Adaptation Strategy or Maladaptation – The conversion of Farm ponds into surface storage tanks in Semi-Arid regions of Maharashtra

CARIAA-ASSAR Working Paper

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About CARIAA Working Papers

This series is based on work funded by Canada's International Development Research Centre (IDRC) and the UK's Department for International Development (DFID) through the **Collaborative Adaptation Research Initiative in Africa and Asia (CARIAA).** CARIAA aims to build the resilience of vulnerable populations and their livelihoods in three climate change hot spots in Africa and Asia. The program supports collaborative research to inform adaptation policy and practice.

Titles in this series are intended to share initial findings and lessons from research and background studies commissioned by the program. Papers are intended to foster exchange and dialogue within science and policy circles concerned with climate change adaptation in vulnerability hotspots. As an interim output of the CARIAA program, they have not undergone an external review process. Opinions stated are those of the author(s) and do not necessarily reflect the policies or opinions of IDRC, DFID, or partners. Feedback is welcomed as a means to strengthen these works: some may later be revised for peer-reviewed publication.

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About ASSAR

All authors of this working paper are team members in the ASSAR (Adaptation at Scale in Semi-Arid Regions) project, one of four hotspot research projects in CARIAA. The international and interdisciplinary ASSAR team comprises a mix of research and practitioner organizations and includes groups with global reach as well as those deeply embedded in their communities. The ASSAR consortium is a partnership between five lead managing institutions - the University of Cape Town (South Africa), the University of East Anglia (United Kingdom), START (United States of America), Oxfam GB (United Kingdom) and the Indian Institute for Human Settlements (India) – and 12 partners – the University of Botswana, University of Namibia, Desert Research Foundation of Namibia, Reos Partners, the Red Cross/Crescent Climate Centre, University of Ghana, ICRISAT, University of Nairobi, University of Addis Ababa, Watershed Organisation Trust, Indian Institute for Tropical Meteorology, and the Ashoka Trust for Ecology and the Environment.

Working in seven countries in semi-arid regions, ASSAR seeks to understand the factors that have prevented climate change adaptation from being more widespread and successful. At the same time, ASSAR is investigating the processes – particularly in governance – that can facilitate a shift from ad-hoc adaptation to large-scale adaptation. ASSAR is especially interested in understanding people's vulnerability, both in relation to climatic impacts that are becoming more severe and to general development challenges. Through participatory work from 2014-2018, ASSAR aims to meet the needs of government and practitioner stakeholders, to help shape more effective policy frameworks, and to develop more lasting adaptation responses.

Why focus on semi-arid regions?

Semi-arid regions (SARs) are highly dynamic systems that experience extreme climates, adverse environmental change, and a relative paucity of natural resources. People here are further marginalized by high levels of poverty, inequality, and rapidly changing socio-economic, governance, and development contexts. Climate change intersects with these existing structural vulnerabilities and can potentially accentuate or shift the balance between winners and losers. Although many people in these regions already display remarkable resilience, these multiple and often interlocking pressures are expected to amplify in the coming decades. Therefore, it is essential to understand what facilitates the empowerment of people, local organizations, and governments to adapt to climate change in a way that minimizes vulnerability and promotes long-term resilience.

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Abstract

Central and State Government programs in India are promoting the construction of Farm ponds[1] as a drought mitigation strategy to secure agrarian livelihoods. The farm ponds aim to harvest rainwater, provide protective irrigation during dry spells, arresting rainfall-runoff, and enhance groundwater recharge. The proposed guidelines to the scheme have undergone drastic changes in terms of both the design and the size of farm ponds by its users. Instead of serving its purpose of storing surface runoff water, these farm ponds are now widely used as surface storage tanks utilizing groundwater. This paper assesses the Benefit-Cost Ratio of this practice, highlighting the unintended consequences of groundwater extraction for surface storage in these structures.

