

**An Economic Study of Ground Water Market in Sikar
District of Rajasthan**

**राजस्थान के सीकर जिले में भूजल बाजार का आर्थिक
अध्ययन**

SEEMA KASOTIYA

THESIS

**Master of Science in Agriculture
(Agricultural Economics)**



उत्तमा वृत्तिस्तु कृषिकर्मैव

2019

Department of Agricultural Economics

College of Agriculture, Bikaner

**Swami Keshwanand Rajasthan Agricultural University,
Bikaner-334006**

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BY

SEEMA KASOTIYA

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**Swami Keshwanand Rajasthan Agricultural University, Bikaner
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This is to certify that the thesis entitled “**An economic study of ground water market in Sikar district of Rajasthan**” submitted for the degree of **Master of Science in Agriculture** in the subject of **Agricultural Economics** embodies bonafide research work carried out by **Miss Seema Kasotiya** under my guidance and supervision and that no part of this thesis has been submitted for any other degree. The assistance and help received during the course of investigation have been fully acknowledged. The draft of the thesis was also approved by the advisory committee on 19/06/2019

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This is to certify that **Miss Seema Kasotiya** of the Department of Agricultural Economics, College of Agriculture, Bikaner (Rajasthan) has made all corrections/modifications in the thesis entitled “**An economic study of ground water market in Sikar district of Rajasthan**” which were suggested by the external examiner and the advisory committee in the oral examination held on ----/-----/2019. The final copies of the thesis duly bound corrected were submitted on ___/___/2019 and forwarded herewith for approval.

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“Kind words can be short and easy to speak, but their echoes are truly endless”.

Mother Teresa

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Place : Bikaner

(SEEMA KASOTIYA)

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1. INTRODUCTION

“The earth, the land and the water are not an inheritance from our forefathers but on loan from our children. So, we have to handover to them at least as it been handed over to us.”- Mahatma Gandhi

Water is a critical input into agriculture in its all aspects having a determining effect on the eventual yield. India has 18 per cent of world population, but it account only 4 per cent of world’s fresh water, out of which 80 per cent is used in agriculture. India’s annual rainfall is around 1183 mm, out of which 75 per cent water is received in only four months of monsoon (July to September). This result in run offs during monsoon and calls for irrigation investments for rest of the year. The population of India is expected to be 1.6 billion by 2050, resultingan increased in demand for water, food and energy in both urban and rural areas. Climate change has negative impact on agricultural productivity ranging from crop selection; time of cultivation, irrigation methods etc.

Ground water is a major source of irrigation in most parts of India. The growth in ground water irrigation has been considered to be the most crucialforerunner of the Green Revolution technology in the country (Chadha, 2002). Tube well technology was responsible not only for introducing new crops,cropping pattern and also for pushing up cropping intensity. Farmers was preferring ground water as they have better control over quantity and the timing of water supply to the crop (Srinivasan & Kulkarni, 2014). This results in higher yields for ground water irrigated crops when compared to surface-water-irrigated crops (Dhawan, 1995).

According to CWC annual report 2016-17, in India the water resource potential or annual water availability of the country in terms of natural runoff (flow) in rivers is about 1,869 Billion Cubic Meter (BCM)/year. However, the water resources of the country have been estimated as 1,123 BCM/year. Out of which the share of surface water and ground water is 690 BCM/year and 433 BCM/year respectively. The net annual ground water accessibility for the entire country is 369 BCM. The contribution of rainfall to the country’s annual ground water resource is 68 per cent and the share of other resources, such

as canal seepage, return flow from irrigation, recharge from tanks, ponds and water conservation structures taken together is 32 per cent only. The ultimate irrigation potential of 140 m ha of land, ground water resources cover 64 m ha which is around 46 per cent. Due to the growing population in the country, the national per capita annual availability of water has been reduced from 1,816 cubic metre in 2001 to 1,544 cubic metre in 2011 which is around a reduction of 15 per cent ground water availability.

Over exploitation of ground water beyond the sustainable level has resulted into significant decline in the ground water table, particularly in northwest India. The Central Ground water Board has categorized 16.2 per cent of the total assessment units: Blocks, Mandals or Talukas numbering 6607 as 'Over-exploited' category. It has categorized an additional 14 per cent as either at 'critical' or 'semi-critical' stage. Most of the overexploited blocks are in northwest region of the country.

Low and erratic rainfall in western Rajasthan's districts and unavailability of proper irrigation facilities are the major constraints to agricultural production in Rajasthan. The quantity of net annual ground water availability was 10828.97 MCM in 2011 which has increased to 11256.77 MCM in 2017 due to comparatively good rainfall during the years 2011 to 2017.

1.1 Problems regarding ground water

The problems of increased demographic pressure and societal advancement have resulted in water shortage for domestic, agricultural and industrial purposes. The rapid exploitation of ground water has resulted in declining water levels, gradual exhaustion of ground water reservoirs and deterioration of ground water quality. The ground water resources are under stress in many areas of the country. This problem is more severe in Rajasthan which is characterized by extreme temperatures, high evapotranspiration, low and erratic rainfall and low ground water potential. Rajasthan has mostly covered by arid (57.31 per cent of total

area) and semi-arid (35.36 per cent of total area) regions. With limiting number of rainy days and high probability of dry years with very little surface water flow characterizes the arid to semi-arid climatic conditions. Therefore, ground water plays an important role in the development resources in Rajasthan.

Notable break through in the ground water irrigation came with the introduction of high yielding varieties and modern ground water extraction technology. The increasing use of ground water for irrigation, *i.e.* from protective role to the productive role of irrigation, leads to the increased ground water depletion and speedy decline in the ground water. Extensive rural electrification, the ready availability of high capacity pump sets and deep drilling technology initially enabled extensive development of deep aquifers. In addition, governmental subsidies for financing well development and highly subsidized electricity in the farming sector have also played a major role. The rapid ground water development catalyzed by these subsidies led to further lowering of water levels with the resultant increase in pumping depths. Declining water levels have led to widespread well failures which further resulted in the increased cost of construction of new wells and pumping costs. The direct consequence is the emergence of a new dimension of inequality between those resource rich farmers, who have been successful in the competitive deepening race and those resource poor, marginal and small farmers, who fails and lose in the race of competitive deepening (Shah, 1993). This resulted in threats to the inter-farm equity in access to irrigation water, yield levels and employment levels.

1.2 Ground water markets

Ground water has contributed significantly to the development of Indian agriculture. Rajasthan has already crossed the phase of ground water 'development' and has entered the phase of ground water 'management' (Shah, 1997), *i.e.* from a stage in which maximizing the benefits of ground water was a priority to a stage in which the cost of ground water overuse have to be minimized. The declining water table has resulted in a widespread failure of wells and leds to increase in the cost of well-deepening, installing new wells and pumping. This has resulted inequality in the access to ground water for

irrigation among resource-poor as well as resource-rich, farmers. This has led to the emergence of Ground Water Markets (GWMs) for providing access to irrigation waters.

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. Ground water trade among farmers is though localized, fragmented, and in the process of evolution as informal market institution, it does have efficiency implications for the utilization of ground water. (Shah, 1993).

The constitution of the existing water market is examined through the determination of the water price–cost ratio. In the short run, water markets improve accessibility to ground water irrigation, particularly for marginal and small farmers. Farmers are able to mitigate water-scarcity-related vulnerabilities as well as the well owners achieve better utilization to their pumping capacity; it increases the cropping intensity and productivity; changes cropping pattern infavour of high value crops and finally all these leads to increased demand for labour which is more evenly spread throughout the year (Shah, 1993; Shah and Raju, 1988 and Shanker, 1992). In regions of abundant and well-recharged aquifers, ground water markets can transform a stagnant traditional agriculture into a modern booming economy with powerful beneficial productivity and equity effects.

The ownership of private wells is confined mostly to resource-rich large farmers who have emerged as sellers of water. The surplus water after meeting their own requirements is sold to the marginal and small farmers, who become the buyers to avoid the huge initial investments needed to install a well. Even large farmers, who have fragmented holdings and are not able to install wells on each parcel of land, have resorted to buying water from the neighboring well-owners,. The phenomenon of ground water marketing by farmers in many parts of the country has been well documented by Dhawan (1991), Kolavalli and Chicoine (1989), Patel and Patel (1969) and Shah (1988; 1993). Thus an attempt has been made to understand the prevailing practice of ground water marketing in the state of Rajasthan.

Therefore the study has been taken under following objectives:

1.3 objectives

- I. To analyze the factors influencing ground water market in study area.
- II. To study the impact of ground water market on changing cropping pattern, productivity and profitability.
- III. To assess the ground water use efficiency and the influence of ground water market on water use efficiency.

1.4 Limitation of the study

The efforts were made to make the study precise, comprehensive and objective, however, certain restrictions do remain. The important limitations of the study are given below:

- I. The primary data were collected from the farmers by survey method based on their memory. Though every effort was made to get accurate and precise information from the farmer's but there is chances of errors, due to forgetfulness of the farmers.
- II. There was shortage of time with the scholar.
- III. There was no facility of any technique to quantify the ground water in field on the farmer's side. So, the comparative analysis was not possible.

2. REVIEW OF LITERATURE

A review of previous research provides information to the researchers regarding the previous work done in their area of research and helps in identifying the theoretical and conceptual framework and methodological issues relevant to the study. This would enable the researchers a proper direction to carry out their research work and enables them to arrive at meaningful results. Keeping in view the objectives of the present study the reviews are presented in the following headings.

2.1 Factors influencing ground water market.

2.2 Impact of Ground water market on changing cropping pattern, productivity and profitability.

2.3 Ground water use efficiency in water use.

2.1 Factors influencing ground water markets-

The factors influencing the ground water markets determine the probability of selling and buying activity of the water for agricultural operations.

Dilli (2004) conducted his study on the ground water markets in Nepal and concluded that household income, access to pump repair shops and credit and number of land parcels positively and significantly affected the Shallow Tube Well (STW) ownership decision of the farmer. The determinants of farmer's participation in the demand-side water market were positively and significantly affected by parcel distance, negatively and significantly by farm size, age and education of decision maker, and area under canal irrigation. On the supply-side significant factors were electric power source (positive) and net operated area and area under water-demanding crops (negative). Net operated area, electric power source, and land parcels positively and significantly affect the amount of water purchased by the farmers.

Bhandari and Pandey (2005) studied the economics of ground water irrigation and Shallow Tube Well (STW) ownership decision making, using

farm-level data. According to them STW irrigation generated a significant effect on rice yield and incomes. Based on a probit analysis, the farm size, land fragmentation, access to electricity, and access to credit were found to considerably influence farmer's choices to have STWs. Although, the water market benefited poor farmers but it was too small and monopolistic in nature. They further suggested reforms were needed to make ground water accessible to the poor.

