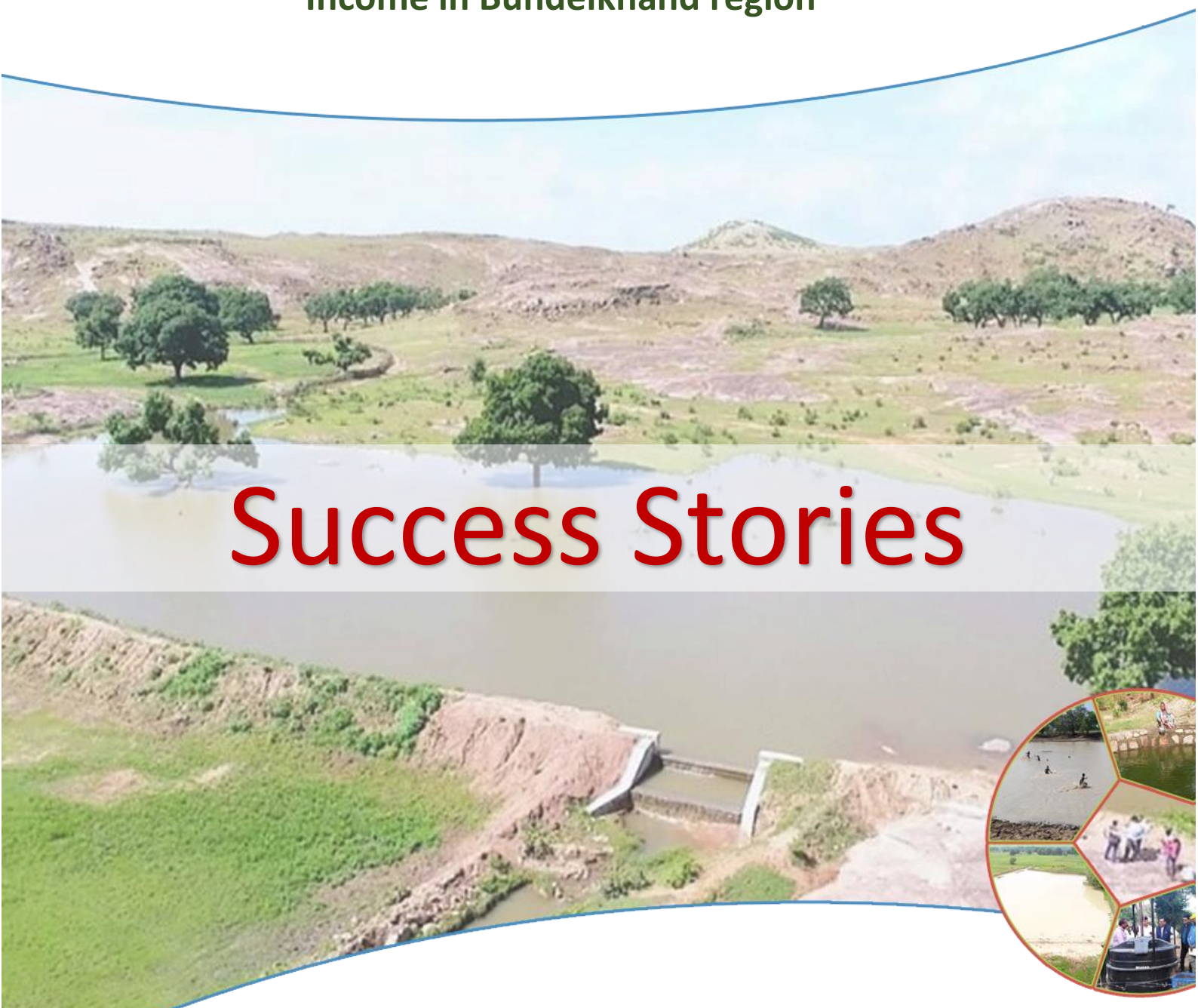
KISAN-MITrA: Knowledge-based Integrated Sustainable Agriculture Network- Mission India for Transforming Agriculture: Doubling Farmers' Income in Bundelkhand region



Success Stories

Submitted to
Government of Uttar Pradesh
June 2021

ICRISAT DEVELOPMENT CENTER
ICRISAT INTERNATIONAL CROPS RESEARCH INSTITUTE FOR THE SEMI-ARID TROPICS
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ICRISAT Happenings Newsletter

NITI AAYOG CITES ICRISAT WATERSHED ACHIEVEMENTS

May 3, 2019

A watershed structure at Parasai-Sindh, Jhansi. Photo: ICRISAT

The NITI Aayog recently commended the impact of community best practices for watershed management, in Jhansi, Uttar Pradesh, India.

