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Drought Proofing and Rural Livelihood Security Through Watershed and Agroforestry Interventions in Bundelkhand Region

(A case study of Garhkundar-Dabar watershed)

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DROUGHT PROOFING AND RURAL LIVELIHOOD SECURITY THROUGH WATERSHED AND AGROFORESTRY INTERVENTIONS IN BUNDELKHAND REGION

(A case study of Garhkundar-Dabar watershed)

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Preface

Bundelkhand, in transitional zone between southern plateau and northern plains, is hot spot of water scarcity. The region is largely fed by ephemeral drains culminating into seasonal rivers originating in central parts of India and ultimately joining river Ganga/Yamuna in north. Although, the region receives 750-1100 mm average annual rainfall in different districts spread over 7.16 million ha area in Madhya Pradesh and Uttar Pradesh; yet depends upon perched water for drinking and crop production which is often vulnerable. This is primarily because of typical geological formation of sub-strata that restricts effective soil depth. Intense radiation during summer months (ambient temperature above 45 °C for months together) coupled with low humidity (8-10%) and hot desiccating winds render life of flora and fauna extremely difficult. Soil moisture becomes main limiting factor leading to narrow growing period. As a result, region supports only dry-deciduous thorny vegetation. Ecologically, the region is vulnerable due to frequent droughts, moisture deficiency and low crop productivity. With the increasing population pressure even marginal lands have been brought under plough. This has led to accelerated natural resource degradation and further threatened delicate eco-balance. However, high rainfall in the region opens up window for hope. Rain water conservation and efficient utilization holds key to sustainability of ecosystem. Agroforestry landuse is considered to be more efficient in water use than agriculture alone. Agroforestry at the same time ensures sustainability in production through conservation of natural resources, bio-diversity enrichment and high carbon sequestration potential. While water resource management is best achieved through watershed management, agroforestry development warrants field level micro planning on individual holding. The two in conjunction can restore productivity and halt ongoing degradation. Tree component in agroforestry is long lasting and perennial in nature. It has immediate negative effect on production due to loss in area and difficulty in agricultural operations but soon it plays role of risk bearer and increases total biomass production per unit area and time. Many farmers who are not actively involved in farming seek opportunity and readily opt agroforestry as long term highly profitable venture.

Keeping in mind above facts, ICAR- CAFRI initiated a project on watershed and agroforestry interventions in 2005 in Niwari *Tehsil* of Tikamgarh district of M.P. The watershed is a true representative of Bundelkhand region in physiography and socio-economic status of inhabitants. The project has demonstrated feasibility of approach in restoring eco-balance along with assured productivity. This technical bulletin is based on observed data and suitable inferences drawn and will provide guide lines for all agencies that are involved in development of the region.

Authors and workers of the project are thankful to the council for financial support. Guidance in implementation of the project given by DDG (NRM), ICAR, New Delhi and ex-Directors (ICAR-CAFRI, Jhansi) from time to time is also gratefully acknowledged.

(O.P. Chaturvedi)

1. Background and Objectives

Agricultural systems especially rainfed agriculture in semi-arid tropics is highly vulnerable due to various types of climatic shocks and socio-economic pressures. Upcoming challenges such as climate change which is characterized by high incidences of extreme events such as frequent drought increasing frequency of heavy downpour, longer duration dry spells, shifting length of growing period, untimely and spatial variability in rains and temperature stress, are being recognized in many parts of India. In such conditions, integrated watershed development (IWD) and agroforestry interventions leverage and strengthen desirable development by improving capacity to cope with inherent dry spells and thereby reducing their negative impacts on crop yields and subsequently, livelihood. Bundelkhand region (23^0 8'- 26^0 31' N, 78^0 11'-81^0 30' E) spread over 7.16 million ha in Central India between seven districts of U.P. (Jhansi, Jalaun, Lalitpur, Hamirpur, Mahoba, Banda and Chitrakoot) and six districts of M.P. (Sagar, Tikamgarh, Chhatarpur, Panna, Damoh and Datia) is resting on vast granite massif. The landscape is undulating with characteristic hillocks and experiences semi-arid climate. Average annual rainfall of different districts ranges 750-1100 mm. The region is prone to drought and is the hotspot of water scarcity, land degradation, poor permanent vegetal cover and miserable socio-economic status.

The region has experienced severe drought during 2004 to 2007 and 2014 to 2015. More than 80% open wells dried up soon after monsoon season due to deficit rainfall and poor ground water recharge. During both the droughts, in the absence of drinking water and livelihood opportunities, a large proportion of rural population migrated to metros in search of livelihood. Cattle were abandoned due to water shortage and less fodder availability. In such situation, natural resource management through watershed interventions with due emphasis on agroforestry appear an effective tool to make the region drought resilient. The ICAR-Central Agroforestry Research Institute, Jhansi with farming community identified Garhkundar-Dabar watershed in Niwari *Tehsil* of Tikamgarh district during 2005-06 as a pilot site for improving natural resource efficiency, permanent vegetal cover through agroforestry interventions and strengthening eco-system services.

The general characteristics, location, land use and resources of watershed are presented in Table 1. The watershed is located about 55 km East of the district headquarter. The project comprises six hamlets namely Kundar, Rautiana, Ubaura, Dabar, Sakuli and Shivrampur.

The watershed area falls between 78^0 52' 39" to 78^0 54' 44" E longitude and 25^0 26'23" to 25^0 28'32" N latitude with an altitude varying from 230 to 280 m above mean sea level (MSL). The total area of watershed is 850 ha which ultimately drains into river *Betwa*. The average annual rainfall of the area is 877 mm. In general, May-June is the hottest while December-January is the coldest months of the year. The soils are highly denuded, dissected, sloppy and poor in fertility. The forest area is overexploited having predominance of lopped trees of *Kardhai, Dhak* and *Ber*.