Sharma and Sharma (2006) conducted a study in the arid and semiarid zones of Rajasthan addressed issues like exploitation of the buyers of water, *i.e.* resource-poor, small farmers, becoming a remunerative business economically for the sellers and showed the prevailing terms of water transactions, particularly 'in-kind' terms, lead to the over-exploitation of ground water resources. The credit and power pricing policies of the government also helped in the unsustainable and inequitable use of ground water. The analysis of farmer's decision to participate in water markets employing logit regression model suggested that the farmers having higher fragmented landholdings had more probability of buying ground water. Joint ownership of wells was negatively associated with the farmer's probability of buying ground water.

Khair *et al.* (2010) studied the effects of different factors on the water table. The results indicates that water table decline increases with; (1) increase in the number of tube wells; (2) continuation of subsidized electric tariff policy; (3) policies of ground water development; (4) increase in tube well irrigated area; (5) annual average rainfall. The coefficient was significant for all factors except rainfall. According to them as an immediate measure; the water saving through electricity rationing seems to be the best way to slow down the water mining as a short run remedy. But in the long run; a more comprehensive sustainable ground water management policy with the involvement of all the stakeholders is needed.

Khair *et al.* (2012) studied ground water markets under the water scarcity conditions: the upland Baluchistan region of Pakistan and they have found that variables such as, tube well ownership, reliability of tube well, soil withholding capacity and farm area significantly affect the water buying decision. While the variables such as age, education, cropping intensity, area

under high delta fruits, area vegetables kharif, water buy kinships, dried tube well ownership, power connection, lack of alternate source of irrigation, and plots number showed the expected effect on the decision to buy water.

Juchems and Schoengold (2012) conducted a study on surface water trading and theoretical approaches to analyzing ground water trading. Ground water trading helped move water from low-value to high-value areas of use for the benefit of participants and public. The results showed that there is a strong desire to participate in trades, but high transactions costs had limited the number of trades that have occurred.

Dutta (2013) studied ground water markets in Assam in Eastern India and the results of the logit analysis on the determinants of buying water which have shown that own farm size, distance of buyers' plots from the nearest source of irrigation, education and age of the farmer have exerted significant influence on water purchase decision of the farmers. The study noted that farmer's better contact with the extension services reduces the probability of a farmer's water buying decision indicating that government's support in farming helps farmers to gain more control on irrigation water.

Manjunatha et al. (2014) analyzed the factors that influence farmer's participation in the informal ground water market using the Cragg's double hurdle model. For the study, primary data collected from 171 ground water farmers belonging to the Eastern dry zone of Karnataka were used. The result shows that agricultural credit and farmers wells positively influence farmer's probability of water buying. With increasing water cost, the farmers were more likely to purchase or sell water and the quantity of water purchased or sold decreases with the increase in irrigation cost. The well-owners who had drip irrigation and land fragments are more likely to sell water.

Tamuli and Dutta (2015) studied ground water markets in Assam. The study is based on the factors influencing water buying decisions of farmers under ground water market in water abundant regions of India taking the case of Assam in eastern India. Using field data from two districts of the state and with the help of logit regression analysis, the results showed that large farm size, access to institutional credit, age and better contact with extension agencies

significantly reduce the probability of water trade decision of a farmer. The probability of buying water is found to be higher for tenant farmers. The results indicated that water buying decision of a farmer in water abundant regions is the result of a collective effect of a number of factors i.e. socio-economic, farm specific and tube well specific factors.

Giannocco (2016) conduct a study on the factors influencing farmer's willingness to participate in water allocation trading. The results indicated that those farmers who were more innovative and had agricultural training show a higher willingness to participate in water trading.

Srivastava et al. (2017) identified factors which effect the ground water depletion in Punjab (India) and examines the economics of ground water irrigation across farm-size categories, varied ground water levels and energy policy scenario. The farm-level evidences pointed out that farmer with smaller land holdings incur 2–3 times ground water cost than those with larger land holdings. Small farmers were affected more adversely due to falling ground water level.

2.2 Impact of Ground water markets on changing cropping pattern, productivity and profitability

Singh and Singh (2003) studied “Ground water markets and the issues of equity and reliability to water access: A case of Western Uttar Pradesh”. Ground water markets had important equity implications under the existing farm conditions. Water markets benefits were carried by both buyers as well as sellers across the farm sizes. Electric operated water extraction mechanisms were economical and hence preferred by most of the farmers, but these were unreliable. This necessitate (i) educating the farmers concerning economical water extraction devices and their management, (ii) quality power supply like uninterrupted, timely and adequate power supply with proper voltage and better service, etc., and (iii) rational electricity tariff which discourages over-exploitation of ground water.

Kajisa and Sakurai (2005) examined effectiveness and equity in ground water markets with special attention to output sharing contracts and to the bargaining relationships between sellers and buyers, using household level data from Madhya Pradesh, India. The results found no significant inefficiency on farms managed by output sharing buyers, presumably because optimal input intensities are achieved through effective monitoring and contract adherence mechanisms embedded in long term and intensive personal relationships between sellers and buyers. As for equity, the finding was that, while output sharing buyers pay higher water prices, the rate of premiums is merely 5 per cent higher than the informal interest rate that they would have had to hold underneath alternative formground water contracts. The results also showed that buyers who have access to alternative water sellers pay lower water prices.

Khanna (2007) estimated inequities in production and income for different categories of water users in the situation of a rapidly depleting resource by estimating technical inefficiency using frontier techniques. The research was based on primary data from a North Indian village that shared characteristics commonly observed in other ground water-dependent agricultural areas. The technical efficiency scores were highest on plots where water was sourced from a privately owned tube well, followed by plots serviced by partnered tube wells and lowest on plots where water is bought. Income gains from improved efficiency followed the reverse patterns with the largest gains of `1082 per bigha estimated for buyers' plots and `649 per bigha for plots with their own tube well with the average of `867 for all plots. A policy package of improved power, joint ownership of tube wells, farmer training and better water transportation systems were prescribed as policy measures to alleviate the differences among water users.

Banerji et al. (2010) analyzed the institutions and informal markets that govern the ground water allocation in the sugarcane belt of North India. They

found that the observed water trades resulted in efficient water allocation across farms. Poor functioning of the electricity sector leads to reduced pumping and a water supply constraint. Simulations showed that power supply reform could significantly increase farm yields, be financed out of the increased farm profits, and provide an instrument to use for attaining inter temporal efficiency in water allocation.

Garrido (2010) addressed the issue by analyzing the functioning of the irrigation communities in pre-1950s eastern Spain. While in some of them the water inhered in the land and could not be sold, in others there were tradable water rights. In the paper it's shown that, in the former, not only was equity greater but in fact the resource was also used more efficiently.

Manjunatha et al. (2011) studied "Can Ground water Markets Promote Efficiency in Agricultural Production" and they found that in the hard rock areas of India overdraft of ground water is resulting in negative externalities such as reduction in water table and tube well failures. This increased the costs of ground water irrigation resulting in inefficiency and welfare losses. Informal ground water markets are slowly emerging with the potential of improving water distribution and mitigating scarcity. The efficiency was estimated for three groups of famers and results indicate that, water buyers were more efficient followed by sellers and the control group, in particular, in using inputs in general and water specifically. Differences in efficiencies between the groups were shown to be significant using a Kruskal-Wallis test.

Khair et al. (2012) analyzed ground water markets under the water scarcity and declining water table conditions. Two common transactions ways were noted – water in exchange for a given crop share and direct cash payment at a flat rate per hour. In all, 60 per cent of respondents reported selling water in exchange for a crop share. Water trading of the study area in the form of cash transactions was practiced by 40 per cent of respondents. The charge per hour also varied with altitude, with

average prices of `100, `112 and `205 per hour according at low, medium and high altitudes, respectively. In upland Baluchistan, the water markets appears to provide a cushion against increasing water scarcity by averting risk to high value horticultural crops and enhancing water use efficiency, as it helps overcome the problem of over irrigation or misuse of water by facilitating the sale of surplus or extra water and more sparing and economical use of purchased water.

Kajisa and Takeshi (2015) examined the efficiency and equity in ground water markets with special attention to output sharing contracts and to the bargaining relationships between sellers and buyers, using household level data from Madhya Pradesh, India. Regression results found no significant inefficiency on farms managed by output sharing buyers, presumably because optimal input intensities are achieved through effective monitoring and contract adherence mechanisms embedded in long-term and intensive personal relationships between sellers and buyers. As for equity, the finding was that, while output sharing buyers pay higher water prices, the rate of premiums is merely 5 per cent higher than the informal interest rate that they would have had to carry under other types of ground water contracts. The results also showed that buyers who have access to alternative water sellers pay lower water prices. These findings indicated that if the imperfections of credit and contingent markets in rural areas are taken into account, informal ground water markets work fairly well in agrarian communities if monitoring and contract adherence mechanisms are embedded and a sufficient number of potential sellers are available.

Manjunatha et al. (2016) analyzed technical, allocative and economic efficiency of ground water-irrigated farms. Using a bootstrapped data envelopment analysis and the determinants of the efficiency were explored using a bootstrapped truncated regression. For this purpose, data were collected from three different groups of ground water-irrigated farmers: (i) a control group of 30 farmers who are neither selling nor buying ground water; (ii) a group of 30 water-selling farmers; and (iii) a group of 30 water-buying farmers. The results demonstrated that there was substantial technical,

allocative and economic inefficiency in the irrigated production due to overuse of inputs and that this inefficiency is higher among the control group farmers followed by water sellers and water buyers. Also in the second-stage regression, participation in the water markets is revealed as an important factor positively affecting efficiency scores.

Mukherjee and Biswas (2016) conduct a study on inter and intra-generational equity implications of ground water markets in the context of subsidized electricity where the market enabled even non-well owners to access ground water for irrigation. The study was based on survey data collected from two districts in the state of Madhya Pradesh, India. The sample includes farmers who use electricity- and diesel-powered pumps to lift ground water. The structure of the existing water market was examined through the determination of the water price–cost ratio. The article found that, in the short run, water markets improve accessibility to ground water irrigation, particularly for marginal and small farmers. With the help of this, farmers were able to mitigate water-scarcity-related vulnerabilities. However, in the long run, electricity subsidy may have negative dynamic implications by causing over-exploitation of ground water that reduces the volume of ground water available for future agricultural use. In other words, this article found that, in the initial phases of the development of the water markets, there are intra-generational equity implications. However, in the advanced phases, the unsustainable extraction of ground water could lead to inter-generational inequities.