“Local community in the water scarce Parasai-Sindh region of Jhansi, #UttarPradesh increased groundwater level by 2-5 meters & made 100 acres of land cultivable by constructing check dams, farm ponds and renovating existing structures in 8 locations. #BestWaterPractices” – said a recent Facebook post from NITI Aayog’s handle.

The Parasai-Sindh watershed of Babina block, Jhansi, was jointly developed by ICAR-Central Agroforestry Research Institute, Jhansi, and ICRISAT Development Center, ICRISAT, with the involvement of the local community between 2012 and 2016. The project focused on rainwater harvesting, productivity enhancement interventions and agroforestry works.

Renovation of traditional water-harvesting tanks and construction of check dams on a major stream in the village helped increase the storage capacity for rainwater to nearly 100,000 m^3. These water-harvesting structures saved over 200,000 m^3 of runoff, on average, every year, raising the groundwater table by 2–5 meters. This benefited crop intensification (from 80% to 140%) and enhanced crop yield (20–30%) and production, both in *Kharif* and *Rabi* seasons.

Nearly 100 ha of fallow land in upland areas were also brought under cultivation with enhanced groundwater availability.

The intervention subsequently reduced fodder scarcity and enhanced milk production. Overall, by the end of the 4-year project, household income in this region more than doubled.

ICRISAT, with over 40 years of expertise in watershed development, has supported watershed-based community initiatives in more than 300 locations across Asia and Africa.

Link:: https://www.icrisat.org/niti-aayog-cites-icrisat-watershed-achievements/

ICRISAT Happenings Newsletter

WATER HARVESTING BRINGS HOME MIGRANT FARMERS

Dec 13, 2019

A woman collects water at a well that was recharged due to water harvesting in Lalitpur district of Bundelkhand. Photo: Shishuvendra K, ICRISAT

Migration is making a U-turn out of Bundelkhand region in India where a project is underway to double farmers' incomes. Water harvesting efforts initiated earlier this year have helped families in a remote village return to their homes and farms after decades of migration.

As a part of the Doubling Farmers Income Project in PooraBirdha village, an 800-meter-long channel and *havelis* (tanks) were built to tap rains. Subsequently, farmers, who earlier had abandoned agriculture for want of water, returned to till their lands this *kharif* season (monsoon June–September). Encouraged by increased water availability, farmers like Yajuthi cultivated groundnut, sesame, lemon and rice on small land patches for the first time.

"I returned to farming after migrating for work many years ago. I have been able to live with my family since my return and resume farming my land with the water made available," the farmer told a team of ICRISAT scientists and officials visiting the region. The visit was organized by ICRISAT Development Center (IDC), which is partnering with the government of Uttar Pradesh State, ICAR-Central Agroforestry Research Institute (CAFRI) and non-governmental organizations to execute the project.

Inadequate rainfall in drought years, compounded by water runoff and flooding of fields during other years, deterred farmers from agriculture during *kharif* in Bundelkhand. After the

harvesting structures were made, water is being drained away from the uplands and made available for irrigation and groundwater recharge in the valleys. Agroforestry initiatives, alongside promoting improved crop varieties and agronomy, are helping the region's farmers vest faith in rainfed farming.

"I used to work for other farmers far away from home but decided to return to my farm when I saw water available. My family is happy that we are farming our land, which was left fallow until monsoon this year," another Birdha farmer Nannu said.

Farmer Bahadur narrates a similar story. After nearly a decade of leaving his land fallow and settling for work with inadequate pay, he returned to farming on the heels of the project. He has harvested 1,200 kilos of groundnut, and over 100 kilos of a mix of crops including black gram, mung bean and sesame from this year's *kharif* cultivation. Assured of water availability, Bahadur's land is being readied for the second crop season.

Link::https://www.icrisat.org/water-brings-home-bundelkhands-migrant-farmers/

ICRISAT Happenings Newsletter

RENOVATED WATER HARVESTING STRUCTURES HAVE IMMENSE POTENTIAL FOR AGRICULTURAL PRODUCTIVITY, SUGGEST RESEARCH FINDINGS

Oct 30, 2020

One of the rainwater harvesting havelis at Parasai-Sindh. Photo: R Singh, ICRISAT

Reviving traditional rainwater harvesting structures in regions with degraded land leads to increased groundwater levels, more arable land, and higher crop productivity and incomes. A recently published scientific research paper offers a case study of Bundelkhand, Central India, where groundwater levels were boosted by 2-5 m by renovating water structures called *havelis*, leading to 10-70% increase in crop yields in the region.

