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Pricing of Groundwater and Constraints of Farmers in Groundwater Marketing in North Eastern Karnataka

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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 present study was conducted in North Eastern dry Zone of Karnataka which falls under semi arid tropic region. The study is based on primary data obtained from 45 water sellers and 45 water buyer farmers through snow ball sampling techniques. The data collected were analysed by using descriptive statistics and Garret ranking method. The cost of irrigation was calculated by employing amortization technique. The findings revealed that there were mainly two methods of transactions that could be seen in the groundwater markets in the study area *viz.,* cash payment and crop share/ kind method. It is also found that relationship between water sellers and water buyers among the sample farmers in the study area. The percentage of neighbourers in the total transaction of groundwater marketing was 55.23 and relatives constituted 26.66 per cent, and the percentage of friends was 21.11. The water price or rents varied with type crops grown by water buyers (₹7848.06, ₹2240, ₹1950 and ₹2350 for paddy, groundnut, pigeon pea and cotton, respectively.) per acre in the study area. High water charges, lack of money to pay for water rent, unable to get water timely, etc were the major constraints of water buyer farmers and difficulty in fixing the price or rent for groundwater, delaying in payment of groundwater by water buyers, irregular power supply in rural area were the major constraints faced by water seller farmers in the study area. Therefore, Government and Agricultural extension institutions should educate the farmers about the pros and cons of over exploitation of groundwater not only for present generation and but also on future generation.

Keywords: Groundwater; water markets; constraints; marketing; buyers; sellers.

1. INTRODUCTION

Groundwater is a precious natural resource for meeting our country's water needs. Since the 1970s, groundwater irrigation in India has grown at a rapid rate, accounting for more than 60 per cent of the total irrigated land in the country. The share of borewell irrigation in India has increased from 1 per cent in 1960-61 to 60 per cent in 2006-07. There are currently over 27 million wells and borewells, with bore wells accounting for more than half of them. Every decade, the proportion of groundwater used for irrigation is increasing [1], [2] and [3].

Groundwater is the major source of irrigation supply in India and is increasing in importance. Wells are owned either by individuals or by public institutions [4]. Groundwater is extracted from both open or dug wells and tube wells. Tube wells are more common in Indian states because of unconsolidated rock formations. Tube wells are increasing proportionally over time. Since groundwater irrigates three times more land than canal system, it remains as a critical factor underlying our agricultural success. The widespread occurrence of groundwater over exploitation and depletion, the early warning signals of an imminent water crisis in many parts of the country has raised a shadow over our ability to sustain our agricultural gains in the long run [5]. The term ‘water markets’ describes a localized, village-level informal arrangement through which owners of a modern water extraction mechanism (WEM) sell water to other farmers at a price. It has been responsible for attaining food security through green revolution, commercialization of farming and promoting equity. The introduction of short duration, high yielding crops along with intensive application of fertilizers, pesticides and mechanization enabled farmers to adopt multiple cropping practices that increased cropping and irrigation intensity substantially. Further, the advantages of groundwater irrigation coupled with favorable government policies and market forces farmers to intensify well irrigation and convert vast dry land areas to water intensive commercial crops. Thus, the demand for groundwater increased remarkably [6] [7], [8] and [9].

The so-called groundwater markets typically involve one or more well/pumpset owning farmers selling groundwater to their neighbourers at a price substantially higher than the average pumping costs. While most of the sellers are the economically strong larger farmers owning deeper wells and larger capacity pumpsets, the buyers are mostly the smaller farmers without wells/pumpsets, though others including those owning wells/pumpsets also relay on GWMs due to fragmentation, absence of adequate water supply in their own wells, costly nature of diesel pumpsets, etc. The groundwater prices are charged mostly on an hourly basis, through payment on a seasonal basis is also reported in

some areas. The payment for the supply of groundwater for a crop season involves, on the other hand, a water rent in the form of a given share in buyers output[10]. The variations in water prices are governed by factors such as water scarcity, the type of pumpset used (i.e., whether diesel or electric and pumpsets including the horse power of the engine), type of power tariff in vogue (i.e., whether power is priced on a unit or flat rate basis), personal relationship, local customs, etc. By considering aforesaid facts above an attempt is made to analyse marketing pattern of groundwater and to identify the constraints in groundwater marketing.