Singh and Arya (2016) studied water markets and its implications on small farmers. The ground water markets were prevalent in all the regions of Indo-Gangetic plains. However, in Trans-Gangetic plains, the buying and selling activities were undertaken by only 16 and 8 percent of the farmers respectively. On the other hand, the ground water buying and selling were prevalent in all categories of farms in upper, middle and lower-Gangetic plains. The farmer's decision to own an electric operated tube well were influenced by size of operational holding, education of head of family, family labour per acre, ground water table, off farm income, selling price of water and joint ownership of tube well in Upper-Gangetic plains. The yields and returns

were high on self-user farms in comparison to purely buyer farms in wheat and paddy crops in all the regions except wheat in Middle-Gangetic plains. The equity analysis showed that the buyers were used significantly lower irrigation hours than self-user forms of water markets.

2.3 Ground water use efficiency in water use

Ground water market provides an equitable access to irrigation water by resource poor farmer. The reviews outlined here, provide a background to study the ground water accessibility and its impact on ground water use efficiency.

Following the pioneer work of **Farrell (1957)**, Economic Efficiency (EE) is usually disaggregated into two types: (a) Technical Efficiency (TE) and (b) Price/ Allocative Efficiency (PE/AE). Technical inefficiency refers to failure to operate on the production frontier which in turn is highest production achieved from a given level of input in population of farmers or it can be defined by reference to a potential frontier based on experimental data. Allocative inefficiency generally refers to failure to meet the marginal condition for profit maximization. The usual test for allocative efficiency is to compare the marginal value product of an input to its normalized price. Farrell's measure of allocative efficiency compared the actual input level of a farmer with the optimum on the frontier and identifies technically inefficient farmer being allocative inefficient as well. He used the deterministic nonparametric frontier approach to measure TE. Economic efficiency can be defined in terms as the product of measured TE and AE.

Zhu et al. (2004) estimated water productivity (both physical productivity and economic efficiency) for many crops in Yellow river basin of China and concluded that among rice, wheat and maize, the physical productivity of water was highest for maize (1.4 kg/m^3) followed by wheat (0.5 kg/m^3) and lowest for rice. The economic efficiency of water was highest for cotton and followed by maize.

Ray (2005) studied the water prices and its impact on irrigation efficiency in one of canal system in Maharashtra. The study revealed that the low water

prices were not the main reason behind the farmer's water inefficient crops choices. Moreover, farm level inefficiencies appeared not to be the most significant prices driving irrigation demand. Thus, a better step would be to enforce simple allocation rules such as per-hectare ratios that would make water scarcity value obvious.

Mahender et al. (2006) suggested optimal crop plan to sustain the use of ground water resource for irrigation in Perambalur district of Tamil Nadu by using liner programming technique. Six typical farms were selected, on each for the open well, wells in tank command area and tube-well irrigated farms in critical and overexploited ground water regimes and also for semi critical and safe ground water regime. In all optimal crop plans, area under high water intensive crop (groundnut and tapioca) showed increasing trend. The net income of the sample farms increased marginally or considerably in all the optimal crop plans.

Singh and Singh (2006) examined the structure, determinants and efficiency of ground water market. For the efficiency of ground water use, Cobb-Douglas production function was used. In case of sugarcane, coefficient of irrigation was found to be positive and significant for water buyers only, suggesting that an increased used of irrigation would further increase the productivity. The irrigation coefficient however was negative and significant for self-users farms indicating over utilization of ground water. Thus, the study suggested the possibility of optimum water use on self-users would increase the availability of water on buyer's farms.

Srivastava et al. (2009) examined the ground water extraction under different water market regimes in the Central Plain Zone (CPZ) of Uttar Pradesh based on the primary data collected from 100 farmer-households in the year 2007, where water-intensive cropping pattern is followed and found that easy access to irrigation water due to emergence of water markets has also led to the shifting of cropping pattern towards water-intensive crops, replacing gram, pigeon pea, groundnut and green gram by rice, wheat and sugarcane. The water productivity and water use-efficiency in the region have not been encouraging as most of the farmers in the region have been found applying more irrigation water than the optimum level due to lack of adequate

knowledge and also more inefficiency was found among tube-well owners, which causes over-exploitation of ground water.

Pervaize et al. (2010) used paired t-test to delineate tube well irrigation on productivity and cropping intensity in four district of North West Frontier Province (NWFP) which was based on primary data found that with the availability of water in the study area, the productivity of wheat and maize increased from 379 kg/acre to 1333 kg/acre and 183 kg/acre to 1017 kg/acre respectively. Before irrigation only medium farmers cultivated maize with total 40 acre in study area and but after irrigation the maize was cultivated by all the three categories of sample respondents i.e. small, medium and large farms and area jumped to 375 acre in study area which shows change in cropping pattern and cropping intensity of the respondents.

Wang J. (2014) explored the impacts of the emergence of the ground water markets on agricultural production – including crop water use and crop yields – and farmer income in northern China. Results indicated farmers that buy water from ground water markets use less water than those that have their own tube wells. However yields of water buyers are not negatively affected. This is probably because water buyers exert more efforts to improve water use efficiency. Results also show that other things held constant, the crop incomes of water buyers are not statistically different from those of well owners. The chapter also finds that ground water markets in northern China are not monopolistic, supporting the notion that they offer poor rural households affordable access to irrigation water.

Khan (2015) studied the water use efficiency in Bangladesh agriculture: management and water charging issues- improving the performance and efficiency of water management in agriculture could save water from existing uses. Better management of irrigation water and appropriate water charging possibly enhanced greater efficiency in water use. This study found that performance and operations of the existing irrigation systems in Bangladesh was too poor in terms of water use efficiency. Moreover, low water pricing was causing excessive and inefficient use of water. Improved management of surface and ground water irrigation and appropriate pricing strategies were suggested for achieving physical and economic efficiency in water use.

Manjunatha et al. (2016) used Data envelopment analysis approach to study the impact of ground water markets in peninsular India on water use efficiency and found that Water Use Efficiency (WUE) was highest among the water buyers (0.77 and 0.84 under CRS and VRS specification respectively), followed by the water sellers (0.73 and 0.77 under CRS and VRS specification respectively) and the control group has the lowest WUE (respectively 0.67 and 0.72) and also found that the group of water buyers consists of resource poor farmers who without water markets would not be able to practice irrigation.

3. RESEARCH METHODOLOGY

In this chapter, an attempt has been made to describe the methodology adopted for the study viz. selection of district, *tehsil*, farmers and method of data collection, and technique used for the analysis of the collected data. The methodological frame work adopted for the present study has been discussed under the following headings:

3.1 Sampling framework

3.2 Collection of data

3.3 Analytical tools and techniques

3.1 Sampling Framework

The semi-arid regions of Rajasthan spread over the western parts of the state. The rainfall is lowest in the western part. There is no major irrigation project. Wells and tube wells are the main source of irrigation. The groundwater is the only source of irrigation in these regions. Groundwater is less scarce in the semi-arid region as compared to arid regions. The groundwater depth is 25-40 m in the semi-arid region. The depth of tube-wells is about 70-125 m in the semi-arid region. So, the present study has undertaken for the analysis of ground water market in state of Rajasthan.

3.1.1 Sampling Method

Multi-stage sampling technique was used for the selection of sample farmers in the present investigation.

3.1.2 Selection of district

Sikar district was purposely selected for the study in the first stage. The district categorized on the basis of over-exploitation of groundwater development, where the buying and selling of ground water were in practice.

3.1.3 Selection of *tehsils*

Among 8 *tehsils* of Sikar district, two *tehsils* were selected on the basis of overexploited category of ground water was selected randomly with the help of *tehsil* Development Officer and Assistant Agriculture Officer of concerned *tehsil*. First was Dhod and second was Sikar.

3.1.4 Selection of villages

Total four villages was selected on the basis of overexploited category of ground water was selected randomly, two from each selected *tehsil*. Villages so selected has been shown in table 3.1.

Table 3.1: List of sampled villages from each *Tehsil*

S.No.	Name of <i>Tehsil</i>	Name of Village	No. of Farmers selected
1.	Dhod	Doojod	20
		Jhingarchoti	20
2	Sikar	Dadli	20
		Hardayalpura	20

3.1.4 Selection of farmers

A list of farmers was prepared from each village with the help of village patwari, Sarpanch, villagers and the farmers, categorized into self-users (SU), self-users + sellers (SU+S), self-users + sellers + buyers (SU+S+B), self-users + buyers (SU+B), buyers (B) and non-users (NU) groups or forms of water markets. From each village 20 farmers were selected ultimately 80 farmers were selected from four selected villages.

3.2 Collection of data

In order to address the objectives of the study, primary as well as secondary data was collected for the study.

3.2.1 Primary Data:

The primary data were collected through well structured, pre-tested and comprehensive schedules exclusively prepared for the study from farmer by personal interview method. The schedule used for the primary data collection was designed based on the objectives of the study. The primary data pertains to agricultural year 2017-18. Some district level information, rules and regulations on groundwater exploitation and other basic information have been collected from various published or unpublished sources of government of Rajasthan.

3.2.2 Secondary Data:

The secondary data were collected from different published, online and others sources.

3.3 Analysis of data

The collected data were analyzed according to specific objective of the study. Different statistical models (both tabular and function analysis) were used.

Simple tabular analysis was followed to examine the determinants of the groundwater markets, i.e., effect of groundwater markets on the changes in cropping pattern, cost of cultivation, productivity, profitability, returns from crops, cost of water extraction, selling of water and overexploitation of water, water use efficiency. Constraints perceived by farmer in groundwater development were examined critically with a view to study the impact on GWMs.

Objective 1: The factors influencing ground water market

The logistic regression analysis was carried out to quantify the relative importance of factors influencing farmer's decision to buy groundwater for

irrigation. In logistic regression analysis, only buyers and sellers of water were included, as farmers of only these categories indulged in water marketing activity.

In the groundwater markets, buying and selling of irrigation water was a dichotomous-dependent variable. Its determinants were assessed using logit model based on logistic cumulative distribution function (Mc Faddan, 1974 and Maddala, 1983).The logit technique allows examination of the effects of a number of variables on the underlying probability of buying or selling the irrigation water.

