upon rainfall pattern, use of fertilizer and incidence of diseases and insect pests. Low yielding local varieties of jowar are grown without fertilization for grain and fodder production. The local jowar varieties are one of the various constraints in fodder production in the watershed. The green fodder production through various sources like crops,

grasses and limited forest trees is clearly inadequate for maintaining proper health of existing animals. Also no use of manure and fertilizer in sesame, no seed treatment with *Rhizobium* culture in pulses are the other production constraints in the watershed. Watershed has good scope for lowland and semi deep water rice cultivation in seasonally submerged area, which remains unutilized during *Kharif* season. Almost in all three villages of the watershed, no compost pits exists and fresh to semi decomposed farm yard manure is applied directly to the agriculture fields. The green manures like *dhaincha*, sun-hemp, *sesbania* have good potential in the watershed. However, the practice of green manure is meager and unpopular in the watershed, in spite of the fact that organic matter status as well as fertility of the agricultural soils is poor to fairly good. The cultivated fallow lands dominate in the watershed which contributes to accelerated soil erosion as well as runoff yields in the watershed.

Among *Rabi* crops, mustard occupies the largest area under agriculture (70 to 80%) followed by the wheat (10%) and pulses like gram and lentil (10%). Farmers are using high yielding varieties of *Rabi* crops like Karan, Krishna, Kranti, Sharda, Moti, Chambal, Nath, Sona, Raj Laxmi, Pioneer, T-59, Rohini, AK-47 in mustard and UP 343, UP 2329, UP 2338, HD 2009 and even very old varieties like Lok-1 in wheat crop. Beside this, *desi* varieties of gram and lentil are also used by the farmers.

Imbalanced fertilizer use in the *Rabi* crops both under rainfed and irrigated areas, absence of sulphur containing fertilizers and inadequate pest control measures with respect to aphid, white blister in mustard and pod borer in gram are some of the reason of low productivity of these crops. The majority of farmers of the watershed are facing considerable problem of fire wood and fodder due to meager or almost negligible forest area, lack of traditional agro-forestry practices and pastures. Cow dung, stover of mustard, sesame, dhaincha and scattered trees of *Prosopis juliflora* are main sources of fire wood specifically to small, marginal and landless farmers in the watershed. The organized orchards as well as forest area are lacking in the watershed. The watershed has a good potential of fruit and forest tree species like Ber, Bael, Aonla, Papaya, Guava, Citrus Species, *Lasoda*, Karonda, *Ramda, Chhokra, Shisam, Gular*, Tamarind, *Neem*, Popular, Desi Babul (Acacia Nilotica), *Palash*, Vilayati Babul (*Prosopis Juliflora*) as agro-forestry systems both under rain-fed and irrigated production systems on leveled to sloping agriculture lands as well as on degraded lands with recommended planting techniques involving appropriate termite control measures are used.

The multipurpose trees have also very good potential for supplementing fuel and fodder demands in the watershed and may be included in appropriate land use options. Sole forestry plantation of *Prosopis juliflora* on degraded and marginal lands also have good potential in the watershed to cater the need of firewood demand. The main source of green fodder for animals is limited to jowar, berseem and grasses in the watershed. Though, the vegetables have good potential in the watershed however, their cultivation is limited mostly to kitchen gardens. Almost all tropical/ sub-tropical vegetable can be successfully grown in the watershed. The vegetables grown in the watershed are cucurbits, okra, radish, tomato, cauliflower, cabbage, garlic, onion, brinjal and chilly.

4. CONSTRAINTS/ PROBLEMS AND THEIR PRIORITIZATION

Food sufficiency, economic growth and environmental security were identified as the major issues to be addressed in the watershed area. The area has undulating topography, steep unstable slopes, and excessive channel gradient, hence highly prone to soil erosion. Effective soil depth is limited spatially highly variable and hampering good crop growth.

Problems identified and prioritized during the transact walk and PRA exercises in all three villages, viz Jalalpur, Dhanina and Deoti were pooled and a list of nine problems representing the whole watershed was prepared. Problems were ranked as per their total weightage in the three villages.

Lack of irrigation water was the greatest problem experienced by the people followed by low production of field crops, lack of fodder availability and low animal productivity Table 3.

Table 3: Problem identification and prioritization for Jalalpur watershed

Problem	Rank
Low production of field crops	5
Lack of drinking water	3
Lack of irrigation water	1
Lack of fodder availability and low annual productivity	8
Non-availability of fuel wood	7
Lack of inputs like quality seeds, fertilizer, pesticides etc.	4
Lack of market facility	9
Lack of medical, educational and transportation facilities	2
Medical and Health care facilities for milching animals and low productivity.	6

4.1: Proposed Land Use

Watershed management plan for Jalalpur watershed was prepared with specific objectives of food sufficiency, income and employment generation with environment security. In plan preparation due importance was given to topographic, land suitability, irrigation potential, prevailing farming systems, micro farming situation, farming, farmers preferences and priorities along with economic and environment securities.Crop and tree selection and area distribution was done as per farmers priorities revealed through PRA exercise.