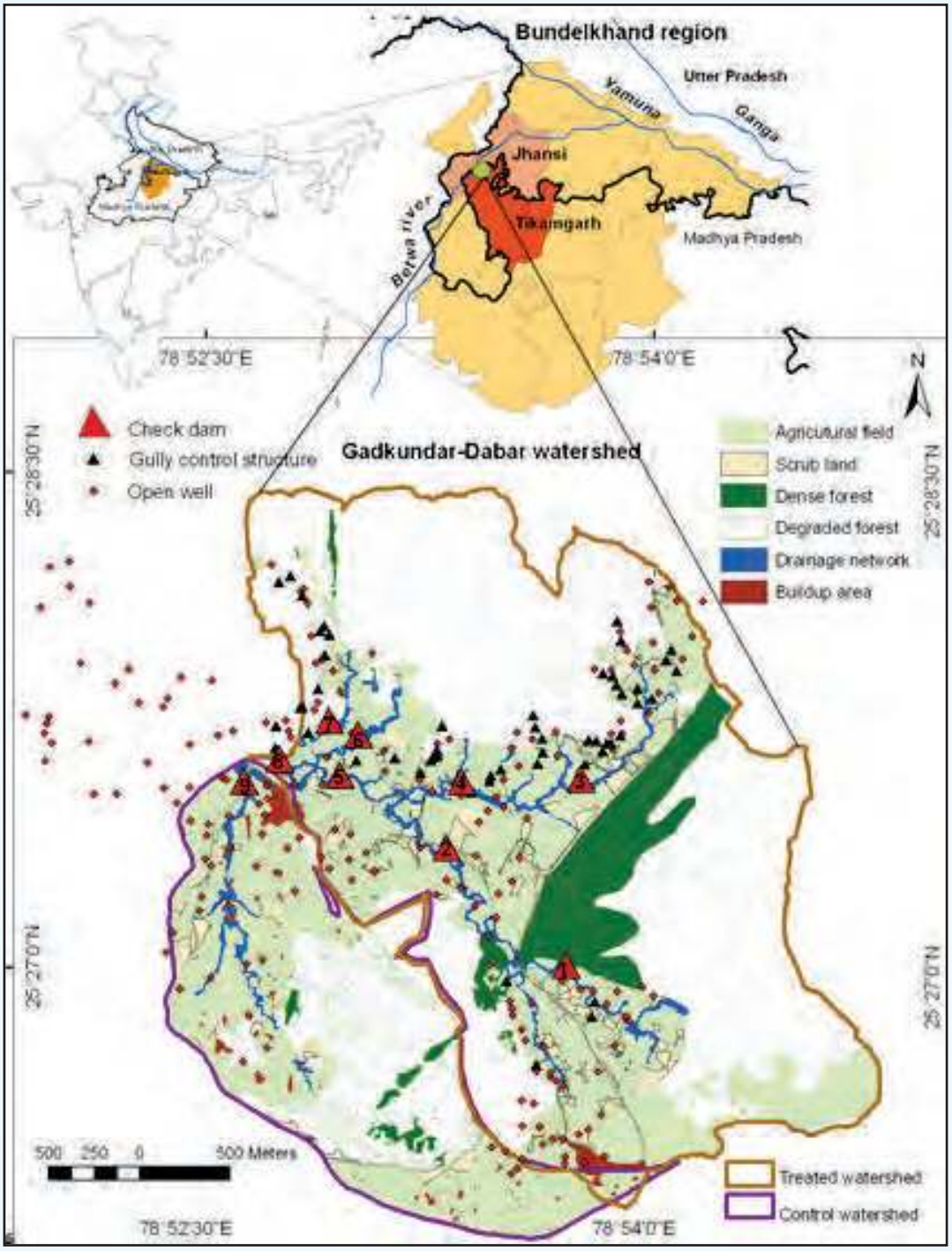
The watershed area was selected based on backwardness and need for development. This area was characterized by acute shortage of water both for irrigation and drinking, large population of downtrodden people (SC, ST and OBC), preponderance of wastelands/degraded lands, significantly lower wages rates and more importantly, the virginity in terms of developmental activities particularly soil and water conservation practices and improved agro-techniques for crop production. Tikamgarh district is also identified as one of the most backward district in the country by Planning Commission, Govt. of India.

Specific Objectives of the Initiative

- To optimize productivity and biomass production
- To restore ecological balance in degraded and fragile eco-system through agroforestry interventions
- To narrow down the disparity between rainfed and irrigated areas
- To create sustained employment opportunities

Table1: General characteristics, land use and resources of *Garhkundar-Dabar* watershed

Location	78°52'39" to 78°54'44" E longitude and 25° 26'23" to 25° 28'32" N (Jhansi-Khajuraho Road- 55 km from Jhansi headquarter)
Watershed Characteristics	
Area	850 ha
Altitude	230 to 280 m above MSL
Relief (m)	50
Length Width ratio	1.57
Drainage density (km/km^2)	2.58
Land use	ha (%)
Agricultural land	263 (30.9)
Scrub land	65 (7.6)
Forest	463 (54.5)
Drain network	46 (5.4)
Habitation	13 (1.5)
Resources	
Total population	895
Male female ratio	1000:765
No. of households	191
Average holding (ha/household)	1.55
Water resources	107 open shallow dug wells (supported 0.5 to 5 hrs continuous operation during pre-watershed interventions)
Soil characteristics	*Rakar* and *Parwa* (red soil) coarsed textured, low in N, P, and O.C., medium in K.
Irrigation	20% land gets life saving irrigation
Vegetation	
Rabi crops	Wheat, chickpea, pea, mustard *etc*.
Kharif crops	Groundnut, blackgram, greengram, *etc.* sesame, *etc*.
Vegetation	*Neem* along road side, scattered *desi ber* on field bunds, *Butea* along the drains, *Kardhai, Mahua, Chirol* and *Semal* in degraded patches. No systematic agroforestry was observed
Life fence	Few farmers have *L. camara* along road side as live fence



Location map of Garhkundar-Dabar watershed, Tikamgarh, Madhya Pradesh

Degraded Forest

Grazing Pressure

Shortage of Fuel Wood

Low Productivity

Dried Well

Shortage of Drinking Water

Problems in Garhkundar-Dabar Watershed

2. Formation of Watershed Committee and Participatory Planning

Watershed committee of Garhkundar-Dabar watershed was constituted to implement the watershed development interventions. As farmers are the primary stakeholders and beneficiaries, involvement of the community was important for successful execution of the interventions and to ensure sustainability of the project. Women and SC candidate were also involved in formation of watershed committee. All the interventions including sites for rainwater harvesting and gabions were identified by the members of the watershed committee along with community in consultation with multi-disciplinary scientific team. The members helped the implementing team in appraisal of basic resources of watershed. Several meetings of implementing team were organized with watershed committee and villagers before finalization of any intervention for its wider acceptability. The members facilitated the team to interact with farmers, especially the farm women. Awareness about conservation and better utilization of natural resources was also created by involving children of the watershed.

Interaction and Transect Walk with Community Members

3. Description of Integrated Watershed Development Interventions

Several *in-situ* and *ex-situ* interventions were implemented under the integrated watershed development program in Garhkundar-Dabar watershed. The most common *in-situ* interventions are field bunding, contour bunding and cultivating crop across the slope, which harvest surface runoff, allow more water to percolate and dispose excess runoff safely from the fields. Field bunding is done in 52 ha land area (20% of agricultural land) and contour cultivation is promoted in rest of the agricultural land in Garhkundar-Dabar watershed. This practice created an opportunity to accumulate surface runoff along the contour line, and also protected soils from erosion. Building checkdams and low-cost gully control structures on the stream network as ex-situ measures reduced peak discharge, runoff velocity and harvested a substantial amount of runoff in watershed and increased groundwater recharge. At the same time, these structures trapped sediment which protected the river ecosystem. Total nine checkdams, including one in control watershed, having storage capacity between 1000 and 6500 m^3; 150 low-cost gully control structures (called gabions locally) of 30-100 m^3 capacity; and 15 numbers of drainage structures for safe disposal of excess water from agricultural fields were

constructed to develop 35000 m^3 of storage space (~ 40 m^3/ha) in watershed. The water in the checkdams could be used directly for irrigation purpose, and simultaneously facilitated artificial groundwater recharge. Other than soil and water conservation measures, focus on productivity enhancement by crop diversification and intensification, introduction of agroforestry system, introduction of improved seed variety, agronomic practices and balanced use of chemical fertilizers were initiated.