The landmark paper, published in the Journal of Hydrology, describes the processes and impacts of reviving traditional rainwater harvesting structures called *havelis*, which have been falling into disrepair. During the years 2012-2016, due to the higher levels of groundwater, about 20% of fallow land was brought under cultivation and farmers' average incomes grew from US$ 960/year to US$ 2,700/year.

To address the challenges of water scarcity and land degradation, from 2012-2016, ICRISAT along with the Central Agroforestry Research Institute (ICAR-CAFRI), developed a site of learning called the Parasai-Sindh watershed in Jhansi district. With support from CSR funds, several parts of old *havelis* were rebuilt in the 1,250-ha area of the watershed following the Ridge-to-Valley approach, leading to the transformation of the region.

This case study of *haveli* renovation is also cited in the ICAR's achievements document entitled "Mahatma Gandhi's Vision of Agriculture: Achievements of ICAR (Chapter 7 Pp: 80-82).
Following the success of this project, ICRISAT has also been working in this region since 2017 through the KISAN MITrA-Doubling Farmers Income Initiative, supported by the Government of Uttar Pradesh. The Doubling Farmers Income project is stepping up its efforts towards rainwater harvesting and drought mitigation largely through *haveli* renovation initiatives in 35,000 ha located in seven districts in Bundelkhand region.

Click here to access the paper, 'Building climate resilience in degraded agricultural landscapes through water management: A case study of Bundelkhand region, Central India': https://authors.elsevier.com/a/1btBg52cuR2W4

For more on our work in the area of natural resource management, click here.

Link::https://www.icrisat.org/renovated-water-harvesting-structures-have-immense-potential-for-agricultural-productivity/

ICRISAT Happenings Newsletter

DOUBLING FARMERS' INCOME PROJECT GETS BOOST FROM AGRICULTURE MINISTER

Jul 17, 2020

Mr Surya Pratap Shahi, Minister of Agriculture, Uttar Pradesh, reviews DFI project and visits project site in Chitrakoot. Photo: ICRISAT Development Center

Strategies to harvest rainwater in drought-prone regions, through the collaborative Doubling Farmers' Income project, received a boost with inputs from the state Agriculture Minister of Uttar Pradesh, India, recently. Focusing on the renovation of the '*Haveli*' water structures in Chitrakoot, Mr Surya Pratap Shahi, Minister of Agriculture, Uttar Pradesh, discussed scaling out of the watershed interventions across the Bundelkhand region as a drought-proofing strategy for the state.

In the Doubling Farmers' Income project in Bundelkhand region, ICRISAT along with the Central Agro-forestry Research Institute and Banda University of Agriculture and Technology (BUAT), is stepping up its efforts towards rainwater harvesting through the construction of check dams and farm ponds, renovation of traditional tanks (*Havelis*), desilting of water harvesting bodies and large-scale field bundings in all seven pilot sites of Bundelkhand region. The project has also introduced new varieties of wheat, chickpea, mustard, agroforestry interventions and agronomic techniques such as laser land leveling, zero-till method etc.

Mr Shahi encouraged the project team to carry out activities related to natural resources management at the earliest. After his visit, the team developed a strategy to strengthen existing rainwater harvesting interventions. Also, it was found that there was scope for construction of more than 10 *haveli* structures within Chitrakoot pilot site.

Click here to read more about this project:

https://www.icrisat.org/water-brings-home-bundelkhands-migrant-farmers/
https://www.icrisat.org/dairying-unproductive-in-harsh-landscapes-not-anymore/
https://www.icrisat.org/revive-havelis-indias-ancient-rain-harvesting-farms-to-save-big-on-money-and-resources/
For more on our work in the area of Natural Resource Management, click here.
Click here to see how ICRISAT can help in the COVID-19 environment in the short, medium and long term

Project: Doubling farmers' income in Bundelkhand Region, Uttar Pradesh
Funder: Government of Uttar Pradesh
Partners: Central Agroforestry Research Institute (CAFRI), Indian Grassland and Fodder Research Institute (ICAR-IGFRI), Banda University of Agriculture and Technology, BAIF, Bharat Agriculture, Lakshya Seva Samiti, Gram Unnati, Samarpan, Jan Kalyan Samiti, Samarth Foundation, Gram Unmesh Sansthan, Gramin Vikas Kendra, Upman Mahila Samstan