The behavioral model was used to examine the factors affecting the purchase of groundwater

$$Y_i = g(Z_i) \tag{1}$$

$$Z_i = a + b_k X_{ki} \tag{2}$$

Where,

Y_i = The observed response of the i^{th} farmer (*i.e.* the binary variable $Y= 1$ for buyer and $Y = 0$ for a non-buyer)

Z_i = An underlying and unobserved index for the i^{th} farmer (when Z_i exceeded some threshold Z^* , the farmer was observed to be buyer; otherwise non-buyer)

X_{ki} = The k^{th} explanatory variable of i^{th} farmer

$i = 1, 2, \dots, N$. Where, N the number of farmers

$k = 1, 2, \dots, M$. Where, M the total number of explanatory variables

a = Constant, and

b = Vector of coefficients.

The logit model postulated that P_i , the probability that i^{th} farmer purchased groundwater, is a function of an index variable Z_i summarizing a set of the

explanatory variables. In fact, Z_i is equal to the logarithm of the odds ratio, i.e. the ratio of probability that the farmer purchase groundwater to the probability that he does not purchase and it can be estimated as a linear function of explanatory variable (X_{ki}). This can be mathematically expressed as:

$$Z_i = \ln \left\{ \frac{P_i}{1 - P_i} \right\} = a + b_k X_{ki} \quad \dots\dots\dots(3)$$

Equation (3) is the logit model (Pindyck and Rubinfeld, 1981), and once this equation is estimated, P_i can be calculated as:

$$P_i = f(Z_i) = f(a + bX_i) = 1/(1 + e^{-Z_i}) \quad \dots\dots\dots(4)$$

$$= 1/1 + e^{-(a+b_k X_{ki})} \quad \dots\dots\dots (5)$$

Where,

'e' represents base of the natural logarithms and approximately equals to 2.718.

In the logistic regression, the parameters of the model were estimated using the maximum-likelihood method, *i.e.* the coefficients that make our observed results most likely selected. The logistic coefficients can be interpreted as the change in log odds associated with one unit change in the independent variable. Since the logistic regression model is non-linear, an iterative algorithm will be used for parameter estimation. The maximum likelihood estimation procedure has number of desirable statistical properties.

The goodness of fit of the model was tested by three approaches. Firstly, predictions were compared with the observed outcomes and expressed in percentage of correctly predicted. Secondly, 2-times the log of the likelihood (-2LL) estimate was used as a measure of how well the estimated model fitted the data. A good model was one that results in a high likelihood of the observed results. To test the null hypothesis that the model fitted perfectly, (-2LL) had a chi-square distribution with N-K degrees of freedom. In this test the large observed significance level indicated that the model did not differ significantly from the perfect model. Lastly, chi-square test was used.

The difference between ($-2LL$) for the model with only a constant ($-2LL_0$) and ($-2LL$) for the current model ($-2LL_{max}$) followed Chi-square (χ^2) distribution. The degrees of freedom for the Chi-square test will be the difference between the degrees of freedom for two models being used as $\{(N-1) - (N-k)\}$.

$$Chi-square = -(LL_0 - LL_{max})$$

Thus, Chi-square tested the null hypothesis that the coefficients for all the explanatory variables in the model except the constant will zero. The nature and magnitude of the estimated coefficients of the logit model will help us to identify the relative importance of different factors underlying groundwater buying-decisions of farmers.

The Model and Hypothesis

With the specification of logit model above, it is hypothesized that the probability of a farmer buying or selling groundwater depends on the total operational area in ha (X_1), number of land fragments(X_2), education of the farmers(X_3), human labour(X_4), age of the farmers (X_5), source of income (X_6), availability of electricity hours(X_7), farm experience of farmer(X_8) and joint ownership of WEM (X_9). The index variable Z_i indicating whether a farmer bought and sell groundwater or not, is expressed as a linear function of the above listed variables as:

$$Z_i = \alpha + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 X_{4i} + \beta_5 X_{5i} + \beta_6 X_{6i} + \beta_7 X_{7i} + \beta_8 X_{8i} + \beta_9 X_{9i} + U_i$$

$$Z_i = \alpha + \beta_1 \text{AREAOWN} + \beta_2 \text{FRAGMENT} + \beta_3 \text{JOINTOWN} + \beta_4 \text{SOI} + \beta_5 \text{EDUCATION} + \beta_6 \text{HL} + \beta_7 \text{FE} + \beta_8 \text{AEH} + \beta_9 \text{AGE} + U_i$$

Where,

U_i was the disturbance-term.

AREAOWN: Farm-size

FRAGMENT: degree of fragmentation of farm-holding

JOINTOWN: Joint ownership of WEM

SOI- Source of income

EDUCATION: Education

HL: Human Labour

FE: Farm experience

AEH: Availability of electricity hours

AGE : Age of farmers

The relative significance of these important factors was quantified by logistic regression analysis for groundwater buying decisions of the farmers.

Objective 2: The impact of ground water markets on changing cropping pattern, productivity and profitability

The objective was achieved using the descriptive statistics. The objective contained sub objectives which were studied separately in following headings.

a) Cost Concepts

Farm business analysis will be undertaken to study the impact of income measures and cost concepts.

Cost A_1 = Paid out costs, imputed value of owned machine power, depreciation on implements and farm buildings, irrigation charges, land revenue and interest on working capital.

Cost B_1 = Cost A_1 + interest on value of owned fixed capital (excluding land).

Cost B_2 = Cost B_1 + rental value of owned land.

Cost C_1 = Cost B_1 + imputed value of family labour.

Cost C_2 = Cost B_2 + imputed value of family labour.

Cost C_3 = Cost C_2 + 10 percent of Cost C_2 accounting for managerial input

Farm Returns

Farm business income = Gross income – Cost A₁

Family labour income = Gross income – Cost B₂

Net income over Cost C₂ = Gross income – Cost C₂

Net income over Cost C₃ = Gross income – Cost C₃

Net income over Cost C₁ = Gross income – Cost C₁

b) Irrigation Cost

The amortized investment on each well was estimated with the help of following formula:

Amortized Investment on well = $[(CI) \times (1 + i)^{AL} \times i] / [(1 + i)^{AL} - 1]$

$$CI = (II) \times (1 + i)^{(dc-di)}$$

Where,

II = initial investment on well

dc = year of data collection

di = year of drilling irrigation well

AL = average life of wells

i = interest rate

CI = compounded investment

Amortized cost of bore well = $[(\text{Compounded cost of bore well}) \times (1 + i)^{AL} \times i] / [(1 + i)^{AL} - 1]$

Compounded cost of bore well = $(BW \text{ cost}) \times (1 + i)^{(dc-di)}$

Amortized cost of pump set and accessories =

$\{[(\text{Compounded cost of pump set} + \text{Compounded cost of pump house}) \times (1 + i)^{AL} \times i] / [(1 + i)^{AL} - 1]\}$

Amortized cost of conveyance = $\{[\text{Compounded cost of conveyance pipe used}] \times (1 + i)^{AL} \times i / [(1 + i)^{AL} - 1]\}$

c) The volume of groundwater exploitation/extraction (in litres)

To supplement accessibility, the volume of groundwater extraction (in litres) was calculated from the following formula (Eyhom *et al.*, 2005), which was considered as a proxy for the extent of ground water exploitation:

$$Q = t \times 129574.1 \times BHP / [d + \frac{255.5998 \times BHP^2}{d^2} \times D^4]$$

Where,

Q = Quantity of groundwater extracted (in litres)

t = Total duration of irrigation (in hours)

BHP = Engine power of pump (in HP)

d = Average depth of the well (in metres)

D = Diameter of the suction pipe (in inches)

Further water requirement by different category of users has been worked out by dividing whole sample into four group a) buyer, b) self-user, c) self-user + buyer, d) self-user + seller.

Objective 3: To assess the groundwater use efficiency and the influence of groundwater markets on water use efficiency.

The prime objective of any farm / firm is to coordinate the farm resources and its utilization in the production process so as to obtain a maximum profit out of it. Regression analysis is a useful tool in analyzing the resource productivity in any production activity including farming. The Cobb-Douglas production function is the most popular among different algebraic forms of production

functions available, as it provides adequate fit to the data, computational simplicity, and sufficient unused degrees of freedom for statistical testing. One of its serious limitations is that it accommodates constant/ increasing/ decreasing marginal productivity and does not allow an input-output curve embracing all the three relationships. Despite of this limitation, it has the greatest use in diagnostic analysis as the regression parameters represent the elasticities and reflect the marginal productivity at the geometric mean level of the input and the output. Because of such overwhelming advantages over the other forms, Cobb-Douglas type of production function will be employed for the current study.

The implicit form of model is;

$$Y = f(X_1, X_2, X_3, X_4, X_5)$$

Where,

Y is yield and X_1, X_2, X_3, X_4 and X_5 denote inputs

The empirical model can be represented as follows:

$$\text{Log (YIELD)} = \alpha + \beta_1 \log (\text{LAB}) + \beta_2 \log (\text{WAT}) + \beta_3 \log (\text{FERT}) + \beta_4 \text{SEED} + \beta_5 \text{PPC} + \beta_6 + (\text{DUM}_1) + \beta_7 (\text{DUM}_2)$$

Where,

Yield = Yield per ha in kg/ha

LAB = Human labour used in man days / ha

WAT =Quantity of water applied litres/ ha

FERT = Fertilizer used in kg/ha

SEED = Quantity of seed kh/ha

PPC = Plant protection chemicals

DUM_1 = Irrigation type (if electric operated then 1, otherwise 0)

DUM₂ = land type (if undulated then 1, otherwise 0)

The value marginal product (VMP) of water was calculated at its geometric mean level of both dependent (Y) and independent variable (X) and the elasticity coefficient b₁ by using formula:

$$VMP_{X1} = b_1(Y/X)$$

Where,

VMP_{X1} = Value Marginal Product of X₁ coefficient

b₁ = The regression coefficient (elasticity coefficient) of X variable (water)

Y = Geometric mean of yield.

X = Geometric mean of X variable

In order to examine the water use efficiency, the VMP_{X1} was compared with its factor cost. For the resource to be optimally located necessary condition is,

$$VMP_{X1} = P_{X1}$$

This can be expressed in the ratio form as follows:

$$VMP_{X1}/P_{X1} = 1$$

If the ratio is equal to unity, the resource will be said to be optimally allocated. If the ratio is more than one it implies that resource will be under used, and if the ratio is less than one, it will suggest that resource is over used. Water Use Efficiency was estimated in different market regime and compared. The results would indicate whether the particular groups of farms under respective water regime are efficient water user or not.

4. RESULT AND DISCUSSION

The findings of the study are presented in this chapter under the following headings in consonance with the objectives of the study.

