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Economics Analysis of Water Use Efficiency in Different Water Forms in Different Crops in Rajasthan State

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ABSTRACT

The present study was carried out in the semi arid and arid region of Rajasthan to analyze the water use efficiency in different crops. For this, the primary data were collected with the help of pre structured schedules and questionnaires in the study area. Total sample size was 238. The farmers were classified in different categories on the basis of their water selling and buying nature for the cropping. Cobb Douglas production function was used for quantifying the resource use efficiency. Four crops namely wheat, mustard, cumin and tomato was taken for the study and found that for the wheat crop, self-user + seller were over utilizing the water resources whereas the other agents of water markets were underutilizing water for the same crop. In the case of mustard crop, buyers were under utilizing the water resources where as other constituents of water market regimes were over utilizing the water resources. All categories were over-utilizing water in mustard except buyers category, which would have implication on sustainability of water availability in future.

Key words: *Groundwater markets, Water use efficiency, Cobb Douglas production function.*

INTRODUCTION

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. Groundwater has contributed significantly to the development of Indian agriculture particularly during the last four decades. Rajasthan has only 1.15 per cent of its water resources supporting 5.67 per cent of human population and 10.53 per cent cattle population of the country. (GOR, 2013) The draft of groundwater for irrigation purpose has increased more than three times in last two and a half decade (from 1984 to 2014). The worsening water balance in the state, has resulted in the ever increasing numbers of blocks under the categories of over-exploited as of 2011, the per cent of total blocks, under over-exploited category has gone up to around 80 per cent that were only 36 per cent in 1984. (CGWB, 2014).

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The declining water level has resulted in a widespread failure of wells and has further led to increase in the cost of well-deepening, installing new wells and pumping. This has resulted in inequality in the access to groundwater for irrigation among resource-poor marginal and small farmers as well as resource-rich, large farmers. This has led to the emergence of Ground Water Markets (GWMs) for providing access to irrigation waters[2].

The abrupt evolution of Groundwater markets gives the better opportunities for equitable access of irrigation water for the small and marginal farmers mainly. Subsequently the owners of WEMs achieve the better opportunity to use their high efficiency of water drafting; it augments the productivity, cropping intensity, irrigation intensity and area of high valued crops. In the study area Groundwater market revolutionize the traditional agriculture into modern agriculture with the income, productivity and equity effects. Water use efficiency deals with the efficient use of the available water in the crops grown. This reflects the better utilization of the groundwater resources and proves the significance role of groundwater markets. With view of above facts, the present study has been undertaken to study about the groundwater markets in Rajasthan state: perspective of agriculture arena with this objective.

MATERIAL AND METHODS

The past studies on the ground water markets provided a sound concern, concept and methodology for smooth conduct of present study. In this chapter, the study area, sampling frame, collection of data, and analysis of data with the appropriate tools is presented.

The Study Area and Sampling Frame

Rajasthan state is the largest state of Indian continent and consist 10.41 per cent of area. But low and erratic rainfall demands the use of ground water. Paucity of water in the area needs the groundwater markets. Hence, Rajasthan state has been selected purposively for the study. There are 80 percent overexploited blocks out of total blocks in the state. (CGWB, 2014) Out of these block the major area confined to arid and semi arid districts. Therefore, arid and semi arid districts were selected purposively. The arid and semi-arid regions of Rajasthan, spread respectively over the western and northeastern parts of the state, cover more than 85 per cent of the total geographical area of the state. The rainfall is lowest in the western part and moderate in the northeast area. The groundwater is the only source of irrigation in both the regions, as more than 90 per cent of the irrigation-demand is met by it. Of the total water availability in the state, only one-fifth is available in the arid region and two-fifths in the semi-arid region. Groundwater is comparatively less scarce in the semi-arid region, while it is most scarce in the arid region as is clear from the fact that the groundwater level was 50-60 m deep in the arid region, and 25-40 m in the semi-arid region. The depth of tube-wells is about 125-175 m in the arid region and 70-125 m in the semi-arid region. As the groundwater markets practices are prevalent in the overexploited and critical blocks of the country (CGWB), study area was selected on the basis of it.

