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Returns on investment in farm pond construction and maintenance

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Abstract
Water scarcity in the semi-arid Latur district of Maharashtra adversely affects agricultural productivity. This study assesses the financial feasibility and return on investment (ROI) of constructing and maintaining farm ponds as a sustainable irrigation strategy. A purposive sampling of 120 farmers (60 farm pond users and 60 non-users) from six talukas was undertaken. Data were collected through personal interviews and analyzed using standard cost concepts, farm income measures, and discounted cash flow methods including Net Present Value (NPV), Benefit-Cost Ratio (BCR), Internal Rate of Return (IRR), and Profitability Index (PI). Results indicated a significant increase in cropping intensity (from 190.57% to 247%) and introduction of *summer* cropping due to farm pond use. Financial analysis revealed lined and unlined ponds to be economically viable, with BCR's of 1.35 and 1.31 and IRRs exceeding 108%. The study concludes that farm ponds enhance water security, increase farm income, and are sustainable investments for farmers in drought-prone areas.

Keywords: Farm pond, ROI, financial analysis, cost-benefit analysis, net present value, internal rate of return

Introduction
Water availability is a crucial determinant of agricultural productivity, especially in semi-arid and drought-prone regions like Latur district in Maharashtra. These areas frequently experience erratic rainfall and prolonged dry spells, which severely impact crop growth and yields. Traditional rainfed farming systems struggle to maintain consistency in production due to the unpredictability of monsoons. In such contexts, farm ponds have emerged as a promising water conservation and management strategy. These small, on-farm reservoirs collect rainwater during the monsoon and store it for use during periods of water scarcity, especially during critical crop growth stages. Their role is particularly important in enhancing resilience in regions where groundwater depletion and climate variability threaten agricultural sustainability (Singh *et al.,* 2012) [11].

While the technical benefits of farm ponds are well acknowledged, their economic viability especially for small and marginal farmers requires careful analysis. Constructing and maintaining a farm pond involves considerable costs related to excavation, lining, and regular upkeep. Cost-benefit analysis (CBA) is essential to evaluate the return on investment, taking into account both direct benefits (higher yields, irrigation efficiency) and indirect benefits (livelihood diversification, risk reduction) (Patel & Reddy, 2015) [8].

Studies have shown that farm ponds can become financially sustainable within 3-5 years, depending on rainfall patterns, crop choices, and water usage. They also reduce farmer's dependency on government relief during droughts and promote long-term income stability (Sharma *et al.,* 2019) [10].

Objectives
1. To study the Socio-economic profile of farm pond farmers.
2. To assess the return on investment (ROI) of constructing and maintaining farm ponds.

Methodology

1. Selection of Sample

The study was conducted in Latur district, Maharashtra, covering six talukas: Latur, Renapur, Chakur, Nilanga, Ausa, and Shirur-Anantpal. For selection of sample respondents purposive sampling design was used in which the list of farm pond beneficiaries was obtained from Agriculture Department of Jilla Parishad, Latur. Using purposive sampling, 60 farm pond owners and 60 non-farm pond farmers were selected. Primary data were collected through personal interviews using pre-tested schedules.

For testing the financial feasibility of an investment in farm pond, 60 farm pond owners were selected, in such way that selected based on the list of farmers who had constructed farm pond 1 to 10 years ago (i.e. before 1, 2, 3, 4…. up to 10 years). Were purposively selected for the study. Accordingly, 2, 4, 2, 0, 9, 11, 18 and 14 farmers were selected respectively.

2. Analysis of data

a. Socio-economic characteristics of selected sample:

The collected data was analyzed using a combination of descriptive and inferential statistical techniques to draw meaningful insights and comparisons between farm pond adopters and non-farm pond adopters.

b. Returns on investment of constructing and maintaining farm ponds: The standard cost of concept was use to achieve the objectives:

