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Changes in Livelihood and Utilization Pattern of Farm Pond Owners in Drought Regions of Maharashtra, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The study aimed to assess the impact of farm pond adoption on the livelihood of beneficiaries in drought-prone regions of Maharashtra, India during 2022-23. Data from 160 beneficiaries and 160 non-beneficiaries were collected through semi-structured interviews, focus group discussions, and published sources and data were analysed, The results shows that a significant increase in various aspects of beneficiary activities, including the utilization of women's productive time (MS 0.43 to 2.47), the regular employment generation index (MS 81.54 to 151.04), the livestock composition

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index (MS 1.46 to 2.39), the enterprises cost-effectiveness index (MS 17.27 to 48.83), the cultivated land utilization index (MS 0.22 to 0.67), and the irrigability index (MS 2.17 to 16.88). In terms of investment, horticultural crops received the highest allocation (MS 401) followed by animal husbandry (MS 360) and agricultural crops (MS 236). Farm pond income was predominantly directed toward purchasing farm inputs (56.88 %), with a smaller portion allocated to equipment (18.13%) and the least to non-agricultural businesses (1.25 %). Overall, the findings showed a significant improvement in the livelihood component of farm pond owners (MS 84.09), with the employment component exhibiting the highest mean score of 81.33, followed by the economic component (MS 75.97). These findings underscore the transformative potential of farm pond adoption in drought-prone regions, as it enhances livelihoods, empowers gender roles, and promotes diversified and sustainable agricultural practices within the locale of the study.

Keywords: Farm pond; livelihood; sustainability; utilization pattern.

1. INTRODUCTION

Maharashtra, a state in western India, has long grappled with the challenges posed by drought and water scarcity, particularly in its arid and semi-arid regions [1]. In these areas, traditional agriculture has often been constrained by unreliable rainfall and inadequate irrigation infrastructure [2]. However, a promising shift has been observed among farm pond owners in these drought-prone regions, as they embrace innovative farming practices to mitigate the impact of water shortages and transform their agricultural landscapes [3,4,5]. Farm ponds, reservoirs constructed on farmlands to capture and store rainwater, have emerged as crucial assets in addressing the water crisis [6,7,8,9]. These ponds serve as a lifeline for small and marginal farmers who rely on rainfed agriculture [10]. Over the past few years, farm pond owners in Maharashtra have recognized the potential of these reservoirs not only for water storage but also as a catalyst for sustainable farming practices [11,12,13]. Farm pond owners are now implementing efficient water management techniques, ensuring optimal utilization of the stored rainwater. Drip irrigation, sprinkler systems, and precision farming methods have become common, reducing water wastage and enhancing crop yields [14]. The availability of reliable water sources from farm ponds has encouraged farmers to diversify their crop choices. They are moving away from water-intensive crops and exploring drought-resistant and high-value crops, such as pulses, millets, and horticultural produce [15,10,16,17]. Enhanced farming practices are not only improving agricultural productivity but also the financial well-being of farm pond owners [18]. Increased yields and diversified income sources are helping them combat the economic uncertainties associated with drought [19,20]. This transformation among farm pond owners in drought-prone regions of Maharashtra signifies a paradigm shift in sustainable agriculture [21]. It showcases the potential of harnessing rainwater through farm ponds as a means to combat water scarcity, boost agricultural productivity, and improve the overall livelihoods of farmers in these challenging environments [22,21,23]. The journey towards more resilient and sustainable agriculture in Maharashtra is a testament to the power of local innovation and community-driven solutions in addressing critical regional challenges [24]. By bolstering agricultural resilience through extensive farm pond integration, drought region can fortify its agricultural sector, enhance food security, and empower farmers to grapple with the vagaries induced by climate change [23,5]. Acknowledging the pivotal role of farm ponds, the Maharashtra government introduced the '*Magel Tyala Shet Tale'* (farm ponds on demand) initiative in 2016, extending partial subsidies to farmers for farm pond construction. This study endeavours to unearth changes in livelihood and utilization Pattern of farm ponds, with the intent of formulating sustainable extension interventions to surmount challenges faced by farmers within the locale of the study. The insights garnered from the study will enrich our holistic comprehension of the exigency and status of farm ponds in Maharashtra, facilitating well-informed decision-making, targeted investments, and the formulation of robust policies conducive to sustainable agricultural practices in the state. By accentuating the enhancement of agricultural resilience through farm ponds, Maharashtra charts a course toward a more secure and prosperous future for its agrarian communities. This paper is focus on change in livelihood and utilization pattern of farm pond owners in drought prone areas of Maharashtra, India.

