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Economic Analysis of Fresh Water Skimming Techniques in Coastal Aquifers of Andhra Pradesh

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ABSTRACT

While the inland crop production can be managed by an effective combination and conjunctive use of canals, tanks and wells, the coastal belt crop production solely depends on the fresh water aquifers levied with a limit on well pumping. Solutions through skimming techniques were considered on a regional perspective for sustenance of technologies and their operational strategies in the coastal area. Besides execution of these technologies, their economic viability and social acceptance at the farmers' level are equally important. The economic viabilities and social acceptabilities of skimming technologies were also ascertained in addition to their technical feasibilities. Impact of the improved technologies on agri-business of the farmers revealed that all the important agro-economic parameters viz., cropped area, yield levels of major crop (ground nut), land value and lease value of land were increased in the study area due to the effective implementation of the improved technologies over traditional method. To be more precise, skimming well technology with horizontal collectors recorded more benefits over shallow tube well and multi-strainer tube well farmers. The economic appraisal of the improved technologies at farmers level – using discounting techniques revealed that Collector well with horizontal collectors contributes higher benefits to the farmers followed by multi-strainer tube well and shallow tube well technologies. The study has revealed that the improved fresh water skimming techniques outlined have promising future prospects for sustaining crop production along the coastal belts.

Key words: Collector well, Discounting techniques, Multi-strainer well, Shallow tube well.

Crop production in most parts of India in general and Andhra Pradesh state in particular largely depends on ground water extraction, even as canal net works and tanks do contribute significantly. While the inland ground water reserves are over-exploited by way of unscrupulous pumping, the coastal aquifers are exposed to a serious threat by sea water intrusion. The inland crop production can be managed by an effective combination and conjunctive use of canals, tanks and wells, the coastal belt crop production solely depends on the fresh water aquifers levied with a limit on well pumping. Rainwater harvesting along coastal belt would serve the purpose of keeping the saline sea water – aquifer fresh water interface at safer levels during pumping.

Hence, solutions through skimming techniques were considered on a regional perspective for sustenance of technologies and their operational strategies in the coastal area. Besides execution of these technologies, their economic viability and social acceptance at the farmers' level are equally important. This is because, socio-economic upliftment of the farming community is the ultimate concern of any agricultural research activity/investment. This is especially true in case of developing nations like India.

To harvest the large quantities of shallow depth fresh water without quality changes in coastal sandy soils, AICRP- Saline Water Scheme has developed Skimming Well Technology. The system is an alternative to traditional *doruvus,* popularly known as Improved *Doruvu* Technology to skim the fresh water floating over saline ground water. The system consists of a sump connected with bilateral horizontal radial collector lines. The sump diameter., collector lines length and depth may vary according to the water requirement of a farm. The bottom of the sump may seldom sealed depending upon the quality of water at the bottom of the sump. Also during the recent past, innovative and progressive farmers tried to install shallow depth (4.5 - 6.0 m deep) low discharge tube wells and multi-strainer bore wells with varying designs in Andhra Pradesh and Tamil Nadu to tap the top layered shallow depth fresh water.

In addition to the hydraulic performance of the above skimming systems, the economic appraisal of fresh water skimming technologies is essential, as the economic viability of these technologies enable the farmers to plan and adopt these technologies in their fields. With this major objective, this study was planned during the year 2004-06.

MATERIAL AND METHODS

The field studies were conducted in coastal sandy soils in and around Bapatla in Guntur district, Andhra Pradesh, where different conventional as well as improved skimming structures are in vogue. The study locations are situated in Bapatla, Karlapalem and Pittalavanipalem mandals of Guntur district. For studying the economic viability and social acceptability of the selected improved ground water skimming technologies, the perceptions of both the sample farmers and officials were taken into consideration. This facilitates the researcher to study about the technologies both from the scientific and field performance angles through the following sample design (Table 1).

The following are the important tools of analysis employed for drawing meaningful conclusions (Ravi et al., 2006) from the collected data/ information:

1. Kruskal-Wallis H – test : This was employed to study the effectiveness of these improved technologies in improving the agri-business of the sample farmers

$$H = \frac{12}{N(N+1)}\left(\frac{R1^2}{n1} + \frac{R2^2}{n2} + \ldots \frac{Rk^2}{nk}\right) - 3(N+1)$$

where, n1, n2 …. nk are number of items in each of 'k' samples, N = n1+n2+…nk and R1, R2 … Rk are the sums of the ranks given to observations in each samples.