Link::https://www.icrisat.org/doubling-farmers-income-project-gets-boost-from-agriculture-minister/

ICRISAT Happenings Newsletter

NEWBORN CALF HOLDS OUT HOPE FOR BUNDELKHAND'S CATTLE

Dec 13, 2019

A biogas plant being demonstrated in Chitrakoot district. Photo: ICRISAT

A female calf birthed recently in a north Indian village, following sexed sorted insemination, could herald the end of rampant abandoning of livestock in the region, thereby increasing farmers' returns.

The calf, born in Nathupura village of Mahoba district in the Bundelkhand region of Uttar Pradesh state, is a result of insemination with sexed sorted semen which has a probability of yielding 90% female births. Extended droughts, fodder and water shortage force farmers in Bundelkhand to abstain from rainfed agriculture and let livestock loose to freely graze in summer. The practice is called '*annapratha*'. The grazing continues well into *kharif* (monsoon) season and is blamed for extensive crop damage. According to various estimates, the area under *kharif* cultivation is just half of that during *rabi*. Nearly a quarter of the crop produced during *kharif* is damaged by the straying cattle.

The state government and its research partners have realized the need for creating more value in livestock to tackle *annapratha* and reduce the liability of animals to farmers. Consequently, increasing the number of high-quality female cattle is being seen as a good solution to provide farmers with livelihood options by way of sale of milk produced by the cows.

In January, BAIF Institute for Sustainable Livelihoods and Development (BISLD) and ICRISAT introduced sexed sorted insemination in Bundelkhand. Sexed semen is produced by sorting male and female chromosomes in the semen. Further, farmers are also being provided with

rapid pregnancy diagnosis facilities, which makes pregnancy detection possible in 18-20 days as compared to three or four months it normally takes.

The Nathupura calf is a buffalo of Murrah breed which was birthed by a 9-year-old female. Ms. Malti Pateria, the farmer who owns the animals, said that the calf has caught the attention of the village. Ms. Pateria's family earns its livelihood by selling the nine liters of milk that its two buffalos produce every day. Since the birth of the Nathupura calf, seven more female calves were born across the region.

Farmer Malti Pateria with the young calf. Photo: BISLD

"A farmer has more reasons to rear livestock if sexed sorted insemination services are provided. This technology can produce breeds of choice for the farming community. Around 310 inseminations were carried out by September in Mahoba and Chitrakoot districts of Bundelkhand. Similar interventions have been initiated in all the seven districts of the region under the Doubling Farmers' Income project from October," said Dr Prakash Rathod, Visiting Scientist, ICRISAT.

To further increase the value of cattle and buffaloes for farmers, around 20 easy-to-install, portable and compact biogas units are being set up across the region after five such plants installed earlier in Mahoba and Chitrakoot districts provided multiple benefits. These include free cooking fuel, freeing women from drudgery of collecting firewood, and preventing exposure of a family, primarily that of women, to hazards of firewood pollution. The slurry left behind after digestion of dung in the unit can be used as manure, Dr Rathod added.

Project: Doubling farmers' income in Bundelkhand Region, Uttar Pradesh
Funder: Government of Uttar Pradesh
Partners: BISLD, ICAR-IGFRI, ICAR-CAFRI, BUAT, Bharat Agriculture, Lakshya Seva Samiti, Gram Unnati, Samarpan Jan Kalyan Samiti, Samarth Foundation, Gram Unmesh Sansthan, Gramin Vikas Kendra, Upman Mahila Samsthan.

Link::https://www.icrisat.org/newborn-calf-holds-out-hope-for-bundelkhands-cattle/

ICRISAT Happenings Newsletter

REVIVAL OF OLD WATER RESOURCES FOR BETTER FARM LIVELIHOODS

Jun 26, 2020

A village in North India sets an example

The Devara Tank in Banda district of Uttar Pradesh. Photo: ICRISAT

A water tank's renovation in one of India's most drought-prone regions benefited as many as 200 farm families last year and opened up aquaculture opportunities for the village. This helped create a storage capacity of about 25,000 cubic meters. The tank filled multiple times during last year's monsoon and provided more than 100,000 cubic meter of surface water. This facilitated groundwater recharge in the village, renewing defunct tubewells that supplied water for domestic and farm use.