4.1 The factors influencing ground water markets

4.1.1 Logit regression analysis for buying of groundwater

4.1.2 Logit regression analysis for selling of groundwater

4.2 The impact of ground water markets on

4.2.1 Changing cropping pattern

4.2.2 Cost of cultivation

4.2.3 Profitability of different crops in study domain

4.3 The ground water use efficiency and the influence of ground water market on water use efficiency

4.3.1 Water use efficiency for different crops under different water market structure in study area

4.1 The factors influencing ground water markets

Groundwater market is the key sector which consist many factors including social, technical, management etc. These factors were quantified by logistic regression analysis for buying and selling of groundwater decision of the farmers participation in groundwater market.

The factors considered to influence the groundwater markets were included in analysis which are Education of the farmer, farm experience, age of the farmer, source of the income, total operational area, joint ownership of WEM, number of land segments availability of electricity hours for WEM, family labour per hectare.

Factors affecting the groundwater were separately analysed for buying and selling decision of groundwater by the farmers. The

self-user of farmers was not included because they were not practicing in the groundwater market.

Table 4.1: Logistic regression analysis of factors influencing for buying of groundwater (2018-19)

S.No.	Independent variables	Coefficient (b value)	Probability of significance
1	Education of the farmer	0.650*	0.055
2	Farm experience	0.040	0.488
3	Source of the income	0.310	0.418
4	Total operational area	0.544**	0.018
5	Joint ownership of WEM	0.522	0.427
6	No of parcel of land	-2.607***	0.001
7	Availability of electricity hours for WEM	0.001	0.962
8	Family labour per hectare	0.153	0.494
9	Age of the farmer	0.053	0.304
10	Constant	3.832	0.148
Chi-square			0.004***
Nagelkerke R square			0.403
Cox and snell R square			0.295
-2 Log likelihood			60.765***
Hosmer and Lemeshow Test			0.487
Number of observation			80

***, ** and * indicate significance at 1, 5 and 10 per cent levels of probability, respectively

Table 4.2: Logistic regression analysis of factors affecting for selling of groundwater (2018-19)

S.No.	Independent variables	Coefficient (b value)	Probability of significance
1	Education of the farmer	-0.572**	0.036
2	Farm experience	0.040	0.434
3	Source of the income	-1.37	0.651
4	Total operational area	-5.26***	0.008
5	Joint ownership of WEM	0.006	0.903
6	No of parcel of land	1.510***	0.006
7	Availability of electricity hours for WEM	-0.008	0.573
8	Family labour per hectare	0.014	0.936
9	Age of the farmer	-0.083	0.101
10	Constant	3.729*	0.088
Chi-square			0.021**
Nagelkerke R square			0.303
Cox and Snell R square			0.217
-2 Log likelihood			81.320***
Hosmer and Lemeshow Test			0.636
Number of observation			80

***, ** and * indicate significance at 1, 5 and 10 per cent levels of probability, respectively.

4.1.1 Logit regression analysis for buying of groundwater

There were several factors which affect the ground water buying decision of the farmers. The result were presented in table 4.1 the result shows the most significant factors affecting the buying decision of farmers were the education of farmer, total operational area and number of land fragments.

The education of farmer, the operational area positively affect the buying decision of the groundwater the number of land fragments was negatively affect the groundwater buying decision. The coefficient of total operational area was positive (0.544) which showed that probability of buying water increase with increase in operational area and vice versa. The coefficient associated with the education of the head of the family was estimated at 0.650.

The similar results were found in the study of Singh and Singh 2003, Sharma and Sharma (2006), Juchems and Schoen gold (2012), Pawariya *et al.* (2017).

4.1.2 Logit regression analysis for selling of groundwater

After studying the determinants of groundwater buying decision of farmers, it is important to study the determinants of ground water selling decision of farmers. The prediction of groundwater selling decision of farmers is presented in table 4.2

The education of farmer, total operational area and number of land fragments were the significant factors which affected the selling decision of groundwater. The coefficient of total operational area was negative (-5.26) which showed that probability of selling water decrease or increase with increase or decrease in operational area and vice versa. The coefficient associated with the education of the head of the family was estimated at -0.572.

Similar results found with *Juchems and Schoengold (2012)*, *Manjunatha et al (2014)* and *Pawariya et al (2017)* studies.

4.2 Impact of ground water market on changing cropping pattern, productivity and profitability

Primary survey conducted in Sikar district of Rajasthan revealed the unequal distribution of land holding as is evident from table 4.3. In Dhod *tehsil* 27.50 per cent farmers are small with 11.89 percent land holding and for the Sikar *tehsil*, it was 30 per cent and 9.12 percent respectively. Medium farmers constituted 35 per cent of sampled farmers in Dhod *tehsil* having access to the 25.65 per cent of land holdings (Table 4.3). Thus, small and medium farmers were comprised of 28.75 per cent having access to only 10.44 per cent of total land holdings among the total farmers in both the *tehsils* whereas 37.50 per cent of large farmer having access to 65.22 per cent of total land holdings in the study area. These indicate inequality in distribution of land in favour of large farmers.

Table 4.3: Distribution of land holding among sample households

<i>Tehsils</i>	Dhod		Sikar		Overall	
	No of farmers	Land holding in ha	No of farmers	Land holding in ha	No of farmers	Land holding in ha
Small (<2 ha)	11 (27.50)	1.40 (11.89)	12 (30.00)	1.18 (9.12)	23 (28.75)	2.58 (10.44)
Medium (2-4 ha)	14 (35.00)	3.02 (25.65)	13 (32.50)	2.99 (23.15)	27 (33.75)	6.01 (24.34)
Large (>2ha)	15 (37.50)	7.36 (62.46)	15 (37.50)	8.75 (67.74)	30 (37.5)	16.11 (65.22)
Total	40 (100)	11.78 (100)	40 (100)	12.92 (100)	80 (100)	24.70 (100)

Note: Figures in parentheses indicate per cent of total.

4.2.1 Cropping pattern

Pearl millet and wheat are the major food grain crops in both the *tehsils* of the selected district. Cropping pattern in an agro-climatic area is mainly influenced by a number of factors such as soil type, size of holding, availability of irrigation facilities etc. Cropping pattern followed by the farmers under different water market regime in the study area is presented in table 4.4. Wheat has dominated the cropping pattern, while Pearl millet seems to be grown only for household consumption (Table 4.4). This may be due to assured irrigation facilities available to them. On the other hand, water buyer mainly focused on cereals crop in the study area.

Table 4.4: Cropping pattern adopted by sample farmers

(in per cent)

Particulars	Self-user	Buyers	Self-user + Seller	Self -user + Buyer
Pearl millet	42	38	43	37
Wheat	39	33	37	34
Other crops	19	29	20	29

4.2.1.1 Average size of farm holding in the study domain

Average size of holding of sample farms under different water regimes are presented in the table 4.5. Average land holding was highest (6.26 ha) for the buyer category. They do not have their own extraction devices due to non-affordability and uneconomic nature of land holding thus became an important agent of water market. Who are relatively large farmer followed by self-user + buyer (6.09 ha). Due to fragmented land holding, self-user + buyer category had to buy water for the fields where they do not have own water extraction mechanism. Self-user category farmers were having average size of 4.40 hectare (Table 4.5).

Table 4.5: Average farm holding and agents of water transaction

Water Market Regime	Small	Middle	Large	Overall (ha)
	(<2 ha)	(2-4 ha)	(>4ha)	
Self-user	1.28	3.01	8.06	4.40
Self-user + Seller	1.23	3.01	8.45	4.81
Self -user + Buyer	1.24	2.98	8.97	6.09
Buyers	1.26	3.35	11.45	6.26

4.2.1.2 Installation cost for WEMs

Installation cost includes costs on digging of pit, pipe, construction of wall, drilling, pump set and irrigation pipe. Installation cost per tube well and well for the Self-user and Self-user+ Seller were found to be more *i.e.* `1,11,000 and `1,20,000 respectively whereas for the Self-user + Buyer it was less *i.e.* `1,08,000. It was due to fact that self-user and self-user + Seller were having high capacity pump set and larger depth of drilled pipe to extract water from deep inside earth. Among different components of installation cost, pump set emerged as the most important component, accounting large part of total cost of the tube well and well system in study area (Table 4.6).

4.2.1.3 Water extracted for Pearl millet and Wheat: Water Market Agent-wise

Water used for pearl millet and wheat has been given in table 4.7. Wheat is the largest consumer of water among study crops. The total water consumed depends upon the number of irrigations and time required for each irrigation. Therefore, both factors are to be considered to estimate water use efficiency and productivity. In both the crops highest amount of water was applied by 'self-user' and least used by the 'buyer' due to constraint in irrigation water market. With the

possession of tube well, 'self-user' could extract comparatively larger quantity of water and hence, application was also more.

Table 4.6: Amortized cost of WEM among different water market structure

(in `)

Particulars	<i>Self-user + Buyer</i>	Self-user + Seller	Self-user
Digging of pit and construction of wall	24948 (23.10)	23520 (19.60)	23865 (21.50)
Pipe	18576 (17.20)	15864 (13.22)	20035 (18.05)
Drilling	7668 (7.10)	18000 (15.00)	9246 (8.33)
Pump set	46224 (42.80)	51840 (43.20)	50172 (45.20)
Irrigation pipe	10584 (9.80)	10776 (8.98)	7681 (6.92)
Total	108000 (100)	120000 (100)	111000 (100)

Figure in parenthesis indicate percentage of total cost

Table 4.7: Water Extraction for Pearl millet and Wheat crops

Particulars	Pearl millet			Wheat		
	Avg. no of irrigation	Time of irrigation (in hrs.)	Water applied (000' litres)	Avg. no of irrigation	Time of irrigation in hrs	Water applied (000' litres)
Self-user	3.6	12.3	115	8.8	24.8	565
Self-user+ Buyer	2.9	10.4	75	7.6	22.7	427

Self-user +seller	2.7	10.1	66	8.2	23.9	449
Buyer	2.1	9.8	43	7.1	21.20	314

4.2.1.4 Groundwater extraction in the study area

Extraction of groundwater, which determines the accessibility to water, depends on depth of water level, engine capacity and size of outlet. In view of different geographical conditions in the study area, water extraction also differs. It was observed that in Dhod *tehsil* water level was much lower than Sikar *tehsil* because of the higher capacity of pump and water availability at less depth.(Table 4.8)

Table 4.8: Groundwater extraction in the study area

Particulars	Dhod	Sikar	Overall
<i>Average depth of water level (metres)</i>	51.78	59.15	55.46
Average size of outlet (inch)	2.36	2.36	2.36
Engine capacity (hp)	14.6	14.1	14.35
Water extracted (litres/hr of irrigation)	32517.43	26560.72	29539.08

4.2.1.5 Total groundwater extracted in different water regimes

Groundwater extracted by the tube well owners of all categories of water transaction has been presented in table 4.9. The result showed that self-user extracted much higher quantity of water to irrigate one hectare land followed by self-user + seller. This could be because of use of high capacity pump sets by self-users with the motive for selling of water and less availability of land for them. At the same time buyers were using less quantity of water in their field with their resource constraint.