2. MATERIALS AND METHODS

The study was conducted in Karnataka state with a focus on the North Eastern Dry Zone (NEDZ). This region includes three districts *viz.,* Kalaburagi, Raichur and Yadgir. However, the study area confined to three districts of Kalyana Karnataka region. The primary data were collected from the selected sample farmers using a well-structured schedule through the personal interview method. The Snow ball sampling procedure was followed for the selection of respondents for the study. The present study was conducted in three districts of NEDZ of Karnataka *viz,* Kalaburagi, Raichur and Yadgir. The snow ball sampling procedure was followed for the selection of respondents from the selected taluks. 15 water sellers and 15 water buyers from each taluk were chosen randomly. In all, a total of 90 sample constituting 45 ground water sellers and 45 ground water buyers were selected for the study.

2.1 Estimation of Cost of Irrigation Water

The amortized cost of irrigation = (Amortized cost of Bore well+ Amortized cost of pump set and electrical installation + Amortized cost of groundwater structure + annual Repairs and maintenance cost).

2.1.1 The Amortized Cost of Bore well (BW)

Amortized Cost of BW= CC of BW × $(1 + i)^{AL}$ ×(i) / $(1 + i)^{AL} - 1$)

CC of BW = Historical Investment on Borewell × $(1 + i)^{\text{Reference Year-Year of Drilling}}$

Where,
i = interest rate = considered as 2%
AL = Average life of wells
CC = Compounded cost
Compounded cost of B = (Historical investment on BW) x (1 + i) (Reference year - year of drilling)

2.1.2 The amortized cost of Pump Set (PS) and Electrical installation (EI)

Amortized Cost of PS = (CC of PS + CC of EI) × $(1 + i)^{n}$ × (i) / $(1 + i)^{n} - 1$)

CC of PS = Historical Investment on PS × $(1 + i)^{\text{Reference Year-Year of Drilling}}$

CC of EI = Historical Investment on EI × $(1 + i)^{\text{Reference Year-Year of Drilling}}$

2.1.3 Water used for irrigation

The number of acre-inches of water used for irrigating each crop in each season (Summer, Kharif, Rabi) = ((area irrigated in each crop) x (frequency of irrigation per month) x (number of months of crop stand) x (number of hours for one irrigation) x (Average yield of well in GPH)) / 22611.

One acre-inch is equivalent to 22611 gallons or 3630 cubic feet and one cubic foot is equivalent to 28.32 liters. Total water used per farm is the total acre inch of water used in different seasons including acre inch of water used per farm for perennial crops.

2.2 Garrett's Ranking Technique

The constraints faced by the sample farmers who are involved in ground water marketing were ranked by using Garrett's ranking technique. As per this method, respondents were asked constraints that they were faced in groundwater markets. Depending upon extent of constraints faced by them rankings was assigned separately to each constraint. Likewise, ranks were assigned to different frequency of various factors/parameters. The results of such rankings were converted into score value by using following formula.

$$\text{Per cent position} = \frac{100 * (\text{Rij} - 0.5)}{\text{N}_j}$$

Where,
R_{ij} = Rank given for the i^{th} factor by j^{th} respondent.
N_j = Number of factors ranked by the j^{th} respondent.

The per cent position of each rank was converted to scores by referring to tables given by Garret and Woodworth [11]. Then for each factor, the scores of individual respondents were summed up and divided by the total number of respondents for whom scores were gathered. The mean scores for all the factors were ranked.

3. RESULTS AND DISCUSSION

3.1 The Marketing Pattern of Groundwater

The marketing pattern of groundwater in groundwater markets is summarized in Table 1. The table depicts that there were mainly two methods of transactions that could be seen in the groundwater markets *viz.*cash payment and crop share. In the crop sharing method of transaction, a share of crop output is given as a price of groundwater by water buyers to the water sellers. In the cash payment kind of transaction, the water sellers sold water was charged at crop basis or hourly basis. The results revealed that majority of farmers (86.67%) prefer cash based transactions rather than the crop share (13.33%). Water sellers revealed that crop share or kind transaction was costlier than cash transaction. It is also found that relationship between water sellers and water buyers among the sample farmers in the study area. Water buyers relationship with water sellers is also important in groundwater marketing to sustain the water trade and for the smooth functioning of water markets. As it was clear from the Table 1. that the percentage of neighbourers in the total transaction of groundwater marketing was 55.23 and relatives constituted 26.66 per cent, and the percentage of friends was 21.11. Trading of water selling and buying of groundwater, the majorly takes place among the neighbour farmers. Good relationship between water sellers and water buyers leads to the smooth functioning of the ground water markets [12].