2. Chi-Square test: This was used to analyze the impact of selected improved technologies in improving both crop yields and irrigation efficiency over traditional method.

$$\chi^2 = \frac{(fo - fe)^2}{fe}$$

where, fo – Observed frequency,
fe – Expected frequency

3. Garrett s Ranking test : This was used mainly to rank different ground water skimming technologies based on the perceptions of the sample farmers in accordance with various parameters under consideration. They include :

- Good quality water harvest
- Employment generation
- Adoption of modern irrigation technology
- Cultivable land wastage
- Evaporation losses
- Cost-effectiveness
- Suitability to larger areas
- More drudgery in operations
- Easy installation

The ranking of these different ground water skimming technologies was based on the rank values (in terms of per cent position) assigned to the above parameters. The selected parameters were ranked for each technology in accordance to high, medium and low benefits due to each selected technology and on the basis of priority from 9 to 1. Later the ranks of the parameters for each technology were converted to percent position, according to the formula given below. The average value of all the percent positions of selected parameters for each technology was worked out and the selected technologies were ranked (prioritized) based on the average values.

$$\text{Per cent position} = \frac{100 \times (R_{ij} - 0.5)}{N_j}$$

Where, R_{ij} = Rank given to i^{th} parameter by j^{th} individual
N_j = Number of parameters ranked by j^{th} individual

4. Discounting techniques: Discounting techniques suggested for drainage projects (Datta and Joshi,1991 and Raghu Babu,2006), were used to appraise the economic viability of

Table 1. Sample design followed for studying the features of the different ground water skimming technologies

S.No	Technology	Farmers	Officials
1	Traditional method (Doruvu)	30	20
2	Collector well	30	20
3	Shallow tube well	10	20
4	Multi-strainer tube well	10	20

the selected improved technologies at the farmers' level. They include viz., Net Present Worth(NPW), Benefit-Cost Ratio(BCR) and Internal Rate of Return (IRR).

a. Net Present Worth (NPW)

$$= \sum_{t=0}^{n} \frac{Bt - Ct}{(1+i)^t}$$

b. Benefit Cost Ratio (BCR)

$$= \sum_{t=0}^{n} \frac{Bt / (1+i)^t}{Ct / (1+i)^t}$$

c. Internal Rate of Return (IRR)

$$= \sum_{t=0}^{n} \frac{Bt - Ct}{(1+i)^t} = 0$$

where, Bt : Benefit/cash inflow over time period 't', Ct : Initial investment in the 't'th period, n : Life of the system(years), i : Rate of interest (%).

RESULTS AND DISCUSSION

1. Effectiveness of the selected technologies in improving the agri-business at the farmers' level - Kruskal-Wallis H-test

Having studied the perceptions of adopted farmers and officials with reference to the relative advantage, compatibility, technical feasibility, economic viability, adoption and scientific management of the improved technological interventions over traditional method, it is thought appropriate to study their effectiveness in improving the agro-economic parameters in the selected command. This study is also essential before assessing the impact of these technologies. Kruskal-Wallis H-test was employed for the same and the data were collected from the sample farmers on four important agro-economic parameters viz., increase in yield, change in water quality, increase in irrigation efficiency and rental value of land (Table 2). The farmers' opinions were given score values based on the degree of perception towards each parameter viz., highly effective (3 marks), moderately effective (2 marks) and less effective (1 mark). The table reveals that, the selected modern technologies were found effective towards improving agroeconomic parameters in the selected command, as indicated by the non-significant Chi-Square calculated value (0.20).

Hypothesis : The selected improved technologies were effective in improving the agroeconomic parameters in the selected command.

2. Impact of selected improved technologies on yields and irrigation efficiency

Chi-Square test was employed to study the impact of selected technological interventions on yield and irrigation efficiency increase in the selected irrigation command. This analysis is important, as it signifies the meritorious effects of the technological interventions so executed at the farmers' level towards the socio-economic upliftment of the farming community through improving the agri-business. The analytical findings (Table 3, 4 and 5) reveals that, the executed technologies at the farmers level, yielded significant benefits both in terms of increasing yields and irrigation efficiency in the selected command, as indicated by the significant Chi-Square calculated values. The informal discussions held with the sample farmers revealed that, they are very much convinced with the benefits derived from these technologies and they further expressed that, these technologies are technically feasible and economically viable.

Hypothesis : The selected improved technologies have not exerted any impact in improving the yields and irrigation efficiency at the farmers' level.