Table 4.9: Total groundwater extracted in different water regimes

Water market regime	Average depth (metre)	Outlet size (inch)	Engine capacity (hp)	No of irrig. per year	Duration Of irrig. (hrs)	Total GW extraction ('000 litres /ha)
self-user	89.84	3.00	17.50	6.80	19.00	334664.60
self user+ Buyer	54.58	2.50	14.50	6.20	16.20	248544.80
self-user +seller	65.28	2.70	15.50	7.12	17.89	307818.20
Buyer	29.25	2.00	12.50	6.02	14.56	182893.20

4.2.1.6 Water productivity under different water market regimes

In this section, crop productivity has been expressed in terms of water use, by computing the ratio of output per litres of water, which shows the amount of water required to produce unit of output of crops. Results shows that farmers belonging to 'Buyer' category applied less amount of water to produce one unit of output while in case of self-user who are utilizing more water (Table 4.10). The reasons for the least use of water in case of water 'Buyer' in Wheat and Pearl millet may be due to 'Buyer' were purchasing water. On the other side 'Self-user' with assured irrigation facilities were found to be using larger quantity of irrigation water to produce the same amount of output in both the crops.

Table 4.10: Water productivity in different water market regimes**(Kg of output/m³ of water)**

Water regime	Pearl millet	Wheat
Self-user	6.08	4.07
Self-user+ Buyer	6.66	4.91
Self-user +Seller	7.57	4.89
Buyer	10.46	6.37

4.2.2 Cost of cultivation and returns of Wheat in the study area

The cost of cultivation and returns was presented in table 4.11. The results show that buyers incurred the highest paid-out cost (₹28,200) because of higher cost of irrigation and higher value of interest on fixed capital. Net income also was higher for buyers ₹38,554 followed by self-users ₹37,575. For the self-users' gross returns were found as ₹71,280 per hectare.

Table 4.11: Cost of cultivation of wheat in study area

(₹/ha)

Particulars	SU	SU+S	SU+B	B
Cost A1	27550	23972	24300	28200
Cost B1	27590	23970	24220	29680
Cost B2	32451	32775	32612	32439
Cost C1	22188	22252	22458	22514
Cost C2	33704	33993	33887	33625
Cost C3	37075	37393	37276	36987
Gross income	71280	70000	71280	72180
Farm business income	51150	49830	50786	51669
Family labour income	38829	37224	38667	39740
Net income over cost C2	37575	36006	37392	38554
Net income over cost C3	34205	32606	34004	35192
Net income over cost C1	49091	47747	48821	49665

4.2.3 Cost of cultivation and returns of pearl millet in study area

In case of pearl millet cost concepts used in farm business analysis depicted that buyers incurred the highest paid-out cost (₹14,997) because of higher rate of irrigation and higher value of interest on fixed capital in farms. Net income also was higher for buyers ₹5,680 followed

by self-users ₹3,544. The gross returns are also higher of buyers ₹27,223 per hectare.

There was notable difference between the two crops with respect to the inputs use. There was higher variable cost for the pearl millet and in case of wheat the rental value for land was higher as it provided more return from the unit area.

Table 4.12: Cost of cultivation of Pearl millet in study domain

(₹/ha)

Particulars	SU	SU+S	SU+B	B
Cost A1	14965	14975	14835	14997
Cost B1	15701	15821	15468	15886
Cost B2	21701	21426	22735	20820
Cost C1	16456	16572	16192	16610
Cost C2	22456	22177	23458	21543
Cost C3	24701	24394	25804	23697
Gross income	26000	26200	26500	27223
Farm business income	11034	11224	11664	12225
Family labour income	4298	4773	3764	6403
Net income over cost C2	3544	4022	3041	5680
Net income over cost C3	1299	1805	2095	3526
Net income over cost C1	9544	9627	10307	10612

4.2.4 Profitability of different crops in study domain

For the analysis of profitability of wheat and pearl millet output input ratio has been calculated on the basis of different cost concepts and gross income. The results revealed that the output input ratio for both the crops for all categories is found as more than one which shows the positive returns to investment on production of wheat crops (Table 4.13) and pearl millet (Table 4.14).

Table 4.13: Profitability of wheat in study domain

Particulars	Gross income (₹)	Net income (₹)	output input ratio
SU	71280	37575	2.11
SU+S	70000	36006	2.06
SU+B	71280	37392	2.10
B	72180	38554	2.15

Table 4.14: Profitability of pearl millet in study domain

Particulars	Gross income (₹)	Net income (₹)	output input ratio
SU	26000	3544	1.16
SU+S	26200	4022	1.18
SU+B	26500	3041	1.13
B	27223	5680	1.26

4.3 Water Use Efficiency in Pearl millet and Wheat

The Cobb Douglas production function used to analyse water resource efficiency. labour, Water, fertilizer, seed and plant protection chemicals as independent variables. The results shown in table 4.14 and table 4.15, for different water market regime.

4.3.1 Water use efficiency for Wheat under different water market regimes

Cobb Douglas production function was estimated and the results showed that each input effects more specifically water on wheat productivity as well as to water use efficiency in different water market forms. It is expressed from the table that the elasticity coefficient of water and labour are positive and significant in all the different categories of water market factors (Table 4.14). The elasticity coefficient of water and labour indicates one per cent increase in input

use of these variables will result in increase of 0.209 per cent and 0.636 percent in yield, respectively in case of 'Water Buyers'. On the other hand for 'self-users', increase of one per cent of water and labour inputs can affect 0.546 per cent and 0.071 per cent increase in yield, respectively. P-value was significant at one percent level of probability for all the water market forms. As far as water for irrigation is concerned, the effect remains more or less same in 'self-user + buyer' category of farmers as that of 'self-user' category.

Table 4.14: Estimation of Cobb Douglas production function for wheat crop under different water markets in regimes

Variables	Self-user	Buyers	Self-user + Seller	Self -user + Buyer
Intercept	4.406	0.156	0.352	-1.700
Labour	0.051	0.636**	0.071*	0.905
Water	0.128**	-0.209*	0.546*	0.761**
Fertilizer	0.407***	0.582	0.175	0.344
Seed	0.101	0.221**	0.279**	0.057
PPC	-0.008	-0.226	-0.134	-0.008

Note: ***, ** and * indicate significance at 1, 5 and 10 per cent levels of probability, respectively.

4.3.2 Water use efficiency for Pearl millet under different water market regimes

The result shows in from the table 4.15 that the elasticity coefficient of water and labour are positive and significant in all the different categories of water market factors (Table 4.15). The elasticity coefficient of water and labour indicates one per cent increase in input use of these variables will result in increase of 0.021 per cent and 0.120 per cent in yield, respectively in case of 'water self-users. On the other hand for 'self-users+ buyers', increase of one per cent of water and labour inputs can affect 0.095 per cent and 0.125 per cent increase in

yield, respectively. P-value was significant at one percent level of probability for all the water market forms. As far as water for irrigation is concerned, the effect remains more or less same in 'self-user + seller' category of farmers as that of 'buyer' category.

Table 4.15: Estimation of Cobb Douglas production function for pearl millet crop under different water market regimes.

Variables	Self-user	Buyers	Self-user + Seller	Self -user + Buyer
Intercept	7.268	10.491	1.406	6.032
Labour	0.120***	0.088	0.007	0.125**
Water	-0.021**	-0.357**	0.503*	0.095**
Fertilizer	0.001	0.045	0.145	-0.070
Seed	0.078	-0.161	-0.211	0.209
PPC	-0.024	0.302**	0.262***	-0.063

Note: ***, ** and * indicate significance at 1, 5 and 10 per cent levels respectively

4.3.3 Water use efficiency for wheat, and Pearl millet under different water market structure in study area

The result shown in table 4.16 revealed that all categories of water user in both crops were came into over utilized categories of water uses. All agents of water markets regime must be encouraged to restrain the use of water especially for wheat crop. The average yield of wheat and pearl millet can be increased through less number of irrigation. All agents of water markets regime must be encouraged to restrain the use of water especially for wheat and pearl millet crop. This could be attained through education programme for awareness and training for adoption of efficient irrigation schedule.

Table 4.16: Water use efficiency for wheat and Pearl millet under different water regime in Rajasthan

Water Market Regime	Pearl millet		Wheat	
	VMP/Px		VMP/ Px	
Self-user	0.001	Over utilized	0.011	Over utilized
Buyers	0.018	Over utilized	0.084	Over utilized
Self-user + Seller	0.018	Over utilized	0.518	Over utilized
Self -user + Buyer	0.004	Over utilized	0.071	Over utilized

5. SUMMARY AND CONCLUSION

Water is a critical input into agriculture in nearly all its aspects having a determining effect on the eventual yield. Irrigation is one of the most important components in the transformation of agriculture which, in combination with technological breakthrough, has already been proved as a key determinant for success of Green Revolution during sixties. Importance of irrigation increases continuously with the passes of time for the country like India due to temporal and spatial variation of rainfall.

Increase in population and changing lifestyles has increased water demand (largely for irrigation) in both urban and rural areas. This helps for infrastructure expansion and improved utilization of resource. Climate change has negative effect on agricultural productivity ranging from selection of crop; time of cultivation, methods of irrigation etc. Rice, wheat and sugarcane contributes about 90 per cent of India's crop production and these crops are the more water consuming crops.

Low and erratic rainfall for consecutive years in western Rajasthan's districts and unavailability of proper irrigation facilities are the major constraints to agricultural production and productivity in Rajasthan. The quantity of net annual groundwater availability was 10828.97 MCM in 2011 which has increased to 11256.77 MCM in 2017 due to comparatively good rainfall during the years 2011 to 2017. This is evident from the report of Government of Rajasthan Ground water Department that in the year 1984 irrigation draft was 4926 MCM with stage of development 35.75 per cent only where as in year 2017 the irrigation draft is estimated 13786.52 MCM and stage of development 139.52 per cent. Out of 249 *tehsils*, in 164 *tehsils* the draft has exceeded the estimated replenish able resource. In 9 *tehsils*, the stage

of development has reached Critical levels and semi critical levels in 28 *tehsils* leaving only 44 *tehsils* in safe category.