Following the multi-stage sampling technique, the farmers were selected from eight villages of four districts from arid and semi-arid regions of Rajasthan. Jodhpur and Nagaur for the arid region and Sikar and Jaipur for the semi-arid region was selected purposively. These districts are categorized as over-exploited stage of groundwater development. From each selected district, one block from the over-exploited category of blocks was selected randomly with the help of Block Development Officer and Assistant Agriculture Officer of concerned block, where the buying and selling of groundwater was in practice. From the list, a cluster of two villages was selected randomly from each selected block. In sum total eight villages were selected for the present study.

A list of farmers was prepared from each village with the help of village patwari, leader Sarpanch and villagers and the farmers were categorized into self users, self-users+sellers, self-users + sellers + buyer, buyers and non-users groups or forms of water markets. From each forms or groups of farmers, fifteen per cent or more farmers were selected randomly. After selection of buyer category was again classified as self users+buyers and buyers for better comparison of data. In this way, 108 farmers from semi-arid region and 130 farmers from arid region with the whole sum of 238 farmers were selected as depicted in table 1.

Table 1: Numbers of farmers selected from selected districts of semi-arid and arid regions of Rajasthan (2015-16)

Category	Semi arid region				Arid Region			
	Jaipur		Sikar		Nagaur		Jodhpur	
	Total	Selected	Total	Selected	Total	Selected	Total	Selected
Self-users	100	15	48	7	60	9	75	12
SU+ Sellers	70	12	60	9	80	12	85	13
SU+S+B	65	9	50	7	50	8	60	9
Buyers*	130	20	118	18	100	15	180	27
Non-users	40	6	35	5	70	12	88	13
Total selected	**108**				**130**			

Collection of data

The present study is based mostly on 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 schedules used for the primary data collection were designed based on the objectives of the study. Some district level information and rules and regulations on groundwater exploitation and other basic information were collected from ground water department and various published or unpublished sources of Government of Rajasthan. The primary data were taken for agricultural year 2015-16 for the study.

Analysis of Data

This part deals with the tools and methods of analysis of data collected from farmers.

The study was based on the primary data collected from sample farmers during the agricultural year 2015-16. The study was adequately supported by the secondary information collected from the relevant government departments.

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

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 has been the most popular of 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 output and X_1, X_2, X_3, X_4 and X_5 denote inputs

The empirical model can be represented as follows:

$$\text{Log (Yield)} = \alpha + \beta_1 \log (\text{LAB}) + \beta_2 \log (\text{WAT}) + \beta_3 \log (\text{FERT}) + \beta_4 (\text{DUM 1}) + \beta 5 (\text{DUM 2})$$

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

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

DUM 2 = land type (if undulated then 1, otherwise 0)

The value of 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:

$$VMP_x = b_1 (Y/X)$$

Where,

$VMPx_1$= Value Marginal Product of X_1 coefficient

b_1= the regression coefficient (elasticity coefficient) of X variable (water)

Y = Geometric mean of yield.

X = Geometric mean of X variable (water)

In order to examine the water use efficiency, the $VMPx_1$ was compared with its factor cost. For the resource to be optimally located necessary condition is,

$$VMPx_1 = Px_1$$

This can be expressed in the ratio form as follows:

$$VMPx_1 / Px_1 = 1$$

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.

RESULT AND DISCUSSIONS

The Cobb Douglas production function analysis was done in WEM irrigated wheat, mustard, cumin and tomato farms to estimate water resource productivity considering yield of the crops as dependent variable and labour, fertilizer and water as independent variables. In addition to these, two dummy variables namely diesel or electric operated WEM and undulated land were also considered. The results are shown in Table 2, Table 3, Table 4 and Table 5 for different water market structure.