The pricing of groundwater is presented in the Table 2. The results revealed that the water price or rents varied with type crops grown by water buyers (₹7848.06, ₹2240, ₹1950 and ₹2350 for paddy, groundnut, pigeon pea and cotton, respectively.) per acre in the study area. In case of water sellers, irrigation cost was ₹5518.03, ₹1272.35, ₹1238.70 and ₹2183.77 for paddy, groundnut, pigeon pea and cotton, respectively. It was noticed in the study area that price or charges of groundwater were decided mutually through the negotiation between water sellers and water buyers. It was also seen that the price or rent of irrigation for paddy is high (₹7848.06) because it requires more number of irrigations and more quantity of water followed by cotton, groundnut and pigeon pea. It was observed in the study area that sometimes the pricing of groundwater was also fixed on the basis of number of irrigation required for the crop. For paddy, cotton and groundnut it was not possible to fix the price of groundwater on the basis of number of irrigation as these crops requires more number of irrigations in crop period. Whereas, pigeon pea crop irrigated by two to three irrigations per season. In the case of water sellers, amortized cost of the bore well its self considered as the cost of the irrigation for the each crop. From the results, it could be concluded that prices are usually fixed by negotiation between buyers and sellers but sellers have more bargaining power than buyers. It usually recovers operational and maintenance cost of wells of water seller. Prices are higher than cost, more than two times in some area. It leads to exploitation of water buyer farmers. The results were in contradiction with results obtained by [13], [14], [15], [16] and [17].

Investment on irrigation bore well is presented in Table 3. From table results, it was revealed that the average investment of water sellers in the study area was ₹156702.74. It includes the average cost of water diviners charges, drilling, casing, PVC pipes, cost of the pipeline, repair of

Table 1. Marketing pattern of groundwater in groundwater markets

Particular	No. of respondents(n=90)	%
A. Method of payment		
Cash payment	78	86.67
Crop share	12	13.33
B .Relation between water sellers and water buyers		
Neighbour	47	52.23
Friend	19	21.11
Relative	24	26.66

Table 2. Price of groundwater under different crops in the study area

	Water sellers			Water buyers		
Crop	**water used (acre inch)**	**₹ Per acre**	**₹ Per acre inch**	**water used (acre inch)**	**₹ Per acre**	**₹ Per acre inch**
Paddy	36.27	5518.13	152.13	32.43	7848.06	242.00
Groundnut	5.82	1272.35	218.61	4.90	2240.00	457.14
Pigeon pea	4.54	1238.70	272.84	3.80	1950.00	513.16
Cotton	9.68	2183.77	225.59	8.54	2350.00	275.18

the pump and electrical installation. The average bore well drilling cost was ₹78400. The average cost of pumpset was ₹28700. The average cost of the casing pipe among water sellers was ₹18250. The average water diviners charges in the study area were ₹2250.54. The average electrical installation charge of irrigation bore well was ₹8809.40. The average cost of the PVC pipes was ₹11542.80. The average charges incurred in installation of pipeline was ₹2500. The average cost of water storage structured established by water sellers in their farm was ₹4100. The annual repairing charge of the pump was ₹2150.The majority of the expenditure was made up of drilling (50.03%) and the irrigation pumpset expenses (18.31%). From the source to the several, scattered and fragmented plots, groundwater was supplied through PVC pipes. The study area had a limited supply of groundwater and an inconsistent supply of energy, so groundwater storage facilities were established by some sample farmers in the study area. The findings are in line with [16], [18] and [19], [20].

