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RAINWATER HARVESTING-ARTIFICAL RECHARGE OF GROUNDWATER IN INDIA

This summary document provides an overview of the state of rainwater harvesting-artificial recharge of groundwater in India. And also covers a literature review of impact studies conducted on rainwater harvesting-artificial recharge of groundwater in India. **It is a part of the larger CEEW study,** *Sustainable Agriculture in India 2021: What We Know and How to Scale Up*

Sustainable Agriculture in India 2021: What We Know and How to Scale Up, is a handbook on the prevalence, practices and state of affairs of the 16 most promising sustainable agriculture practices in the country. It presents the economic, social and environmental impacts of these practices with recommendations on their potential to scale-up sustainable agriculture in India.

The study is available at: https://www.ceew.in/publications/sustainable-agriculture-india-2021

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Rainwater harvesting (RWH) is a process of collecting, conveying and storing the rainfall in an area for beneficial purposes.[1] RWH is done by storing rainwater on the surface for future use and through recharge to groundwater. It is also known as artificial recharge when rainwater is directed into the ground – either by spreading it on the surface, by using recharge wells, or by altering natural conditions to increase infiltration – to replenish an aquifer.[2] This chapter covers both aspects, but uses rainwater harvesting as an encompassing term that includes both harvesting rainwater and artificial recharge on the surface and deep underground (abbreviated as RWH-ARG).

RWH systems can be constructed for domestic, irrigation and industrial purposes.

The most common facilities are rooftop RWH systems, which are economically feasible and easy to construct. Larger catchments are used in rural areas for collecting runoff into village ponds and reservoirs. Community RWH systems collect runoff through watershed management methods. Structures generally used to recharge groundwater are recharge shafts (vertical, lateral shafts with bore wells), spreading techniques (check dams, nala bunds, percolation tanks, ponds, ditches, furrows), and injection wells. The most popular of these structures are percolation tanks, which are an artificially created water body to allow surface runoff to percolate and recharge groundwater. On gentle slopes with smaller streams, generally check dams are constructed and recharge pits are made to recharge shallow aquifers.

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Rainwater harvesting's linkages to FAO's agroecological elements

In principle, RWH-ARG adheres to and promotes many agroecological elements as defined by the FAO

Elements	Description of agroecological linkages
Diversity	The practice can lead to an increase in vegetation cover due to additional water availability in the soil, as well as indirect benefits such as decreased soil erosion, increased flora/fauna, including migratory birds, thereby contributing to biodiversity.[3]
Co-creation and sharing of knowledge	RWH-ARG is a traditional practice in India, since reinvented as science and promoted as a technology. Farmers in the field face contextual challenges in dealing with water shortages and sharing knowledge. These challenges can be mitigated through peer-to-peer knowledge exchange as farmers build and manage these structures collectively, leading to co-creation and innovation (stakeholder consultation).
Synergies	An increase in vegetation due to more water availability improves biodiversity and reduces soil erosion. Better percolation of rainwater into the sub-surface enhances ecological functions leading to synergies.
Efficiency	Capturing surface runoff, which otherwise drains off, reduces water inputs (optimising resources). Using locally available materials and human resources for constructing these structures also contributes to resource efficiency by reducing costs.
Recycling	RWH-ARG uses rainwater, surplus water diverted from natural streams, properly treated municipal and wastewater for surface and subsurface recharge, thereby increasing resource use efficiency, minimising waste and pollution, and recycling wastewater.
Resilience	RWH-ARG contributes to water resilience, especially in rainfed regions of the country.
Human and social values	Water recharge programmes are participatory in nature, contributing to managing common pool resources (ponds, wells) collectively in a decentralised manner.
Diversity	The practice can lead to an increase in vegetation cover due to additional water availability in the soil, as well as indirect benefits such as decreased soil erosion, increased flora/fauna, including migratory birds, thereby contributing to biodiversity.[4]

A brief context in India

Rainwater harvesting was being practised in India's arid and semi-arid tracts as early as the sixth century. In many decentralised artificial recharging activities, rainwater harvesting is a part of the decentralised artificial recharge.[5] Experiments on artificial recharge to aquifers started from 1980 onwards and were done by Central and State Government Departments, and a few NGOs. They revealed early signs of groundwater overexploitation. Since the 1990s, techniques such as rainwater tanks for buildings, canal barriers, percolation tanks, trenches along slopes and hills, dugs, and borewells have been built in far greater numbers. More than 500,000 tanks and ponds exist all over the country, especially in peninsular India.