Technological options were blended with the ITK based on the latest available research / experimental findings for this region. Due attention was given to the resources of the farmers and adjustments were made in capital intensive/ high resource demanding technological outputs while making them adoptable to the resource poor farmers. Emphasis was laid on maximum use of farm yard manure. The present and proposed land use plan is given in Table 4.

Table 4. Present and proposed land use plan of the Jalalpur watershed

S.N.	Land use	Present (ha)	Proposed area (ha)
1	Agriculture		
a	Rainfed	380.77	346.77
	I Crops	380.77	338.52
	II Agro-forestry	Nil	8.25
b	Irrigated	118.38	152.38
	I Assured	39.46	73.46
	II Partial	78.92	78.92
2	Waste land	180.95	180.95
a	Aforestation	Nil	24
b	Pasture	Nil	116.35
c	Untreatable	40.6	40.6
3	Village land	17.4	17.4
	Total	697.5	697.5

4.2: Proposed Plan for Irrigation Development of Existing Water Resources

For efficient utilization of available water resources in the Jalalpur watershed, present system of irrigation and wastage of water during October–November need to be made more efficient from water management point of view by minimizing conveyance losses in the existing water courses. The up gradation of the existing system of irrigation will result in:

i. Minimization of conveyance losses
ii. Increase in frequency of irrigation
iii. Adoption of high yielding varieties of crops, and assured cultivation of cash crops
iv. Solution to drinking water problem
v. Improvement in local eco system

4.2.1: New water harvesting structures (Ponds)

Two new dug out type water harvesting structures (pond) of capacity about 1400 cum (each) have been proposed to harvest excess runoff of the watershed for supplementary irrigation and fish rearing.

4.2.2: Ground water recharge

In order to augment the flow in the drainage line, it is necessary to undertake moisture conservation and water recharge measure in the watershed area. For the purpose of ground water recharge, the area of the upper side of Dhanina village is recommended for ground water rechatge. For ground water recharge and moisture conservation, contour staggered trenches (2m in length with cross section of 0.3 X 0.3 m and having intensity of 200 trenches / ha) may be constructed covering an area 50 ha and 10 numbers of recharge filter are proposed in the watershed.

5. RESEARCHABLE ISSUES

There have been growing concerns over stagnant agricultural production and depleting and degrading its natural resource base such as soil and water. These concerns are equally valid for Yamuna ravine regions in Uttar Pradesh in the irrigated as well as rainfed areas. The critical concerns requiring immediate and long term planning for research in the region include:

- Devising crop diversification strategies by identification of suitable cropping systems which involves crops that require least disturbance to soil health and quality and produce more biomass for recycling in the Yamuna region.
- Development of physical, chemical and biological indicators for assessment of land degradation and impact of conservation measures on soil health.
- Evaluation of conservation agricultural practices for resource conservation under rainfed condition of Agra region.
- Finding ways for enhancing nutrient use efficiency through integrated use of organic manures and fertilizers for resource conservation and sustained productivity.
- Assessment of rain water storage potential in this region in different terrain conditions and improve rain water use efficiency/water productivity through prolonged storage and multiple water use especially in the light of climate change impact.
- Upscale existing agro-forestry system in degraded lands by conducting trials in Yamuna ravine areas in order to develop location specific technologies relevant to socio economic scenario.
- Identify suitable fruits, trees and grasses to address the issues of climate change impacts and sustained productivity.
- Study the below ground root biomass for tree-crop interaction and its impact on resource conservation for developing sustainable tree based production systems.
- Improving soil carbon sequestration through identification and evaluation of potential systems for carbon sequestration through best management practices, under different land uses and conservation agriculture.

6. EXECUTION OF WORKS

6.1: Community Organization, Entry Point Activity and Capacity Building

6.1.1: Community organization

Number of meetings was organized in the all villages of Jalalpur watershed for finalization of activities of developmental programs. PRA were also done in Jalalpur and Dhanina villages. Developmental activities on arable land, non-arable land, drainage line treatment, livelihood support system and production & micro enterprises were finalized during these meetings and PRA exercises (Photo 1).

Photo 1: PRA exercise and discussions with community of watershed

6.1.2: Entry point activities

Two entry point works were carried out on the basis of community demand in Dhanina village (construction of waste weir and two bath rooms for women) near main water body catering multiple uses like drinking water for human and livestock, bathing and washing etc. Third bath room was constructed on other of water bodies where schedule caste community live. In Jalalpur village, community was facing acute problem of drinking water particularly in summer season, therefore, drinking water supply through 2000 liters tank was created and handed over to the community. A sum of Rs 2.50 lakhs was invested on different entry point interventions (Photo 2).


