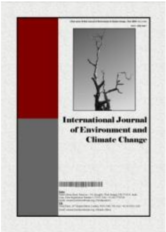

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Socio Economic Factors Responsible for Groundwater Consumption in Purba Bardhaman District of West Bengal

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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

Groundwater is the biggest freshwater reservoir in the world. More than 95% of the unfrozen water comes from groundwater. Factors responsible for groundwater consumption by rice growers have been included in the study. For the study, Purba Barddhaman district was selected purposively considering the pattern of agriculture and extent groundwater use in the state. One community development block from the district has selected based on crop diversity, type of irrigation, amount of water extraction for irrigation purposes. From the selected block a big parcel of cultivating land (*Math*) were again selected randomly keeping the consideration of homogeneity in lad type, soil type, type of crops, variety and seasons. Farmers' knowledge level, farmers' attitude towards irrigation, economic motivation, improved water extraction mechanism and method of irrigation are the major contributing factors in predicting the amount of groundwater consumption when crop and land situation are constant.

Keywords: Groundwater; socioeconomic factors; irrigation; knowledge level; attitude towards irrigation.

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1. INTRODUCTION

Groundwater is the biggest freshwater reservoir in the world. More than 95% of the unfrozen water comes from groundwater. Groundwater is an essential part of the hydrological cycle and is a valuable natural resource providing a primary source of water for agriculture, domestic, and industrial uses throughout the world. Nearly half of all drinking water in the world and about 43% of all water effectively consumed in irrigation is sourced from groundwater. Groundwater is vital for sustaining many streams, lakes, wetlands, and other dependent ecosystems [1].

On an average, globally71% of the total extracted groundwater is used in Agriculture and it is 89% for India. The water use efficiency in India is low as compared to other sectors. It is estimated that irrigated agriculture contributes to 70% of India's food grain production in which groundwater plays a major role. As a result of technological advances, groundwater use has spread rapidly in recent decades, increasing reliability of irrigation supplies, encouraging crop diversification and expanding the cropping season. Even in cases where groundwater development is costly the poor can benefit from buying water in informal groundwater markets [2]. Groundwater pumping has also brought immense benefits for safe drinking water supplies, particularly in rural areas. More than 1.5 billion people in the world rely on groundwater for their primary source of drinking water [3]. India's irrigated area expanded at a steady rate during the last few decades. The net irrigated area has increased by 24% during 1980-81 to 1990-91; by 18% from 1990-91 to 2000-01 and by 20% during 2000-01 to 2010-11. The inference is that Indian agriculture has clear limits on the extensive margin because the net irrigated area has been growing at a very slow pace. Irrigation intensity representing the intensive margin has increased by 8.8% over the past two decades [4]. Productivity of groundwater irrigated areas is more than canal irrigated areas by one- third to one-half because it offers greater control over water supply [5].At an aggregate level, India exploits about 58 per cent of annual utilizable potential. However, groundwater over-exploitation is a major concern in certain states of the country like Punjab (145 per cent), Rajasthan (125 per cent) and Haryana (109 per cent) [6].Groundwater over extraction has resulted in decline in water levels, dwindling well yields and drying up of dug wells. Besides, there is an overall increase of background salinity in groundwater. This is apart from the known ambient higher values of EC in arid regions of India, as well as in coastal tract. This has prompted to conclude that groundwater over extraction is deteriorating the ambient quality of groundwater also [7].