The findings in this paper emerge from a study of 206 farm ponds constructed in six villages (between 2006 and 2017) in the Ahmednagar district of Maharashtra. The benefit-cost analysis is made at two scenarios, 1) considering the direct investment costs of structures and, 2) considering the indirect costs associated with structures (evaporation losses and land opportunity cost). We find that small landowners own 47 % and medium landowners own 31% of the total farm ponds. Almost 70% of these structures are unlined and thus are not used by farmers during post-monsoon seasons. Small farm ponds bring in higher economic returns due to low indirect costs involved. The indiscriminate and unregulated practice of filling up the farm ponds by groundwater extraction makes the region more vulnerable to groundwater depletion, resulting in harmful social and environmental implications.

Keywords:

Cost-Benefit Analysis, Drought mitigation, Evaporation losses, Farm ponds, Groundwater extraction, Opportunity costs

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[1] Farm ponds are surface structures constructed to harvest surface runoff or rain-water and to use the same in lean period

1. Introduction

Groundwater is a common-pool resource that is fast depleting in India. An important component in agro-ecosystem services, groundwater contributes to stream flows and also a major source of irrigation and drinking water in semi-arid regions in the state of Maharashtra, especially during the prolonged periods of dry spells during June to September (Monsoon period). The exponential population growth and aspirations of people have put tremendous pressure on water resources. The spatial and temporal variations in rainfall further impacts groundwater availability. The state of Maharashtra faces frequent droughts and water shortages, which reduces agriculture productivity. Due to shortages in surface water, farmers rely primarily on groundwater for agriculture and domestic use. Moreover, farmers switching from rain-fed to cash crops to increase their household income have resulted in the over-exploitation of groundwater. The outcome- the increasing depth of borewells for tapping deeper aquifers to meet the ever-growing demand for water (Kale 2017). As Maharashtra is made of Deccan basaltic aquifers which are heterogeneous, such hard rock aquifers[2] show limited storage capacity and low groundwater yield (CGWB 2014). The continuous digging of bore-wells is creating further pressure on an already limited resource.

The decline in the water table gives rise to technological demands of rising costs of installing new wells, deepening of existing wells, and the lifting of water (Moench 1992; Shah 1993). Micro-level studies demonstrate that the existing inequality in landholdings leads to inequity in access to groundwater, which in turn, changes the skewness pattern in assets and income distribution (Dubash 2002; Nagaraj and Chandrakanth 1997). The capital intensity of groundwater extraction thus, makes it easier to exclude rival users, especially within the fragile resource regions, making the resource used largely by a few well-to-do households (Shah 1993). Moreover, the declining water table may not only raise the marginal operational cost but also give rise to a situation of diminished water availability, resulting in a decrease in productivity (Dhawan 1975) and subsequent decrease in net returns (Sarkar 2011).

Under these conditions, amongst various government schemes on drought-proofing, farm ponds are being encouraged on a large scale. Farm ponds are in principle, traditional rainwater harvesting structures that are supposed to have an inlet to allow runoff to ingress in the pond and an outlet to let out excess water. Their purpose is to help farmers adapt to the vagaries of monsoon by harvesting rainwater for protective irrigation. A farm pond is constructed on the farmland depending upon the topography of the area, soil condition, drainage of the area, local rainfall pattern, and distribution (Reddy et al. 2012). Farm ponds are considered an effective tool for rainwater harvesting, especially in storing runoff rainwater that is later used during dry spells.

Farm ponds are promoted on a large scale by the State government of Maharashtra since 2010 (GR Ref. 2009/130/7) under various schemes, namely *Jalyukt Shivar* (JYS2014) and *Magel tyala shettale* (farm pond on demand). Construction of farm ponds is also promoted through Central government programs like National Horticulture Mission (NHM 2014), *Pradhan Mantri Krishi Sinchai Yojana* (PMKSY2016), and *Rashtriya Krishi Vikas Yojana* (RKVY 2017).

[2] Aquifers are water holding rocks which can store and transmit water through pore spaces from one point to another

Farm ponds are observed to have wide deviations from the Government prescribed structure, design, and as well as their use (GoM 2016/37/11*Magel tyala shettale*). The findings in this paper highlight that farm ponds in the study area are filled using groundwater extracted from bore wells and deep wells instead of harvesting rainwater.

