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RESEARCH PAPER

A holistic view on financial feasibility of different irrigation methods for major crops in Belagavi district, Karnataka

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Abstract: The present study was conducted to assess the financial feasibility of different irrigation methods for major crops in Belagavi district in Karnataka. The multi-stage purposive sampling technique was employed for the collection of primary data from 120 sample farmers. Financial feasibility of drip and sprinkler irrigation systems was analysed comparing flood method using project evaluation technique based on various indicators namely, Net Present Value (NPV), Benefit-Cost Ratio (BCR), Internal Rate of Return (IRR) and Payback Period (PBP). Information regarding costs and returns for four major crops *viz*., sugarcane, sorghum, groundnut and maize was elicited from sample farmers for the cropping year 2022–23. Results indicated that drip and sprinkler irrigation methods, especially with intervention of subsidies offered higher returns and profitability with shorter payback period when compared to flood irrigation. where the micro irrigation method not only ensures high productivity and profitability on crops considered sustainable in terms of water use efficiency. The study concludes that investment on micro-irrigation is a financially feasible and environmentally sustainable alternative than traditional flood method. This shows the investment on drip and sprinkler irrigation system was sound and economically viable for up scaling their adoption in the water scarce rain fed area to benefit farm economy on a larger scale.

Key words: BCR, Drip irrigation, Flood irrigation, Financial feasibility, IRR, NPV, PBP, Sprinkler irrigation

Introduction

Agriculture serves as the primary sector in Indian economy, with irrigation development being a key intervention in boosting its growth. Over 55 per cent of the population is directly employed in this sector as source of employment and income, which contributes approximately 18.30 per cent to the country's GDP (Anon, 2024). In India, irrigation is indispensable for agriculture as a vital input and guarantees the optimal growth of crops by supplying the required water for higher production. Roughly 90 per cent of water resources in the country are allocated to agriculture (Anon, 2023), but less than 50 per cent is effectively utilized by plants and remaining water resources are lose due to deep percolation. (Liu *et al.*, 2022)

Water is fundamental for agriculture in ensuring food security. In essence, irrigation acts as a catalyst in providing nutrition to millions of people. According to World Bank report, 20 per cent of cultivated land is irrigated and produces 40 per cent of food grains, a quantity deemed inadequate for the global population of 8 billion. However, with increase in population and climate change, the world's freshwater supply is decreasing and where the demand for food is on the increase. Hence, it is crucial to develop and expand irrigation facilities to address this challenge. These benefits are evident in increased crop yields, lower energy consumption, reduced use of chemical fertilizers and pesticides (Kumar *et al*., 2023).

Indiscriminate use of water is common in surface and groundwater irrigation areas hence, in order to increase the application efficiency of irrigation, farmers must be encouraged to optimise water use efficiency, adopt water saving techniques for irrigation using micro-irrigation, especially among small land holders with poor resource base. Micro-irrigation is a strategy for managing water demand with scientific interventions to enhance water consumption efficiency and its productivity. It involves drip irrigation which delivers water to the crop root zone directly using a system of pipes and emitters and sprinkler irrigation disperses water similar to rainfall through nozzles, where water breaks into small droplets on the field surface. (AGRIVI, 2022)

Agriculture remains the largest consumer of water and a key source of employment and income supporting total population (45.8%) and rural population (75%) (Anon 2023). Therefore, implementing micro irrigation system is crucial for the country. With this background the study has been conducted with the objective, to evaluate the financial feasibility of different irrigation methods for major crops in the study area.

Material and methods

The study was conducted in Belagavi district of Karnataka during the cropping year 2023-24. The multi-stage purposive sampling technique was employed to select the sample farmers with the sample size of 120. In the first stage, Belagavi district was purposively selected due to the highest gross and net irrigated areas (among the seven districts under UAS Dharwad jurisdiction). In the second stage, Athani and Gokak taluks in Belagavi district were chosen based on the highest gross and net irrigated areas considering triennium average from 2018- 19 to 2020-21. In the third stage, four villages namely Bammanal, Khatageri, Kokatnoor, Sankonatti from Athani taluk and

Hirenandi, Chikanandi, Kalloli, Sanaganakere from Gokak taluk were selected based on the highest irrigated area. Finally, five small landholders of less than 5 acres of land holdings using drip and sprinkler methods were selected randomly from each village and interviewed personally using a pre-tested schedule. Further, equal number of farmers adopting traditional (flood) method of irrigation were selected for comparision.