Ground water is the largest source of fresh water in West Bengal that occurs in saturated zone of variable thickness and depth, below the earth surface. In West Bengal, most of the local or urban area depends on the ground water. Agriculture in West Bengal is dependent on irrigation during the dry eight months from mid-October to mid-June when rainfall is minimum. Groundwater supplies about 75% of dry season irrigation and almost all municipal water supplies. West Bengal, lying in the lower Indo-Gangetic Basin is the single largest contributor of rice (15-16%) production in India. Of the three rice growing seasons in West Bengal, summer rice is exclusively irrigated and it alone accounts for 60% of total rice from 25 % of net rice area of West Bengal. Again, out of 50% net irrigated area, 70-80% area is irrigated by taping underground water through Deep tube well, Shallow tube well, and Dug well etc. During late 70's to mid 90's there was a noticeable increase in irrigated area and it was mostly due to rise in summer rice area. At present, India is the second highest rice producer in the world (103.5 MT). West Bengal is predominantly an agricultural state and its economy depends on agriculture. In West Bengal, geoclimatic variations and agriculture's dependence on rainfall have resulted in three distinct rice growing seasons: kharif rice (June/July to November/December); autumn rice (November/December to Feb/March); and summer rice (Feb/March to May/June). The natural catastrophe like floods, droughts etc. hinder the agricultural development. Flood and drainage congestion generally destroy the Kharif crop in many parts of West Bengal. Therefore, farmers especially the small farmers have to obtain summer rice as a second crop, and for this they have to depend upon groundwater. Water wells have helped small farmers to obtain a second (and even third) crop per year, and made irrigation possible beyond the anal command of government irrigation projects.

Often neglected, but nonetheless very important, are the social and economic impacts of intensive groundwater use. Such impacts may be either positive or negative depending on the factors, such as nature of the aquifer, pressure on the aquifer, recharge rates, types of use, climate and so on. However, most frequently, it is seen that at least in the short and medium term, impact of groundwater use is positive and includes such benefits as increased productivity, food security, job creation, livelihood diversification and general economic and social involvement. In the long run, depending on the factors as mentioned above, the impact might be negative, such as permanent lowering of the water table, deterioration of water quality, saline intrusion in coastal areas, emergence of arsenic problem, rise in lifting cost of irrigation water, squeezing of command area and area under crops, reduced crop output, crop diversification towards superior and cash earning crops, and thereby affecting rural employment, sustainability of agriculture system and food security of the country. The key challenge then becomes to manage risk in such a way as to minimize chances of long term negative impacts without seriously damaging short- term and medium-term benefit flow. In order to understand and manage risk, it is important to understand the social and economic dimensions of groundwater use, and its benefits and dis-benefits.

In this broader context, this paper tries to give an insight into several factors associated with groundwater consumption in West Bengal.

2. RESEARCH METHODOLOGY

2.1 Locale of Research

The study was conducted in the district named Purba Bardhaman in West Bengal. It focused Bhatar Block of Purba Barddhaman district. The farmers who use groundwater for the irrigation purpose were considered as the respondents of the present research work.

2.2 Pilot Study

Before taking up actual study, a pilot study was conducted to understand the areas, people, institutions, communication and extension system and the knowledge, perception level and attitude towards groundwater consumption.

2.3 Sampling Design

The state, district, sub divisions were selected using non-probability sampling technique called purposive sampling and the respondents were selected using simple random sampling method. The block was selected purposively. 80 respondents were selected randomly for final data collection.

2.3.1 Preparation of interview schedule

On the basis of findings of pilot study a preliminary interview schedule was formed with the help of literature, and by the assistance of Chairman of Advisory Committee and subsequent discussion with the members of the advisory Committee.

2.3.2 Finalizing of schedule after pre-testing

The draft schedule for collection of data, incorporating the tools and techniques of different variables were presented twice each time on respondents. The quantification was done for each and every variable after operationalized them. Before starting final data collection, entire schedule was pretested for elimination, addition and alternation with respondents of the study area.

2.3.3 Techniques of field data collection

Respondents were personally interviewed during the growing season of Boro paddy. Items were asked in Bengali as well as English version so that the members could understand easily. The entries were done in the schedule by student investigator himself at the time of interview.

2.3.4 Variables and their measurements

After reviewing various literatures related to the field of study and consultation with the respected chairman of Advisory Committee and other experts, a list of variables were prepared. On the basis of selected variables, a schedule was formed. Analyses were done by SPSS V20.0 software.

2.3.5 Dependent variable (Y)

Amount of groundwater extracted by a farmer in a particular season for irrigation.