Photo 2: Entry point activities in Jalalpur watershed

6.1.3: Farmer's training

Six farmer training programmes each of three days duration were organized at the Research Centre, Agra. Farmers were trained in soil and water conservation, agroforestry and other profitable land use options, improved package of practices of crops, livestock management, bee keeping, mushroom cultivation etc. Exclusive women training programme was also organized. Training module comprised of an optimum blend of lectures and field visits. The total investment on farmer training was 4.80 lakhs (Photo 3).


Photo 3: Farmer's training at IISWC, RC,

6.1.4: Kisan gosthis

Four kisan goshis were organized in Jalalpur watershed (two each in Jalalpur and Dhanina village) at the beginning of both *Kharif* and *Rabi* seasons in order to provide detailed information on package of practices of different crops, agronomical demonstrations and on farm trials and all other interventions to be taken up in the watershed. Experts from agricultural department and animal husbandry were also called and relevant lectures on crops and animal husbandry were delivered. More than 300 farmers attended Kisan Gosthis and benefited from deliberations. The total expenditure on Kisan Gosthis was 0.2 lakhs (Photo 4).


Photo 4: Kishan Gosthi's in Jalalpur watershed

6.2: Watershed Development Works

6.2.1: Desiltation work from existing water bodies

Dhanina village having one old water harvesting structure (village pond) that is serving the purpose of drinking water to cattle and others uses like bathing, washing clothes, recreational, percolation etc. Over the period of time, its capacity has considerably been reduced due to siltation. Therefore, this village pond was desilted (approx.2000 M^3) with a cost of Rs 0.90 lakhs to enhance capacity of pond and increase ground water recharge. So that acute water crisis is solved up to grear extent (Photo 5).

Photo 5: Enhanced rain water storage in desilted ponds for

6.2.2: Animal health camps

Four animal health camps were organised in Jalalpur and Dhanina (two in each village) by calling Doctors from Animal Health Department, Agra (U.P.) and CIRG, Makhdum (Mathura). More than 1023 animals were tested and medicines were given according to their diseases. The total cost of animal health camps was about Rs 1.18 lakhs. After animal health camp in both the villages, general health of animals improved and milk production increased by 39 % (Photo 6).


Photo 6: Animal health camps in Jalalpur watershed

6.2.3: Construction of vermicomposting pits

Twelve vermi compost units (twine set) were constructed in the three villages (Deori, Jalalpur and Dhanina) of Jalalpur watershed with a cost of 0.92 lakhs. BPL farmers having sufficient cattle were given the vermi-compost units with a view to improve their livelihood after selling vermi compost to the watershed farmers. Farmers are using this compost in their fields and selling also to the watershed farmers @ Rs. 6.50 per kg (Photo 7).


Photo 7: Vermicompost unit in watershed and Inspection by DDG (NRM

6.2.4: Bee keeping demonstrations

Twenty five units of honey bee boxes having 10 plates along with high quality bees were purchased from Pune with a cost of Rs 0.82 lakhs for demonstration purpose among BPL and landless farmers in Jalalpur watershed in order to improve their livelihood and economic status. Each unit is producing 70 to 80 kg honey of cost Rs.125 per kg to total worth per set is Rs. 80000 to Rs. 10,000 per season (Photo 8).


Photo 8: Bee keeping activities in watershed

6.2.5: Development of silvi-pastoral system

Sivi-pastoral systems were developed on an area of about 3.08 ha by planting about 1119 seedlings of *Prosopis juliflora* (168 on 0.17 ha), *Acacia nilotica* (168 on 0.41 ha), *Acacia arabica* (162 on 0.42 ha), *Azadirachta indica* (379 on 1.11 ha), papdi (142 on 0.61 ha) and karang (100 on 0.36 ha) with grasses like napier, para, guinea and anjan. The tree seedlings were planted in pits of 60 x 60 x 60 cm after filling the pit with farm yard manure (2 cubic feet), Malathion (100 g) and good quality soil. The cost of development of silvi-pastoral systems was about 1.75 lakhs (Photo 9).

Photo 9: Plantation pits for Aonla plantation with alignment in watershed

6.2.6: Development of dryland horticulture

2238 fruit species were planted on an area of 14.32 ha that comprised of aonla, bael and ber graft/budded plants of 788, 615 and 835 in number on an area of 5.04, 3.94 and 5.34 ha, respectively. These fruit species were planted in pits of $1m^3$ by the farmers who were handed over the responsibility of all future management and care of fruit tree species. The knowledge of package of practices was given to the farmers by organizing meetings in Jalalpur watershed itself (Photo 10).