A. Cost concepts

a. **Cost A_1** = All paid cost + depreciation + land revenue + Interest on working capital + miscellaneous cost
b. **Cost A_2** = Cost A_1 + Rent paid for leased-in land
c. **Cost B_1** = Cost A_1 + Interest on fixed capital (excluding land)
d. **Cost B_2** = Cost B_1 + Rental value of owned land + rent for leased-in land
e. **Cost C_1** = Cost B_1 + Imputed value of family labour
f. **Cost C_2** = Cost B_2 + Imputed value of family labour
g. **Cost C_3** = Cost C_2 + 10 Per cent of Cost C_2 as management cost
h. **Cost of production**

$$\text{Cost of production per quintal} = \frac{\text{Cost of cultivation per hectare}}{\text{Quantity of main produce per hectare}}$$

B. Farm Income measures

1. **Gross income (GI):** It is the total value of main product and by product.

$$GI = (Q_m x\ P_m).(Q_b x\ P_b)$$

Where,
Q_m = quantity of the main produce
P_m = price of the main produce
Q_b = quantity of the by produce
P_b = price of the by produce

2. **Return over variable costs**

$$RVC = \text{Gross income} - \text{Cost } A_1$$

3. **Farm business income**

$$FBI = \text{Gross income} - \text{Cost } A_2$$

4. **Family labour income**

$$FLI = \text{Gross income} - \text{Cost } B_2$$

5. **Net income**

$$NI = \text{Gross income} - \text{Cost } C_2$$

6. **Returns to management**

$$RM = \text{Gross income} - \text{Cost } C_3$$

C. Financial feasibility of farm pond

a. Net Present Value (NPV): Net Present Value (NPV) of the project is estimated using the following equation:

$$NPV = \frac{P_1}{(1+i)^{t_1}} + \frac{P_2}{(1+i)^{t_2}} + \ldots + \frac{P_n}{(1+i)^{t_n}} - C$$

Where,
P_1 = Net cash flow in first year,
i = Discount rate,
t = Time period,
C = Initial cost of the investment.

b. Benefit: Cost Ratio: A second discount measure of project worth is the benefit-cost ratio.

$$B - C \text{ Ratio} = \frac{\sum_{t=1}^{n} \frac{B_t}{(1+r)^n}}{\sum_{t=1}^{n} \frac{C_t}{(1+r)^n}}$$

Where,
B_t = Benefit
C_r = Cost

c. Internal Rate of Return (IRR): It is calculated by

$$IRR = r_L + (r_H - r_L)\left(\frac{NPV_L}{|NPV_L - NPV_H|}\right)$$

Where,
r_L = Lower discount rate
r_H = Higher discount rate
NPV_L = NPV at lower discount rate
NPV = NPV at higher discount rate

d. Profitability Index (PI): The profitability index (PI) is as follows:

$$PI = \frac{NPV}{co} = \frac{1}{co}\sum_{1=0}^{n}\frac{cr}{(1+i)^n}$$

Where,
C_r = Total capital required
Co = Initial capital expenditure

Results and Discussion

1. Socio-economic characteristics of selected sample

The socio-economic profile of the participants was evaluated in order to comprehend the farmers backgrounds and their ability to implement agricultural interventions, such as farm ponds.

1.1 General profile of respondents

It plays crucial role in socio-economic and impact assessment studies. The significance of capturing and analyzing this profile is multidimensional. Table 1 presents the socio-demographic characteristics of selected respondents categories into two groups: farm pond farmers and non-farm pond farmers, with 60 respondents in each group.

1. **Gender:** It is observed from the table that among the farm pond farmers, a majority were male (85%), while female constituted only 15 per cent. These indicates male predominance in farming activities across the group. This aligns with findings by Gupta and Dey (2015) [4], who observed that agricultural decision making in rural India is primarily dominated by male.
2. **Age:** It is found that majority of users were middle age category, comprising 63.33 per cent followed by young farmers (28.33%) and elders (8.33%). In contrast, non-farm pond farmers were slightly more distributed with 48.33 per cent in middle age group. This observation corroborates the results of Gupta & Dey (2015) [4], who reported that middle age farmers are more proactive in adopting farm.
3. **Marital status:** From table 1, it is seen that 85 per cent of the farm pond farmers and 98.33 per cent non-farm pond farmers were married, indicating a predominance of married individuals in both groups possibly reflecting stable family structures commonly engaged in farming. Njera *et al.*, (2017) [6] emphasized that married farmers are more inclined towards long term investments such as farm ponds as these are perceived to provide security for the families future.
4. **Religion:** Regarding religion composition it is found that the majority of respondents in both groups, belong to the Hindu religion- 96.67 per cent among farm pond farmers and 90 per cent among non-farm pond farmers. Bhutti *et al.*, (2015) [2] noted that minority community sometimes face challenges in accessing public schemes and subsidies (Due to lack of awareness of systematic barriers).