Thus, a sample of 60 farmers comprising 20 under drip irrigation, 20 under sprinkler and another 20 farmers adopting traditional method (flood) of irrigation was selected from each taluk making a total of 40 farmers adopting drip and 40 farmers under sprinkler and 40 farmers under traditional method of irrigation from both taluks together.

Analytical tools

Project evaluation technique have been used to compare the parameters of financial analysis associated with cultivation of sugarcane, sorghum, groundnut and maize crops of both with and without subsidy situations. Since drip and sprinkler irrigation involves capital investment, Its economic viability is assessed by estimating the net present value (NPV), benefit-cost ratio (BCR), internal rate of return (IRR) and payback period following discounted cash flow technique (Gittinger, 1984). The cash inflows and cash outflows were assessed on project life period. Mathematically, the NPV, BCR, IRR and PBP are expressed as:

Net present palue (NPV)

The NPV is the difference between the sum of the present value of benefits (cash inflows) and the costs (cash inflows) accrued during the life period of the drip and sprinkler sets.

Decision rule

If NPV is positive, the investment on micro irrigation is feasible

If NPV is negative, the investment on micro irrigation is infeasible

If NPV is zero, it is matter of indifference

$$NPV = \sum_{i=1}^{n} Yi\,(1+r)^{-n} - I$$

Where,

Yi = Net cash flows in the i^{th} year (i=1,2,….n)

r = Discount rate at 12% per annum

I = Initial investment on the project

t = life period of the micro irrigation project

Benefit cost ratio (BCR)

It is the ratio between the discounted cash inflows and discounted cash outflows. The ratio must be unity or more for an investment to be considered worthwhile. The Benefit Cost Ratio was worked out by using the following formula.

$$BCR = \frac{\text{Discounted cash inflows}}{\text{Discounted cash outflows}}$$

Internal rate of return (IRR)

The internal rate of return is the rate at which the net present value from investment on micro irrigation is equal to zero. The net cash flows were discounted to determine the present worth. The exact IRR is obtained using the following interpolation technique by trial and error method for a project to beneficially feasible, the IRR need to be more than the opportunity cost of capital invested.

$$\text{IRR} = \text{(Lower discount rate) at lower discount rate} + \text{(Difference between two discount rates)} \times \frac{\text{Present worth of cash flow at lower discount rate}}{\text{Absolute different between present worth of cash flows stream at the two discount rates}}$$

Pay back period (PBP)

The length of time in years taken to liquidate the investment. The payback period was estimated by summing up all the undiscounted net benefits over the years to make up the initial investment incurred for establishment of the micro irrigation system

$$P = \frac{I}{Y}$$

Where,

P = Payback period in pre-defined time units(years).

I = Capital investment on the project in rupees.

Y = Net income realised after meeting production expenditure

According to the Net Present Value (NPV) criterion, micro irrigation is considered financially feasible, if the present value of benefits exceeds the present value of costs. The benefit-cost ratio is closely linked to net present value and if the benefit cost ratio value is greater than one with shorter payback period, the investment is deemed to be financially feasible. However, when working with cross-sectional data, it is challenging to determine the actual cash flows for the entire life span of a irrigation system. Therefore, cash inflows and outflows are estimated based on certain assumptions such as,

- The life span of the drip and sprinkler set is typically five years. But, based on the experience of adopters of irrigation sets can last up to 10 years, hence estimation was done assuming the lifespan of the drip and sprinkler sets for 10 years.
- The discount rate or the opportunity cost of capital is assumed at 12 per cent per annum
- Same crops were grown season after season without any crop failure.
- Annual production costs and returns from crops assessed on per hectare basis considering percentage area occupied by each crop is the cropping pattern as a weightage
- These costs and returns realized for each crop were elicited from farmers for one year and assumed 2 per cent increment in each for the life period of drip and sprinkler systems to arrive cost and benefit streams.