Photo 10: Agro forestry system in watershed

6.2.7: Renovations/construction of old/new bunds

Old bunds having existing cross sectional area 0.38 with dimensions top width: 0.45 m, bottom width: 1.45 m and height: 0.5 m was renovated with cross sectional area of 0.9 M^2 with top width: 0.45 m, bottom width: 1.95 m and height: 0.75 m in 20 h area that constituted 3500 running meter length. New bunds with dimensions of top width: 0.45 m, bottom width: 1.95 m and height: 0.75 m (about 2500 running meter length) with cross section area of 0.9 M^2 were constructed. The total cost of bunding work in Jalalpur watershed was 2.215 lakhs (Photo 11-13).


Photo 11: Construction of bund in watershed


Photo 12: Contour bunds in field


Photo 13: Crops in bunded area

6.2.8: Staggered trenching

Staggered trenches (dimension; 30 cm: bottom width; 120 cm: top width and 45 cm: depth) were dug out in 7.0 ha area (2000 rm) with a cost of 1.856 lakhs to harvest runoff to increase moisture availability to plants as well as to allow water to infiltrate in to soil (Photo 14).


Photo 14: Trenches in waste land

6.2.9: Recharge filters

Five recharge filters were constructed in two bandhis' submergence areas in villages of Jalalpur and Dhanina with 2.35 lakhs in order to promote artificial ground water recharge. Rechatge filter units had dimensions of top: 5 x 5 m and depth: 1.5 m with 1.0 m filled with the boulders: 30 cm jelly: 30 cm and 20 cm river sand. Depth of the recharging ptofile is 45 cm. Due to five recharge filters area under irrigation increased by 27 % and drinking water availability to Dhanina and Jalalpur village improved lot. Additional 50 ha area has come under irrigation (Photo 15).


Photo 15: Recharge filter for GW recharge in field

6.2.10: Gully plugs (retaining wall)

Ten gully plug structures (masonry retaining wall type) were constructed with a cost of Rs 1.873 lakhs to harvest rain water as well as to retain soil behind the structures. Enhanced soil moisture on account of soil and water conservation at upper reaches may be utilized for improving the agricultural productivity. After construction of gully plug (retaining wall), runoff and soil loss from the watershed have drastically reduced (Photo 16).


Photo 16: Gully plug in drainage line

6.2.11: Construction of gauging station

Two gauging stations were constructed in watershed to monitor runoff and soil loss from waste land and agricultural land and third gauging structure was constructed at outlet of the watershed having mix land uses (waste land +Agriculture) with a cost of all three Rs 3.5 lakhs. Data have been recorded from these gauging structures (Photo 17).

Photo 17: Silt load in runoff before treatment and after treatment

6.2.12: Meteorological observatory

A met observatory having instruments like rain guages (standard and recording type), U.S. Class I pan evaporimeter, anemometer, thermometers (dry and wet) and soil thermometer was established in Jalalpur watershed for precise data collection on different weather parameters with a cost of Rs 1.60 lakhs (Photo 18).

Photo 18: Meteorological observatory

6.2.13: On farm agronomical trials in watershed

Pulses are important and widely grown agricultural crops in semi-arid tracts (SAT) from point of view of food security to large vegetatian society in rural areas. Cultivation of pulses generally involves low cost, low irrigation and low fertilizer uses. SATs are beset with diversified production constraints viz poor socio-economic status, lack of infra-structure and hostile climate (high evapotation and erratic distribution of limited annual rainfall).

Pulses are usually deep rooted, have good soil binding and mitigate water erosion hazards on low to mild sloping lands if grown pure or as inter/ strip crops. Pulses are generally cultivated on marginal to sub marginal soils without use of *Rhizobium* or PSB culture, irrigation, fertilizers and insect-pest control. Farmers are also repeatedly using seeds of unidentified old varieties of pulses year after year which is also one of the reasons behind poor pulse productivity. Therefore, to improve the pulse productivity, following on farm trials were conducted in backdrop of PRA.

6.3: Development of Nutrient Schedule for Different Crops

6.3.1: Development of nutrient schedule in lentil *(lens esculenta* L.)

An on farm study was conducted in Jalalpur and Dhanina villages by sowing lentil (Cv. K-75) in rain-fed fields of 12 farmers covering wide variations in crop history and soil texture (light to heavy), fertility and water holding potential, during first fortnight of November.

Table 5: Effect of different nutrient management options on grain, straw and biological yield (kg ha^{-1}) and harvest index of lentil in semi-arid alluvial soils.