Estimation of Cobb Douglas production function for wheat under different water market regime

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 2). The elasticity coefficient of water and labour indicates one per cent increase in input use of these variables will result in increase of 0.450 per cent and 0.647 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 0.225 per cent and 0.825 per cent increase in yield respectively. F- Value was significant at one percent level of significance 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. It is also worth noting that the dummy variable taken for the analysis (i.e. whether the tubewell is electrical operated) invariably has similar influence on wheat crop yield among all agents of water transaction.

Table 2: Estimation of Cobb Douglas production function – wheat crop under different water markets in Rajasthan

Variable	Buyers	Self-users	Self-users +Buyers	Self-users + Sellers
Intercept	2.310**	1.70*	1.163**	1.417*
Labour	0.450*	-0.143	0.232**	0.825**
Fertilizer	-0.520	0.520*	0.340	-0.182
Water	0.647**	0.223**	0.710***	0.225*
Electrical/Diesel	0.003	0.025**	0.207*	000
Undulated	0.012**	0.019	0.001	0.010
R^2	0.730	0.710	0.716	0.692
F- Value	79.230***	76.810***	78.512***	82.126***

*,**,*** are significant at 1%,5% and 10 per cent level of significance

Estimation of Cobb Douglas production function for mustard under different water market regime

It could be observed from the Table 3 that the elasticity coefficient of water and labour were positive and significant in all the different categories of water market regimes except for self-user where in labour coefficient turned out to be insignificant. However fertilizer coefficient for self users found to be significant which greatly influences the mustard yield (one per cent increase in fertilizer can effect an increase of wheat yield by 0.520 per cent). The elasticity coefficient of water and labour indicates one per cent increase in input use will result in increase of yield by 0.685 per cent and 0.511 per cent respectively in case of Water Buyers (Table 7.2). On the other hand for self-users, increase in one per cent of water and fertilizer input result in 0.215 per cent and 0.520 per cent increase in yield, respectively. F- Value was significant at one percent level of significance for all the water market forms.

Table 3: Estimation of Cobb Douglas production function – mustard crop under different water markets in Rajasthan

Variable	**Buyers**	**Self-users**	**Self-users +Buyers**	**Self-users + Sellers**
Intercept	2.52**	1.709**	1.201**	1.399*
Labour	0.511*	0.143	0.255**	0.835**
Fertilizer	-0.515	0.598*	0.420	-0.164
Water	0.685**	0.215**	0.755***	0.867**
Electrical/Diesel	0.002	0.012	0.222	0.010
Undulated	0.011	0.002	0.003	0.010
R^2	0.750	0.716	0.734	0.651
F- Value	81.450***	65.334***	89.312***	76.821***

*,**,*** are significant at 1%,5% and 10 per cent level of significance

Table 4: Estimation of Cobb Douglas production function – cumin crop under different water markets in Rajasthan

Variable	Buyers	Self-users	Self-users +Buyers	Self-users + Sellers
Intercept	2.31**	1.898*	1.197**	1.412*
Labour	0.560*	-0.135	0.246**	0.825**
Fertilizer	0.461	0.610*	0.330	-0.148
Water	0.746**	0.233**	0.796***	0.923**
Electrical/Diesel	0.004	0.011**	0.210*	0.000
Undulated	0.015	0.001	0.002	0.001
R^2	0.670	0.620	0.635	0.617
F- Value	65.590***	69.733***	81.214***	80.012***

*,**,*** are significant at 1%,5% and 10 per cent level of significance

Estimation of Cobb Douglas production function for cumin under different water market regime

It could be observed from the Table 4 that the elasticity coefficient of water and labour were positive and significant in all the different categories of water market regimes except for self-user where in labour coefficient turned out to be insignificant. However fertilizer coefficient found to be significant which greatly influences the cumin yield (one per cent increase in fertilizer can affect an increase of cumin yield by 0.610 per cent). The elasticity coefficient of water and labour indicates one per cent increase in input usage of these variables will result in increase of yield by 0.746 per cent and 0.560 per cent respectively in case of water buyers (Table 4). On the other hand for self-users, increase in one per cent of water input result in 0.233 per cent increase in yield. F- Value was significant at one percent level of significance for all the water market forms.