2. MATERIALS AND METHODS

The programme was implemented in 2016 For this study, hence an *ex post facto* research design was used to know intervention on beneficiaries of the programme. The Marathwada and Vidarbha regions of Maharashtra were chosen for the current study as they are high in their drought-affected state. Two districts were selected from each region, and further two blocks from each district were selected purposively due to having the highest number of farm ponds. Two villages were selected randomly from each block for the study. For the study, a total of 16 villages were drawn randomly. Twenty (20) respondents from each village, including farm pond beneficiaries and non-beneficiaries were selected randomly. Around 80 respondents from one district were selected, making a total of 320 respondents from four selected districts constitute the sample.

A structured schedule for data collection was used to assess changes in agricultural activities and farm pond practices by utilizing various indicators as follows, i.e livestock composition index, women productive time utilization ratio (WPTUR), regular employment generation index (REGI), irrigability index (II), cultivated land utilization index, enterprise cost-effectiveness index, and cumulative cube root frequency [25]. Indicators are variables or statistics that help to measure changes in a given situation/phenomenon, changes in state of something valued or change of quality. They are defined as specific and objectively verifiable measures of changes or results brought about by an activity (Guidelines UNDP, 1984). Careful selection of key indicators for monitoring and impact assessment is cost-effective as it is not possible to monitor every aspect of a project. The main challenge in identifying indicators is to select those that are sufficiently representative and at the same time easy to understand and measure on a routine basis.

The data and results should be cost effective in terms of time and money required to obtain them. Some indicators have been evolved and used in the world, mainly for assessing the bio-physical impacts in the watersheds [26, 27, 28, 29, 30]. However, many of these indicators cannot be easily understood or employed by the agencies implementing watershed development programmes in India. Recently, Sharda *et al.* [31] also evolved several indicators for assessing some of the bio-physical as well as socioeconomic impacts of the watershed development projects in the country which we used for this study. The following indicators were used in the study,

Women Productive Time Utilization Ratio (WPTUR): will help in indirectly assessing the benefits derived by the women stakeholders from watershed management programmes.

Women Productive Time Utilization Ratio = Time spent on more productive activities/Time spent on less productive activities

where, more productive activities cover dairying, cottage industry, cropping, horticulture and agri-business while less productive activities include fuel wood collection, water collection, grazing etc. An improvement in the ratio will indicate more productive utilization of the time by women folk in the watershed and vice versa

Regular Employment Generation Index (REGI): Watershed management projects are a great source of generation of one-time employment through land-based activities such as soil conservation, plantation (horticulture, forestry), and other works, as well as regular employment by introducing labour intensive new agricultural production technologies and non-land-based activities such as cottage industry or thrift societies for the land less rural masses. In case of regular employment, which is more important than the casual employment, the watershed management impact can be assessed through the Regular Employment Generation Index

$$\text{Regular Employment Generation Index (REGI)} = \sum_{i=1}^{n} Ei \times Ai(after\ the\ project) \times 100 \ / \sum_{j=1}^{k} Ej \times Aj(before\ the\ project)$$

where,

Ei = The number of man days utilized per hectare in the i enterprises (crop, horticulture, agro-forestry, forestry, livestock, fishery etc.) in a year after the project

Ai = Area in hectares utilized in the i enterprise (crop, i horticulture, agro-forestry, forestry, livestock, fishery etc.) in a year after the project,

Ej = The number of man days utilized per hectare in the j j enterprise (crop, horticulture, agro-forestry, forestry, livestock, fishery etc.) in a year before the project,

Aj = Area in hectares utilized in the j enterprise (crop, j horticulture, agro-forestry, forestry, livestock, fishery etc.) in a year before the project, and

k,n =Number of enterprises before and after the project, respectively.

Regular Employment Generation Index can attain any positive value, and any value higher than 100 will indicate the percentage improvement in regular employment leading to reduction in out migration under ceteris paribus condition.