The main objective of this study is to understand the cost of investments and benefits received from farm ponds that are converted to groundwater storage structures/tanks. The benefit-cost analysis is conducted using two scenarios, first considering the direct costs involved in the construction of farm ponds and the application of water for agriculture stored in the farm ponds. The second scenario captures the unintended consequences from increased groundwater extraction by drilling bore wells to fill up farm ponds and using it as a surface water body that is subjected to evaporation losses. These consequences are valued as indirect costs such as avoided costs and opportunity costs.

The results of this study provide insights into whether the people's practice of converting the farm ponds to surface groundwater storage structures fulfills the intended adaptation purpose. Also, it comments on whether these practices are economically, socially, and environmentally viable, or is it merely a mal-adaptation intervention.

2. Study Area

The study was carried out in six villages of Sangamner block (located in Mula-Pravara sub-basin), in Ahmednagar district of Maharashtra. Sangamner block falls in the 'rain shadow zone' and experiences uneven rainfall distribution between 484 mm to 879 mm (CGWB 2014). The climate of the region is characterized by hot summers and generally dry weather conditions throughout the year.

The Spatio-temporal land use land cover changes in the Mula-Pravara river basin in Sangamner block shows an increase of cropped area and area under horticulture plantations by about two times and 16 times between 1991-2016 respectively. This spread in the cultivable area is attributed to an increase in access to groundwater, development of irrigation projects, and watershed development programs (Duraisamy, Bendapudi, and Jadhav 2018).

Six villages namely Gunjalwadi, Jawale baleshwar, Bhojdari, Karjule Pathar, Wankute, and Dolasane are selected based on their groundwater vulnerability were assessed under hydrological investigations (Thomas and Duraisamy 2018). The findings from the research show that almost 87 percent of the area in the study villages is classified as 'high' to 'extreme' groundwater vulnerable zones with very low hydraulic yields and storage capacities of basalt (Figure 1).

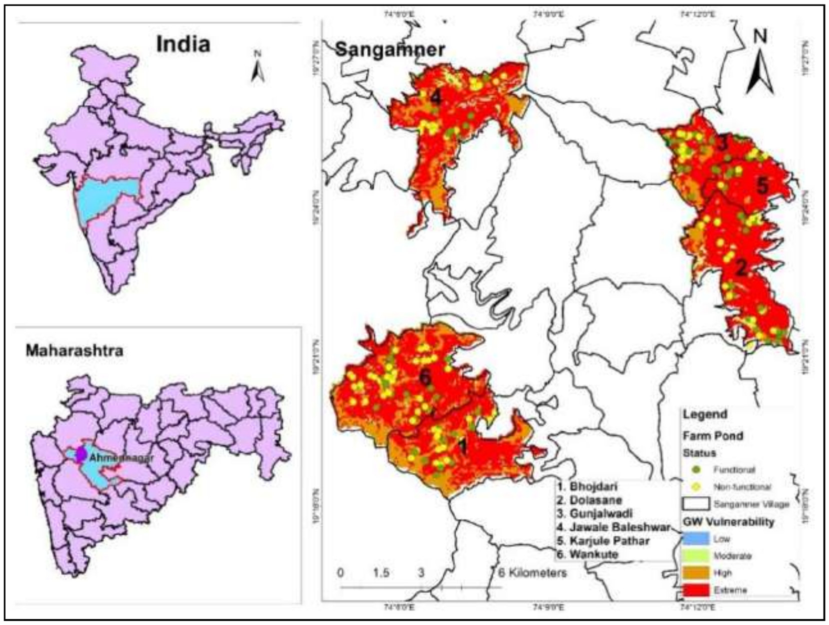


Figure 1: Location of Farm Ponds in villages identified as extremely groundwater vulnerable (Sangamner Block)

These six villages have a large number of farm ponds (Figure 1). Water storage in the farm ponds has come from dug wells and bore-wells, whose numbers have recently increased(Thomas and Duraisamy 2018)which has rapidly lowered groundwater levels. This among other irrigation practices and industrial water usage has resulted in a 'semi-critical' condition of groundwater resources in Sangamner block (CGWB 2014).