Therefore study has been under taken on following objectives:

- IV. To analyze the factors influencing ground water market in study area.
- V. To study the impact of ground water market on changing cropping pattern, productivity and profitability.
- VI. To assess the groundwater use efficiency and the influence of groundwater market on water use efficiency.

The present study has been carried out by using both the primary as well as secondary data. The primary data were collected through well structured, pre-tested and comprehensive schedules exclusively prepared for the study from farmer by personal interview method. The schedule used for the primary data collection was designed based on the objectives of the study. Some district level information, rules and regulations on groundwater exploitation and other basic information have been collected from various published or unpublished sources of Government of Rajasthan. Multi-stage sampling technique was used for the selection of sample farmers in the present investigation. The present study has been conducted in Sikar district of Rajasthan. Two *tehsils* were selected on the basis of overexploited category of groundwater was selected randomly from the selected district. Total four villages was selected on the basis of overexploited category of groundwater was selected randomly, two from each selected *tehsil*. From each village 20 farmers were selected and therefore, total of 80 farmers were selected.

5.1 Factors influencing ground water market in study area

From the results of the revealed that could be inferred that with one unit increase in the size of total operational area with farmers, the

probability of buying groundwater was increase to 0.544 percent and one unit increase the number of land fragments with farmers, the probability of buying groundwater was reduce to 0.607 percent because the coefficient was -2.607. The education of the farmer has positive significant effect on buying of groundwater.

The size of operational area, number of land fragments and year of education of the family were the significant factors which affected the selling decision of ground water. The coefficient of operational area was negative (-5.26) which showed that one percent increase in the size of operational area owned, ceteris paribus, decrease the selling probability of groundwater by 5.26 per cent.

5.2 Impact of ground water markets on changing cropping patter, productivity and profitability

The study are conducted in Sikar district of Rajasthan and mainly focused on wheat and pearl millet crop because they are major food grain crops in this region. The observation therefore exhibited that tube well is becoming the major source of irrigation during the recent periods while rainfall was the major source of irrigation in the past. This may be due to private ownership of tube well, which makes it independent of Government regulation and control. And also the relative easier potential had already been utilized and further development was more difficult.

Total input cost varied considerably among the different forms of water market. The total input cost as well as the share of irrigation input cost observed to be increased with the increase in the proportionate area under buying groundwater and this was due to higher charges paid by buyers of water for purchased irrigation service. The other major components of input cost were human labour, machine power and chemical fertilizers. The quantum of use of these inputs were higher in

farms of buyers by buying groundwater and small size of holdings, and least on non-users farms due to un access to irrigation water. Buyers incurred higher inputs costs and paid-out costs as well as other costs used in farm business analysis on account of higher use of inputs and higher charges paid for irrigation ware purchased in the study area and in turn received lower net returns. Self- users and sellers of water incurred lower input costs and used owned irrigation sources hence, received higher net returns. Non-users in the absence of access to irrigation water incurred less on inputs and received lowers in the study area.

It is worth nothing that the farm size effect in the regression equations was positive implying thereby the equal access to groundwater. The human labour increased with the increase in the proportionate area per hectare use of under irrigation from buying groundwater. The variation in use of human labour was less in cultivation of wheat crop. The use of hired labour increased and family labour decreased as the size of holdings increased under different forms of water market.

5.3 Groundwater use efficiency and influence of groundwater market on water use efficiency

In the study domain Cobb Douglas production function was estimated and the results showed that each input effects more specifically water on wheat productivity as well as to water use efficiency in different water market forms. It is expressed from the table that the elasticity coefficient of water and labour are positive and significant in all the different categories of water market factors. The elasticity coefficient of water and labour indicates one per cent increase in input use of these variables will result in increase of 0.209 per cent and 0.636 per cent in yield, respectively in case of 'Water Buyers'. On the other hand for 'self-users', increase of one per cent of water and labour inputs can affect 0.546 per cent and 0.071 per cent increase in yield, respectively. P-

value was significant at one percent level of probability for all the water market forms. As far as water for irrigation is concerned, the effect remains more or less same in 'self-user + buyer' category of farmers as that of 'self-user' category.

5.4 Conclusions of the study –

On the basis of the results obtained in the present study, the following conclusions may be drawn.

- The ground water buying and selling decision of farmers identified the total operational area, education of the farmers and numbers of land fragments are significant factors determinants of groundwater buying and selling decision of farmers.
- Farmers belonging to 'Buyer' category applied less amount of water to produce one unit of output while in case of self-users who are in other extreme in utilization of water. To maintain the sustainability the optimum water use for self-user + seller in wheat crop, and self-users, self-user + buyers, self-user + sellers in pearl millet crop, to be taken care as they were over-utilizing the ground water for the cultivation.
- In case of food grain crops pearl millet and wheat cropping pattern are distributed in economic form, wheat is the higher yield producing crop comparative pearl millet and the analysis of profitability of wheat and pearl millet output input ratio has been calculated on the basis of different cost concepts and gross income. The results revealed that the output input ratio for both the categories is more than one which shows the positive returns to investment on production of both crops.
- There was no absolute rule for the ground water management in the state. There were some schemes which were realized by the state for the recharge of water and to maintain the level of groundwater for drinking on priority.

- The existing measures were envisioned with the regulation in some extent but fail to achieve the stated objectives.
- Availability of labour and water were the biggest hindrance in the GWMs whereas electricity tariff was least perceived constraints by farmers.

LITERATURE CITED

Anonymous 2016 -17. Indian Economic Survey, Ministry of Agriculture, Govt. of India. New Delhi.

Banerji, A., Khanna, G. and Meenakshi, J.V. (2010). Social contracts, markets and efficiency: Ground water irrigation in north India. Centre for development economics department of economics, Delhi school of economics. Working paper **183**.

Bhandari, H. and Pandey, S. (2005). Economics of groundwater irrigation in Nepal: Some farm-level evidences. *Journal of Agricultural and Applied Economics*, **38**: 185-199.

Chadha, D.K. (2002). Ground water development and artificial recharge-way to prosperity in sustainable agriculture. *Water Resources Development and Earth Care Policies*, Bhoovigyan Vikas Foundation, New Delhi.

Dhawan, B.D. (1991). Developing groundwater resources merits and demerits. *Economic and Political Weekly*, **26**(18): 425-429.

Dilli, K. C. (2004). Study on groundwater markets in Nepal. *Agricultural Economics Research Review*, **19**: 95-108.

Dutta, M. K. (2013). What determines farmer's decision to buy irrigation water in water abundant regions? A study of ground water markets in Assam in eastern India. Report, 1-39.

Eyhom, E., Mader, P. and Ramakrishnan, M. (2005). The impact of organic cotton farming on the livelihoods of small holders: Evidence from the maikaal bioRe project in central India. *Research Report*. Research Institute of Organic Farming

Farrell, M.J. (1957). Measurement of production efficiency. *Journal of Royal Statistical Society*, **120**(3): 253-289.

- Garrido, S. (2010). Governing scarcity. water markets, equity and efficiency in pre 1950s eastern Spain. *Sociedade spañola de historia agraria documentos de Trabajo DT-SEHA*, 10-12.
- Giannoccaro, G. (2016). Factors influencing farmer's willingness to participate in water allocation trading. A case study in southern Spain. *Spanish journal of Agriculture Research*, **14**:81-95.
- Juchems, E. M. and Schoengold, K. (2012). A comparison of actual and predicted groundwater trading behavior: The role of transaction costs and trading restrictions in explaining deviations. *Water Sustainability and Climate Grant*, Nebraska, Lincoln, 1-27.
- Kajisa, K. and Sakurai, T. (2005). Efficiency and equity in groundwater markets: The case of Madhya Pradesh, India. *Environment and Development Economics*, 801-819.
- Khair, S. M., Mushtaq S., Culasc R. J. and Hafeeza, M. (2012). Groundwater markets under the water scarcity and declining water table conditions: The upland Baluchistan Region of Pakistan. *Agricultural Systems*, **107**: 21–32.
- Khair, S.M., Culas, R.J. and Hafeez, M. (2010). The causes of groundwater decline in upland Balochistan region of Pakistan: Implication for water management policies. *Paper presented at the 39th Australian Conference of Economists (ACE 2010)*, Sydney, Australia. 27–29 September 2010
- Khan, M.I. (2015). Water use efficiency, agriculture: Management and water charging issues in Bangladesh. *International Journal of Business Quantitative Economics and Applied Management Research*, **1**(12): 44-62.
- Khanna, G. (2007). Improving agricultural efficiency amongst groundwater users: The case of sugarcane in north India. *Journal of Public and International Affairs*, **18**: 80-88.

- Kolavalli, R. Shashi, K. and Chicoine, D.L. (1989). Groundwater markets in Gujarat India. *International Journal of Water Resource Development*, **5**(1): 38-44.
- Maddala, G. S. (1983). Limited dependent and qualitative variables in econometrics. *Cambridge University Press*, Cambridge.
- Mahindra, R., Chandrasekaran, M. and Gurunathan, S. (2006). A study on evolving optional cropping pattern in groundwater over-exploited region of Perambalur district of Tamil Nadu. *Agricultural Economics Research Review*, **19**: 95-108.
- Manjunatha, A. V., Speelman, S., Chandrakanth, M. G. and Huylbroeck, V. G. (2011). Impact of groundwater markets in India on water use efficiency: A data envelopment analysis approach. *Journal of Environmental Management*, **30**:1- 6.
- Manjunatha, A. V., Speelman, S., Chandrakanth, M. G., Nuppenau, E. A. and Van, H.G. (2011). Can ground water markets promote efficiency in agricultural production. *Contributed paper for the 13th Biennial Conference of the International Association for the Study of the Commons (IASC)*, Hyderabad, India.
- Manjunatha, A.V., Anikb, A. R., Speelman, S. and Nuppenau, E.A. (2014). Farmer's participation in informal ground water market in hard rock areas of peninsular India. *Agricultural Economics Research Review*, **27**: 45-54.
- Manjunatha, S., Speelman, A., Sreejith, T. S., Amjath, B. and Mal, P. (2016). Impact of informal groundwater markets on efficiency of irrigated farms in India: a bootstrap data envelopment analysis approach. *Irrigation Science*, **34**(1): 4152.
- McFaddan, D. (1974). Conditional logit analysis of qualitative choice behavior in: *Frontiers in Econometrics* Ed P. Zarembka. New York, USA: *Academic Press*.