"Before the tank was renovated, our tubewells could supply water only two hours a day. This year, even in the summer, we had continuous supply. We did not take water from the tank as the tubewells located close to our fields provided plenty of it," said Mr. Ramlakhan Nishad, a farmer of Devara village in Bundelkhand region, which is located in the Indian state of Uttar Pradesh.

The Devara tank benefited all villagers equally irrespective of the location of their farm with respect to the tank, Mr Nishad added. Farmers in Devara mainly cultivate wheat in winter.

Working with its partners in the Doubling Farmers' Income project, ICRISAT restored the village tank by desilting and construction of a masonry outlet in May-June 2019.

Additionally, large scale field-bunding around the village tank helped enhance soil moisture in the fields and reduce sedimentation load in the village tank, which is essential for long term sustainability. Rejuvenating the village tank also led to starting of aquaculture. The water body has also become a place for worship during community gatherings and a recreational site for children. With monsoon arriving on time this year, Mr Nishad said his village has more reasons to cheer. Several such tanks are being restored across the region under the project.

Project: Doubling Farmers' Income in Bundelkhand
Funder: Government of Uttar Pradesh
Partners: BISLID, ICAR-CAFRI, ICAR-IGFRI KVKs and NGOs

Link::https://www.icrisat.org/revival-of-old-water-resources-for-better-farm-livelihoods/

MASONS HELP FARMERS HARVEST RAINS IN BUNDELKHAND

Doubling farmers' income in Bundelkhand

Partners:

- Government of UttarPradesh

Project objectives:

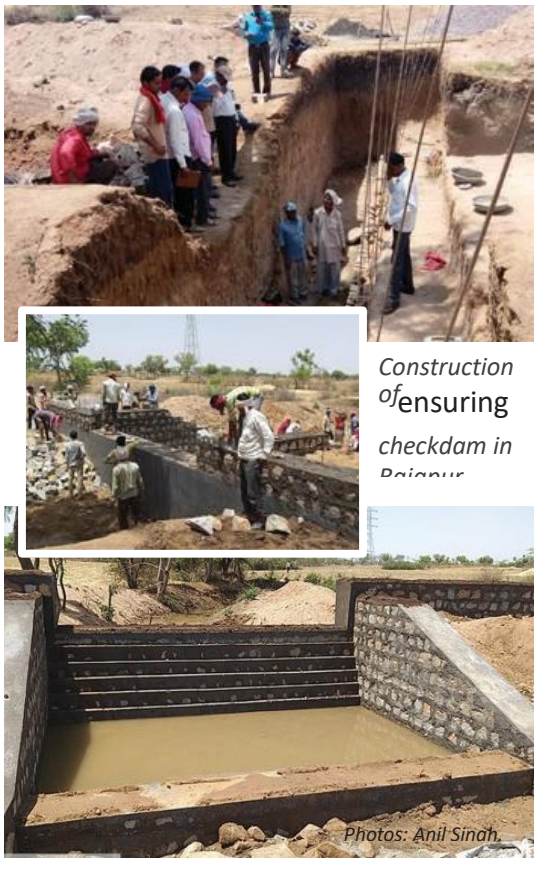
- Enhancing water availability across seven districts
- Introduction of new varieties of wheat,chickpea and mustard
- New agronomic techniques like laser land leveling and zero till method of sowing to be introduced.

How important are masons in agriculture? If the success of ICRISAT's watershed efforts in Bundelkhand region is an indication, skilled masons are crucial in helping farmers double their incomes.

The 'Doubling farmers' income in Bundelkhand' project aims to develop 5,000 ha in each of the region's seven districts. Water harvesting works which were initiated earlier are now being scaled up, increasing the demand for skilled manpower. To meet the demand, skill enhancement training programs are being conducted for masons.

Two masons from each district have been chosen for work at a pilot site of the project in Jhansi, while being supervised by Mr Ram Prakash Kumar, the lead mason, and the ICAR-Central Agroforestry Research Institute (CAFRI) team led by Principal Scientist Dr Ramesh Singh.

This month, 15 masons were trained in excavation, reducing the width of the foundation, placing iron bars, constructing various components of rainwater harvesting system (RWHS), avoiding preferential flow in varied situations and material quality. After training, they will be deputed to their districts to construct water harvesting structures in consultation with the CAFRI and ICRISAT teams. Rainwater harvesting through check dams, farm ponds, check walls and well recharge systems increase water availability and irrigated land, good crop growth. It is often seen that these structures, when built in the best of ways, continue to function efficiently long after their intended lifetimes.