3. Methodology

3.1. Sample selection

All 188 farmers who constructed farm ponds till July 2017 from the six study villages were interviewed using a structured questionnaire. These 188 farmers reported a total of 206 farm ponds wherein 18 farmers own more than one farm pond.

The information and data set collected from the respondents mainly include the detailed cost of cultivation and production, irrigation using farm ponds, other sources of irrigation, the dimension of the farm ponds, investment costs occurred on constructing farm pond and plastic lining. The information also includes the perceptions of farm pond owners regarding the use and benefits received.

3.2. Analytical framework

3.2.1. Benefit-Cost Ratio

Using the Benefit-Cost analysis, the discounted sum of all future benefits and costs associated with the ponds are compared (Liang et al. 2007). Net Present Value (NPV) and Internal Rate of Return (IRR) is used to analyze the costs and benefits of the farm ponds. We used a 10% interest rate as the discount rate (Vongsana 2014). The useful life of a farm pond structure is assumed to be 10 years (Yuan et al. 2003; Vongsana 2014). In general, investments are viable if the benefit-cost ratio, Bt/Ct > 1; IRR is the discount rate where NPV equals zero (or Bt-Ct =0). Since farm ponds were dug at different periods (between 2006 to July 2017) and not compatible with direct summing, the investment values are adjusted to reflect the calendar year 2015.

These farm ponds are used to store extracted groundwater as surface water, thereby exposing the water body to evaporation losses. Therefore, the costs considered include both the direct costs (investment costs of the farm pond structures) and indirect costs (including the value of water lost due to evaporation and land used for farm pond structure). The indirect costs are the benefits or the investment costs that farmers could have saved. Evaporation losses are the avoided costs that farmers could otherwise use directly from the wells to irrigate their crops. While the foregone agricultural production is used as the opportunity cost of the land area lost to farm pond area. This cost is estimated by multiplying the area of farm ponds by the average net returns from rain-fed agriculture. The benefits from farm ponds include the net returns from agricultural production, calculated as gross returns minus input costs including the imputed cost of own labour.

3.2.2. Evaporation rate calculation

Farm ponds in the study area are filled with groundwater extracted from dug wells and bore-wells for irrigation needs for the *Rabi* (winter) and summer crops. This exposes the water stored to high temperatures resulting in significant evaporation losses.

The evaporation rates are computed for the specific study area using Penman's evaporation rate equation, which gives the fine-scale daily or monthly estimates using local meteorological data (Edward 2003). Temperature and mean dew point temperature data from automated weather stations installed in the study villages are used to estimate the rate of evaporation.

The value of evaporation losses is estimated by multiplying the annual evaporation losses of respective farm ponds (in m^3) with net returns per m^3 of irrigation given. The volume of irrigation is computed as 'irrigation hours x number of irrigation days x discharge rate (lit/hr)'.

4. Findings and observations

4.1. Who owns the farm ponds?

The central and state Government provides large subsidies for farm ponds, and therefore, it is important to assess the characteristics of the major beneficiaries of the farm pond schemes. The sample of farm pond owning farmers is distributed based on the land ownership categories. The total sample of 188 farmers covers 21% large landholding farmers, 31% medium landholders, and 48% small landholders (Table 1).

Table 1: Land ownership categories of the study sample of households owning farm ponds

Landholding category	HH Number	Percentage	Mean (Ha)
Large land holder farmers (> 4 ha)	39	21	5.67
Medium land holder farmers (2-4 ha)	58	31	2.57
Small land holder farmers (< 2ha)	91	48	1.24
Total	188*	100	

*Of the 188 households, 18 households possess more than one farm ponds. Source: WOTR, 2017

Although agriculture is reported as the main source of income by the majority of sampled households (60.11% sampled households), the sources of income of remaining households differ substantially. Other major income sources of sampled households include petty and medium business (11.17%) farm labour (8.51%), service sector (6.38%), remittances sent by family members staying outstation and pension (7.98%), livestock rearing, particularly small ruminants (3.19%) and dairy production (2.66%).