Livestock Composition Index: For measuring the change in livestock composition between PrP and PoP scenarios, the ratio of total livestock units of improved breeds of cows and buffaloes and total livestock units of local breeds of cows and buffaloes is a useful indicator. The ratio can vary from 0 to infinity.

Livestock Composition Index (LCI) = Total livestock units of improved buffaloes & cross bred cows / Total livestock units of local buffaloes & cross bred cows

Enterprise Cost Effectiveness Index (ECEI): Benefits accrued out after introduction of an improved technology in a watershed can be assessed by Enterprise Cost Effectiveness Index which can be defined as:

ECEI= {(Benefits from improved technology /Benefits from traditional practice)/ (Cost of production through improved technology/ Cost of production through existing technology)} ×100

It can be computed separately for different physiographic locations of the watershed and for each important technology. The value of ECEI may vary from 0 to 100 and a higher value indicates higher net returns from the improved technology as compared to traditional practice followed by the farmers.

Cultivated Land Utilization Index (CLUI) indicates the impact of watershed interventions on changes in cultivable land area and duration of crop cultivation in PrP and PoP periods. It is calculated by summing the products of land area planted under each crop, multiplied by actual duration of days of that crop, and dividing the sum by the total cultivated land area times 365 days as given:

Cultivated Land Utilization Index (CLUI) = $\frac{\sum_{i=1}^{n} ai\ di}{\mathrm{A} \times 365}$

where, n are the total number of crops; a_i is the area occupied by i^{th} crop; d_i are the days that the i^{th} crop occupied in the a_i area; and A is total cultivable land area. The CLUI can attain a maximum value of 1.0 and higher value of CLUI indicates that the maximum part of cultivable area is under crop production for maximum period in a year.

2.1 Irrigability Index

Major utilization of the harvested water is for irrigation of crops to ensure sustainable agricultural production in the watershed. Irrigability Index (II) is a ratio of additional gross irrigated area and net incremental irrigated area. Gross irrigated area may be estimated by adding the net incremental irrigated area as many times as it was irrigated.

Irrigability Index (II) = $\frac{\text{Additional gross irrigated area}}{\text{Net Incremental irrigated area}}$

The index can attain any value more than 0, and a higher value will indicate successful utilization of harvested water in the watershed management project.

3. RESULTS AND DISCUSSION

The data related to major changes in the activities of farm pond owners is presented in Table1. The results revealed there is substantial improvements in several key indicators following the implementation of the farm pond. Specifically, the Enterprises Cost-Effectiveness Index was increased from 17.27 before the farm pond to 48.83 after farm pond establishment, with an index value of 9.31 and a t-value of -33.15, indicating a highly significant positive change ($p < .001$). Similarly, the Cultivated Land Utilization Index rose significantly from 0.22 to 0.67, with an index value of 0.67 and a t-value of -38.73, also demonstrating a strong and statistically significant improvement ($p < .001$). These results underscore the effectiveness of the farm pond in enhancing both the cost-effectiveness of enterprises and the utilization of cultivated land. Similarly, women's productive time utilization index, regular employment generation index, livestock composition index, and irritability index were also showed significant positive improvement. These findings are in line with a study done by Chowdary and Meghana [11].

Table 1. Major Changes in Activities of Beneficiary after Adoption of Farm Pond (n=160)

S. No.	Indicators	Before farm pond Mean score	After farm pond Mean score	Index value	t value	P>t
1.	Women's productive time utilization index	0.43	2.47	2.47	-18.58	.000***
2.	Regular employment generation index	81.54	151.04	185.23	-30..26	.000***
3.	Livestock composition index	1.46	2.39	2.39	-5.67	.000***
4.	Enterprises cost-effectiveness index	17.27	48.83	9.31	-33.15	.000***
5.	Cultivated land utilization index	0.22	0.67	0.67	-38.73	.000***
6.	Irrigability index	2.17	16.88	6.27	-33.52	.000***

****1% level of probability*

Table 2. Categorization of beneficiary based on cumulative cube root frequency method (n=160)

S. No.	Index	Low	Medium	High
		%	*%*	*%*
1.	Women's productive time utilization index	35.63	45.63	18.75
2.	Regular employment generation index	45.63	37.50	16.88
3.	Livestock composition index	62.50	21.88	15.63
4.	Enterprises cost-effectiveness index	22.50	46.25	31.25
5.	Cultivated land utilization index	19.38	35.63	45.00
6.	Irrigability index	27.50	53.13	19.38

The adoption of farm ponds has led to profound and statistically significant improvements in various aspects of beneficiary activities. Notably, there was a substantial increase in women's productive time utilization, empowering them to engage more effectively in productive activities. Additionally, farm ponds have become catalysts for job creation and income generation, contributing to economic well-being. Furthermore, improvements in livestock composition, enterprise cost-effectiveness, cultivated land utilization, and irrigability index underscore the multifaceted benefits of farm pond adoption, enhancing agricultural productivity and resource utilization.