Following five group of activities, depicted with technical details in tabular form, were executed and monitored in the watershed in a holistic manner by a multi-disciplinary team of scientists (Table 2). An adjacent watershed was also monitored as control. None of the activity was done in control watershed except a gauging station at the outlet for monitoring of hydrological parameters.

Table 2: Technical specifications of integrated watershed development (IWD) and agroforestry interventions in the watershed

A. Soil and Water Conservation Measures

1. Checkdams

Checkdam No.	Approx. Catchment (ha)	Storage capacity (m^3)	Length of crest (m)	Height of weir (m)	Height of water drop (m)
1	261	909	5.3	1.00	1.80
2	350	2670	6.0	1.45	2.00
3	92	2624	4.3	1.75	2.00
4	225	3951	12.0	1.00	2.00
5*	650	5327	7.7	1.50	2.75
6	150	2302	5.7	1.40	2.75
7*	76	1438	4.95	1.75	2.00
8	850	3743	14.3	1.70	2.00

2. Other moisture conservation measures

Other conservation practices	Approx. Catchment (ha)	Length (m)	Height (m)	Volume (m^3)
Gabion (in 1st and 2nd order drain)	1-5	3-5	1.0	3-5
Khadin	2-5	25	0.6	-
Contour/Field and Marginal Bund	52	4000	0.6-1.2	-

B. Crop Demonstrations with improved agro techniques

Crop	Variety	Fertilizer (N:P:K)	Sowing method	No. of demonstration
Groundnut	Kaushal	20:60:40 and micro- nutrients	Along contour	20
Sorghum	CSV- 13	80:60:40	-do-	5
Sesame	Shekhar	60:40:20	-do-	15
Blackgram	T-9	20:40	-do-	16
Greengram	Satya, Samrat, Meha, Pusa Baisakhi	20:40	-do-	14
Pigeonpea	ICPH-2433, ICPH-2671	20:40:20	-do-	2
Soybean	JS-335, PS-1042	20:60	-do-	2
Wheat	Lok-1, WH-147, HD-2932, GW-322	120:60:40	-do-	20
Gram	Avrodhi	20:40	-do-	2
Fodder	Sorghum MP Chari	80:60:40	-do-	3
Total				**99**

C. Agroforestry Development				
Tree Species	**Variety**	**Spacing (m)**	**Pit Size**	**Crop sequence**
Aonla	NA-7	8x8, 8x7	90x90x90 cm	Groundnut-wheat
Guava	Allahabad Safeda, L49	8x6	75x75x75 cm	Groundnut-wheat, Blackgram-wheat, Sesame-wheat
Citrus	Kagaji lime	8x6	75x75x75 cm	Groundnut-wheat, Blackgram-wheat, Sesame-wheat

D. Plantation Activities	
Plantation of Multi-Purpose Trees (MPTs)	Total-9472 [5316 (mainly along water courses in 2007); 350 (2008); 1150 (2009); 1321 (2010); 1335 (2012-13)]
Grasses	Munj (1000 slips), Ginni (2000 slips), Guinea (2 kg seeds sown along the bunds)
ber rejuvenation	550 plants
Area under agrihorticultural system	4.0 ha
Area under agrisilviculture (boundary plantation of teak and Kumat)	24 ha
Development of live fence	1.7 ha
E. Capacity Building and Livelihood Generation Activities	
Trainings	Budding/Pruning, Agarbatti (incense) making, Fabrication of gabion mesh, Lac cultivation, biofuels
Kisan Mela / Kisan Ghosti/Field days	11
Vanmahotsav	01
Exposure visit	05
Successful Self Help Group (SHG)	01- female
Watershed committee	01

*Low Cost




Water Resource Development




Pressurised Irrigation to Improve Water Use Efficiency




Agroforestry Interventions in Watershed

4. Data Monitoring in Treated and Untreated Watershed

Since inception of the project, attention was given on data monitoring at Garhkundar-Dabar watershed (treated) and also in nearby control watershed of 276 ha area. Topographic, soils, climate condition and socio-economic status of control watershed are almost identical to treated watershed. Farmers' in control watershed follow traditional farming practices and no such IWD interventions implemented. Data on surface runoff and base flow, soil loss, groundwater recharge, agricultural water use, crop yields, reservoir hydrology, sedimentation of reservoirs, area under different kinds of agroforestry, change in land use pattern and impact of interventions on socio-economic conditions were monitored in treated and control watersheds.

5. Skill Development Initiatives

People's participation is key to perpetuity of natural resource conservation effort. This warrants awareness and capacity building of all stakeholders. With this objective, following capacity building activities were initiated in watershed.

Kisan Mela / Kisan Ghosthi/Field days: Eleven Kisan Mela and Field Days were organized in the watershed to aware the community about up-to-date information about sustainable land use in tandem with available natural resources. Farmers were also demonstrated pressurized irrigation system for better water use efficiency.

Skill development: Training in top working of *desi ber* plants were conducted in each village of the watershed. One farmer was provided with budding knife and secateur. Farmers were also imparted the skill of making NADEP. Two NADEPs were constructed on farmer's field.

Soil Health Cards: Soil health cards were also prepared and distributed to the farmers for encouraging balanced fertilizer use. Use of pond sediment in field for improving soil quality was also demonstrated.

Exposure visits: Visits to ICAR-CAFRI, IGFRI and Development Alternatives (Taragram), Jhansi, ICRISAT, Hyderabad, were organized to educate the farmers about recent developments in agriculture, agroforestry and animal husbandry.

Institution building: Watershed Committee was constituted for planning and execution of all kinds of natural resource management activities. Self Help group (SHGs) were formed and encouraged to take up group activities, inter personal loaning and capacity building. Exposure visits were organized for SHGs members to other successful SHGs of Chhatarpur, M.P. and Kothapalli watershed, Hyderabad for motivation and guidance.

Employment generation: During the course of watershed development, 7000 (skilled & unskilled) human-days employment was generated. Further, 22000 human days/annum employment have been generated from enhanced agriculture and agroforestry interventions.

Site of learning: Scientists from University of Florida; USA; ICRAF, Nairobi, Kenya; national scientist & professors, District Magistrate; Chief Executive Officer, Tikamgarh; group of farmers and officials from various development departments visited the site under different training programs organized by state line department to visualize and learn concept of managing natural resources through watershed and agroforestry interventions in semi-arid region.