4.2. Characteristics of the Farm Ponds

For simplifying our analysis farm ponds are categorized into large, medium, and small sizes based on categorization proposed by Mushtaq et al. (2000). According to this categorization, farm ponds having more than 10000 m^3 storage capacity are treated as large farm ponds, whereas with a capacity between 1000 to 10000 m^3 as medium and less than 1000m^3 as small (Mushtaq et al. 2000). In our study, out of the total of 206 farm ponds, 59% are large, 14% medium and 27% are small farm ponds. As shown in Table 2, the largest number of farm pond owners belongs to the small landholder category (46.6%), and together with the medium land holding group, they own 43.2% of the large farm ponds.

Table 2: Landholding category-wise farm pond ownership

Landholding categories	Large Farm Pond	Medium Farm Pond	Small Farm Pond	Total
Large landholders	33 (16%)	2 (1%)	12 (5.8%)	47 (22.8%)
Medium landholders	47 (22.8%)	3 (1.5%)	13 (6.3%)	63 (30.6%)
Small landholders	42 (20.4%)	24 (11.6%)	30 (14.6%)	96 (46.6%)
Total	122 (59.2%)	29 (14.1%)	55 (26.7%)	206 (100%)

Source: WOTR, 2017

Only 30 percent of the total constructed farm ponds are in use and used for irrigation. For the remaining farm ponds that remain unused, farmers usually cited insufficient funds, ineligibility to receive subsidies because of incorrect site selection, tedious paperwork, and even non-affordability of the good quality plastic lining as determining causes.

4.3. Farm ponds converted to groundwater storage structures

In practice, farm ponds are filled up with the groundwater instead of harvesting rainwater while the plastic lining prevents water loss through percolation. Farm ponds having dimensions much larger than the Government prescribed dimensions tends to store large volumes of groundwater through overexploitation, thereby creates inequity in access to groundwater, which also increases the vulnerability of other users. Farm pond owners have also invested in new bore wells and dug wells to fill up the farm ponds by using groundwater (Photo 1).

4.4. Economics of Farm ponds in use

The long term efficiency of the farm pond depends on its benefits in comparison with the cost involved in subsequent years for farm pond usage. The benefit-cost analysis is important to assess investments made on farm ponds, which may result in positive returns over the long term or may show negative trends in substantial returns. To make an economic assessment of farm pond usage and groundwater storage practice, benefit-cost analysis of two scenarios is carried out: 1) considering direct investment costs in construction and use of farm pond and 2) including indirect costs of evaporation losses of groundwater stored and land opportunity cost.

Photo 1: Groundwater extraction from borewell to fill up farm pond (Karjule Pathar)

Photo courtesy: WOTR, Kumbharwadi, 2015

4.4.1. Direct investment costs

Direct costs include 1) excavation costs, 2) cost of plastic lining, 3) fencing made for protection purpose, 4) purchase of pumps and electrical connections/accessories at inlet and outlets of farm ponds, and 5) pipelines laid from the pond for irrigation purpose. The average cost of large farm ponds is INR 584, 948; INR 144,041 for medium farm ponds and INR 74,491 for small farm ponds (Table 3). The excavation cost accounts for the major portion of the total investments, followed by investments in the plastic lining (Table 3). Pump capacities used by sample farmers range between 2 to 5.5 HP. It is important to note that electricity for irrigation in the study area is charged at a flat quarterly rate which only depends on pump capacity used. This system encourages the unrestricted use of electricity by farmers, which in turn influences the free extraction of groundwater.