Treatment	Grain yield	Straw yield	Biological yield	Harvest Index
T_1: Farmer's practice	887.17	1064.33	1951.50	45.46
T_2: No fertilizer	896.83	1053.33	1950.16	45.99
T_3:Phosphorus Solubilizing Bacteria (PSB)	981.00	1135.08	2116.08	46.36
T_4: *Rhizobium*	1073.58	1227.00	2300.58	46.67
T_5: PSB + *Rhizobium*	1115.58	1268.33	2383.92	46.80
T_6: Recommended dose of fertilizers (RDF)	1185.58	1323.00	2508.58	47.26
T_7: PSB + Rhizobium + RDF	1302.83	1450.83	2753.67	47.31

Results revealed that the performance of lentil under farmer's practice and no fertilizer was almost at par which may be attributed due to raising high yielding lentil variety without fertilizers while farmers applied limited fertilizers in their own varieties in T_1. Data (Table 5) indicated that all nutrient management options invariably improved the grain and straw yield of lentil over farmer's practice which ranged from 10.58 % in T_3 (PSB) to 46.85% in T_7. Similarly, enhancement in straw yield of lentil due to nutrient management options over farmer's practice ranged from 8.43% in T_3 to 41.11% in T_7. Data clearly indicated that source to sink relation (translocation of food material from aerial parts to grain) was improved to a tune of 0.9 to 1.85 % under different nutrient management options over the farmers practice.

Seed treatment with *Rhizobium* outperformed PSB while *Rhizobium* + PSB outproduced the independent use of either *Rhizobium* or PSB alone. Similarly, *Rhizobium* + PSB + RDF outperformed the RDF in grain and straw yield of lentil (Photo 19).

Photo 19: Bumper crop of lentil in watershed

Table 6: Mean performance of four gram varieties under different nutrient management options in respect of grain, straw and biological yield (kg ha^{-1}) and harvest index of gram in semi-arid Aravalli hills.

Treatment	Grain yield	Straw yield	Biological yield	Harvest Index
T_1: Farmer's practice	561.22	691.33	1252.56	44.83
T_2: No fertilizer	579.78	711.11	1290.84	44.94
T_3: Phosphorus Solubilising Bacteria (PSB)	640.33	779.44	1419.78	45.18
T_4: *Rhizobium*	706.11	845.33	1551.44	45.60
T_5: PSB + *Rhizobium*	826.22	975.00	1801.22	45.92
T_6: Recommended dose of fertilizers (RDF)	876.00	1026.89	1902.89	46.09
T_7: PSB + *Rhizobium* + RDF	960.78	1116.67	2077.44	46.29

Results revealed that performance of the farmer's practice and no fertilizer treatment was almost at par which may be attributed due to no fertilizer use in high yielding variety of gram but farmer's used limited DAP in their own varieties. Data Table 6 indicated that all nutrient management options invariably improved the gram grain yield over farmer's practice which ranged from 10.58 % in T_3 (PSB) to 46.85 % in T_7 (PSB + *Rhizobium* + RDF). Similarly, various nutrient management options also improved the straw yield of lentil over farmer's practice which ranged from 8.43% in T_3 to 41.11 % in T_7. Data clearly indicated that source to sink relation (translocation of food material from aerial parts to grain) was improved to a tune of 0.9 to 1.85 % due to different nutrient management options.

Rhizobium outperformed PSB while *Rhizobium* + PSB outproduced the independent use of either *Rhizobium* or PSB alone. Similarly, *Rhizobium* + PSB + RDF were superior to RDF alone in producing higher grain and straw yield of gram.

6.3.2: Nutrient management in green gram (*Vigna radiata*), black gram (*Vigna mungo*) and arhar (*Cajanus cajan* L.)

Data (Table 7) showed that the highest grain yield of all *Kharif* legume crops was recorded in T_6 showing that effect of *Rhizobium* + PSB + RDF, was more pronounced on productivity of *Kharif* legumes than independent use of *Rhizobium*, PSB or RDF on semi arid soils in Aravalli hills. On these poorly fertility soils, kharif legume productivity of was $T_7 > T_6 > T_5 > T_4 > T_3 > T_2 > T_1$ (Photo 20).

Photo 20: Bumper crop of Arhar in watershed

Table 7: Grain yield (kg ha^{-1}) of green gram, black gram and arhar under different nutrient management options in semi-arid soils of Aravalli hills.

Treatment	Green gram	Black gram	Arhar
No fertilizer	466.7	387.5	1096.7
Farmers practice	443.3	361.9	1018.0
PSB only	483.3	395.6	1223.3
*RDF	512.2	416.3	1257.8
Rhizobium only	533.3	441.2	1268.9
Rhizobium + PSB	564.4	466.9	1312.2
Rhizobium + PSB + RDF	607.8	498.6	1372.2

*RDF is recommended fertilizer dose

6.3.3: Nutrient management in jowar *(Sorghum bicior* L.) and bajra *(Pennesetum typhoides* L.)