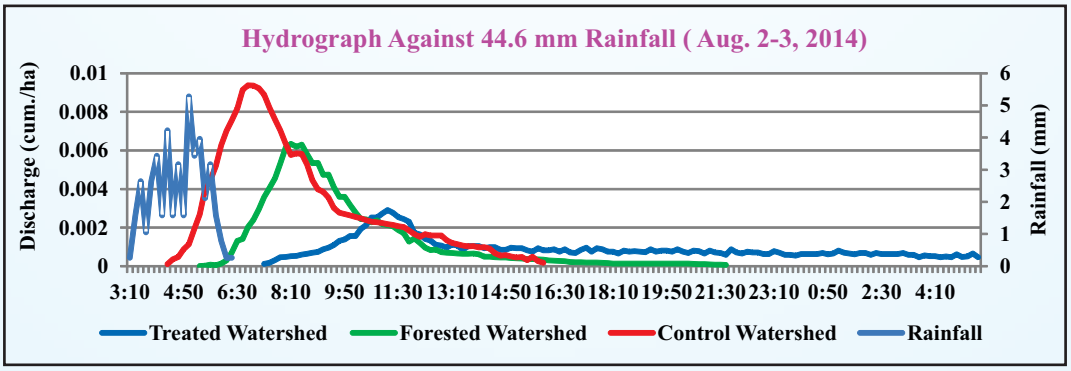
Alternative livelihood support: Lac cultivation, gum and resin extraction techniques, fisheries and preparation of organic manure, SHG based micro enterprises, etc. are being promoted in order to develop alternative livelihood support systems in the watershed area.

Imparting Skill to Farmers in Watershed

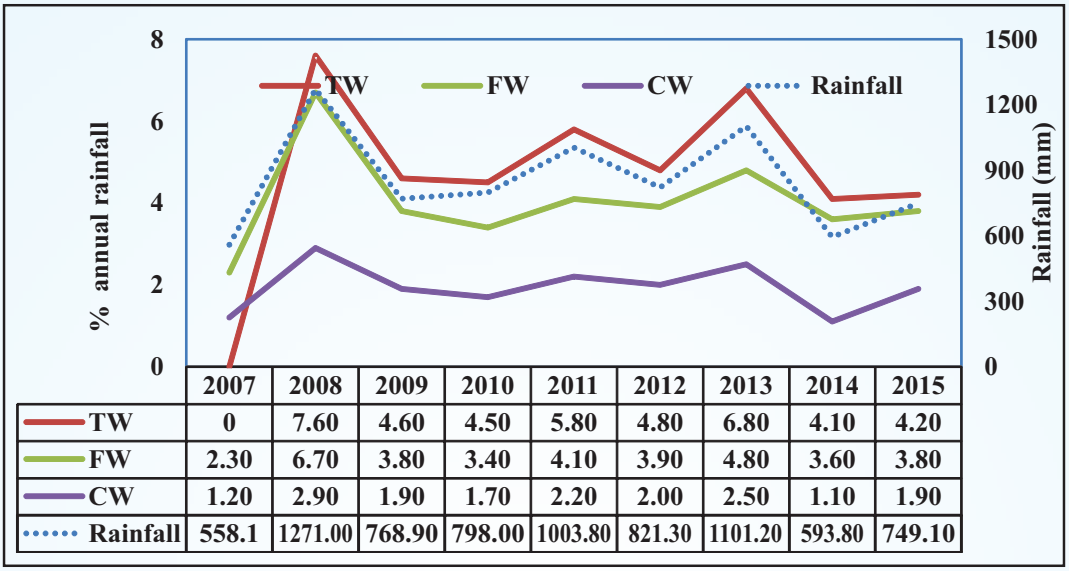
6. Impact of Watershed and Agroforestry Interventions

The watershed development programme is identified as an adaptation strategy for increasing agricultural production and income under present and future climatic situation of dry lands in general and Bundelkhand region of Central India in particular. In this study, impact of IWD interventions on water balance components and different ecosystem services were assessed using field and watershed scale monitoring. The key findings of this study are:

- IWD interventions changed the hydrological components as ET increased from 58% to 64%, runoff reduced from 35% to 25%, groundwater recharge and base flow enhanced from 7 to 11% and 1.2 to 7.2%, respectively, of rainfall received in monsoon as compared to no intervention stage. Soil loss from treated watershed was 45 - 70% lower than untreated watershed.



- IWD interventions however, reduced storm flow substantially but it enhanced base flow in terms of total quantity and duration during monsoon and post monsoon period. As a result, checkdams harvested more than eight times water than their storage capacity during monsoon season.

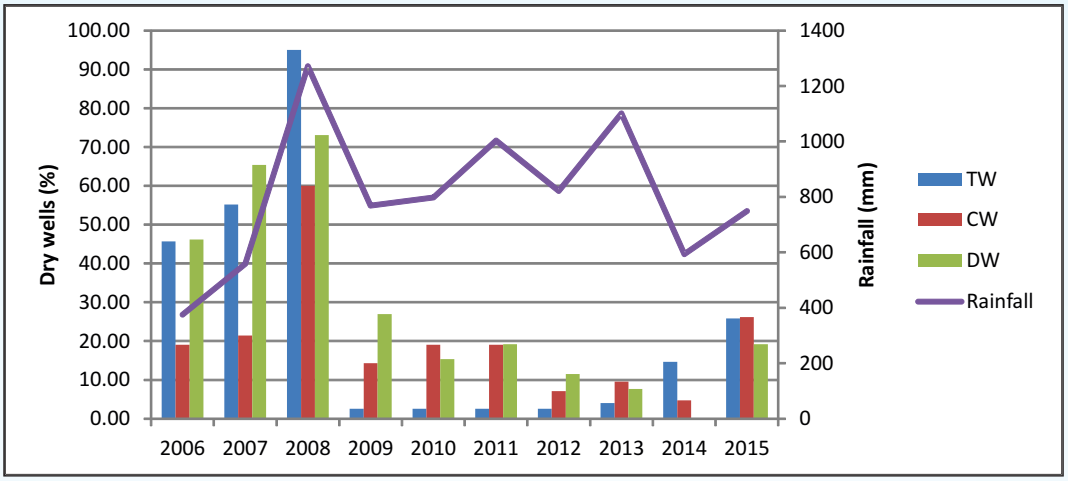


	2007	2008	2009	2010	2011	2012	2013	2014	2015
TW	0	7.60	4.60	4.50	5.80	4.80	6.80	4.10	4.20
FW	2.30	6.70	3.80	3.40	4.10	3.90	4.80	3.60	3.80
CW	1.20	2.90	1.90	1.70	2.20	2.00	2.50	1.10	1.90
Rainfall	558.1	1271.00	768.90	798.00	1003.80	821.30	1101.20	593.80	749.10

Base Flow from Treated, Forested and Control Watersheds

Base Flow During Summer

- Higher groundwater and surface water availability in treated watershed changed cropping pattern. Cropping intensity increased from 69 to 207% after the interventions. The productivity of different crops enhanced by about 20 to 60%. During May 2008, in treated watershed 95% wells were dry, however, after IWD interventions only 26% wells were dry in May 2015 in spite of 32% deficit of rainfall during 2014 and extensive wheat cultivation in the watershed.