Table 1. Financial feasibility of investment on drip and flood method of irrigation for sugarcane crop in the study area (Per hectare)

Year	Drip irrigation with subsidy				Drip irrigation without subsidy				Flood method of irrigation			
	Cash outflow	Cash inflow	Net cashflow	Discounted Net Cashflow	Cash outflow	Cash inflow	Net cashflow	Discounted Net Cashflow	Cash outflow	Cash inflow	Net cashflow	Discounted Net Cashflow
0	307649.40	0.00	-307649.40	-307649.40	382649.40	0.00	-382649.40	-382649.40	304221.22	0	-304221.22	-304221.22
1	165902.39	375416.60	209514.21	187066.26	165902.39	375416.60	209514.21	187066.26	183825.64	307239.8	123414.16	110191.21
2	169220.44	382924.93	213704.50	170363.92	169220.44	382924.93	213704.50	170363.92	187502.16	313384.596	125882.44	100352.70
3	172604.84	390583.43	217978.59	155152.85	172604.84	390583.43	217978.59	155152.85	191252.20	319652.2879	128400.09	91392.64
4	176056.94	398395.10	222338.16	141299.92	176056.94	398395.10	222338.16	141299.92	195077.24	326045.3337	130968.09	83232.58
5	179578.08	406363.00	226784.92	128683.85	179578.08	406363.00	226784.92	128683.85	198978.79	332566.2404	133587.45	75801.10
6	183169.64	414490.26	231320.62	117194.22	183169.64	414490.26	231320.62	117194.22	202958.37	339217.5652	136259.20	69033.15
7	186833.03	422780.07	235947.03	106730.45	186833.03	422780.07	235947.03	106730.45	207017.53	346001.9165	138984.38	62869.47
8	190569.70	431235.67	240665.97	97200.95	190569.70	431235.67	240665.97	97200.95	211157.88	352921.9548	141764.07	57256.13
9	194381.09	439860.38	245479.29	88522.29	194381.09	439860.38	245479.29	88522.29	215381.04	359980.3939	144599.35	52143.97
10	198268.71	448657.59	250388.88	80618.52	198268.71	448657.59	250388.88	80618.52	219688.66	367180.0018	147491.34	47488.26
Total	2124234.26	4110707.03	1986472.77	965183.84	2199234.262	4110707.02	1911472.76	890183.84	2317060.74	3364190.09	1047129.35	445540.04
	NPV (₹)	9,65,183.84	NPV (₹)	8,90,183.84	NPV (₹)	4,45,540.04						
	IRR (%)	52	IRR (%)	39	IRR (%)	26						
	BCR	1.73	BCR	1.64	BCR	1.31						
	PBP (year)	1.47	PBP (year)	1.83	PBP (year)	2.47						

Note: NPV, IRR and B:C Ratio were calculated at 12 per cent discount rate

Table 2. Financial feasibility of investment on drip and flood method of irrigation for Sorghum crop in the study area (Per hectare)