3.2 Constraints Faced by Farmers in Marketing of Groundwater

Constraints faced by water buyers during groundwater marketing were presented in Table 4. The water sellers opined the top most constraint as they were facing the problem high water charges for irrigation with Garret score 64 because there is no fixed price for water and price is fixed by negotiation between water sellers and water buyer. The other constraints faced by the sample respondents were lack of money to pay for water rent (II Rank) because of the low production and low income they were unable even to pay for irrigation water also, they were not getting water for irrigation timely during critical stage (III Rank) because sellers also use tubewell for irrgation at the same time, non-availability of water in the farm (IV Rank) due low groundwater table in some parts of study area, wastage of water during irrigation or supplying of water to water buyers field (V Rank) and lack of Government regulation on groundwater marketing(VI Rank). The results are in line with results reported by Gupta [13] conducted study on study on economics of groundwater markets in Durg district of Chhattisgarh.

Constraints faced by water sellers during groundwater marketing were presented in Table 5. Irrespective of advantages, some constraints were faced by water sellers in groundwater markets in the study area. Sample farmers stated top most constraint as the difficulty in fixing the price or rent for groundwater with Garret score 70 because there was no standard price for ground water, price was fixed by negotiation of sellers and buyers, followed by delaying of payment of groundwater by water buyers with garret score 59.33 as the second most constraint, irregular power supply in rural area (III Rank) because there was a power cut problem occurred in rural area , problems in electrification in their field (IV Rank), sellers were facing the problem of electrification and decreasing groundwater level or water table in study area (V Rank) because over exploitation of groundwater and sellers do not bother about groundwater recharge.

Table 3. Investment on bore well by water sellers in the study area

Sl. No	Particulars	Average cost(₹)	%
1	Water diviner charges	2250.54	1.44
2	Drilling charges	78400	50.03
3	Cost of casing	18250	11.65

Sl. No	Particulars	Average cost(₹)	%
4	Cost of pumpset	28700	18.31
5	Electrical installation cost	8809.40	5.62
6	Cost of PVC pipes	11542.80	7.37
7	Cost of pipe line	2500	1.60
8	Water storage structure cost	4100	2.62
9	Repair of the pump	2150	1.37
	Total	156702.74	100.00

Table 4. Constraints faced by water buyers in groundwater markets

Sl. No.	Constraints	Garret Score	Rank
1	High water charges	64.00	I
2	Lack of money to pay for water	59.66	II
3	Unable to get water timely	50.93	III
4	Non availability of water in the farm	42.13	IV
5	Wastage of water during irrigation	29.86	V
6	Lack of Government regulation on GW marketing	27.40	VI

Table 5. Constraints faced by water sellers in groundwater markets

Sl. No.	Constraints	GarretScore	Rank
1	Difficulty in fixing the price for groundwater	70.00	I
2	Delaying of payment by water buyers	59.33	II
3	Irregular power supply	53.66	III
4	Problems in electrification	36.33	IV
5	Decreasing of groundwater table	30.66	V

4. CONCLUSION

Groundwater markets were playing a crucial role in raising the income among resource poor farmers, those who were unable to make investment on bore well. It has been found in the study that that majority of farmers prefer cash transactions rather than the crop share. Water seller farmers opined that crop share or kind transaction was costlier than cash transaction.. It was noticed in the study area that price or charges of groundwater were decided mutually through the negotiation between water sellers and water buyers. It was also seen that the price or rent of irrigation for paddy is high (₹7848.06) because it requires a greater number of irrigations and more quantity of water followed by cotton, groundnut and pigeon pea. It was observed in the study area that sometimes the pricing of groundwater was also fixed on the basis of number of irrigations required for the crop. The water buyer opined the top most constraint as they were facing the problem of high water charges for irrigation followed by lack of money to pay for water rent, unable to get water timely, non-availability of water in the farm and wastage of water during irrigation or supplying of water and lack of government regulation on groundwater marketing were the major constraints of water buyer and difficulty in fixing the price or rent for groundwater, delaying in payment of groundwater by water buyers, irregular power supply in rural area, problems in electrification in their field and decreasing groundwater level or water table were the major constraints faced by water seller farmers in the study area. Groundwater markets will help in increasing agricultural production and securing livelihood for marginal and small households of farmers.

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 this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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