Table 3: Average investment costs of farm ponds in use (INR)

Particulars of investments	Large farm ponds (n=49)	Medium farm ponds (n=7)	Small farm ponds (n=6)
Excavation costs	284,140 (48.6%)	64,586 (44.8%)	31,464 (42.2%)
Plastic lining	194,895 (33.3%)	41,973 (29.1%)	26,567 (35.7%)
Electrical pumps and connections	26,119 (4.5%)	4,235 (2.9%)	2,667 (3.6%)
Fencing, bunding, planting trees, and other	37,551 (6.4%)	8,311 (5.8%)	5,980 (8.0%)
Drip and pipes	42,243 (7.2%)	24,936 (17.3%)	7,814 (10.5%)
Total investments	584,948 (100%)	144,041 (100%)	74,491 (100%)

*Figures in parenthesis are percentages to total; Source: WOTR, 2017

According to the farm pond users, there have been no recurring costs till date as the farm ponds are relatively new, but they expect the replacement of plastic lining (due to using of low-cost poor quality (non-ISI mark) lining material) to be an important recurring cost in the future.

4.4.2. Indirect costs involved in Farm pond usage

Maharashtra faces recurring droughts and extreme climatic conditions which further affects the already depleting the groundwater levels. The groundwater resources are further put under stress by local climate variability and unregulated extraction for various purposes. In the study area, due to the higher temperatures, groundwater stored as surface water in the farm ponds is lost due to faster rates of evaporation. Hence, the amount of evaporation loss of groundwater stored in the farm ponds as an important avoided cost associated with the farm pond use has also been factored in. Similarly, the land opportunity cost is calculated of land utilized to construct farm pond which could be used to cultivate crops.

4.4.2.1. Evaporation losses

An important loss from farm ponds converted to surface groundwater storage structures is from evaporation. The average annual estimated evaporation losses are 3766 m^3, 655 m^3, and 229 m^3 for the large, medium, and small farm ponds respectively in the year 2016 (Table 4). These are avoidable losses if the groundwater is not pumped to the surface and rather would have used directly from wells to irrigate crops.

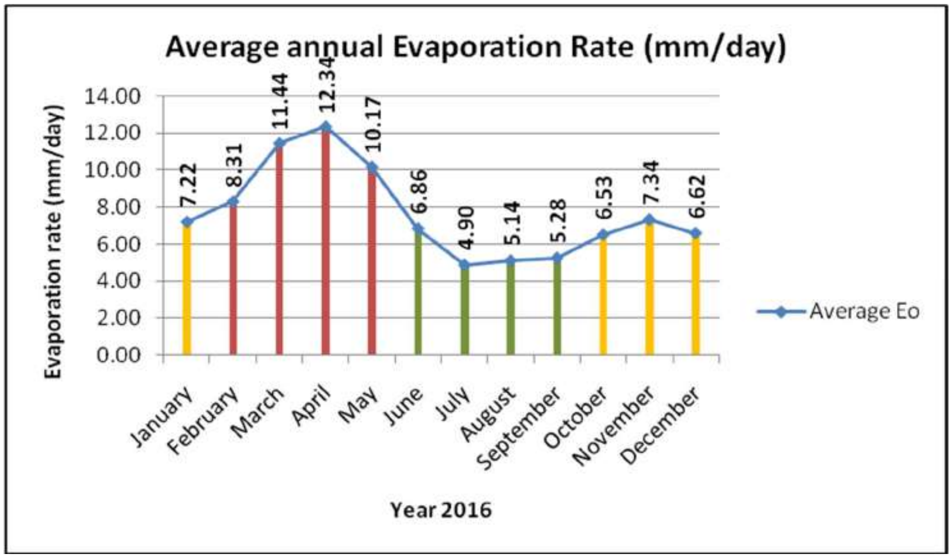
Table 4: Annual Evaporation losses in the year 2016

Farm pond size-wise evaporation losses	Mean evaporation losses (m^3)	Std. Deviation (m^3)	Minimum (m^3)	Maximum (m^3)
Large farm ponds (N=49)	3766	2983	479	15803
Medium farm ponds (N=7)	655	222	460	1086
Small farm ponds (N=6)	229	92	58	310