Year	Drip irrigation with subsidy				Drip irrigation without subsidy				Flood method of irrigation			
	Cash outflow	Cash inflow	Net cashflow	Discounted Net Cashflow	Cash outflow	Cash inflow	Net cashflow	Discounted Net Cashflow	Cash outflow	Cash inflow	Net cashflow	Discounted Net Cashflow
0	192161.17	0.00	-192161.17	-192161.17	268917.14	0.00	-268917.14	-268917.14	174376.76	0.00	-174376.76	-174376.76
1	68504.39	143730.30	75225.91	67165.99	65195.48	143730.30	78534.82	70120.37	75864.30	117601.00	41736.70	37264.92
2	69874.48	146604.91	76730.42	61169.02	66499.39	146604.91	80105.51	63859.62	77381.58	119953.02	42571.44	33937.69
3	73368.21	149537.00	76168.80	54215.45	67829.38	153935.15	86105.77	61288.39	78929.21	125950.67	47021.46	33468.95
4	74835.57	152527.74	77692.17	49374.78	69185.97	157013.85	87827.89	55816.21	80507.80	132248.20	51740.41	32881.96
5	78577.35	155578.30	77000.95	43692.41	70569.69	160154.13	89584.44	50832.62	82117.95	138860.61	56742.66	32197.31
6	80148.90	158689.87	78540.97	39791.30	71981.08	163357.21	91376.13	46293.99	83760.31	145803.65	62043.33	31433.08
7	84156.34	161863.66	77707.32	35150.85	73420.70	166624.36	93203.66	42160.60	85435.52	153093.83	67658.31	30605.18
8	85839.47	165100.94	79261.47	32012.38	74889.12	169956.85	95067.73	38396.26	87144.23	160748.52	73604.29	29727.54
9	87556.26	168402.95	80846.70	29154.13	76386.90	173355.98	96969.08	34968.02	88887.11	168785.95	79898.83	28812.32
10	89307.38	171771.01	82463.63	26551.08	77914.64	176823.10	98908.47	31845.88	93331.47	177225.24	83893.77	27011.55
Total	984329.51	1573806.684	589477.18	246116.21	982789.49	1611555.85	628766.36	226664.83	1007736.24	1440270.69	432534.45	142963.74
	NPV (₹)	2,46,116.21	NPV (₹)	2,26,664.83	NPV (₹)	1,42,963.74						
	IRR (%)	24	IRR (%)	15	IRR (%)	13						
	BCR	1.39	BCR	1.34	BCR	1.22						
	PBP (year)	2.55	PBP (year)	3.38	PBP (year)	4.18						

Note: NPV, IRR and B:C Ratio were calculated at 12 per cent discount rate

Results and discussion

The financial feasibility analysis in drip method with subsidy consistently provided (Table 1) the highest returns in sugarcane crop. Cash streams (costs and returns) for project life in case of sugarcane were considered for financial feasibility with subsidy and it was observed that there was highest cash flow indicated by NPV of 9,65,183 and B.C. ratio of 1.73, IRR of 52 per cent with a very short payback period of 1.47 years. While, performance of the drip irrigation method without subsidy showed that the NPV was ₹ 8,90,183 with the B C ratio of 1.64, IRR was 39 per cent per annum and the payback period of 1.83 years in drip method. In contrast, flood method of irrigation showcased the NPV of 4,45,540 and B C ratio of 1.31, IRR of 26 per cent and higher payback period of 2.47 years. Similar study was found by Walia *et al* in 2023 that net present value was positive with 3,84,895and IRR accounts 57.99 per cent with B-C ratio of 3.30 and payback period 3years which indicated, investment on sprinkler irrigation system was sound and economically viable.

For sorghum, financial feasibility analysis with subsidy accounts (Table 2) highest with NPV of 2,46,116 and B.C. ratio of 1.39, IRR of 24 per cent with a payback period within three years. While, performance of drip method of irrigation without subsidy, the NPV was 2,26,664 with the B C ratio of 1.34 a moderate IRR of 15 per cent with payback period between 3 to 4 years on the other hand investment analysis of flood method of irrigation, showed relatively low NPV of 1,42,963and B C ratio of 1.22 with lowest IRR of 13 per cent depicting only one per cent addition rate and return over opportunity cost of capital and higher payback period of 4.18 years. Evidence from a previous analogous study suggests a similar pattern from Devika *et al* in 2017 that NPV at 10 per cent discount rate for five years of life period for drip irrigation system is ₹ 3,59,129 per acre and B:C ratio is 3.92 which concluded that the investment on drip irrigation in red chilli cultivation is economically viable.

The financial feasibility in sprinkler method (Table 3) for groundnut where with subsidy accounted highest NPV of 4,66,075 and B.C. ratio of 1.76, highest IRR of 40 per cent with a short recovery period of two years. While, the sprinkler method without subsidy showed the NPV of 3,55,161 with B C ratio of 1.52, IRR of 24 per cent with payback period of nearly three years. In contrast, flood method of irrigation realised the NPV of 2,99,803 and B C ratio of 1.40, IRR relatively lower at 20 per cent and the payback period of 2.88 years.