Table 2. Effectiveness of the improved technologies towards improving agro- economic parameters in the selected irrigation command

Items	Radial collector well	Shallow tube well	Multi-strainer tube wells
Increase in yield	30	27	16
Change in water quality	10	30	17
Increase in irrigation efficiency	29	15	17
Rental value of land	20	13	19
Chi-Square value		**0.20 NS**	

Note : NS – Not significant

3. Garrett's Ranking Test

This test was employed to rank the selected ground water skimming technologies by the sample farmers in accordance with the various parameters of each technology. This enables the researchers to identify the technology, which is strongly preferred by the sample farmers on prioritized basis. The analytical findings (Table 6) reveals that, collector well technology was ranked first by the sample farmers followed by the multi-strainer tube wells and Shallow tube wells over traditional method, as indicated by the score values. This is mainly because, in case of collector well technology, modern irrigation equipment can be employed, it avoids cultivable land wastage and evaporation losses and reaps good harvest to the farmers. However, the farmers opined that, this technology involves high irrigation costs and needs large installation area and technical assistance. Shallow tube wells and multi-strainer tube wells recorded less score values because of poor water quality as wells as priming problems.

4. Impact of the selected improved technologies on agri-business of the farmers

Having studied the meritorious features of these improved technologies, their effectiveness in improving the agri-business, it is thought appropriate to study their impact on various agro-economic parameters. It is evident from the results (Table 7) that, all the important agro-economic parameters viz., cropped area, yield levels of major crop (ground nut), land value and rental value of land were increased in the study area due to the effective implementation of the improved technologies over traditional method. To be more precise, collector well technology recorded more benefits over Shallow tube wells and multi-strainer tube wells to the farmers. Hence, the sample farmers prioritized this improved technology over other two technologies. As the modern technologies were mainly aimed towards improving the irrigation efficiency at the farmers' level, the share of irrigation cost in total operational cost of the crop(groundnut) and economic efficiency of irrigation water resource were worked out. In terms of these, collector well technology ranked first, as indicated by the low share irrigation cost in total operational cost of the groundnut (10.89%) and higher economic efficiency of irrigation water resource (5.90%) over other two improved technologies and traditional method. In case of multi-strainer tube well, even though, the share of irrigation cost in total operational cost of ground nut (11.25%) is higher than Shallow tube wells, the

Table 3. Impact of Radial collector well technology on yields and irrigation efficiency at the farmers' level

Treatment	Yield & irrigation efficiency increase	No impact	Total
Before technology use	2	28	30
After technology use	24	6	30
Total	26	34	60
Chi-Square value	**29.93****		

Note : ** - Significant at 1% level

Table 4. Impact of Shallow tube well technology on yields and irrigation efficiency at the farmers' level

Treatment	Yield & irrigation efficiency increase	No impact	Total
Before technology use	1	9	10
After technology use	7	3	10
Total	8	12	20
Chi-Square value	**5.21****		

Note : ** - Significant at 1% level

Table 5. Impact of Multi-strainer tube well technology on yields and irrigation efficiency at the farmers' level

Treatment	Yield & irrigation efficiency increase	No impact	Total
Before technology use	2	8	10
After technology use	9	1	10
Total	11	9	20
Chi-Square value	**7.27****		

Note : ** - Significant at 1% level

Table 6. Farmers' preferences of different ground water skimming technologies

S.No	Technology	Avg. Value	Rank
1.	Collector well	81.17	I
2.	Shallow tube wells	68.92	III
3.	Multi-strainer tube well	73.69	II
4.	Traditional *Doruvu*	54.14	

economic efficiency of irrigation water resource is higher for multi-strainer tube wells over Shallow tube wells. This is mainly due to improved quality of irrigation water from multi-strainer tube wells contributing to higher yields and net income of the farmer. On the whole, the analysis reveals that, the three improved technologies were found superior over traditional method in improving the agro-economic parameters.

5. Economic appraisal of the improved technologies at the farmers level

Discounting techniques viz., NPW, BCR and IRR were employed to study economic viability and technical feasibility of the improved technologies at the farmers' level. These techniques are important, as they take into consideration both the time element and market rate of interest of the investments made in the production programme. The following are the important assumptions taken into consideration for employing these techniques :

* Market rate of interest is 10 per cent
* Life span of the investment is 25 years
* Input-output prices are constant for the period under consideration
* Net income increase of the improved technologies over traditional method was taken as benefits of the investment
* The net income benefits were assumed constant through out the life of the installed technologies (25 years)

For the improved technologies to be economically viable, NPW should be greater than zero, BCR should be greater than one and IRR should be greater than market rate of interest or Opportunity cost of capital. The analytical findings (Table 8)

Table 7. Impact of the selected improved technologies on agri-business of the farmers

S.No.	Items	Tradi-tional	Radial collector well		Shallow tube well		Multi strainer tube well	
			Before	After	Before	After	Before	After
1	Cropped area (ha)		23.2	30.0	6.0	8.0	6.0	7.2
2	Share of irrigation cost in total operational cost of crop* (%)	15.19	10.89		11.16		11.25	
3	Economic efficiency of irrigation water resource#	5.17	5.90		5.23		5.51	
4	Yield levels of crop* (tonnes ha^{-1})	2.11	2.81		2.67		2.73	
5	Land value (Lakh. Rs ha^{-1})	1.20	1.60		1.35		1.35	
6	Rental value of leased in land (Rs ha^{-1} year)	6000	9000		7500		7500	
7	Average annual income/farmer (Rs/year) @	43000	69000		67100		67580	

Note : * - Ground nut crop, # Net returns/ Irrigation cost incurred,
@ - Groundnut + Summer crops

Table 8 : Economics appraisal of improved technologies at the farmers' level at constant input and output prices.