Table 5: Estimation of Cobb Douglas production function – tomato crop under different water markets in Rajasthan

Variable	Buyer	Self- users	Self-user+ Buyer	Self-user+ seller
Intercept	2.034*	1.345**	0.899*	1.005***
Labour	0.322*	0.987***	0.351**	0.761**
Fertilizer	-0.311	-0.632	-0.183	0.015
Water	0.428**	0.698**	0.690***	0.259**
Electrical/ diesel	-0.016	0.013	0.008	0.006**
Undulated/Even	0.013	0.001	0.027*	0.004
R^2	0.812	0.831	0.791	0.805
F- Value	72.510***	78.433***	82.450***	65.345***

*,**,*** are significant at 1%,5% and 10 per cent level of significance

Estimation of Cobb Douglas Production Function for Tomato under different Water Market Regime

It could be revealed from the Table 5 that water and labour were positive and significant in all the different categories of water market structure. The elasticity coefficient of water and labour indicates one per cent increase in input usage of these variables will result in increase in yield by 0.428 per cent and 0.322 per cent, respectively for water buyers whereas for self-users, 0.698 percent and 0.987 percent respectively yield increase with the use of one per cent of water and labour input in tomato production in the study area. F- Value was significant at one percent level of significance for all the water market forms (Table 5).

Water use efficiency for wheat, mustard, cumin and tomato under different water market structure in study area

The resultant Cobb-Douglas production function was further used to analysis the water use efficiency under different water market forms for the crops namely wheat, mustard, cumin and tomato. It was evident from the table 6 and table 7 that for the wheat crop, self-user + seller were over utilizing the water resources whereas the other agents of water markets were underutilizing water for the same crop. In the case of mustard crop, buyers were under utilizing the water resources where as other constituents of water market regimes were over utilizing the water resources (Table 6). All categories were over-utilizing water in mustard except buyers category, which would have implication on sustainability of water availability in future. Similar results were found in the study of Singh *et al.*[4] and Kishore[1]. All agents of water markets regime must be encouraged to restrain the use of water especially for mustard crop. This could be attained through education programme for awareness and training for adoption of efficient irrigation schedule. Likewise, all categories of water markets except self-user + seller for the cumin crop were under utilizing the water resources. So, more use of water resources with the availability will augment the efficiency level. For the tomato crop buyers and self user + buyer were underutilizing the water resources whereas self user and self user + seller were over utilizing the water resources. Sustainable development can be achieved if the self-user and self user + seller use the optimum use of the water resource.

Table 6: Water use efficiency for wheat and mustard under different water regime in Rajasthan

Water Market Form	Wheat		Mustard	
	VMP/Px		VMP/ Px	
Buyer	1.430	Under-utilized	1.380	Under-utilized
Self-user	1.351	Under-utilized	0.210	Over-utilized
Self-user +buyer	1.852	Under-utilized	0.620	Over-utilized
Self-user +Seller	0.861	Over-utilized	0.854	Over-utilized

Table 7: Water use efficiency for cumin and tomato under different water regime in Rajasthan

Water Market Form	Cumin		Tomato	
	VMP/Px		VMP/ Px	
Buyer	1.520	Under-utilized	1.474	Under-utilized
Self-user	1.563	Under-utilized	0.125	Over-utilized
Self-user +buyer	1.924	Under-utilized	0.833	Under-utilized
Self-user +Seller	0.671	Over-utilized	0.722	Over-utilized

CONCLUSION

From the above result and discussions it can be concluded that for the wheat crop, self-user + seller were over utilizing the water resources whereas the other agents of water markets were underutilizing water for the same crop. In the case of mustard crop, buyers were under utilizing the water resources where as other constituents of water market regimes were over utilizing the water resources all categories of water markets except self-user + seller for the cumin crop were under utilizing the water resources. So, more use of water resources with the availability will augment the efficiency level. For the tomato crop buyers and self user + buyer were underutilizing the water resources whereas self user and self user + seller were over utilizing the water resources. Sustainable development can be achieved if the self-user and self user + seller use the optimum use of the water resource.

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