At present, around 33 states/UTs have made RWH mandatory by enacting laws or regulations, including provisions in building bye-laws or through government orders. Tamil Nadu made it mandatory for all existing and new buildings to provide rainwater harvesting facilities under its municipal laws and to include rooftop RWH structures in building plans.[6]

Existing schemes, such as the *Mahatma Gandhi National Rural Employment Guarantee Scheme (MNREGS),* watershed development programmes etc. are dovetailed towards water conservation efforts. Around 293,873 water conservation and water harvesting works/structures are known to be completed under the MGNREGS as of February 2020. The Ministry of Jal Shakti is spearheading efforts for water conservation via a peoples' movement through the Jal Shakti Abhiyan. The Central Ground Water Board (CGWB) took up experimental studies initially, which turned into pilot studies and then into demonstrative studies in the VIII to XI Plan periods. As most of the studies were executed through the state agencies, these efforts helped to build state institutional capacities and led to knowledge transfers for replication.

Financial assistance to farmers for constructing RWH-ARG structures is provided through the *MNREGS, Pradhan Mantri Krishi Sinchayee Yojana-Watershed Development Component (PMKSY-WDC), Integrated Watershed Management Programme (IWMP), National Agricultural Development Programme (RKVY), and National Horticulture Mission (NHM).*

Rainwater harvesting: acreage, geographies, and cultivation details

How much area in India is under RWH-ARG? As the area involved in RWH-ARG may range from an entire watershed to a limited area such as an urban, rural, or industrial centre, it is challenging to identify an aggregated figure covering the entire country.

Nonetheless, as reported by the Ministry of Rural Development, Department of Land Resources, around 8,214 watershed developments are known to be sanctioned (from 2009-10 to 2014-15) across India under the Integrated Watershed Management Programme, which constitute a total area of 39.07 million hectares from projects completed in 28 states. As water conservation or harvesting of water is an inherent aspect of watershed development activities in rainfed areas, it is safe to presume that about 50-70 per cent of the 39.07 mha would involve harvesting water or water conservation. This leads to a rough estimate of around 20-27 mha under water-harvesting activities in the country[7] (stakeholder consulted at CGWB).

At what farm size is RWH-ARG practised? While these practices are undertaken at all farm scales, it is more appealing for medium to large scale farmers as smallholder farmers are concerned about the loss of land to RWH structures. It is also widely done at the landscape or community level.

How many farmers in India are practising RWH-ARG? There is no absolute count of the number of farmers adopting the practice due to its fragmented nature. However, considering the area under the practice is around 20-27 mha, an estimate of under 5 million adopters are assumed to implement RWH activities.

Where in India is RWH-ARG prevalent? Gujarat (North Gujarat, Saurashtra, and Kachchh), Rajasthan, Maharashtra, Tamil Nadu, Karnataka, Andhra Pradesh, Madhya Pradesh, Orissa and Chhattisgarh have taken up RWH-ARG programmes on a large scale. But the practice is followed across all the States in the country.

Which are the major crops cultivated under RWH-ARG in India? All types of crops can be grown with the help of RWH.

Impact of rainwater harvesting-artifical recharge of groundwater

This section considers the economic, social, and environmental impacts of RWH-ARG.

ECONOMIC IMPACT

1. Yields

RWH-ARG structures increase the overall arable area by improving otherwise unproductive land. They also increase land productivity as more water is accessible for use.[8] This is substantiated by a case study which showed how farm/percolation ponds significantly increased productivity.[9] An assessment of farm ponds in five major rainfed states (Andhra Pradesh, Maharashtra, Karnataka, Tamil Nadu and Rajasthan) found an increase in yield of major crops ranging from 5 per cent to 72 per cent. There was also an increase in gross cropped area of between 5 per cent and 20 per cent across districts.[10] In the Research on Sustainable Rural Livelihood Security project undertaken in Andhra Pradesh, RWH was a prime activity (digging new ponds, de-silting of existing water bodies, renovating check dams) and led to increases in the mean cropping intensity in all the 8 project clusters to 152 per cent from the baseline value of 96 per cent.[11]

Farm ponds are the most popular RWH structures. In Anantapur (Andhra Pradesh) where several of them were built under the MGNREGS, crop yields increased by 20-25 per cent in most crops due to greater water availability. Changes in cropping patterns and cropping intensity were also observed. Water from farm ponds was used to recharge irrigation wells which helped to enhance cropping intensity and yields significantly. However, farmers were concerned about the loss of land to farm ponds and usually poor quality of land are allotted to these ponds. Despite its benefits, limited scientific literature exists on the subject. Most information is from project-based case studies presented in reports.