a. **Land holding pattern of respondents:** The Table 2 shows the distribution of land holding sizes among farm pond adopters and non-farm pond adopters in the study area. The table revealed that among farm pond adaptors, 56.67 per cent were marginal farmers, 40 per cent were small farmers and only 3.33 per cent had semi-medium holdings. Among non-farm pond users a similar trend was observed According to Njera *et al.*, (2017) [6] small and marginal farmers often adopt farm ponds when supported by government subsidies, as they lack the capital to invest independently.

b. **Sources of irrigation:** Source of irrigation plays a vital role in determining a stability and productivity of farming in drought prone regions like Latur. It is evident from the table 3 that, 38.33 per cent of farm pond users and 36.67 per cent of non-users found to be using open well. While borewells, the most common traditional source used by 63.33 per cent farm pond adopter and 65 per cent of non-adopters. These findings aligned well with Sabina *et al.*, (2023) [9] study found that 23 per cent of farmers had relied solely on farm ponds, and 37 per cent had used ponds along with borewells, indicating a clear shift away from traditional water sources like open wells and rainfall dependence.

c. **Cropping pattern of before and after construction of farm pond farmers:** The Table 4 presents the cropping pattern before and after farm pond construction. Gross Cropped Area (GCA) increased from 1.72 ha to 2.24 ha, and Cropping Intensity (CI) rose from 190.57% to 247%. *Summer* crops like sugarcane and coriander were introduced post-pond construction, showing better land use and crop diversification. Deshmukh *et al.*, (2019) found that, the construction of farm pond leads to significant increase in GCA and CI among small and marginal farmers in drought prone areas of Maharashtra. These findings corroborated with Tadigiri *et al.*, (2023) [12], reported a rise in cropping intensity from 203.75 per cent to 225 per cent, along with the introduction of *summers* crops and expansion of high-value *rabi* crops-indicating a comparable shift in cropping pattern and land use.

d. **Cropping pattern of non-farm pond farmers:** The cropping pattern of the non-farm pond farmers in the study area is presented in Table 5. It is observed from the table that non-farm pond users had limited cropping confined to *kharif* and *rabi* seasons, lacking *summer* crops and diversification. These findings mirrored with Kumar *et al.*, (2016) [5], revealed a substantial increase in cropping intensity and crop diversification after the construction of farm ponds.

2. Returns on investment of constructing and maintaining farm ponds

It provides a quantifiable and direct measure of the financial viability of farm ponds, which is essential for evaluating their impact on farmer's economic well-being. ROI analysis enables a clear understanding of whether the costs incurred in constructing and maintaining these ponds are justified by the returns in terms of increased agricultural productivity, cropping intensity, and income.

2.2 Construction cost breakup of farm pond:

Based on Table 6, it is seen that, the total construction cost, lined ponds cost ₹1,22,132.50, while unlined ponds cost ₹87,894.00. Lined ponds incurred higher costs due to plastic lining (27.16%), whereas fencing and earthwork dominated costs in unlined ponds. The cost structure highlights the affordability and durability trade-off between pond types. The construction cost components detailed in Table 6 closely mirrored the findings of Bhandari and Mailapalli (2021) [1], who evaluated farm ponds in the Kharagpur blocks of West Bengal. Their study emphasized that major expenditures were consistently incurred on earthwork, pump sets, and fencing, similar to the present results where these components made up the bulk of total costs in both lined and unlined ponds.

3 **Annual operational and maintenance cost:** The Table 7 presents the annual operational and maintenance (O&M) costs associated with both lined and unlined farm ponds.