- Mohanty, N. and Gupta, S. (2002). Water reforms through water markets: International experience and issues for India. *India Infrastructure Report*. New Delhi: Oxford University Press.
- Mukherjee, S. and Biswas, D. (2016). An enquiry into equity impact of groundwater markets in the context of subsidized energy pricing: a case study. *IIM Kozhikode Society and Management Review*, **5**(1): 63–73.
- Patel, S. M. and Patel, K. V. (1969). Economics of tube well irrigation. *CMA report*, Indian Institute of Management, Ahmedabad (Mimeo).
- Pawariya, V., Sharma, R.C. and Sharma, B.K. (2017). Economics analysis of water use efficiency in different water forms in different crops in Rajasthan state. *International Journal of Pure and Applied Bioscience*, **5**(4): 131-138.
- Pervaize, U., Akram, M. and Nawab, K. (2010). Productivity enhancement through tubewell irrigation. *Sarhad Journal of Agriculture*, **26**(1): 97-102.
- Pindyck, R.S. and Rubinfeld, D.L. (1981). Econometric models and economic forecasts. *McGraw-Hill*, New York.
- Ray, I. (2005). Get the price right: Water price and irrigation efficiency. *Economic and Political Weekly*, **11**(33): 365-366.
- Saleth, R. M. (1998). Water markets in India: Economic and institutional aspects. *Markets for Water: Potential and Performance*, 187-205.
- Shah, T. (1988). Managing conjunctive water use in canal command: Lessons from the analysis of the mahi right bank canal, Gujarat. Research paper 3, An and, India: Institute of Rural Management.
- Shah, T. (1993). Groundwater markets and irrigation development. Political Economy and Practical Policy. Bombay: Oxford University Press.
- Shah, T. and Raju, K.V. (1988). Groundwater markets and small farmers development. *Economic and Political Weekly*, **23**(13): A23-A28

- Shankar, K. (1992). Water markets in eastern UP. *Economic and Political Weekly*, **26**(17): 931-933.
- Sharma, P. and Sharma, R. C. (2006). Factors determining farmers decision for buying irrigation water: Study of groundwater markets in Rajasthan. *Agricultural Economics Research Review*, **19**: 39-56.
- Singh, D. R. and Singh, R. P. (2006). Structure, determinants and efficiency of ground water markets in western Uttar Pradesh. *Agricultural Economics Research Review*, **19**(1): 220-228.
- Singh, D.R. and Singh, R.P. (2003). Groundwater markets and the issues of equity and reliability to water access: A case of western Uttar Pradesh. *Indian Journal of Agricultural Economics*, **58**(1):115-127.
- Singh, D.R. and Arya, P. (2016). Water markets and its implications to small farmers. *Agricultural Economics Research Review*, **32**: 56-69.
- Srinivasan, V. and Kulkarni, S. (2014). Examining the emerging role of ground water in water inequity in India. *Water International*, **39**(2): 172-186.
- Srivastava, S. K., Kumar, R. and Singh, R. P. (2009).Extent of groundwater extraction and irrigation efficiency on farms under different water-market regimes in central Uttar Pradesh. *Agricultural Economics Research Review*, **22**(1): 180-195.
- Srivastava, S.K., Chand, R., Singh, K., Singh, J., Kaur, A.P., Jain, R., Kingsly, I. and Raju, S.S. (2017).Revisiting groundwater depletion and its implications on farm economics in Punjab, India.*Current Science*, **113**(3): 422-429.
- Tamuli, J. and Dutta, M.K. (2015). What determines farmers' decision to buy irrigation water in water abundant regions? A study of groundwater markets in Assam in eastern India.Working paper 03. *International Network for Economic Research*.

Wang, J., Zhang, L., Huang, Q., Huang, J. and Scott, R. (2014). Assessment of the development of groundwater market in rural China. *Global issues in water policy* 11, *Springer Science Business*.

Zhu, X. Z., Cui, Y. L., Guo, M. and Ma, S. J. (2004). Analysis of water productivity change in China. *China Rural Water and Hydropower*, **2**: 57-62.

*An Economic study of Ground Water Market in Sikar
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ABSTRACT

The present investigation was carried out to analyse the factors influencing ground water market, impact of ground water market on changing cropping pattern, productivity and profitability, ground water use efficiency and the influence of ground water market on water use efficiency in Sikar district of Rajasthan. Water is a critical input in agriculture in nearly all its aspects having a determining effect on the eventual yield. Rajasthan state has 80 per cent *tehsil* as overexploited in the groundwater. A sample of 80 farmers has been taken from four villages of two *tehsils* from Sikar district was selected for the study. Both primary and secondary data were collected through field survey with the help of pre tested schedule and secondary data were collected from publication and other concern water departments for agricultural year 2017-18. The analysis revealed that total operational area, education of farmers and number of land fragments increased the probability of buying and selling water. Wheat and pearl millet was the dominated cropping pattern for buyer. The study revealed that the profitability or output input ratio for the wheat and pearl millet, cropping pattern was found as profitable which is more than one was. The amortized cost was found highest for pump sets followed by cost of digging pit and construction of well and cost of pipe for all the categories. The results also showed that water extraction for both the crops was high for the self-user category. Self-users were having the maximum net returns for the cultivation of crops where as buyers have

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the less net return. Cobb-Douglas production function showed that water quantity was significant and positive for all forms of water markets for wheat and pearl millet crops. And revealed that all categories i.e., self-user, self-user + seller, self-user + buyers, buyer in wheat and pearl millet crop to be taken care as they were over- utilizing the ground water for the cultivation.

राजस्थान के सीकर जिले में भूजल बाजार का आर्थिक अध्ययन

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सारांश

भूजल बाजार को प्रभावित करने वाले कारकों का विप्लेषण करने के लिए वर्तमान जांच की गई, बदलते फसल प्रतिरूप, उत्पादकता और लाभप्रदता पर भूजल बाजार के प्रभाव, भूजल उपयोग दक्षता और राजस्थान के सीकर जिले में जल उपयोग दक्षता पर भूजल बाजार के प्रभाव का विप्लेषण किया गया। लगभग सभी पहलुओं में कृषि में पानी एक महत्वपूर्ण उत्पादक सामग्री है, जिसका अंतिम परिणाम उपज पर पड़ता है। राजस्थान राज्य में भूजल में 80 प्रतिशत तहसील है। अध्ययन के लिए सीकर जिले के दो तहसील के चार गांवों के 80 किसानों का नमूना लिया गया है। पूर्व परीक्षण अनुसूची की मदद से क्षेत्र सर्वेक्षण के माध्यम से प्राथमिक और माध्यमिक दोनों आधार सामग्री एकत्र किए गए थे और प्रकाशन और अन्य चिंता जल विभागों से माध्यमिक आधार सामग्री एकत्र किए गए थे कृषि वर्ष 2017-18 के लिए। विप्लेषण से पता चला कि कुल परिचालन क्षेत्र किसानों की शिक्षा और भूमि के टुकड़े की संख्या ने पानी खरीदने और बेचने की संभावना को बढ़ा दिया। गेहूँ और बाजरा खरीददार के लिए वर्चस्व वाली फसल था। अध्ययन से पता चला कि गेहूँ और बाजरा के लिए लाभप्रदता या बी.सी. अनुपात, फसल प्रतिरूप लाभदायक पाया गया जो एक से अधिक था। पंप सेटों के लिए परिषोधन लागत सबसे अधिक पाई गई, इसके बाद गड्ढे खोदने, अच्छी तरह से निर्माण और सभी श्रेणियों के लिए पाइप की लागत थी। परिणामों ने यह भी दिखाया कि स्व-उपयोगकर्ता श्रेणी के लिए दोनों फसलों के लिए पानी की निकासी अधिक थी। स्व-उपयोगकर्ताओं के पास

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फसलों की खेती के लिए अधिकतम सकल वापसी थी जहां खरीदारों के पास कम सकल वापसी थी। कॉब-डगलस उत्पादन समारोह ने दिखाया कि पानी की मात्रा गेहूँ और बाजरा की फसलों के लिए सभी प्रकार के जल बाजारों के लिए महत्वपूर्ण और सकारात्मक थी और पता चला है कि सभी श्रेणियों यानी, स्व-उपयोगकर्ता, स्व-उपयोगकर्ता + विक्रेता, स्व-उपयोगकर्ता + खरीददार, गेहूँ और बाजरा की फसल में खरीददार को ध्यान में रखा जाना चाहिए क्योंकि वे खेती के लिए भूजल का अधिक उपयोग कर रहे थे। कृषि कार्यों के लिए व प्रोत्साहन से भूजल के दोहन में वृद्धि हुई।

ANNEXURE-I

Schedule for primary data collection

An Economic Study of Ground Water Market in Sikar District of Rajasthan

Department of Agricultural Economics

College of Agriculture, SKRAU Bikaner

1. Date of interview: ----- Name of interviewer: -----

2. Village: ----- Tehsil: -----District: -----

3. Mobile No:-----

A. General information

4. Name of respondent: ----- Age (in years): -----

5. Relationship with the head-----

6. Education: Illiterate / Primary / Middle / High school / College

7. Family size: M ----- F----- C-----

8. Caste: -----

the crop		of the water	type		water user S/B/Both

E. Cost factors & Income of the crop grown-

	Particulars	1.Crop (Rabi)	2.Crop (Kharif)	3.Crop (Zaid)	4.Overall
29.	Cost of Human Labour • Hired • Owned				
30.	Cost of Animal Labour • Hired • Owned				
31.	Cost of Machine power • Hired • Owned				
32.					
33.	Cost of Seed • Purchased • Owned				
34.	Cost of FYM • Purchased • Owned				
35.	Fertilizers				
36.	Plant protection chemicals				
37.	Electricity				

39.	charges				
40.	Irrigation Charges				
41.	Depreciation				
42.	Land preparation				
43.	Lease Cost				
	Miscellaneous expenses				
	Interest on working capital				
	Total Cost				
	Total yield				
	Gross income				
	Net income				

F. Problems faced by the farmers-

Particulars	Not at all	Low	Moderate	High	Severe
Non-availability of surplus water					
Non-availability of credit					
Lack of power supply					
Electricity tariff					
Fragmented land holding					
High cost of diesel and its availability					

Lack of access to water market					
High cost of irrigation water					
Irregularity in water transaction					
Non-availability of labour at proper time					
Too small holdings					
Lack of suitable variety					
Lack of irrigation technology(e.g. micro irrigation)					
Poor soil quality					
Poor topographic condition					
Lack of infrastructure (Conveyance pipe etc.)					
Lack of training on water use and management					
Lack of information in efficient water use (ext. agent)					

Scale: Not at all – 1, Low – 2, Moderate – 3, High – 4, Severe- 5