2. Income

Most watershed programs in the country are aimed at development and improving income levels of rural households. Farmers with augmented water are able to secure two to three crops a year, thus improving their income and quality of life. Even when a farmer applies irrigation scheduling to attain water use efficiency can reduce the input cost for water and labour through fewer irrigation requirements. It can increase the net returns by increasing yields and the quality of crops. The saved water can be utilised in dry spells for irrigating crops and could result in additional returns.

There are fewer studies assessing impacts of farm ponds at a micro scale compared to community watershed-based harvesting programs. Most economic assessments on a watershed level focus on cost-to-benefit ratios, with rainwater harvesting being among several activities assessed. From the evidence, there is broad consensus that RWH structures increase farmers' incomes from the rise in crop production and the increase in arable land. RWH structures also led to increases in non-crop incomes as people are able to take up fishing, cattle herding, and producing fermented beverages.[12] One study of the impact of RWH (farm ponds) on farm incomes in five major rainfed states (Andhra Pradesh, Maharashtra, Karnataka, Rajasthan and Tamil Nadu) found that households' additional net returns were positive with and without subsidies (capital subsidies provisioned for building RWH structures). For instance, with a 50 per cent subsidy, the net returns ranged from USD 85 to USD 362 per annum per household, and USD 48 to USD 140 per annum per household (with no subsidy). The production of high-value crops using the harvested water was vital in attaining higher economic benefits from the RWH systems.[13]

However, the profitability of farm ponds depends on having enough rainfall to affect the water levels; it could be hampered in initial or drought years when the ponds are dry or water levels are low.

SOCIAL IMPACT

1. Human health

Literature on the impacts on human health is scarce. A few mentioned RWH-ARG structures as a dilutant for cleaning water[14] that essentially has positive health benefits. In principle, water collected from a rooftop RWH structure is usually pure and potable. However, it may come into contact with dust or debris and the tanks may have algae or insects breeding in them. The health benefits of the water depend on the regular maintenance of these systems, either through bleaching powder to disinfect water or chlorine tablets.[15]

Reviews of the impact of check dams on water quality in several states/regions found improved groundwater quality, primarily a reduction in fluoride concentration and salinity, and the dilution of ions in water.[16] More experimental studies need to be done to understand the direct impact of these structures on water quality and human health, in particular the relationship between RWH for recharge and groundwater salinity.[17]

2. Gender

Overall, there is a lack of evidence in academic peer-reviewed journals on the impact of RWH-ARG on women. Most evidence lies in the form of case studies that emphasise women's empowerment from RWH-ARG projects and how these facilities have saved time for women community in a few states.

One such project was undertaken by the Hindustan Unilever Foundation across several States (Maharashtra; Madhya Pradesh; Gujarat and Karnataka) resulting in reduced working hours for women, improving their quality of life and more participation in water management programmes. Few case studies indicate women's participation through membership in SHGs and village development committees empowering them in the process. However, a challenge that emerged is in terms of groundwater management and use in Rajasthan where more than 75 per cent of women interviewed indicated that water collection was primarily done by them. This signifies increase in workload and drudgery for women communities.

ENVIRONMENTAL IMPACTS

1. Soil and nutrients

RWH structures like percolation tanks, check dams help in checking soil erosion by reducing surface runoff. Thus, water harvesting structures can conserve soil and water and lead to higher crop yields. Farm ponds are particularly observed to conserve soil and nutrients apart from water.