Source: WOTR, 2017

These evaporation losses are directly influenced by temperature. Figure 2 shows the trend of average evaporation rates across the year 2016. Evaporation rates are high in the summer months (March to May) with rising atmospheric temperatures, while the rates reduce in the *Kharif* season (June to September) when dew point temperatures drop significantly. The evaporation rates show a steadily increasing trend again from the end of *Kharif* to the *Rabi* season (October to December). However, even though the loss of water due to evaporation is lower in the cooler months, there are still losses, where a minimum of 5 mm of surface water is lost to evaporation daily.

Figure 2: Average annual Evaporation Rate (mm/day) for the year 2016 in selected villages



Note: Eo= Annual Evaporation rate (mm/day)

The opportunity costs from evaporation losses range from INR 60,913 for large farm ponds, to INR 11,781 for small farm ponds (Table 5).

Another important indirect cost is the opportunity cost of land lost in the construction of farm ponds. The field data collected shows the average cultivable areas lost in the case of a large, medium, and small farm ponds are 0.13 ha, 0.02 ha, and 0.01 ha respectively. The opportunity cost from foregone potential income in rain-fed agriculture from land is estimated to be as high as INR 13,620 for a large farm pond structures.

The amount of losses also reflects the type of crops grown by respective farmers. For example, farmers with large farm ponds mostly go for plantations such as pomegranate, whereas small farm pond owners prefer to cultivate short growing period crops, such as onion and wheat.

Table 5: Average value of losses of Farm ponds in use (in INR)

Indirect costs	Large FP	Medium FP	Small FP
Opportunity costs from evaporation losses	60,913	5,117	11,781
Opportunity costs of land lost for constructing farm pond	13,620	239	842
Total indirect costs	74,533	7,513	12,623

Source: WOTR 2017

4.4.3. Benefits from Farm Ponds

There is a significant change in the cropping pattern by farmers since their adoption of farm pond practices. The mean area under perennial horticulture such as pomegranate has increased by approximately 890% during the period 2010-17 in the study villages (Duraisamy, Bendapudi, and Jadhav 2018). There is also an increase in area under onion (22.8 percent) grown with irrigation in the *Rabi* season. Farmers have also started cultivating tomato in summer using farm ponds.

Table 6: Change in cropping pattern by farm pond owners

Season	Crop	Mean Area (Ha) (2016-17)	Percentage Change 2010-17
Perennial	Pomegranate	2.48	890.5
Kharif	Pearl millet	1.88	-9.9
	Green pea	1.27	12.0
	Groundnut	0.96	3.3
	Maize	2.16	15.0
	Onion	1.80	36.6
	Soya bean	1.05	16.5
	Tomato	0.95	39.3
Rabi	Chickpea	1.05	10.2
	Sorghum	1.26	-6.1
	Onion	1.82	22.8
	Wheat	1.20	16.4
Summer	Tomato	1.10	119.3

Source: WOTR, 2017

Major crops cultivated by the large farm pond owners are pomegranate (59% of respondent farmers) followed by wheat (22% of respondent farmers), whereas the small farm pond owners cultivate onion and wheat. The net returns are highest for pomegranate (INR 502,031 per ha) followed by onion (INR 116,056 per ha). Apart from these crops, farm pond owners also cultivate few plots of tomato and sorghum using farm ponds

Table 7 highlights the net income received from different categories of farm ponds for 2016-2017. The calculations show that large-sized farm ponds give the highest average returns followed by small farm ponds while medium-sized farm ponds give the least average returns even when accounted for indirect costs.