Construction of checkdam in ensuring

Photos: Anil Singh.

Instances where such structures lasted less than 8 years, it was learnt that poor foundation, absence of cutoff and toe walls, short extension wall and use of sub-standard material were some reasons for failure.

As part of ICRISAT and ICAR-CAFRI – led projects in Bundelkhand region, low-cost robust designs for rainwater harvesting structures were developed and tested during 2012 -2016 in Parasai-Sindh watershed, Jhansi.

ICAR-CAFRI also worked in Garkundar-Dabar watershed of Tikamgarh district, Madhya Pradesh, where many water harvesting structures were constructed in 2006 and 2007; these structures did not require maintenance for 14 years after construction despite witnessing heavy floods. During the implementation of these watershed projects, only a few masons could learn and develop the skills necessary for constructing strong rainwater harvesting structures.

Dr Ramesh Singh of CAFRI and Dr Kaushal Garg of ICRISAT contributed to this story.

Link::http://idc.icrisat.org/idc/index.php/masons-help-farmers-harvest-rains-in-bundelkhand/

REVIVE HAVELIS, INDIA'S ANCIENT RAIN HARVESTING FARMS, TO SAVE BIG ON MONEY AND RESOURCES

Haveli with harvested rainwater (R) Wheat is grown in the drained haveli, post-monsoon.

Have you ever heard of a dual-purpose farm that is a reservoir in the monsoon and a fertile farm in the next season? If you did, it might have been about the ancient Indian haveli system – a 200-300-year-old rainwater harvesting system that once greened the Bundelkhand region, one of the most drought-prone areas in India.

Compared to check dams, havelis come with numerous benefits. Renovating a haveli is 10 times cheaper, the water storage capacity is on an average 20 times more and the productivity of crops grown on the silt-rich soil of the drained reservoir during the postrainy (*rabi*) season is higher. These observations are from a study on the haveli in one of our Corporate Social Responsibility watershed projects in Parasai village, Jhansi.

The haveli utilized 8 ha under submergence out of 400 ha (i.e. 2%) over which the village is spread. Thousands of such havelis are lying defunct in the region and their renovation can lead to better water conservation and improved crop productivity in a cost-effective way.

How it works: The havelis built centuries ago were designed in topographical sequence such that the runoff generated is harvested in a cascading manner from upstream to downstream (Prakash et al., 1998; Shah et al., 2003). The haveli acted as a reservoir during monsoon and as cultivable land post-monsoon. Provision was made to drain out impounded water during September / October to help farmers start preparing their land for *rabi* cultivation.

Productivity of the haveli fields is relatively higher as it holds more residual moisture, humus and nutrients as it also harvests silt and organic matter from the upstream fields. It also acts as a carbon sink (Sahu et al., 2015).

Cost benefits: The unit cost of rainwater harvesting through the haveli system is much cheaper than other measures such as check dams or farm ponds. The cost of haveli renovation in Parasai village was ₹800,000(~US$ 13,000) with a storage capacity of 73,000 m^3. Whereas average investment made for a check dam was ₹ 350,000 (~US$ 5,800) for a storage capacity of3000 m^3. The unit cost of creating storage capacity by renovating haveli and check dam is ₹ 11 /m^3 and ₹117 /m^3, respectively.

Creating awareness: It is important to note that check dams are built across village streams belonging to public/government land. Since havelis are generally located on land owned by farmers/community, their rejuvenation/repair will need community agreement. The community is aware about defunct havelis, their history and potential benefits. Incentivizing the communities to arrive at a consensus, sensitizing policy makers, identifying suitable technical expertise and capacity building are necessary to scale up haveli renovation/repair on a large scale.

The zone of influence of havelis from groundwater recharge can be much larger compared to check dams making them a preferred option of rainwater harvesting. There is a strong need to articulate the cost and benefit aspects of haveli structures in a simple and effective way in order to help policy makers make a right choice when it comes to large-scale investments in drought-proofing measures.

Link::http://idc.icrisat.org/idc/index.php/revive-havelis-indias-ancient-rain-harvesting-farms-to-save-big-on-money-and-resources/

FAO ACKNOWLEDGES ICRISAT'S CONTRIBUTIONS TO KEY REPORT ON OVERCOMING WATER CHALLENGES IN AGRICULTURE

A check dam in Parasai-Sindh watershed in Jhansi, Uttar Pradesh. Photo: Ramesh Singh, CAFRI

The Food and Agriculture Organization (FAO) has acknowledged ICRISAT scientists Drs Kaushal K Garg, KH Anantha, Sreenath Dixit and Anthony Whitbread for their contributions to the 2020 edition of its annual flagship publication, **The State of Food and Agriculture**. The edition was dedicated to overcoming water challenges in agriculture.