Lined ponds required ₹10,201.60 annually, while unlined ponds needed ₹8,056.27. The higher cost in lined ponds is due to increased maintenance for lining, bunds, and energy use, but it ensures better water retention. The results of the present study regarding annual operational and maintenance costs (Table 7) aligned well with the findings of Bhandari and Mailapalli (2021) [1]. They highlighted that recurring costs such as cleaning/desilting, pump repair, and energy use significantly influence total annual expenditure for both lined and unlined farm ponds.

4 **Incremental crop income attributable to farm pond**: The Table 8 illustrates the increase in crop yields and income resulting from the use of farm ponds for irrigation. The data clearly demonstrates that farm ponds have contributed significantly to higher yields and incremental income for multiple crops in the Latur district Table 8 shows income gains from irrigation using farm ponds. Soybean yield increased by 16.02 q/ha, earning an additional ₹68,758.80. Pigeon pea gained 16.62 q/ha, translating into ₹78,521.19. Chickpea yield increase added ₹38,677.33. These figures confirm that farm pond irrigation enhances productivity and profitability. Among the evaluated crops, soybean, pigeon pea, and chickpea showed notable yield increases when irrigation was available through farm ponds. The findings from Table 8 confirm that farm ponds significantly enhance crop yields and income levels. The findings of the present study on incremental crop income attributable to farm pond use (Table 8) showed close similarity with those reported by Gulkari, *et al.*, (2020) [3]. Their study conducted in Vidarbha also reported significant increases in yields and farm income for crops like soybean and pigeon pea when supported by farm pond-based irrigation, which closely mirrored the incremental gains observed in data.

5 **Annual cash flow statement for returns over investment**: The Table 9 presents a comparative analysis of the annual cash flows for both lined and unlined farm ponds over an eight-year period. The cash flow is evaluated based on cash inflow (returns), cash outflow (costs), and net cash flow (inflow minus outflow) for each year. In the first year, both types of ponds show negative net cash flows due to the high initial investment cost. For lined ponds, the cash inflow was ₹1,50,557, but the outflow was ₹1,98,958, resulting in a net loss of ₹48,401. Similarly, for unlined ponds, the cash inflow was ₹1,22,258 and the outflow was ₹1,57,343, resulting in a net loss of ₹35,085. Despite showing negative cash flows in the first year due to high capital investment, both pond types turned profitable from the second year onward, demonstrating their potential as sustainable water management solutions. This analysis strongly supports the use of farm ponds as an effective strategy for improving farmer's income, reducing water risk, and enhancing agricultural productivity in the study area. This trend closely aligned with the findings of Palanisami *et al.*, (2011) [7], who assessed the economic returns from watershed development programs using an economic surplus method and reported substantial increases in annual cash inflows and net returns over time due to improved water availability and resource management.

6 **Economic indicators of farm pond investment**: The Table 10 presents the economic indicators for lined and unlined farm pond investments using standard financial appraisal tools. The Net Present Value (NPV) of the lined farm pond was found to be ₹2,12,417.65, while the NPV for the unlined farm pond stood at ₹1,64,228.97. A positive NPV in both cases confirms that the investment in farm ponds generates returns above the assumed opportunity cost of capital, i.e., 12 per cent. The Benefit-Cost Ratio (BCR) was calculated as 1.35 for lined ponds and 1.31 for unlined ponds. Both values are greater than 1, which means that the present value of benefits exceeds the present value of costs in both cases. The Internal Rate of Return (IRR) for lined ponds was estimated at 108.87 per cent, and for unlined ponds, it was 109.33 per cent. These values are significantly higher than the discount rate of 12 per cent, indicating high profitability and rapid capital recovery in both systems. These findings are well-aligned with the results reported by Palanisami *et al.*, (2011) [7], who evaluated watershed development programs using the economic surplus method and found that investments in water harvesting structures such as farm ponds yielded positive NPVs, BCRs greater than 1, and IRRs well above the discount rate, making them highly profitable and sustainable for farmers in semi-arid regions.