Table 7: Average returns from farm ponds

Average returns (INR) per farm pond categories (for the year 2016-17)	Large size farm ponds	Medium size farm ponds	Small size farm ponds
Net income from agriculture production under farm ponds (without accounting for indirect costs)	167,361	22,843	29,900
Net benefits from farm ponds (accounting for indirect costs)	92,828	15,330	17,278
Net returns per hectare (without accounting for indirect costs)	29517	8888	24113
Net returns per hectare (accounting for indirect costs)	13145	2923	10180

Source: WOTR, 2017

4.4.4. Benefit-Cost Analysis

The benefit-cost analysis of the farm pond users is presented in table no. 8. The investments in farm ponds appear profitable when indirect costs are not considered. The Internal Rate of Returns (IRRs) is high: NPVs positive with benefit-cost ratios greater than 1. The benefit-cost ratios are higher in the case of smaller farm ponds as compared to the large-sized farm ponds.

However, when indirect costs/losses from evaporation and opportunity costs of land lost to farm pond structure are accounted for, the NPV becomes negative with Benefit-Cost Ratio (BCR) less than 1 for larger farm ponds. Only the small farm ponds are found to be viable with positive NPV and benefit-cost ratio even after taking into account the losses. This is mainly due to lower evaporation losses from the smaller surface area of farm ponds as compared to the high evaporation losses from larger farm ponds.

Moreover, the small-sized farm pond owners (mainly large and medium landowners) are observed to cultivate cash crops such as onions, tomato, and wheat, rather than going in for plantations, which brings in seasonal benefits with sufficient input costs. Whereas large sized farm pond owners tend to choose horticulture or perennial crops with the aspiration of good irrigation provision investing large initial agricultural input costs. Crop selection also determines the extent of the economic returns such as the case of the medium-sized farm pond owners. Crops like green peas, soybean, and vegetable crops were irrigated by medium-sized farm ponds required heavy investments, while returns were lowered due to market values.

Table 8: Net Present Values, IRR and Benefit-Cost Ratios

Pond size	NPV (10%)	IRR (%)	BCR (10%)
Without indirect costs			
Large	443,416	25.71%	1.76
Medium	-3,680.2	9.40%	0.97
Small	109,235	38.61%	2.47
With indirect costs			
Large	-14,558	9.42%	0.99
Medium	-49,844	1.15%	0.74
Small	31,673	19.18%	1.21

Source: WOTR, 2017

5. Discussions

The major concern in the present context of farm ponds is the deviation from the recommended standards of farm pond dimensions and its original concept, where instead of rainwater harvesting the farm ponds are converted into groundwater storage structures with the indiscriminate extraction of groundwater. As per section 8 (chapter II) of the Maharashtra

Groundwater (Development and Management) Act, 2009, drilling of deep wells and borewells in notified areas is prohibited. In the study villages, it is observed that number of new bore-wells and deep wells drilled with an aspiration to larger access to groundwater while farm ponds are often used as privatized water bodies used to store secured share of groundwater. This is in contradiction with the state groundwater policies which treat groundwater as a public trust and focuses on the regulation of groundwater use, but the reality seems to exacerbate water scarcity conditions.

6. Recommendations

Harvesting a good volume of rainwater during monsoon makes assured provisions available for critical periods. Insightful decisions on farm pond dimensions, its efficient usage along with wise crop selection make farm ponds an important support system to the farmers. The benefit-cost analysis of sampled farm ponds shows that the farm ponds are practically beneficial and economically viable given that avoided/indirect costs are minimized by the efficient use of the water resources and by taking into consideration the externalities like climate variability, market forces, and affordability of individual interventions.

To guarantee the sustainable management and use of water resource it is therefore imperative that monitoring systems are in place, especially at the Panchayat level, so that farmers adhere to guidelines and norms prescribed for constructing farm ponds rather than mal-adapt by converting them into groundwater storage structures, which in turn makes them vulnerable to future risks of groundwater depletion and debts.

Also, there is an urgent need to regulate the practice of farm pond usage at the policy level such as in National Horticulture Mission and *Magel Tyala Shettale* Scheme in Maharashtra, ensuring that farmers follow the specified standards and dimensions. More importantly, there needs to be a strict monitoring system of controlling the practice of groundwater extraction to fill the farm ponds. This will ascertain that farm ponds are used as well-adapted drought mitigation measures.

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