Dynamics of Dry Wells in Treated, Control and Downstream of Watershed

- Better moisture management through different kinds of bunding, and *khadins* resulted in increased productivity of cropland and common property resources (CPRs).
- Systematic agroforestry development (aonla, guava, citrus based) and promotion of boundary plantation in the watershed (teak, *Acacia* spp.) have enhanced risk bearing ability of farmers and helped in improvement of vegetal cover. About 500 *ber* plants have been top worked which are now bearing fruits. Homestead agroforestry developed in majority of households in general and particularly at tribal's houses, which supports nutritional security to the weaker section of the community.
- More than 75 per cent population migrated to the metros during summer season of 2007 and 2008 in search of livelihoods. Now, forced migration has been stopped, however, few youths went to metros to earn wages during lean period only.
- The watershed area turned fodder surplus from a net fodder deficit due to plantations, conservation measures and water availability.
- Mitigation of drinking water hardship for human and animal.
- During 2006-07, about 7000 days employment was created through construction activities and adoption of agroforestry interventions. Now, more than 22,000 additional human days are being created annually due to increased cropping intensity, crop demonstrations, agroforestry interventions, *etc*.
- Average economic water productivity and income in treated watershed increased from 2.5 to 5.0 INR m^{-3} and 11,500 to 27,500 INR ha^{-1} yr^{-1} after IWD interventions, respectively.
- Benefit-cost ratio of the project interventions is 3.3 considering full project cost and four years of payback period, indicating economic feasibility of IWD interventions to scale-up at large scale in Bundelkhand region.
- Even with deficit rainfall by about 32 per cent, water crisis in drought prone Bundelkhand region can be averted by adopting agroforestry and watershed interventions as it will recharge the weathered zone by 86 per cent which will serve the purpose of drinking and irrigation. Rainfall during 2014 and 2015 were about 35% less than average in the region, still, farmers grew good

crops in 100% area during *rabi* 2014 and in about 70% area in 2015. Now, it is a site of learning for line departments, NGOs, students, farmers, policy makers, *etc.*

These interventions were replicated in Parasai-Sindh and Domagor-Pahuj watersheds in Jhansi district, Uttar Pradesh and findings were validated.

7. Bio-Physical Indices to Assess Impact of Watershed Interventions

The following values of different bio-physical indicators indicate that farmers of the watershed showed keen interest in utilizing harvested water and brought significant area under vegetation through crops and agroforestry interventions. The information generated could be used by different watershed development implementing agencies in SAT region for targeting outcomes before implementing such projects. This would result in more quantitative Detailed Project Reports of watershed projects.

- Land Levelling Index (LLI) improved from 0.22 to 0.57 as the farmers of the watershed improved their fields through field bunding after assured availability of water for irrigation and on account of awareness created by the implementing agency.
- Critical Area Index (0.85) shows that 85 per cent critical area is benefitted through IWD interventions.
- Gully Stabilization Index of 70, point-out that the gully is under stabilization as the 100 indicates fully stabilized gully.
- Due to assured availability of irrigation water, Cultivated Land Utilization Index (CLUI) increased by 257 per cent, however, Water Storage Capacity Utilization Index (WSCUI) was 368 per cent as the ratio of harvested water vs. surface storage created is more than 8 times indicating base flow for longer duration.
- Irrigability Index of more than 1.25 indicated judicious utilization of harvested water.
- Crop Productivity and Diversification Index increased by 29.3 and 19.7 per cent due to IWD interventions
- Conserved Water Productivity Index (CWPI) of 0.65 shows closer to targeted production.
- Crop Fertilization Index (CFI) increased by 177.3 per cent. The value of 0.61 specifies that farmers of the watershed using 61 per cent doses of recommended fertilizers during post project period which was only 22 per cent before implementation.
- Induced Watershed Eco-Index (IWEI) indicates that 41 per cent additional area brought under vegetation through crops and agroforestry interventions.

8. Drudgery Reduction

- **In collection of drinking water and fuel wood:** Prior to implementation of project in the watershed area, village women used to bring water from 2-3 km on head or 4-5 km by bicycle/bullock cart. The drudgery is greatly reduced through availability of water in wells and hand pumps due to augmented groundwater recharge resulting from interventions. Consequent upon development of agroforestry, fuel and fodder availability increased in the watershed which reduced drudgery of women and children who used to fetch the same from forest area travelling more than 4-5 kms. spending 3-5 hours/day.
- **In irrigating wheat crops:** Before interventions, open wells were hardly supporting for 0.5 to 5 hrs during *rabi* season due to low water column. Again, the pumping was done next day after

well got recharged. Therefore, farmers generally took 10 to 15 days to irrigate one ha. wheat crop. Mainly women were engaged in irrigation to field crops and generally they spent 40-50 hrs to complete irrigation in one ha. Due to IWD interventions, majority of the wells are supporting round the clock and they can complete irrigation within a day (15-20 hrs). Now, the farmers, especially women have more time to care their children and other households' activities. It also reduced cost of wheat cultivation by Rs. 6000.00 to 8000.00 per ha.

9. Cost-effective Technology and design for Rainwater Harvesting Structures (RWHS) Developed

Importance of the Technology

The results of the recently completed global Comprehensive Assessment of Water for Food and Water for Life showed that a vast scope exists for doubling the productivity of rainfed agriculture in India and other Asian countries with available technologies. More investments in developing countries are needed in rainfed areas, as there is little scope to expand large-scale irrigation in India and other Asian countries considering economic viability and environmental concerns. In India, the needed increase in food production to meet increasing demand has to come largely from 94 m ha of rainfed areas under cultivation. In turn, Government of India has to invest huge sum towards rainwater harvesting structures to augment water availability in such region. Therefore, cost effective design of water harvesting structures will lead to significant saving of public money.

Details of the Technology

Construction cost of water harvesting structures (masonry checkdam) was reduced through decreased width of foundation after 50 to 70 cm below ground level till depth of foundation. About 10 to 33 cum stone masonry could be saved. This technique was applied in all the checkdams constructed in Garhkundar-Dabar, Domagor-Pahuj and Parasai-Sindh watersheds and these checkdams are serving the community efficiently since 2006 without any repair and maintenance.