Groundwater users used groundwater lifted by pump of 5 hp with 3” diameter of delivery, and the average flow rate of the WEMs is 0.19 m^3/min i.e. 11.36 m^3 per hour.

Amount of water (m^3 / per hour) = Running hour x 11.36

2.3.6 Independent variables(X)

The causal variables in this study have been presented in the bellow mentioned sequence.

2.3.6.1 Age(X_1)

In all societies, age is one of the most important determinants of social status and social role of the individual. Age of the head member of the family had only been considered for the purpose of the study.

2.3.6.2 Education (X_2)

It refers to the respondents" academic attainment through formal schooling. To quantify the educational status of the respondents, the scoring system followed by Pareek and Trivedi [8] in their socio-economic status scale-rural was used.

2.3.6.3 Topography (X_3)

Topography is the study of the forms and features of land_surfaces. The topography of an area could refer to the surface forms and the elevation or height of land is recorded as part of topography. It is usually recorded in reference to sea level. Topography often used in agriculture to determine how water will flow over the land. In this study the variable had been classified in to three categories that are high land, medium land and low land.

2.3.6.4 Irrigation water management (X_4)

Irrigation water management is the act of timing and regulating irrigation water applications in a way that will satisfy the water requirement of the crop without the waste of water, soil, plant nutrients, or energy. In this study questions were asked to the respondents whether they followed water management practices or not.

2.3.6.5 Method of Irrigation(X_5)

Irrigation is the artificial application of water for the purpose of supplying moisture essential to plant growth is called irrigation. There are various ways in which irrigation is applied to the field. This variable had been classified in to five categories and the scores were given according to the water use.

2.3.6.6 Improved water extraction mechanism (X_6)

Groundwater needs to be extracted for farm irrigation, deep well drilling and more. To do this, irrigation equipment's are required. This variable had been classified in to three categories and the scores were given according to the water extraction capacity.

2.3.6.7 Economic Motivation(X_7)

Economic motivation has been conceptualised as the values or attitude, which attach greater importance to profit maximisation as the end of the means. The economic motivation was tested with the help of three sets of statements consisting of three parts; the statements were scored as 1. 2 and 3. The respondents had two alternatives i.e. most like and least like. On the value of the assignment the result was concluded.

2.3.6.8 Production orientation (X_8)

Production orientation relates to the individuals orientation toward maximisation of returns per area. The scale developed by Samanta [9] for measurement of production orientation was used.

2.3.6.9 Participation in water market (X_9)

Groundwater market has emerged where well owners have surplus water and also there is high demand of water for irrigation. In this study questions were asked whether they sold groundwater to others or not.

2.3.6.10 Other source of surface water for irrigation(X_{10})

Surface water is any body of water above ground, including streams, rivers, lakes, wetlands, reservoirs etc. Questions were asked if any other sources of irrigation were available or not available in that area.

2.3.6.11 Knowledge level (X_{11})

Knowledge is generally understood as an intimate acquaintance of an individual with facts. Knowledge was defined as the behaviour or test situations, which emphasize the remembering, either by reorganisation or recall of ideas material or phenomenon [10]

The steps in developing a knowledge test is explained following Haque [11], Sagar 12] and Basu [13].

The knowledge level was tested through a questionnaire of 32 questions, prepared on the information collected from the state department of agriculture, I.C.A.R and a report published by NABARD. Each correct answer was assigned the score of “1” and “0” was assigned for the wrong answer.

2.3.6.12 Attitude towards groundwater consumption (X_{12})

In the present study, efforts have been made to determine the attitude of farmers towards groundwater consumption. Thurstone [14] defined attitude as the degree of positive or negative effect associated with psychological objects like symbol, phase, slogan, institution, ideas etc. towards which people can differ in varying degrees.

For the measurement of attitude, Thurstone and Chave’s equal appearing interval scale [15] and Likert’s technique of summated rating scale [16] are quite well known but out of the two, Likert’s method of summated ratings of attitude measurement was used in this study, because it requires less number of judges to start with and also less time consuming. The Attitude towards ground water consumption scale was incorporated in the final format of the interview schedule for administration to the farmers. The scale for administration was provided with four response categories strongly agree, agree, disagree, strongly disagree with the score 4,3,2,1 for the positive statements and reverse for the negative statements.