Table 4 depicts the financial feasibility of investment in sprinkler method of irrigation for maize where investment with subsidy accounted the highest NPV of 2,24,549 and B.C. ratio of 1.43, IRR of 23 per cent having a short payback period of nearly three years. While, the sprinkler method without subsidy, the NPV at 3,55,161 with the B C ratio of 1.52, IRR of 24 per cent and a recovery period of 3.20 years in sprinkler method. In contrast, flood method of irrigation, the NPV was found to be 1,14,257 with the B C ratio of 1.20, a lower IRR of 12 per cent which is on par with the opportunity cost separated

Table 3. Financial feasibility of investment on sprinkler and flood method of irrigation for groundnut crop in the study area (Per hectare)

Year	Sprinkler irrigation with subsidy				Sprinkler irrigation without subsidy				Flood method of irrigation			
	Cash outflow	Cash inflow	Net cashflow	Discounted Net Cashflow	Cash outflow	Cash inflow	Net cashflow	Discounted Net Cashflow	Cash outflow	Cash inflow	Net cashflow	Discounted Net Cashflow
0	189410.04	0.00	-189410.04	-189410.04	266410.04	0	-266410.0	-266410.0	276715	0	-276715	-276715
1	67738.24	170051.70	102313.46	91351.30	67738.24	170051.7	102313.5	91351.3	78249	173147	94898	84730
2	69093.01	173452.73	104359.73	83194.94	69093.01	173452.73	104359.7	83194.9	79814	176609.94	96796	77165
3	70474.87	182125.37	111650.50	79470.62	70474.87	176921.78	106446.9	75766.8	81411	180142.13	98731	70275
4	73998.61	185767.88	111769.27	71031.39	71884.36	180460.22	108575.9	69001.9	83039	183744.98	100706	64001
5	75478.58	195056.27	119577.69	67851.59	73322.05	184069.42	110747.4	62841.0	84700	187419.88	102720	58286
6	76988.15	198957.40	121969.24	61793.42	74788.49	187750.81	112962.3	57230.2	86394	191168.27	104775	53082
7	80837.56	208905.27	128067.71	57931.33	76284.26	191505.83	115221.6	52120.4	88122	194991.64	106870	48343
8	82454.31	213083.37	130629.06	52758.89	77809.95	195335.95	117526.0	47466.8	89884	198891.47	109007	44026
9	86577.03	217345.04	130768.01	47156.26	79366.15	199242.66	119876.5	43228.7	91682	202869.30	111188	40095
10	88308.57	221691.94	133383.37	42945.88	80953.47	203227.52	122274.1	39369.0	93515	206926.69	113411	36515
Total	961358.96	1966436.97	1005078.01	466075.57	1008124.87	1862018.67	853893.8	355161.0	1133525	1895911.34	762387	299803
	NPV (₹)	4,66,075.57	NPV (₹)	3,55,161.03	NPV (₹)	2,99,803.10						
	IRR (%)	40	IRR (%)	24	IRR (%)	20						
	BCR	1.76	BCR	1.52	BCR	1.40						
	PBP (year)	1.85	PBP (year)	2.60	PBP (year)	2.88						

Note: NPV, IRR and B:C Ratio were calculated at 12 per cent discount rate

Table 4. Financial feasibility of investment on sprinkler and flood method of irrigation for maize crop in the study area (Per hectare)