Results Table 8 revealed that the highest grain yield of pearl millet and jowar were produced under T_8 which establishes that combined effect of RDF + PSB + weed mulch was higher than the independent effect of RDF, PSB and weed mulch alone. Treatments combining *in-situ* weed mulch produced higher grain yield of jowar and bajra than other treatments which may be attributed due to higher rain water conservation and suppression of weed growth which enabled both the crops to withstand droughts of variable duration and intensity, common in semi arid regions. T_1 produced numerically higher grain yield of both pearl millet and bajra than T_2 which may be attributed due to fact that farmers use new seeds of high yielding hybrids, composites and varieties of these crop every year and also apply limited quantity of fertilizers in these crops.

RDF produced higher grain yield of both pearl millet and jowar than 75% RDF either alone or in combination with PSB or weed mulch or PSB + weed mulch showing that recommended fertilizer dose must be applied for higher productivity of jowar and bajra on semi arid soils of Aravalli hills (Photo 21).

Photo 21: Bumper crop of Bajra in watershed

Table 8: Grain and straw yield of pearl millet and jowar (kg ha^{-1}) under different nutrient management options on semi arid soils of Aravalli hills.

Treatment	Bajra	Jowar
Farmer's practice	1388	838.9
HYV seed	1390	823.9
75% RDF*	1497	880.0
100% RDF	1552	918.9
75% RDF + PSB	1644	856.1
100% RDF + PSB	1714	949.6
75% RDF + weed mulch	1723	1040.0
100% RDF + weed mulch	1861	1086.1
75% RDF + PSB + weed mulch	1816	1129.6
100% RDF + PSB + weed mulch	2086	1171.1

*RDF is recommended fertilizer dose.

6.3.4: Other crops in watershed

Other crops such as mustard, wheat, potato, sugarcane, etc were also demonstrated in the watershed and they performed well (Photo 22 & 23). The land use after implementation of watershed activities was increased and given in Table 9.


Photo 22: Mustard and Potato crop after watershed development programme


Photo 23: Bumper crops of wheat and sugarcane in watershed

Table 9: Land use plan of watershed after implementation of SWC technologies

S. N.	Land use	Before (ha)	After (ha)
1	Agriculture		
a	Rainfed	380.77	346.77
	I Crops	380.77	338.52
	II Agro-forestry	Nil	8.25
b	Irrigated	118.38	152.38
	I Assured	39.46	73.46
	II Partial	78.92	78.92
2	Waste land	180.95	180.95
a	Aforestation	Nil	24.00
b	Pasture	Nil	116.35
c	Untreatable	40.60	40.60
3	Village land	17.40	17.40
	Total	697.50	697.50

7. MONITORING AND IMPACT EVALUATION OF SOIL AND WATER CONSERVATION MEASURES OF JALALPUR WATERSHED

The survey was conducted for studying the impact of watershed development programme on land use, cropping pattern and crop productivity; horticulture plants and livestock; ground water and water table. Three villages of watershed namely Jalalpur, Dhanina and Deori were selected for household data collection. In each village, the care had been taken for selection of households representing marginal, small, medium and large size farm holdings. For collection of primary data, 120 households were selected from watershed area. In addition to the above due weightage was given to caste composition while selecting sample households. The data of pre and post-development of watershed pertaining to various aspects were collected on developed structured schedule by interviewing the respondents personally and collected data were analyzed and compared.

7.1: Impact on Irrigated Area, Water Availability and Water Table Depth

Out of total cultivated area 647 ha during base year 2009-10, the irrigated area was 381 ha and rainfed area was 266 ha. While in 2013-2104 year, the irrigated area was increased by 35.17 % (515ha) and rainfed area has decreased by 50.37 % (132ha).

In Jalalpur watershed, 16 wells were selected to determine the effect of various soil and water conservation structures on ground water recharge. The data on the water table depth was compared with the pre-development data and average increases in water table depth in the wells on the downstream were calculated. On the basis of data collected from observation wells, it was observed that average water table rose from 3.1m to 6.3m. Increased water availability duration in wells was also observed.

The duration of water availability in wells went up from 3-7 months before watershed interventions to 8-12 months after watershed interventions. This was attributed to *in-situ* soil moisture conservation measures and water resources development in the watershed areas Table 10 (Photo 24).

Table 10: Impacts of implemented SWC measure in watershed

Impact	Pre-development (2009-10)	Post-development (2013-14)
Irrigated area (ha)	381	515
Rainfed area (ha)	266	132
Horticulture plants (No.)	28	359
Livestock (No.)	782	1172

Photo 24: Impact on water table and ground water quality before and after implimentation of Programme

7.2: Impact on Horticulture Plants and Livestock

Total fruit crops were 28 in pre-development period (2009-10) while in post development period (2013-14) total fruits were increased upto 359. The fruit crops like mango (*mangifera indiaca*), aonla (*emblica officinalis*), nimbu (*citrus lime*), orange (*citrus aurantifolia*), guava (*Psidium guajava*),banana(*musaparadisica*), ber (*Ziziphus spp.*) pomegranate (*punica granatum*) are present in watershed area after watershed development programme.