The major changes in agriculture activities of farm pond owners are classified according to cumulative cube root frequency method (CCFM) and are given in Table 2. According to CCFM, in the women's productive time utilization index, it is found that the majority of the respondents (45.63 %) were observed in the medium category followed by low (35.63 %) and high category (18.75 %), respectively. In the regular employment generation index, it is found that the majority of respondents (45.63 %) were observed in the low category followed by medium (37.50 %) and high category (16.88 %), respectively. In the case of the livestock composition index, it is found that the majority of respondents (62.50 %) were observed in the low category followed by medium (21.88 %) and high category (15.63 %), respectively. In the enterprise's cost-effectiveness index, it is found that the majority of respondents (46.25 %) were observed in the medium category followed by the high (31.25 %) and low category (22.50 %). In the case of the cultivated land utilization index, it is found that the majority of respondents (45 %) were observed in the high category followed by medium (35.63 %) and low category (19.38 %), and in the irrigability index majority respondents (53.13 %) were in medium category followed by low (27.50 %) and high category (19.38 %), respectively.

3.1 Utilization Pattern of Agriculture Income by the Farm Pond Owners

A glance at Table 3 showed that majority of beneficiaries has allocated their income for essential agricultural purposes, with 56.88 per cent directed towards farm inputs like fertilizers, seeds, and pesticides. Furthermore, 18.13 per cent invested in farm equipment, emphasizing improved agricultural productivity and efficiency. A smaller fraction (2.50 %) was used for personal reasons, such as family functions, while 5.00 per cent was invested in purchasing cattle, indicating income diversification. Additionally, 7.50 per cent was used to repay money lenders, and 3.75 per cent is allocated for repaying old debts to banks, reflecting financial obligations in the agricultural sector. A minor portion (1.25%) is utilized to purchase land, possibly for expansion or investment, while another 1.25 per cent is designated for non-agricultural businesses. A similar percentage lends their income to others, supporting local economic activities. Lastly, 2.50 per cent of beneficiaries have specified other purposes for their income, demonstrating individual preferences and diverse needs, The agriculture farm pond incomes primarily serve the needs of the agricultural sector, with a significant emphasis on inputs and equipment. However, it also plays a role in the personal and financial aspects of beneficiaries' lives, showcasing the multifaceted nature of agricultural income in rural livelihoods.

3.2 Investment in Farm Component by Farm Pond Owners

The data related to investment in farm pond components by beneficiary is depicted in Table4. The results found that a majority of the farm pond owners’ investment in horticultural crops with a mean score of 401 followed by investment in animal husbandry (MS 360), investment inthe agricultural crop (MS 236), investment in maintenance cost of farm pond (MS 136) and investment on food (MS 132).

The categorization of investment on farm component by farm pond owners, according to the cumulative cube root frequency method, investment on food items found that the majority of respondents (48.75%) were observed in low category followed by medium (27.50%) and high category (23.75%), respectively. In investment agriculture revealed that the majority of respondents (45%) were observed in the medium category followed by the low (41.25%) and high category (13.75%), respectively.

Regarding investment in horticultural crops, 48.12 per cent were observed in the medium category followed by the high (31.87%) and low category (20%), respectively. In the case of investment in animal husbandry (livestock & fishery), a majority of respondents (48.75%) were observed in the low category followed by the medium (40%) and high category (11.25%).