3. RESULTS AND DISCUSSION

3.1 Mean Standard Deviation and Variance of 12 Independent Variables

Table 1 presents the distribution of 12 independent variables in terms of their Mean, Standard deviation and variance**.** The mean age of the respondents was about 49 years exhibiting a standard deviation of 8.933 and variance was 79.804. The variable Education was recorded with a mean of 4.15 with a standard deviation of 1.51 thus the variance was 2.285 , the variables topography and irrigation water management were measured with mean values 2.275 & 2.55 exhibiting standard deviations 0.452 & 0.986 and variance 0.204 & 0.972 respectively. The mean value of method of irrigation was recorded as 3.395 exhibiting a standard deviation of 0.221 and variance 0.049. The improved water extraction mechanisms showed the mean value of 2.475 with the standard deviation of 0.506 and variance representing 0.256. The psychological variables i.e. economic motivation, production orientation, knowledge level regarding irrigation, attitude towards irrigation, recorded the mean values of 6.25, 18.025, 82.875, 55.825 exhibiting the standard deviations of 0.707, 1.151, 3.763, 1.866 with the variance 0.50, 2.281, 14.163, 3.481 respectively. Finally the variables participation in water market and other source of irrigation showed the mean values of 0.450, 0.050 with exhibiting the standard deviations of 0.504 and 0.221 and the variance of 0.254, 0.049.

3.2 Coefficient of Correlation (r): Total Amount of Groundwater Extracted (y) vs. 12 Independent Variables

According to the simple correlation i.e. Pearson correlation, it was found that the variables except Age(x_1), Topography(x_3), irrigation water management (x_4), method of irrigation(x_5), production orientation(x_8), other source of irrigation (x_{10}), other 6 independent variables had been found significant relationship with the dependent variable i.e. Amount of groundwater extracted by a farmer in a particular season for irrigation. These 6 independent variables had not any significant correlation with the dependent variable. Education (x_2) was negatively significant at 0.05 level of probability. It can be inferred that respondents having higher degree of education the amount of water extracted was less for irrigation. Economic motivation (x_7) was positively significant at 0.05 level of probability with the dependent variable. Thus it can be said that respondents with higher economic motivation extract more groundwater for irrigation.

The independent variables improved water Extraction mechanism (x_6) and Participation in water market(x_9) were positively significant at 0.01 level of probability with the Amount of Groundwater extraction. This indicates that more use of improved water extraction mechanism i.e. technologically advanced and buried deep underground the amount of groundwater extraction is more and the respondents who had participated in groundwater marketing extracted more groundwater.

The independent variable attitude towards irrigation (x_{12}) was positively significant at 0.01 level of probability. That means farmers having higher degree of attitude towards irrigation extracted more groundwater for irrigation.

Table 1. Mean standard deviation and variance of 12 independent variables

Variable	Mean	Std. Deviation	Variance
Age(x_1)	49.125	8.933	79.804
Education(x_2)	4.150	1.511	2.285
Topography(x_3)	2.275	0.452	0.204
Irrigation water management(x_4)	2.550	0.986	0.972
Method of Irrigation (x_5)	3.950	0.221	0.049
Improved Water Extraction Mechanism(x_6)	2.475	0.506	0.256
Economic motivation (x_7)	6.250	0.707	0.500
Production orientation(x_8)	18.025	1.510	2.281
Participation in water market(x_9)	0.450	0.504	0.254
Other sources of irrigation(x_{10})	0.050	0.221	0.049
Farmer's knowledge level regarding irrigation (x_{11})	82.875	3.763	14.163
Attitude towards irrigation(x_{12})	55.825	1.866	3.481

Table 2. Coefficient of Correlation (r): Total amount of groundwater extracted (y) vs. 12 Independent variables