The livestock survey in the area indicated increasing trend in livestock over pre-development period (2013-14). The increased in number of buffalo, cow, goat and sheep was 58.96, 36.30, 43.89 and 28 %, respectively over pre-development watershed period it may be due to increase in availability of feed and fodder. After the availability of fodder, farmers were encouraged to have more number of livestock to achieve higher level of income.

7.3: Impact on Crop Sown Area and Crop Productivity

In watershed area, main *Rabi* crops grown by the farmers are wheat, mustard, lentil, barley and gram whereas in *Kharif* season bajra is main crop and very little area is under sesame, redgram, greengram and blackgram. In post-development period farmers also started to grow the sugarcane crop as well as vegetables in the watershed area. The area under major crops and their productivity in *Rabi* and *Kharif* seasons in pre-development and post-development period of watershed is presented in table 11.

It is seen that in *Rabi* season, area under wheat and mustard was found to be increased by 12.70 and 18.17 %, respectively whereas area under lentil crop was found to be decreased by 14.28 %. Productivity of wheat, mustard and lentil were found to be increased by 12.31, 16.66 and 14.88 % respectively. The area under bajra crop in *Kharif* season was found to be decreased by 21.17% and its productivity was found to be increased by 7.55 %. Increased area under wheat and mustard crop was attributed to the availability of irrigation water as well as increased in water table depth. The better management practices, land improvement and intervention of high yielding variety as well as availability of irrigation facilities increased the productivity of all crops. The Increase in crop productivity and livestock population resulted in better economic condition of farmers, which led to improvement in living standard of watershed community.

Table 11: Impact of SWC measures on area under major crops and their productivity in watershed

Crops	Pre-development (2009-10)		Post-development (2013-14)		Percent Change	
	Area (ha)	Productivity (q/ha)	Area (ha)	Productivity (q/ha)	Area	Productivity
Wheat	176.78	33.00	199.24	37.06	12.70	12.31
Mustard	267.38	12.75	315.97	14.88	18.17	16.66
Lentil	112.70	7.50	96.60	8.80	-14.28	14.88
Bajra	223.75	17.15	176.36	18.45	-21.17	7.55

7.4: Economics of Different Crops in Watershed Villages

Bajra, mustard, wheat, lentil and gram were the main crops grown in Jalalpur watershed villages. All crops were economically viable in all the three watershed villages (Jalalpur, Deori and Dhanina) based on B:C ratios Table 12. Out of these crops, the B:C ratio was highest in case of lentil crop (Jalalpur; 2.28 , Deori; 2.48 and Dhanina; 2.86) and lowest in Bajra cultivation (Jalalpur; 1.18 , Deori; 1.23 and Dhanina; 1.20) in all three villages.

Table 12: Average economics of different crops in Jalalpur watershed villages

Crops	Jalalpur				Deori				Dhanina			
	Cultivation cost (Rs/h)	Gross income (Rs/ha)	Net income (Rs/ha)	B:C ratio	Cultivation cost (Rs/ha)	Gross income (Rs/h)	Net income (Rs/h)	B:C ratio	Cultivation cost (Rs/ha)	Gross income (Rs/ha)	Net income (Rs/ha)	B:C ratio
Bajra	14949	17675	2726	1.18	12597	15500	2903	1.23	15600	18745	3145	1.20
Mustard	18230	35650	17420	1.96	18168	35650	17482	1.96	17361	33810	16449	1.95
Wheat	26853	45474	18621	1.69	28818	42900	14082	1.49	25337	43030	17693	1.70
Lentil	18139	41350	23211	2.28	16327	40500	24173	2.48	16733	47925	31192	2.86
Gram	15201	25278	10077	1.66	20679	24115	3436	1.17	17874	35260	17386	1.97

8. LESSON LEARNT AND RECOMMENDATION

Gully erosion and ground water deletion are major degradation process threatening sustainability of production potential of rainfed ecosystem of the region. Low and high erratic rainfall pattern associated with hot and extended summers limits the option for cultivation and productive utilization of uncultivable lands. With lack of education and scanty resources the rural communities are poor equipped to face the challenge of unfriendly environmentally. The starvation deaths reported from this region during last decade due to drought are indicative of grievous situations.

The conservation measures applied in the Jalalpur watershed were highly ameliorative in this ravine terrain. Reclamation of gullied land increased soil moisture was the most apparent and immediate benefits experienced. With improved cropping practices these ameliorative effect can be enhanced to quickly

recovet the cost of conservation measutes. However, undet severe drought situation as experienced during year 2010 and 2011, conservation measures and improved cropping practices were found inadequate to sustain even minimum level of productivity required to support livelihood of human and cattle population of Jalalpur watershed. However, strengthening existing water harvesting structure and developing additional village pond effectively reduced drought effect.