Table 1: General profile of respondents

Sr. No.	Particulars	Farm pond Farmers (N=60)	Percentage (%)	Non-farm pond farmers (N=60)	Percentage (%)
I. Gender					
1	Male	51	85.00	56	93.33
2	Female	9	15.00	4	6.67
	Total	60	100.00	60	100.00
II. Age Group					
1	Young (25-44 years)	17	28.33	15	25.00
2	Middle (44-60 years)	38	63.33	29	48.33
3	Elder (60-75 years)	5	8.33	16	26.67
	Total	60	100.00	60	100.00
III. Marital Status					
1	Married	51	85.00	59	98.33
2	Unmarried	9	15.00	1	1.67
	Total	60	100.00	60	100.00
IV. Religions					
1	Hindu	58	96.67	54	90.00
2	Muslim	2	3.33	6	10.00
3	Other	0	0.00	0	0.00
	Total	60	100.00	60	100.00

Table 2: Land holding pattern of respondents

Sr. No.	Land holding size	Farm pond Farmers (N=60)	Percentage (%)	Non-farm pond farmers (N=60)	Percentage (%)
1	Marginal (<1 ha)	34	56.67	37	61.67
2	Small (1 - 2 ha)	24	40.00	23	38.33
3	Semi-medium (2 - 4 ha)	2	3.33	0	0.00
4	Medium (4 - 10 ha)	0	0.00	0	0.00
5	Large (above 10 ha)	0	0.00	0	0.00
	Total	60	100.00	60	100.00

Table 3: Source of irrigation

Sr. No.	Source	Farm pond Farmers (N=60)	Percentage (%)	Non-farm pond farmers (N=60)	Percentage (%)
1	Farm Pond	60	100.00	0	0.00
2	Open well	23	38.33	22	36.67
3	Bore well	38	63.33	39	65.00

Table 4: Cropping pattern of before and after construction of farm pond farmers

Sr. No.	Season	Crop	Before farm pond (ha.)	Percentage (%)	After farm pond (ha.)	Percentage (%)
A	*Kharif*	Soybean	0.73	42.24	0.51	22.52
		Pigeon pea	0.81	10.35	0.40	17.95
		Total (A)	0.91	52.59	0.91	40.47
B	*Rabi*	Chickpea	0.67	38.64	0.16	7.32
		Sorghum	0.15	8.77	-	-
		Wheat	-	-	0.42	18.93
		Sugarcane	-	-	0.30	13.29
		Total (B)	0.82	47.41	0.89	39.54
C	*Summer*	Sugarcane	-		0.30	13.29
		Coriander	-		0.15	6.69
		Total (C)	-		0.45	19.98
	Gross cropped area (A+B+C)		1.72	100	2.24	100
	Net cropped area		0.91	100	0.91	100
	Double cropped area		0.81		1.34	
	Cropping Intensity		190.57		247	

Table 5: Cropping pattern of non-farm pond farmers

Sr. No.	Particulars	Non-Farm pond	
		Average	Percentage (%)
	A. *Kharif*		
1	Soybean	0.36	23.01
2	Pigeon pea	0.43	27.41
	Total (A)	0.79	50.42
	B. *Rabi*		
3	Chick pea	0.36	22.70
4	Sorghum	0.42	26.88
	Total (B)	0.78	49.58
	Gross Cropped Area (A+B)	1.57	100
	Net Cropped Area	0.79	100
	Double Cropped Area	0.78	
	Cropping Intensity	197.98	

Table 6: Construction cost breakup of farm pond

Sr. No.	Components	Lined farm pond		Unlined farm pond	
		Total cost	Share in total cost	Total cost	Share in total cost
1	Earthwork	27620.00	22.61	27892.00	31.73
2	Lining (plastic)	33171.50	27.16	0.00	0.00
3	Inlet-outlet pipe and valve	5389.00	4.41	5551.00	6.32
4	Pump Set	21552.00	17.65	22520.00	25.62
5	Fencing	28300.00	23.17	29831.00	33.94
6	Transportation	1280.00	1.05	2100.00	2.39
7	Anchoring the lining	4820.00	3.95	0.00	0.00
	Total	122132.50	100.00	87894.00	100.00

Table 7: Annual operational and maintenance cost

Sr. No.	Particulars	Lined farm pond		Unlined farm pond	
		Frequency	Cost	Frequency	Cost
1	Cleaning and desilting	1	3196.00	1	2585.71
2	Repair of bunds	1	1328.00	1	1232.00
3	Pump repair	1	2731.60	2	1546.28
4	Electricity or Diesel cost	Monthly	1200.00	Monthly	1500.00
5	Labour charges	Seasonal	1746.00	Seasonal	1192.28
	Total		10201.60		8056.27