Table 3. Utilization pattern of farm pond income by the beneficiary (n=160)

S. No.	Utilization of Agriculture Income	%
1.	To purchase farm inputs (fertilizers, seeds, pesticides, etc.)	56.88
2.	To purchase farm equipment (e.g., tractor, thresher)	18.13
3.	For family function	2.50
4.	To purchase cattle	5.00
5.	To return money to a money lender	7.50
6.	To return the bank's old debt	3.75
7.	To purchase land	1.25
8.	For non-agricultural business	1.25
9.	To lend out to others	1.25
10.	Other (specify)	2.50

Table 4. Investment on farm component after adoption of farm pond (n=160)

S. No.	Component	Mean score	Low		Medium		High	
			f	***%***	***f***	***%***	***f***	***%***
1.	Investment on food (Nutrition and food security)	132	78	48.75	44	27.50	38	23.75
2.	Investment on agricultural crop	236	66	41.25	72	45.00	22	13.75
3.	Investment on horticultural crops	401	32	20.00	77	48.12	51	31.87
4.	Investment on animal husbandry (livestock & fishery)	360	78	48.75	64	40.00	18	11.25
5.	Increasing in maintenance cost of farm pond	136	88	55.00	53	33.12	19	11.88

Table 5. Change in livelihood component of beneficiary after adoption of farm pond (n=160)

S. No.	Livelihood Component	Mean Score
1.	General component	49.56
2.	Economic component	75.97
3.	Social component	66.38
4.	Material component	68.78
5.	Employment component	81.33
6.	Overall component	84.09

Table 6. Categorization of Beneficiary According to the Cumulative cube root frequency method (n=160)

S. No.	Category	CCRF Score	*f*	%
1.	Low	< 82.62	68	42.50
2.	Medium	82.62 – 86.28	65	40.63
3.	High	> 86.28	27	16.87

In addition, in the maintenance of the farm pond, the majority of respondents (55%) were observed in the low category followed by medium (33.12%) and high (11.88%), respectively.

3.3 Change in Livelihood Component of Farm Pond Owners

The change in the livelihood component of farm pond owners was analysed and is presented in Table 5. The result related to the overall change in the livelihood component of farm pond owners after the adoption of farm ponds was found significant change with a mean score of 84.09. Among livelihood components employment component had the highest mean score i,e 81.33 followed by the economic component (MS 75.97), material component (MS 68.78), social component (MS 66.38), and general component (MS 49.56) of the farm pond owners.

The change in the livelihood component of farm pond owners is classified according to the cumulative cube root frequency method (Table 6). It is found that the majority of respondents (42.50 %) were observed in the low category followed by medium (40.63%) and high category (16.87%) of change in the livelihood of farm pond beneficiaries.

3.4 Extension Interventions for Successful Utilizationof Farm Ponds

The following extension interventions have been suggested for successful utilization of farm ponds:

- The state should promote farm pond technology adoption among non-beneficiary farmers to maximize irrigation potential and increase crop yields per drop.
- Prioritize the continuation of the farm pond program, focusing on small and marginal farmers due to its positive economic and social impact.
- Re-evaluate subsidy distribution, giving more emphasis to assisting marginal and small farmers to minimize losses from land allocation for farm ponds.
- Regulate groundwater extraction for storage in agricultural ponds in officially designated exploited watersheds and water scarcity zones.
- Include provisions for controlling the quantity and size of agricultural ponds based on geographical variables in each village within the farm pond program.
- Collaborate with local institutions or non-governmental organizations to develop sustainable alternatives to plastic linings in agricultural ponds, supported by state extension agencies.
- Mandate efficient irrigation methods like drip and sprinkler systems for farm pond beneficiaries to enhance crop yields and increase subsidies for such practices.
- Promote integrated farming systems that encompass horticulture, livestock, and fisheries components to improve long-term revenue and resource efficiency.
- Establish community platforms in each village to facilitate knowledge exchange, resource mobilization, and technology utilization.
- Implement geo-tagging and monitoring of farm ponds every 3 to 5 years, and provide financial support for maintenance and construction, while also encouraging direct marketing, mechanization, and ongoing

program improvement for the economic well-being of farm pond beneficiaries.