For the publication, the ICRISAT team contributed a background report on strengthening resilience through water management in rain-fed agriculture systems. Case studies from India and Ethiopia were also submitted. ICRISAT's contributions to the FAO publication were made in collaboration with Prof Jennie Barron of the Swedish University of Agricultural Sciences, Uppsala.

The India case study was of scaling up water management interventions in Bundelkhand region to transform it into a productive landscape for sustainable farm livelihoods. The interventions reduced run-off by 36% in the intervention area of Parasai-Sindh watershed in the region. Soil loss reduction of 62% was achieved. This increased groundwater recharge by 46% and crop productivity in the range of 10 to 70%.

Similarly, government-led sustainable land management programs for landscape rejuvenation in Ethiopian highlands were discussed in the Ethiopia case study. In the Yewol Mountains, for instance, a five-fold increase in irrigable land was recorded after the interventions took effect. Collaborations between Ethiopia's Ministry of Agriculture and national and international innovation and knowledge centers were crucial for the work in the

highlands. Both government and non-government organizations supported transfer of technology and development of tools to scale it up.

The State of Food and Agriculture report also mentions interventions in Kothapally watershed in south India. ICRISAT has implemented several interventions in this watershed area. The report states that these interventions reduced sediment loads in rivers and has had a positive impact on in-stream river ecology and lifespan of reservoirs.

REJUVENATION IN BUNDELKHAND: HOW AN UPLAND WATERSHED GOT ITS GROUNDWATER BACK

A haveli structure in Birdha village, Lalitpur district, Bundelkhand renovated under ICRISAT's Doubling Farmers' Income Project. Runoff from most of the upland location is harvested in the haveli, while a long core wall covered with soil and a masonry outlet facilitates excess runoff. Photo: Dr Ramesh Singh/ICRISAT

Originally published on thrive

The world of water management is replete with stories about traditional systems that break down, such as the one we reported in November from Karnataka, South India. Age-old, decentralized approaches to managing water and watersheds do fall apart, leaving farmers high and dry. However, a remarkable study published in the Journal of Hydrology documents just how rapidly farmers can reap the benefits when an old system is restored and enhanced.

Researchers at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and their collaborators selected for a five-year study two degraded watersheds in the hilly, semi-arid region of Bundelkhand, which is divided between Madhya Pradesh and Uttar Pradesh in central India. Farmers in the region – a third to half of whom subsist below the poverty line – live in villages that traditionally have an earthen rainwater harvesting tank called a *haveli*. These *havelis* act as reservoirs during the monsoon (June to September), and after draining they are used for crop cultivation during the post-monsoon (October to February). By facilitating groundwater recharge the system ensures water security for households, livestock and agriculture. Farmers maintained their *havelis* together for hundreds of years, but many of the structures have collapsed along with the rural institutions that created them. When the monsoon comes now, rainwater quickly flows downhill. Rainfall is becoming more and more variable every year, with climate change cutting some rainy seasons down to a fraction. Yet even after a good monsoon, more than 80% of open wells soon run dry.

Bringing back the *haveli* system

From this rather sobering baseline analysis, the story gets much better. The researchers targeted one of the two watersheds for rejuvenation, first restoring a defunct *haveli* to service and upgrading its earthen wall with a concrete core for improved storage and longevity. This was just the beginning of a five-year watershed monitoring, adaptive management and resilience-building scheme. The plan extended to other low-cost rainwater harvesting structures – check dams along drainage lines, and systems of contouring and bunds in farmers' fields – along with tree planting and crop management demonstration. The second watershed, similar in all other respects, served as an experimental control.

Watershed management is nothing new in India, where more than $14 billion has been invested since 1990 to solve the connected problems of land degradation, water scarcity and unproductive agriculture. Public programs have even made a push to repair and maintain *havelis* in the last two decades, although the impact was short-lived due to frequent breach. The shortfall has also been in monitoring and understanding the impact of such efforts – on hydrology, water balance, upstream–downstream trade-offs, land use and livelihoods. Where most watershed planning has been based on assumptions about these factors, the new study looked at five years of substantial evidence.