Year	Sprinkler irrigation with subsidy				Sprinkler irrigation without subsidy				Flood method of irrigation			
	Cash outflow	Cash inflow	Net cashflow	Discounted Net Cashflow	Cash outflow	Cash inflow	Net cashflow	Discounted Net Cashflow	Cash outflow	Cash inflow	Net cashflow	Discounted Net Cashflow
0	233981.85	0.00	-233981.85	-233981.85	233981.85	0.00	-233981.85	-233981.85	183354.84	0.00	-183354.84	-183354.84
1	55061.49	128260.93	73199.44	65356.64	49162.04	128260.93	73199.44	65356.64	60087.69	108674.50	48586.81	43381.08
2	57814.56	130826.14	73011.58	58204.39	46089.41	130826.14	73011.58	58204.39	63092.07	110847.99	47755.92	38070.72
3	58970.85	133442.67	74471.81	53007.57	41974.29	133442.67	74471.81	53007.57	64353.915	113064.95	48711.03	34671.55
4	60150.27	136111.52	75961.25	48274.75	38226.58	136111.52	75961.25	48274.75	65640.99	118718.20	53077.20	33731.52
5	61353.28	138833.75	77480.48	43964.50	34813.50	138833.75	77480.48	43964.50	66953.81	121092.56	54138.75	30719.78
6	62580.34	141610.43	79030.08	40039.10	31705.15	141610.43	79030.08	40039.10	68292.89	123514.41	55221.52	27976.94
7	63831.95	144442.63	80610.69	36464.18	28874.33	144442.63	80610.69	36464.18	69658.74	125984.70	56325.95	25479.00
8	65108.59	147331.49	82222.90	33208.45	26296.27	147331.49	82222.90	33208.45	71051.92	128504.39	57452.47	23204.09
9	66410.76	150278.12	83867.36	30243.41	23948.39	150278.12	83867.36	30243.41	72472.96	131074.48	58601.52	21132.30
10	67738.97	157792.02	90053.05	28994.67	21810.14	157792.02	90053.05	28994.67	73922.42	133695.97	59773.55	19245.48
Total	795942.6432	1342993.409	555926.79	203775.81	576881.94	1408929.69	555926.79	203775.81	858882.27	1215172.16	356289.89	114257.63
	NPV (₹)	2,24,549.89	NPV (₹)	3,55,161.03	NPV (₹)	1,14,257.63						
	IRR (%)	23	IRR (%)	24	IRR (%)	12						
	BCR	1.43	BCR	1.52	BCR	1.20						
	PBP (year)	2.68	PBP (year)	2.60	PBP (year)	3.79						

Note: NPV, IRR and B:C Ratio were calculated at 12 per cent discount rate

considered for the study and payback period about 4 years. Similar Study found from Nasution *et al* 2018 about the financial analysis that NPV is high and positive with IRR of 27 per cent and B-C ratio of 4.6 which concluded that project development plan was very viable in both economic and financial way.

The two irrigation methods namely drip and sprinkler irrigation highlights the considerable investment on micro irrigation with higher profitability and investment efficiency with subsidy when compared to without subsidy and flood irrigation method across crops varieties. The economic indicators are markedly superior for investment on drip system to those of sprinkler and substantially over flood irrigation, showcasing micro irrigation systems efficiency to optimize returns and recoup invested capital more quickly by effectively managing irrigation water and other resources to achieve greater crop yields and returns. The results of the present study corroborate with the findings of Rudrapur (2016), who have reported, NPV is positive with highest B: C ratio and shorter life period in all crops for with subsidy followed by without subsidy when compared to investment in flood irrigation system.

Conclusion

The study clearly demonstrates that the drip and sprinkler irrigation methods provide significant advantages over flood irrigation method in terms of higher economic returns, crop productivity, water use efficiency considerly resulting in greater financial feasibility which clearly indicates that adoption of micro-irrigation could be a best and viable solution both technically and financially for achieving the goal of **'per drop more crop'**. Therefore, with increasing competition for water among different sectors, and the fact that availability of water for irrigation is expected to decline significantly in the future, which is posing a serious threat to the sustainability of agriculture.

The findings demonstrate that investment in micro irrigation system is not only financially feasible but also an environmentally sound alternative to flood irrigation method. The provision of subsidies further enhances the financial feasibility of investment in irrigation systems, making them more accessible, adoptable and profitable from farmers point of view, in the cultivation of major crops like sugarcane, sorghum, groundnut and maize considered in the study. However, despite evidence that supports the financial feasibility of micro irrigation systems, the high initial investment required for installation of irrigation equipment remains out of reach for small land holders, necessitates the need to improve access to financial resources for small land holders to facilitate the speedy adoption of this technology for sustained benefits.

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