4. CONCLUSION

The study unequivocally demonstrates the transformative impact of farm pond adoption on the livelihoods of beneficiaries in drought-prone regions of Maharashtra, India. All major activities of farm pond owners exhibited significant changes after adoption, and these changes were highly statistically significant at the 1% level. Notably, the increase in the women's productive time utilization index underscores the gender-empowering effects of farm ponds, enabling more effective engagement of women in productive activities. The substantial rise in the regular employment generation index reflects farm ponds' pivotal role in job creation and income enhancement for beneficiaries. Furthermore, improvements in livestock composition, enterprises' cost-effectiveness, cultivated land utilization, and irrigability index highlight the multifaceted benefits of farm pond adoption, including enhanced agricultural productivity and resource utilization. The utilization pattern of agriculture income by farm pond owners demonstrates a judicious allocation of income primarily towards agricultural needs, with a notable focus on inputs and equipment. The investments in various components indicate a strong emphasis on horticultural crops and animal husbandry, reinforcing the diversification of income sources among beneficiaries. Therefore, the findings of the study underscore the significance of sustainable water management practices in addressing the challenges of agriculture and livelihood enhancement in drought-prone regions for significant changes in the livelihood components of farm pond owners.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Patel PM, Saha D, Shah T. Sustainability of groundwater through community-driven distributed recharge: An analysis of arguments for water scarce regions of semi-arid India. Journal of Hydrology: Regional Studies. 2020;29:100680.
2. Raman R, Khan KA. Failing agriculture and frazzled farmers: The inside story of india’s most populous States—UP and Maharashtra. Development Challenges of India after Twenty-Five Years of Economic Reforms: Inequality, Labour, Employment and Migration. 2020;331-353.
3. Babu S, Das A, Mohapatra KP, Yadav GS, Singh Raghavendra, Tahashildar Moutusi, Prakash N. Pond dyke utilization: an innovative means for enhancing productivity and income under integrated farming system in north east hill region of India. Indian Journal of Agricultural Science. 2019;89 (1):117-122.
4. Singh R, Akuraju V, Anantha KH, Garg KK, Barron J, Whitbread AM, Inder dev, Dixit S. Traditional rainwater management (haveli cultivation) for building system level resilience in a fragile ecosystem of Bundelkhand Region, Central India. Frontiers in sustainable food systems. 2022;6:826722.
5. Gireesh S, Kumbhare NV, Padaria RN, Burman RR, Kumar P, Bhoumik A, Shiv Prasad. Beneficiary participation and sustainability of farm pond in Maharashtra’s Marathwada and Vidarbha regions. Journal of Community Mobilization and Sustainable Development. 2023; 180(3): 365-371.
6. Yadav BM, Tibile RM, Indulkar ST, Sharangdhar ST. Aquaculture based interventions for livelihood and empowerment of women in konkan region of Maharashtra. Asian Journal of Agricultural Extension, Economics & Sociology. 2022;40 (10):215-20.
Available:https://doi.org/10.9734/ajaees/2022/v40i1031063
7. Barman Sinki, Animesh Deka, Rudra Narayan Borkakati, Niranjan Deka, and Prasanna Kumar Pathak. Evaluation of ICAR schemes / approaches- progressive farmers perception on kvks activities. Journal of Experimental Agriculture International. 2022;44 (10):100-104.
Available:https://doi.org/10.9734/jeai/2022/v44i1030883.
8. Mushtaq S, Dawe D, Lin H, Moya P. An assessment of the role of ponds in the adoption of water-saving irrigation practices in the Zhanghe Irrigation System,