Impact of Technology

This technique will reduce the expenditure by about Rs. 30000 to 100000 in construction of checkdam in watershed of about 1000 ha area. Technology was advocated and demonstrated to the Project Implementing Agencies (PIAs), watershed committees and gram panchayats' members, students, researchers and policy makers through more than 45 trainings and site visits. Technique has been widely adopted by PIAs of watershed projects under Integrated Watershed Management Programme in U.P. and M.P., gram *panchayats* of Jhansi and Tikamgarh districts and NGOs in Bundelkhand region.

10. Way Forward

The project has amply proved that rainwater harvesting alone can cope up to 32% deficit in rains. Rainfall above or equal to normal can meet essential water requirement of inhabitants for atleast two years. Agroforestry fortification requires constant awareness. This can further jump provided farmers stay in their field even during nights for about minimum 3-4 years. This will ensure protection of plants which is major concern in agroforestry development. The technique demonstrated in Garhkundar-Dabar watershed has been successfully revalidated in Parasai- Sindh watershed in Babina block of Jhansi district (UP). There is a need to up scale the technology. The watershed is an ideal learning site for policy makers, development workers and students.

Success Stories and Case Studies

1. *Garhkundar-Dabar* Watershed project: A successful model for water conservation in Bundelkhand region

A water conservation model for the drought prone Bundelkhand region has been successfully developed and tested in Garhkundar-Dabar area by the ICAR scientists at the National Research Centre for Agroforestry (NRCAF), Jhansi. The model has shown a promising way to fight drought in the region and so may help to bring in greenery and prosperity there.

Bundelkhand region is spread over 7.16 million ha in the central India covering seven districts of Uttar Pradesh (Jhansi, Jalaun, Lalitpur, Hamirpur, Mahoba, Banda and Chitrakoot) and six districts of Madhya Pradesh (Sagar, Tikamgarh, Chhatarpur, Panna, Damoh and Datia). The region has semi-arid climate with an average annual rainfall of 750-1100 mm. Most of the soil in the region is rocky having low capacity for holding water and rest is prone to water logging. Hence, soil working is difficult for agricultural operations. The forest cover is also confined to only 21.4%, in the region which is even less than 11% in some districts. Garhkundar-Dabar area, located 55 km from Jhansi on the Jhansi-Khajuraho Road, represents the geological, physiographical and ecological conditions of the entire Bundelkhand region. For this reason, NRCAF selected Garhkundar-Dabar area as a model for developing

Implementation of the project in Garhkundar-Dabar area included the construction of nine checkdams, 150 gabions, 15 drainage structures, three water spreaders and field bunding of 40 ha along the *Nallah*. With a construction cost of Rs.19.74 lakhs only, the project has resulted in a water storage capacity of 24103 m^3 spread in an area of 40302 m^2. This has resulted in a reduction of soil loss and runoff by 34% in treated areas as compared to 43% reduction in untreated/control area. More than 53.3% wells in the region have recorded an increase of water level by more than two metres. Water replenishment through watershed project has reduced the num *ber* of dry wells to 2% in 2009 as compared to 86% in 2006. Now sufficient water is available in the region for drinking and irrigation purposes. Earlier surface water in *Nallahs* was available for four months only, which is now available for the entire year.

Cropping intensity in the watershed area has increased to 116% as compared to 96% in untreated area. Productivity of wheat and groundnut increased from 2424 to 2845 Kg ha^{-1} and from 1180 to 1320 kg ha^{-1}, respectively in the treated area. Now farmers in the watershed area are increasingly using improved seeds for cultivation and their number has gone up to

67%. With the increased availability of water and with the proper use of agro-techniques, seed rate of wheat has gone down from traditional rate of 240 to 125 kg ha^{-1}. This reduced seed rate led to a net saving of 101 quintal seeds of wheat from 175 ha cropped area.

The *Garhkundar-Dabar* watershed project covering an area of 850 ha has benefited 191 households having a total human population of 891. Five farmers adopted aonla, guava and citrus based agroforestry system in four hectare area. One farmer planted live fencing of karonda along 100 m of the field boundary. About 6000 forest tree saplings were planted along the *Nallah,* teak plantation was done on 0.23 ha of private land and about 250 *ber* plants were topworked. The project committee has also encouraged the formation of self-help groups for personal loaning and capacity building. Two women self-help groups have gathered assets of Rs. 35,000 and Rs 25,000 respectively and have successfully gained self-reliance in terms of small credit requirements. The project construction work also created about 7000 human days employment during the year 2006-07 and 7500 additional human days during the next year 2007-08 for various other interventions and activities. It is further expected that an employment of 29000 human days per annum will be generated from enhanced agricultural activities.

Human resource development activities were also carried in the watershed where farmers were trained for various agro-techniques through awareness and visit programmes. In addition, livelihood support activities like lac cultivation, gum and resin tree cultivation, fish farming in checkdams and goat rearing were also introduced. This way, NRCAF scientists have successfully changed the scenario of life, agriculture and livelihood and so bringing happiness and greenery in the drought prone Garhkundar-Dabar area. The success of this project opens doors for its replication in the entire Bundelkhand region. According to Director of NRCAF, there was plenty of water available in the checkdams and wells in the region despite of the insufficient rainfall this year. He says that such a success was not possible without the participation and cooperation of the farmers.

According to NRCAF, Garhkundar-Dabar Watershed as a model is replicable to 56% red soils of Bundelkhand region, *Vindhyanchal* range, *Satpura* and *Arawali* ranges. Successful adoption and replication of these water conservation techniques and agroforestry can help overcome the problems of soil erosion and water crisis for drinking as well as for irrigation in the entire region of Bundelkhand.

(Source: NAIP - Mass Media Project, DIPA, ICAR Website)

2. Agroforestry brings back smile to Dhani Ram

Dhani Ram Kushwaha alias Dhanua, a farmer of village Ubaura, *Tehsil* Niwari, Distt. Tikamgarh (MP) owns 4 acre cultivated land adjacent to forest area which is far away from his village. His holding is sloppy with typical red soil having poor nutrient status. This is only source of livelihood for Dhani Ram. Due to age old practices and continuous drought his income of Rs.14,000 per annum from land could barely meet his expenses. On hearing that an institute (NRC for Agro-forestry) has initiated a program in his village on water harvesting, crop demonstrations, and agroforestry Dhani Ram approached the institute and requested to look at his field.

He opted for demonstration of agroforestry systems in his field and installation of two gabion structure in *nallah* passing through his field. In *kharif* 2006, for demonstration Sh. Dhani Ram was provided with groundnut seed var. Kaushal and balanced doze of fertilizer for one acre land. He harvested 6 q groundnut yield from demonstration plots which was 1.5 times higher than his traditional practice. In following *rabi* season, he sowed wheat in four acre area out of which one acre was put to demonstration of var. WH-147 with recommended doze of fertilizers and package of practices.