Sl. No.	Independent Variables	'r' Value	Remarks
1	Age(x_1)	-.222	
2	Education(x_2)	-385	*
3	Topography(x_3)	.194	
4	Irrigation water management(x_4)	-.124	
5	Method of Irrigation (x_5)	.180	
6	Improved Water Extraction Mechanism(x_6)	.702	**
7	Economic motivation (x_7)	.316	*
8	Production orientation(x_8)	.287	
9	Participation in water market(x_9)	.679	**
10	Other sources of irrigation(x_{10})	.028	
11	Farmer's knowledge level regarding irrigation (x_{11})	-.317	*
12	Attitude towards irrigation(x_{12})	.465	**

Table 3. Stepwise regression analysis: Total amount of groundwater extracted (y) vs. 12 independent variables

Sl. No	Variables	Reg. coef. B	S.E. B	β	t value	R^2	The standard error of the estimate
1	Improved Water Extraction Mechanism(X_6)	4133.192	733.831	.594	5.632	0.670	2134.18194
2	Education(X_2)	-585.555	229.945	-.252	-2.547		
3	Attitude towards irrigation (X_{12})	539.464	201.463	.286	2.678		

r square: 67.00 per cent

Independent variable farmer's knowledge level regarding irrigation (x_{11}) was negatively significant at 0.05 level of probability it can be inferred that respondents having higher degree of knowledge of irrigation the amount of water extracted was less for irrigation.

The findings of the study are on the line of the study made by Srivastava et al. [17].They observed that most of the farmers in the central plain zone (CPZ) of Uttar Pradesh region have been found applying more irrigation water than the optimum level due to lack of adequate knowledge and under the impression that water alone can replace the requirement of other critical inputs.

3.3 Stepwise Regression Analysis: Total Amount of Groundwater Extracted (y) vs. 12 Independent Variables

Table 3 represents the step wise multiple regression between the dependent variable amount of groundwater extraction and the other 12 independent variables. It was also found that the independent variables education(x_2) improved water extraction mechanism (x_6), and attitude towards irrigation (x_{12}) had been retained after eliminating the other trivial variables in the preceding steps.

Improved Water Extraction Mechanism (X_5) recorded highest regression effect on the amount of groundwater extracted having the β value of 0.594. Thus representing a positive effect on the amount of groundwater extraction and with the unit change in this variable had contributed 4133.192 unit changes, which is also the highest contribution of all.

The variable Education (X_2) had a negative effect on amount of groundwater extraction exhibiting the β value of -0.252. A unit change in this variable had contributed 585.555 unit changes (Negatively) in the amount of groundwater extraction.

The variable Attitude towards irrigation (x_{12}) had a positive effect on amount of groundwater extraction exhibiting the β value of 0.286. A unit change in this variable had contributed 201.463 unit changes in the amount of groundwater extraction.

Here the R^2 value being 0.670, it is to infer that the 3 variables together explain 67.00% variation embedded with the predicted variable of amount of groundwater extraction.

4. CONCLUSION

In this research we found that the majority of the farmers are marginal and small farmer therefore they have to cultivate two or three crops in a year. Availability of groundwater throughout the year is enabling them to do so. Dependence on surface water sources is not feasible as the canal irrigation is not available in all the areas and also the ponds are dried up during summer months that do not allow the farmers to grow crops. Farmers cultivate boro paddy to a large area in Bhatar block of Purba Barddhaman district. This crop cannot be removed from the cropping sequence as there is a strong marketing channel as well as the demand. Actually, farmers do not choose crops on the basis of water requirements, rather they choose crops based on water availability and estimated net returns. It was previously commented by Sarkar and Das [18]. The farmers were not following efficient and judicious use of groundwater. Ignorance and carelessness to the issue leads to drawdown of aquifer. However, for ensuring sustainable use of groundwater, changes in attitude, knowledge and management aspects of ground water irrigation of the farmers have to be given due attention at this juncture. Planning, decision making, and operation of controls and dissemination of appropriate knowledge from experts' level to farmers' level through capacity building should be promoted immediately with respect ground water management to protect our future.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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