The data flows in

The team collected hydrological data through carefully placed runoff gauging stations, and through water level measurements taken monthly at all 388 dug wells in the intervention watershed. The results couldn't have been clearer. The rainwater harvesting structures, which added up to 100,000 cubic meters of new storage capacity, significantly enhanced groundwater recharge by reducing surface runoff from an average 250mm a year to 150mm a year. The difference was very noticeable to every member of the community: well water levels stood 2–5 meters higher than in the control watershed.

The trend of extreme variability in monsoon seasons, linked to global climate change, was very evident in the five years of research, and this variability led to some of the most important findings. One was on upstream–downstream trade-offs. The data from Bundelkhand showed that the interventions did affect water availability downstream, but only in intermediate rainfall years; there was no loss downstream in very dry years, when runoff is minimal anyway, or in very wet years, when *havelis* release ample excess water.

The real difference the structures made was to the recharge of shallow groundwater aquifers. Following the interventions, a single recharge in a wet year could sustain groundwater supplies through two subsequent years of low rainfall – meaning that most dry years would not become drought years for farmers. Within the study period, 2015 was an exceptionally dry year, with just 404mm of rain. At the end of the monsoon, 30% of dug wells in the control watershed were already dry, whereas only 6% of the wells in the intervention watershed had run out of water.

A watershed breaks the cycle of upland poverty

What difference does a few more meters of groundwater make? A very large one, according to the study's analysis of household farming changes in the watershed. The researchers gathered evidence through crop cutting estimates, taking samples from 50 farmers' fields and extrapolating to estimate agricultural production in the entire watershed each year. Overall dairy income, too, was estimated from the livestock kept by individual households.

Secure groundwater availability led to shifts in cropping patterns throughout the agricultural calendar. Nearly 20% of fallow land was brought under cultivation, and farmers planted higher-value crops, expanding groundnut production in the wet season and barley and wheat in the dry season. These three crops showed 50–70% increases in their yields. Cultivation of green fodder and vegetables spread from just 5 hectares to 70 hectares, and with more fodder, more farmers invested in dairy buffaloes. In the span of just a few years, annual household incomes shot up from USD 960 to USD 2,700.

Looking to other watersheds and some lessons from history

Clearly, there is untapped potential in the renovation and improvement of traditional rainwater harvesting structures. Uncounted thousands of these defunct structures exist all over India and in other countries, and they need to be re-examined and reconsidered to prepare for fluctuating rainfall regimes. Repairs and modifications are less expensive than many other solutions to drought, and the Bundelkhand study indicates just how effective these can be. Looking to how such traditional systems were once sustainably managed, furthermore, reveals the role of communities and social mobilization in their success – another rich area of research that has also been recently explored in India in a study combining archaeology, history and collective action.

The Bundelkhand study did show that in years of intermediate rainfall, the *haveli* and other structures reduced flows downstream by harvesting nearly 40% of runoff. This reinforces the need for monitoring, impact analysis and management at larger scales, possibly with measures to compensate domestic, agricultural and industrial water users downstream. Yet from the perspective of equitable resource distribution, the study documents a significant boost for upland communities – typically some of the most resource-deprived and most vulnerable to drought and climate change. Rainwater harvesting in the uplands protects these communities from drought by retaining a larger fraction of their rainwater as groundwater, smoothing over uncertainties and making better livelihoods possible.

Read more about ICRISAT work in Natural Resource Management on EXPLORE*it*

Authors: Dr Kaushal Garg, Senior Scientist, ICRISAT Development Center, Asia Program and **Paul Farah Cox,** Senior Writer and Editor (Communications Services) at Scriptoria

About ICRISAT

International Crops Research Institute for the Semi-Arid Tropics

ICRISAT is a member of the CGIAR Consortium

The **International Crops Research Institute for the Semi-Arid Tropics** (ICRISAT) is a non-profit, non-political organization that conducts agricultural research for development in Asia and sub-Saharan Africa with a wide array of partners throughout the world. Covering 6.5 million square kilometers of land in 55 countries, the semi-arid tropics have over 2 billion people, of whom 644 million are the poorest of the poor. ICRISAT innovations help the dryland poor move from poverty to prosperity by harnessing markets while managing risks – a strategy called Inclusive Market-Oriented Development (IMOD).

ICRISAT is headquartered in Patancheru near Hyderabad, Andhra Pradesh, India, with two regional hubs and five country offices in sub-Saharan Africa. It is a member of the CGIAR Consortium. CGIAR is a global research partnership for a food secure future.

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