The Centre demonstrated guava and citrus based agroforestry system on his three acre crop land. Sixty eight guava plants (cv. Allahabad *Safeda*) and forty two citrus plants (*Kagzi*) were planted at spacing of 6x8 m. Expenditure on pitting, FYM application, weeding and watering were met by farmer himself. During *kharif* and *rabi* demonstrations for ground nut and wheat were arranged which included truthful level seed of groundnut var. Kaushal and wheat var.WH-147 and balanced doze of fertilizer in terms of N P & K for one acre each crop.

During the year 2007, check dam near Dhani Ram's field over flew twice in monsoon resulting in 2 m water recharge in well. His income doubled in the very first year from crops. Farmer was supplied with seedlings of Lasoda for plantation along roadside, Karonda as live fence along one side of field boundary and teak on boundary bordering forest. He was given aonla plants (cv. Krishna) for planting in crop land on other side of *nallah*. He sowed sweet chilli in an area of 0.5 ha on the other side of *nallah*. He contributed forty percent for field bunding across the slope. Good rains, plenty of water in well, one year old improved seed of wheat accompanied with across the slope field bunding resulted in bumper wheat yield to the tune of 35 q/ha. After *rabi* harvest, he sowed brinjal, karela, chilli, bottle gourd, blackgram, etc. in about 0.2 ha area for regular cash income during summer. In 2009 due to good antecedent moisture condition, the check dam over flew and again he harvested bumper *kharif* and *rabi* crops. Guava plants flowered and yielded about 2.0 q fruits which added to his regular income. In a small patch of about 50 m^2 he has transplanted napier grass for feeding to his bullocks. During *rabi* 2009 he had 21 crops/vegetables/spices/fruit trees in combination in the same field. The vegetables, fruits, crops, grasses are grown from the same land almost simultaneously. He never leaves field without crop and maintains the fertility of soil by use of organic manure. His family is getting year round employment and earning regular income. For the last 2 years, he is earning around 40-50 thousand per annum from his land. The smile brought back to Dhani Ram.

(Source: NAIP - Mass Media Project, DIPA, ICAR Website)

3. Himmat's himmat (courage) brought laurel to his name and fame through agroforestry

Sri Himmat Ahirwar, village Shivrampur, *Tehsil* Niwari, Distt. Tikamgarh (M.P.) is a humble farmer. Although, he owns 10 acre of land but due to non-availability of water in his holding he lives a miserable life along with his 3 married sons and their family. He is supporting a family of 14 members. One of his fields of about 2.5 acre is located on the top reaches of Garhkundar-Dabar Watershed. He has one shallow dug well in this holding but no water to irrigate. As such he grew til (sesame) and occasionally gram in this field. Sri Himmat was convinced by scientist of ICAR-CAFRI, Jhansi for agroforestry land use in this field but protection and watering to plants in initial two year of plant establishment was a major concern. Sri Himmat showed courage and planted anola cv. NA-7 in 2007 in an area of around 1.0 acre. He planted 56 plants spaced 8x8 m. He was also suggested to grow blackgram during *kharif* for initial 2-3 years and gram in *rabi* to avoid shading to anola plants during their establishment phase. Further, to protect grafted saplings of aonla he was suggested to use brushwood fencing with available brushes on his field bunds. In 2010, he was suggested to plant *Acacia senegal* on his field boundary. As such, besides regular crop yield he is now getting anola fruits worth Rs.10000/ every year, 25-30 kg fuel wood from pruning of *Acacia senegal* from the same piece of land. From his field he was earliar not getting even Rs 2000/ per year due to several constraints but now getting assured income. During summer months when temperature was above 45 ^{0}C with 8-12 % relative humidity, farmer don't go to field to escape hot desiccating wind. This is the period when loose cattle destroy every green vegetation. Two-three year's hard work of Himmat has made this field as oasis. Villagers passing by prefer to sit underneath the greenery and enjoy beauty. Anola plants due to new flush in Feb-March remain green in summer. Himmat has proved where is will, there is way and sustainability can be assured through agroforestry. Due to sparse canopy of anola, he continues to grow crop in interspaces. Further deciduous nature of anola enrich soil by adding leaf litter and protect soil organic carbon from burning in scorching summer. This also improves micro-climate of the area.