Table 8: Incremental crop income attributable to farm pond

Sr. No.	Crop	Yield with farm pond (q/ha)	Yield without farm pond (q/ha)	Incremental Yield	Price (Rs)	Incremental Revenue
1	Soybean	33.02	17.00	16.02	4292.06	68758.80
2	Pigeon pea	29.22	12.60	16.62	4724.50	78521.19
3	Wheat	44.79	-	-	2313.86	-
4	Chickpea	18.29	10.35	7.94	4871.20	38677.33
5	Sorghum	-	15.08	-	2303.05	-
6	Sugarcane	1713.00	-	-	340.08	-
7	Coriander	12.72	-	-	15000.00	-

Table 9: Annual cash flow statement for returns over investment

Year	Lined farm pond			Unlined farm pond		
	Cash Inflow (Rs.)	Cash Outflow (Rs.)	Net Cashflow	Cash Inflow (Rs.)	Cash Outflow (Rs.)	Net Cashflow
1	150557	198958.00	-48401.00	122258.0	157343.0	-35085.0
2	150778	102130.84	48647.16	122258.0	90059.7	32198.3
3	156916	103430.84	53485.16	132103.0	92093.0	40010.0
4	160236.00	104330.84	55905.16	142890.0	94393.0	48497.0
5	171067.00	106210.84	64856.16	148840.0	96043.0	52797.0
6	178067.00	109490.84	68576.16	156793.0	98393.0	58400.0
7	188540.00	109780.84	78759.16	158267.0	102293.0	55974.0
8	201246	111906.84	89339.16	168430.0	104743.0	63687.0

Table 10: Economic indicators of farm pond investment

Sr. No.	Particulars	Lined farm pond	Unlined farm pond
1	Net Present Value (NPV) @ 12% discount rate	212417.65	164228.97
2	Benefit: Cost Ratio (BCR) @ 12% discount rate	1.35	1.31
3	Internal Rate of Return (IRR)	108.87	109.33
4	Profitability Index (PI)	1.89	1.87

Conclusion

The study provides a detailed analysis of the economic returns from the construction and maintenance of farm ponds in Latur district of Maharashtra—a region frequently affected by drought and erratic rainfall. The findings offer compelling evidence that farm ponds are not only technically effective but also financially viable tools for enhancing agricultural productivity and farmer income. The adoption of farm ponds led to a marked increase in cropping intensity (from 190.57% to 247%) and introduced *summer* cropping, which was previously absent. The Gross Cropped Area also expanded, and farmers began cultivating high-value crops such as sugarcane and coriander. These changes were not observed among non-farm pond users, who remained dependent on traditional rainfed systems and grew primarily subsistence crops. The ROI analysis revealed that despite high initial investment costs—particularly for lined ponds—farmers started realizing positive returns from the second year. Financial viability was confirmed by strong economic indicators, with Net Present Values of ₹2.12 lakh for lined ponds and ₹1.64 lakh for unlined ponds. The Internal Rate of Return (IRR) exceeded 108% for both pond types, far above the assumed 12% discount rate. Similarly, the Benefit-Cost Ratios (1.35 for lined and 1.31 for unlined) and positive profitability indices highlighted the sustainable financial performance of these interventions. Moreover, lined ponds, while more expensive, demonstrated longer-term water retention, better crop outcomes, and higher profitability. These insights suggest that targeted support for lined ponds may yield superior results, especially in areas with poor percolation and groundwater recharge.

The study emphasizes the importance of continued government support through schemes like “Magel Tyala Shettale,” which significantly lower the financial burden on marginal and small-scale farmers. It also recommends broader dissemination of technical knowledge and maintenance practices to maximize long-term benefits.

Farm ponds serve as an effective climate adaptation strategy that improves water availability, supports crop diversification, and enhances economic resilience. Their widespread implementation can play a pivotal role in ensuring agricultural sustainability in semi-arid regions of India. Policymakers, researchers, and extension agencies must work collaboratively to scale up this intervention while tailoring it to local agro-ecological and socio-economic contexts.

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