Techniques/ Period	Collector well	Shallow tube well	Multi-strainer tube well
NPV			
10 years	31813	15688	27821
20 years	53716	30412	47993
25 years	58926	33914	52791
B:C Ratio			
10 years	1.27	0.70	1.14
20 years	2.15	1.35	1.96
25 years	2.36	1.51	2.15
IRR			
10 years	35%	25%	33%
20 years	37%	27%	35%
25 years	37%	28%	35%

reveals that, the selected improved technologies were found to be economically viable, as indicated by the values of NPW, BCR and IRR for the overall period of 25 years and even for sub-periods viz., 10 and 20 years. This implies that, the investments at the farmers' level contribute higher incomes to the farmers in their agri-business. To be more precise, collector well technology contributes higher benefits to the farmers followed by multi-strainer tube wells and Shallow tube wells technologies. It is important to note that, in case of Shallow tube wells and multi-strainer tube wells, the wells needs to be re-installed in different locations by changing the materials once in 4-5 years. It involves additional labour costs for installation of the systems.

Sensitivity analysis was done for these improved technologies taking into consideration two extreme situations viz., 5% increase in costs, 5% decrease in returns and 5% decrease in costs, 5% increase in returns and economic viability of the investments was studied again. The analytical findings (Table 9) reveals that, even under adverse situation of increase in costs and decrease in returns to a tune of 5 per cent each of original situation, the farmers will still reap the benefits, as indicated by the higher values of NPW, BCR and IRR.

CONCLUSION AND SUGGESTIONS

It can be concluded from the study that, the selected skimming technologies were found to be technically feasible and economically viable in the farmers' fields. Their execution in the farmers' fields improve the agri-business through increasing both physical and economic water use efficiencies over traditional method. Further, the land values improved through construction of shallow depth skimming structures and accordingly the rental value of land. To be more precise, collector well technology recorded more benefits over Shallow tube wells and multi-strainer tube wells to the farmers. Hence, the sample farmers prioritized this improved technology over other two technologies. In collector wells technology, the share of irrigation cost in total operational cost of the groundnut (10.89%) is lowest over the other two improved technologies and traditional method. Hence, the economic efficiency of irrigation water resource (5.90%) is highest for this technology over other technologies. In case of tube well (multi), even though, the share of irrigation cost in total operational cost of groundnut (11.25%) is higher than Shallow tube wells, the economic efficiency of irrigation water resource is higher for multi-strainer tube wells over Shallow tube wells. This is mainly due to improved quality of irrigation water from multi-strainer tube wells contributing to higher yields and net income of the farmer. On the whole, the analysis reveals that, the three improved technologies were found superior over traditional method in improving the agro-economic parameters. The economic appraisal of these improved technologies proved that, they were found to be economically viable, as indicated by the values of NPW, BCR and IRR for the overall period of 25 years and even for sub-periods viz., 10 and 20 years. To be more precise, collector well technology contributes higher benefits to the farmers followed by multi-strainer tube wells and shallow tube wells technologies. The sensitivity analysis also proved that, these improved technologies were viable even during adverse situations of increasing costs and decreasing returns to a tune of five percent than normal (present) level of prices in the market economy.

Table 9: Sensitivity analysis of economic appraisal techniques of the selected improved technologies at the farmers' level

Techniques/ Period	Collector well	Shallow tube well	Multi-strainer tube well
5% increase in costs and 5% decrease in returns			
NPV			
10 years	27146	6711	18000
20 years	47733	18406	34858
25 years	52629	21188	38867
B:C Ratio			
10 years	1.03	0.28	0.70
20 years	1.82	0.78	1.36
25 years	2.00	0.90	1.51
IRR			
10 years	31%	16%	25%
20 years	33%	20%	27%
25 years	33%	21%	28%
5% decrease in costs and 5% increase in returns			
NPV			
10 years	36479	24672	37648
20 years	59700	42426	61137
25 years	65223	46648	66724
B:C Ratio			
10 years	1.54	1.15	1.62
20 years	2.51	1.98	2.63
25 years	2.75	2.18	2.87
IRR			
10 years	40%	33%	41%
20 years	41%	35%	43%
25 years	41%	35%	43%

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