4. Siya Tiwari credits agroforestry for unity and welfare of his family

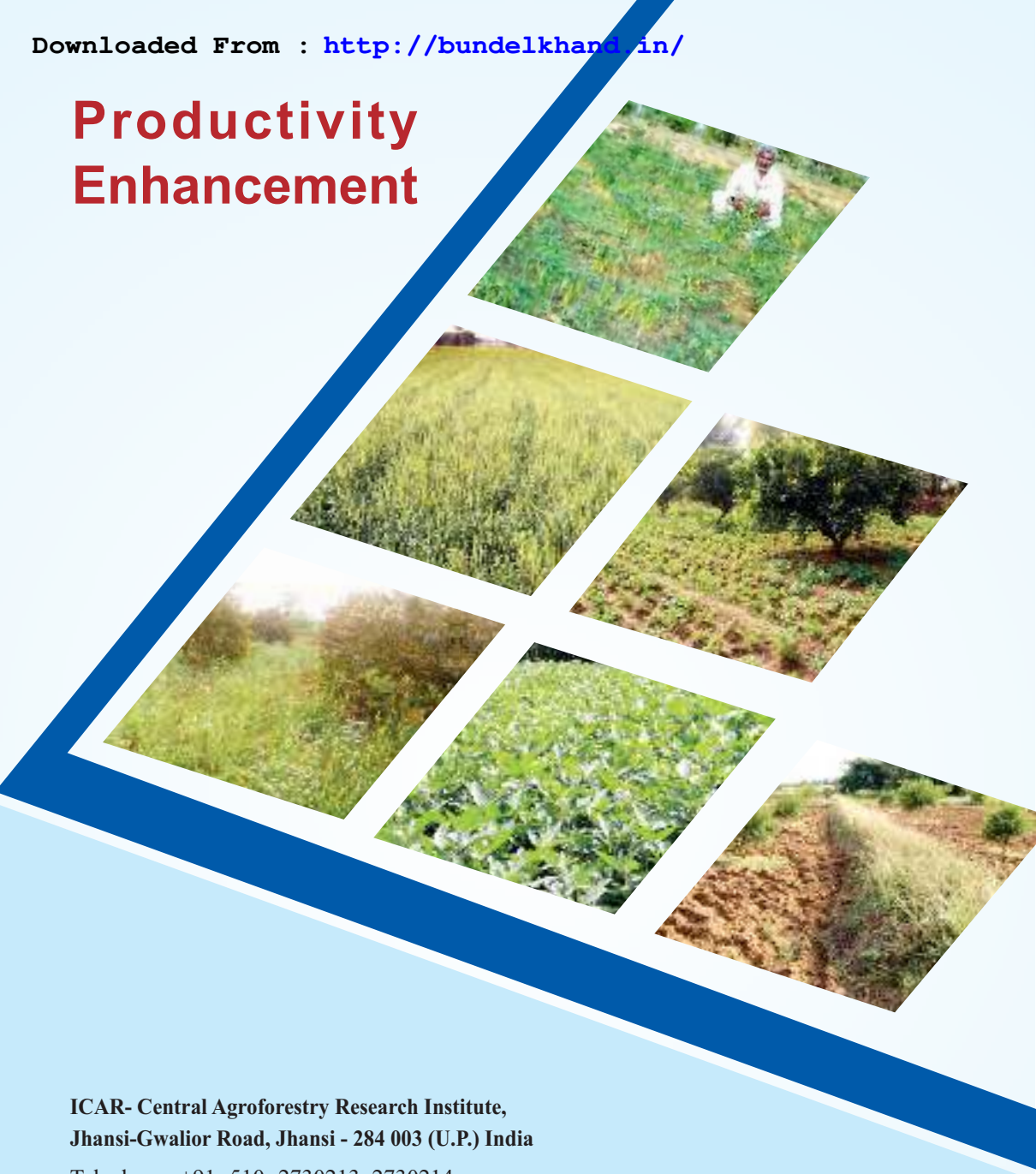
Siya Tiwari is name of a humble farmer in village Kundar, Naibasti, *Tehsil* Niwari, Distt-Tikamgarh (M.P). Poor farmer has two unemployed married sons. He owned 6 acre of land on roadside. Live fence of *Prosopis juliflora* on roadside was perpetuated for protection of crops against stray cattle. He has one dug well in his holding and grows seasonal crops for livelihood. Both of his sons migrated to cities in search of respectable jobs, but poor education came in way. They served as watchmen in industry and lived miserable life. Siya, 65 years old wished that his sons should come back and look after him and his land property which is day by day appreciating. Sri Siya approached scientist of ICAR-CAFRI (the then NRCAF) who regularly used to visit Garhkundar-Dabar watershed nearby his village. Sri Tiwari was suggested to plant guava under agroforestry. He was facilitated in terms of quality planting material and technical guidance. He planted guava in an area of 1.2 acre spaced 8x6 m. thus, planted 100 grafted plants of guava variety L-49 in year 2010. He was encouraged to raise crops in interspaces. His dedication and accessibility of land paid rich dividends. His guava started fruiting from 2014 onwards. He paid attention to his plantation and raised wheat during rabi and, blackgram in kharif and summer vegetable, particularly sponge gourd and bottle gourd. Remaining crop lands he rented out. He continued to produce cereals in AF Plantation to meet his food requirement and rest of produce from rented out land was sold in local market to meet his other requirements. In first two year, there was no loss in crop production due to trees. In third year there was about 20 % reduction in wheat but this loss was compensated by cultivation of blackgram in summer. Meanwhile, in 2012 early summer he headed back 14 *desi ber* plants on his field bund and got them rejuvenated by Banarasi karaka an improved *ber* variety in July. Four of these rejuvenated *ber* plants flowered in September month of the same year. During 2013 all 14 ber plants produced ber fruits each 5-20 kg which were sold at premium price in local market. His sons were regularly visiting parents at least once in a year. Now both of them have decided to stay back in village. One of them has opened a petty shop on the road near his holding and other is looking after croplands and plantation. Now, they are making happy living with self-pride. Old Siya is happy, his family is living together and earning 25-30 thousand per annum besides food requirements. During 2015, he purchased two buffaloes for livelihood support. He thanks ICAR-CAFRI for facilitating and guiding him in ensuring sustained production which brought back his sons to birth place. He is better, contented and leading respectful old life.

5. Journey of small farmer from rags to riches through agroforestry interventions

Shri Salim, resident of village Shyamasi, *Tehsil* Niwari, Disst. Tikamgarh (M.P.) is now role model of marginal farmer of Ubaura. Shri Salim owns 3 acre of land along nallah. The other side of his holding is dense scrub forest of *Annogeissus pendula*. Shri Salim hardly could make his living from his piece of land as it was away (2 km) from his residence.

He has one well near the nallah where from he irrigated his crops of wheat/gram in *rabi*. During *kharif*, he could not grow crops in 1/3 rd of his holding due to water logging. In top 2/3 rd area he used to sow groundnut. Sometimes, preceding high rainfall, he grow summer vegetables in 1/3rd of area for cash. He supports 7 family members from this holding and lived miserable life till 2005. As an alternative livelihood, he had 8-10 units of chicken and 3-4 goats. Soil and water conservation activities in Garhkundar-Dabur watershed started in 2006 and 8 structures in series were constructed by 2007 to harvest rainwater in *nallah*. Sri Salim's land is along this treated nallah. Although 2007 was fourth year of consecutive drought in his area yet he had enough water to grow rabi crops in his holding and did not migrate. During the year scientists of the project convinced Shri Salim to adopt guava based AF system and grow crops as usual. He planted guava variety L-49 in 1.8 acre of land at 7x6 m spacing as such 172 plants were accommodated. Due to adjoining forest and blue bull pressure, he could save 94 plants upto 2014. He continued to grow groundnut in *kharif* and wheat in *rabi* in inter spaces and harvested satisfactory yields. He rented in 6 acre of land on the other side of nallah, adjoining to his holding and grew blackgram in *kharif* and wheat in *rabi*. Consequent upon construction of one checkdam about 400 m above his holding and another 800 m below his holding (1.5 km distance between two consecutive structures in *nallah*) he had plentiful water to support both the crops and increase his income from farming. Although, two more shallow dug wells were constructed by different farmers in the same area as such now he rents in crop lands located about 600 m away from *nallah* and continues to harvest good crops. This enhanced his income and he bought plastic pipes to avoid conveyance loss of water. He added 5 hp pumping set on his well. Now he is a well to do farmer of the village. Meanwhile, he constructed two *pucca* rooms. From 2014 onwards, he is not able to grow crop in guava planting but he is earning around Rs. 20,000.00 per year from sale of fruits. Since guava starts ripening in early winters, there is no risk of changing climate on his earning. Besides guava he had about 15 *ber* plants along *nallah* and towards forest side. He got them top worked with improved variety "Banarasi Karaka" as of now, he owns 8 top worked *ber* plants and earns about Rs. 4,000.00 year from sale of *ber* fruits in local market. He regularly prunes his *ber* trees for fodder, fuel wood and containing size of tree. In 2014, he planted *Bambusa vulgaris* along *nallah* and could ensure survival of 11 clumps out of 18 planted. Thus, Salim is sustaining his income from tree produce and leading happy life. His annual income from all sources in 2006-07 was around 7-8 thousand besides meeting food needs of his family and now earns about 70-80 thousand. He still continues to have 6-7 unit of chicken for home consumptions and 2-3 goat units. Now, he rents in 6-7 acre of crop land every year during *rabi* season. Salim availed opportunities and reaping benefits.

Productivity Enhancement



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