However, the rate at which water percolates into the soil depends upon the soil type, moisture content, vegetative cover, seasonal factors, etc.[18] For instance, lateritic soil and sandy cover increase infiltration and percolation rate, thus enhancing groundwater recharge.[19] Even black soils have potential for RWH without lining as the seepage is minimum. The depth of soil is equally important when constructing RWH structures, as deep soils store harvested water for a longer period of time and there are reduced evaporation losses.[20]

Structurally, farm ponds are best suited to soils with a low infiltration rate. Percolation tanks are most favoured in areas with deep alluvial soils, sandy loams with low clay and kankar contents that have good potential to store water for later use.[21] Existing and abandoned dug wells are utilized as recharge structures after cleaning and desilting them which generally has a positive impact on soil nutrients. Even irrigation scheduling methods save nutrients. Sewage water contains nutrients, including nitrogen, phosphorus, and potash. Once it undergoes a natural process of percolation in RWH-ARG structures, it considerably reduces toxicity. There are a few examples of water reclamation where the water is cleaned after it is stored and recharged for a considerable period through a natural process. When used for farming, this water has the potential to reduce the overall investment in nutrients required for growing vegetables and crops.[22]

2. Water

RWH-ARH provides a feasible solution to storing water at both macro and micro levels for mitigating water scarcity during drought situations, particularly in rainfed areas where there is a paucity of exploitable water resources. As the country is characterised by diverse topographic, climatic, environmental factors, RWH technologies are highly location-specific. But they have a similar purpose of storing and harvesting surplus water in the monsoons which would otherwise be wasted in surface structures (village ponds, tanks, and small dams, percolation tanks) or groundwater reservoirs. The concept of irrigation scheduling is very relevant as it allows farmers to decide the time and amount of water to be supplied to the farm, achieving greater water efficiency.

In large parts of the country, where rainfall is limited to about 20 to 30 days, natural groundwater recharge is restricted. Artificial recharge aims to increase the recharge period in the post-monsoon period (extended to three months) which allows more time for recharge and makes more water available during leaner seasons. A rise in groundwater levels in the vicinity of recharge structures has been observed post-implementation of recharge structures in several projects implemented by the CGWB across the country. These structures are known to slow falling water levels, especially in the summer seasons, and they also improve groundwater water quality due to greater dilution. Yet the increase varies depending upon the structure type, size of the project, hydrogeology, locational factors, etc.[23]

But there are certain drawbacks as well, including the high evaporation rate from RWH structures with a large surface area (tanks, ponds, dams).

3. Energy

In principle, RWH structures are known to reduce the energy required to pump water. For instance, a one metre rise in water levels saves about 0.40 kWh of electricity. RWH structures have the potential to reduce emissions when they reduce the energy needed to pump water. However, there are no systematic studies on the subject.

4. Biodiversity

The limited studies found for biodiversity suggest that RWH structures lead to an increase in the vegetation cover due to more water availability, thereby improving the flora/fauna, including migratory birds.[24] For example, in-situ RWH activities in the degraded Aravalli hills of Rajasthan were found to enhance vegetation and biomass by minimising the runoff effects on hillslopes. But more systematic studies are needed to understand the genuine impacts on biodiversity.

Impact evidence

State of available research discussing the impact of RWH-ARG on various outcomes.

Evidence Type	Yield	Income	Health	Gender	Soil and nutrients	Water	Energy	GHG emissions	Bio-diversity
Journals	3	2	1	0	8	9	0	1	1
Reports	0	6	0	2	9	12	0	1	1
Articles/ case-studies	0	0	0	4	1	0	0	0	0
Others **	0	0	1	1	8	13	1	0	0
Total	**3**	**8**	**2**	**7**	**26**	**34**	**1**	**2**	**2**

*** Thesis, guidelines, conference papers, etc*

Source: Authors' compilation

Note – The evidence is from the first 75 results examined in Google Scholar Advanced search and the first 30 results from Google Advanced Search. Only those papers which clearly established the evidence for different indicators were selected.

Stakeholder mapping

The following institutions are involved in the research and promotion of RWH-ARG; a few were consulted for this research:

Government institutions	Research/implementation institutions	NGOs/Civil society organisations
Central Ground Water Board, MoWR	International Water Management Institute (IWMI)	Advanced Center for Water Resources

		Development and Management
ICAR-Indian Institute of Water Management	Indian Institute of Management (IIM), Ahmedabad	Samerth Charitable Trust
Central Research Institute for Dryland Agriculture (CRIDA)	Physical Research Laboratory (PRL)	Centre for Science and Environment (CSE)
CSIR-National Environmental Engineering Research Institute (CSIR-NEERI)	Institute of Rural Management, Anand (IRMA)	Arghym

Source: Authors' compilation

Note – The stakeholders list is indicative and not exhaustive

Endnotes

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Contact shanal.pradhan@ceew.in/ abhishek.jain@ceew.in for queries

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