It is clear from the developmental work in the Jalalpur watershed that irrespective of male or female farmers, improved level of socio –economic status, knowledge, risk taking ability and positive attitude were positively and significantly correlated with the farmer's participation in planning phase. Thus, right from beginning (report building phase) , care should be taken, to involve those who are low on vatious independent vatiable, to get the vatiable ideas and experiences from every strata of the village society, a prime requisite for perfect participatory planning, development and finally management of natural resources.

The implementation of watershed development project in Jalalpur watershed has surfaced some of the concerns and constraints need to be focused upon by research and developmental agencies.

- One of the major constraints experienced in the project implementation was excessive biotic interference which was a major limitation restricting the successful establishment of vegetation in community pasture land as well as in the private waste land. Open grazing habit of large animal population, largely owned by nomadic tribes, was difficult to regulate.
- There is good scope of enhancing drought resistance potential and sustainability of production system through promoting appropriate silvi pastotal system on community land and planting fodder or timber tree species on field bunds. Concept of social fencing needs to be strengthened to regulate grazing habits of animals. Also behaviot of nomadic tribes and their animals needs to be focused to developed alternate viable strategies.
- Formation of surface and subsurface cracks due to high proportions of expanding clay often lead to pot – hole formation, extension of gully heads and failute of bunds and masonry structures. Soil surface management strategies to minimize crack formation at critical locations need to be evaluated and developed.
- There is need to identify and refine remunerative alternate land uses and management options which can ensute minimum productivity under drought situation and improve potential to maximize production in normal rainfall yeat.
- Synergies and complementariness of joint management of arable and non-arable lands following farming systems approach need to be explored on watershed basis. Community conflicts, equity and lack of institutionalized management mechanism are the emerging issues and need attention.
- Ravines ate one of the worst forms of terrain deformation, predominantly inhabited by poor communities. The sustained development of these areas largely depends on external support. Therefore, Rs.12,000/ per ha was not adequate amount for complete rehabilitation of the watershed. It is recommended that per ha cost of such projects shall be revised.

9. GAPS IDENTIFIED AND SUGGESTIONS FOR POLICY MAKERS

- In most of the watershed management projects emphasis is on improving agricultural productivity. Alternate livelihood options are not experimented with. Including animal husbandry and allied agricultural activities like apiary, fish culture, strengthening local cottage industries need major attention.
- During planning phase participation of local stake holders needs to be increased. Tools like PRA/ RRA need to be meticulously utilized for this purpose.
- There is need for sensitizing farmers on the issues related to soil and water conservation.
- The principle of reward for protector of soil and water conservation is relevant in ravine areas as options for ground water recharge lack incentives for upstream stake holders.

- The watershed management programmes shall be spread over 7-8 years so that maintenance of previous year's works can be insured. Currently despite provisions of post project management funds there is little maintenance of CPRs once the projects are over.
- Monitoring of watershed management programmes shall be taken up right from the beginning especially before implementation of treatments starts.
- For development of wastelands as fuel/fodder reserves there is need to sensitize local populace towards benefits of stall feeding and use of top feed species especially in ravine regions.

10. SUGGESTIONS FOR IMPROVING THE WATERSHED MANAGEMENT PROJECTS IN RAVINE REGIONS

The ICAR-IISWC, Research Centre, Agra has developed two model watersheds and the scientists of the research centre, Agra have worked in the ravine region for several years. Based on the experiences of scientists of the centre about IWMP projects developed by the centres and exposure to the watershed management projects conducted by NGOs and state government agencies in the ravine region, the centre is of the view that unlike the watersheds in plains, the watershed management projects in the ravine region pose major constraints for planning and field execution.

The relatively better success of the watershed management projects developed by the centres of IISWC as compared to other agencies is largely due to the following broad reasons:

- There is definite superiority in the watershed development team of the IISWC and its centre as compared to the WDT of other agencies. Experienced scientists contribute at the planning and implementation phase at IISWC while most of the times the WDT of other agencies lacks services of properly trained manpower.
- Many a times it has been experienced that state government officers trained at IISWC, Dehradun and its centre are engaged in other jobs after returning to their department and the job of watershed management projects are assigned to people lacking concepts in the watershed management.
- Most of the times the WDT of other agencies are overworked as they are assigned to develop more than one watershed at one time. At times officers for watershed management team are also assigned tasks related to other government schemes unrelated to watershed management. This leads to rushing against time during the important phases of planning and implementation.
- Especially in case of state government agencies the approach in watershed development is target orientated rather than result orientated. This leads to development of DPRs based on pre decided format and leaves little room for out of the box thinking to incorporate innovative solution for location specific problems.
- Unlike the watersheds in the plains the ravine watersheds need more cost intensive mechanical measures and implementation of vegetative measures is also more costly due to topographic and physical constraints. Thus priorities in the ravine watersheds are different than the watersheds located in plain areas.

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