China. Agricultural Water Management. 2006;16;83(1-2):100-10.
9. Tariqul Islam M, Mohabbat Ullah M, Mostofa Amin MG, Hossain S. Rainwater harvesting potential for farming system development in a hilly watershed of Bangladesh. Applied Water Science. 2017; 7:2523-32.
10. Rao, Ch Srinivasa, Rejani R, Rama Rao CA, Rao KV, Osman M, Srinivasa Reddy K, Manoranjan Kumar, and Prasanna Kumar. Farm ponds for climate-resilient rainfed agriculture. Current Science. 2017: 471-477.
11. Chowdary N, Mukherjee M. Agrarian potential of in-situ water harvesting. Economic & Political Weekly. 2019; l(4):26 & 27.
12. Ghungarde DS. Impact of farm-ponds on changing cropping pattern: A Case study of wadule village in parner tehsil of ahmednagar district (Maharashtra). Peer Reviewed International Research Journal of Geography. 2021;38(2):23-29.
13. Shivakumarappa G, Kumbhare NV, Padaria RN, Burman RR, Kumar P, Bhoumik A, Prasad S. Constraints in the adoption of farm pond in drought regions of Maharashtra. Indian Journal of Extension Education. 2023;59(1):142-145.
14. Koech R, Langat P. Improving irrigation water use efficiency: A review of advances, challenges and opportunities in the Australian context. Water. 2018;10 (12): 1771.
15. Robert M, Thomas A, Sekhar M, Badiger S, Ruiz L, Willaume M, Bergez JE. Farm typology in the Berambadi Watershed (India): Farming systems are determined by farm size and access to groundwater. Water. 2017;9(1):51.
16. Jakkawad SR, Ahire RD, Sawant RC. Impact of farm ponds on its beneficiaries in terms of technological and economical changes. Journal of Entomology and Zoology Studies. 2020; 8(1):1469-1473.
17. Gireesh S, Kumbhare NV. Awareness and adoption of pigeonpea and chickpea production technologies in marathawada and vidarbha regions of Maharashtra, India. Journal of Community Mobilization and Sustainable Development. 2022;17(4): 1065-1070.
18. Kiresur VR, Nayak MR, Gaddi GM, Khyadagi KS. Improved farm technology adoption and its role in doubling farmers' income: A case of dry zones in Karnataka. Agricultural Economics Research Review. 2017;30:(347-2017-2754).
19. Anantha KH, Garg KK, Moses DS, Patil MD, Sawargaonkar GL, Kamdi PJ, Wani SP. Impact of natural resource management interventions on water resources and environmental services in different agroecological regions of India. Groundwater for Sustainable Development. 2021;13: 100574.
20. Das A, Choudhury BU, Ramkrushna GI, Tripathi AK, Singh RK, Ngachan SV, Patel DP, Layek J, Munda GC. Multiple use of pond water for enhancing water productivity and livelihood of small and marginal farmers. Indian Journal of Hill Farming. 2013;26(1):29-36.
21. Shah SH, Harris LM, Johnson MS, Wittman H. A 'drought-free' Maharashtra? Politicizing water conservation for rain-dependent agriculture. Water Alternatives. 2021;14 (2):573-596.
22. Mondal S, Vema VK, Kurian C, Sudheer KP. Improving the crop productivity in rainfed areas with water harvesting structures and deficit irrigation strategies. Journal of Hydrology. 2020;586:124818.
23. Prasad P, Damani OP, Sohoni M. How can resource-level thresholds guide sustainable intensification of agriculture at the farm level? A system dynamics study of farm-pond based intensification. Agricultural Water Management. 2022; 264:107385.
24. Shah M, Vijayshankar PS. Symbiosis of water and agricultural transformation in India. In Indian Agriculture Towards 2030: Pathways for Enhancing Farmers' Income, Nutritional Security and Sustainable Food and Farm Systems . Singapore: Springer Nature Singapore. 2022;109-152.
25. Sharda VN, Dogra P, Dhyani BL. Indicators for assessing the impacts of watershed development programmes in different regions of India. Indian Journal of Soil Conservation. 2012;40(1):1-12.
26. Sanchez E, Colmenarejo MF, Vicente J, Rubio A, García MG, Travieso L, Borja R. Use of the water quality index and dissolved oxygen deficit as simple indicators of watersheds pollution. Ecol. Indic. 2007;7(2):315-328.
27. Chen W, Wei X. Assessing the relations between aquatic habitat indicators

and forest harvesting at watershed scale in the interior of British Columbia. Forest Ecol. Manag. 2008;256(12):152-160.

28. Sinclair A, Hebb D, Jamieson R, Gordon R, Benedict K, Fuller K, Stratton GW, Madani A. Growing season surface water loading of faecal indicator organisms within a rural watershed. Water Res. 2009;43(5):1199-1206.
29. Fitch DT, Stow DA, Hope AS, Rey S. MODIS vegetation metrics as indicators of hydrological response in watersheds of California Mediterranean-type climate zones. Remote Sens. of Environ. 2010;114: 2513-2523.
30. Careya RO, Migliacciob KW, Lic Y, Schafferd B, Kikere GA, Brownf MT. Land use disturbance indicators and water quality variability in the Biscayne Bay Watershed, Florida. Ecol. Indic. 2011;11(5):1093-1104.
31. Sharda VN, Samra JS, Dogra P. Participatory watershed management programmes for sustainable development: Experiences from IWDP. Indian J. of Soil Conserv. 2005;33(2): 93-103.

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