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Equity Assessment for Ground Water in Different Forms of Water in Rajasthan State

Vikash Pawariya[1*], R. C. Sharma[2] and B. K. Sharma[3]

[1]Research Scholar, [2]Professor & Head, [3]Professor

Department of Agricultural Economics, SKN College of Agriculture, Jobner- Jaipur

*Corresponding Author E-mail: vikashpawariya@gmail.com

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ABSTRACT

Present investigation was carried out in the arid and semi arid district of Rajasthan state to analyze equity assessment for ground water in different water categories in Rajasthan state. For this, primary data were collected with the help of pre structures schedule in the study area. Total sample size was 230 farmers. The farmers were classified in different categories on the basis of water transaction nature. There was a reasonable degree of fairness in the distribution of water between the different forms of water and thereby, realized equal yield levels if different forms of water market and thereby, realized equal yield levels of different crops. Farm size effect in the regression equations was negative implying thereby the equal access to groundwater. Thus the vertical equity is being there for different water forms.

Key words: *Equity, Groundwater Markets, Different form of water.*

INTRODUCTION

Agriculture is India's largest user of water as it is evident from the fact that Total utilizable water resource in the country has been estimated to be about 1123 BCM (690 BCM from surface and 433 BCM from ground), which is just 28% of the water derived from precipitation. About 85% (688 BCM) of water usage is being diverted for irrigation, which may increase to 1072 BCM by 2050. Major source for irrigation is groundwater. Annual groundwater recharge is about 433 BCM of which 212.5 BCM used for irrigation and 18.1 BCM for domestic and industrial use (CGWB, 2011). Groundwater irrigation, which expanded rapidly in the last few decades, has rapidly emerged to occupy a dominant place in India's agriculture and food security. It accounts for over 61 per cent of the irrigated area in the country (MOA, 2008-09). Groundwater is a vital resource, with a large fraction of the population relying on the resource directly or indirectly for livelihoods. The heavy reliance on groundwater for both domestic water and irrigation purposes is now approaching its limit as an increasing number of aquifers reach unsustainable levels after decades of exploitation.

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A crisis situation now exists in a number of states. In India, the stage of ground water development is 61 per cent (CGWB, 2014). The gravity of the situation can be appreciated from the fact that the proportion of overexploited blocks nationwide has tripled from 5% to 15% between 1995 and 2009. 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. It has been responsible for attaining food security through green revolution, commercialization of farming and promoting equity. Its exploitation in India is largely in the hands of private individuals and its development has grown exponentially over the years. The introduction of short duration, high -yielding crops along with intensive application of fertilizers, pesticides and mechanization enabled farmers to adopt multiple cropping practices that increased cropping and irrigation intensity substantially. Further, the advantages of groundwater irrigation coupled with favorable government policies and market forces induced farmers to intensify well irrigation and convert vast dry land areas to water intensive commercial crops. Thus the demand for groundwater increased remarkably[1].

The previous studies and present study shows that Rajasthan passed the stage of groundwater development already and as data show that 70 per cent blocks are over exploited. Therefore, the management of existing resources for the better productivity in the study area is needed. Groundwater resources in the state are being over drafted and this tendency is really crucial to think. Further, the main occupation is agriculture which cannot be spared at any cost even non availability of water and WEM. So the purchasing and selling of water for the regular agricultural operations is existing. This leads the emergence of Groundwater markets. The equity for groundwater is being aggraved.

MATERIALS AND METHODS

The Study Area and Sampling Frame

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 122 farmers from arid region with the whole sum of 230 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				122			

*****Buyers further categorized as Self-users + Buyer and Buyer category of groundwater market

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.

Measurement of equity

In the context of present study, two distinct types of equity concerns were used. The first was the horizontal equity which is defined as the condition of equal amount of water being delivered, resulting in an equal average yield per unit area among different forms of water markets. The frequency of watering is taken as a proxy for actual volumetric measurement. The second type, known as vertical equity involving a main view of society which examines whether the effect extends to a particular social or economic class at the expense of another (eg., between small and large farmers.)

Horizontal Equity

To examine the significance the impact of different forms of groundwater markets on horizontal equity, the analysis of variance (F-test) was carried out on number of irrigations applied and productivity realised as:

Null hypothesis (Ho) ; $\mu_1 = \mu_2 = \mu_3 = \ldots\ldots \mu_k$, i.e. means of variable under consideration will be equal under k forms of water market.

F_k-1, N-k = MS_{Mr}/ MS_E

Where,

MS_{Mr} (Water market mean square) = SS_{Mr} /k-1

MS_E (error mean square) = SS_E /N-k

The total sum of squares (SS_{total}), water markets sum of squares (SS_{Mr}) and error sum of squares(SS_E) will be computed as follows :

$SS_{Mr} = \Sigma\ Ti^2/ni - T..^2/N$

$SS_{total} = \Sigma\ \Sigma X_{ij}^2 - T..^2/N$

$SS_E = \Sigma\ \Sigma\ X_{ij}^2 - \Sigma\ Ti^2/ni$

Where,

X_{ij}= factor level of j^{th} farmer under i^{th} form of water markets (taken as under-root transformation, i.e. x = $\sqrt{X+0.5}$ in case of number of irrigations)

Ti= total factor level under i^{th} form of markets

T..= Grand total of factor under consideration

N= Total sample size

ni= Sample size under ith form of markets.

I =1,2……,k where, k being the form of water markets.

J= 1,2…….,ni.

If estimated F value is greater than the tabulated F value at k-1 and N-k degree of freedom and α level of significance, we rejects the null hypothesis and conclude that the means of factor under consideration between different forms of water markets differ significantly and vice-versa.

Coefficient of variation (c.v.) was worked –out as follows:

c.v. (%) = $\frac{\sigma}{X} \times 100$ = (standard deviation/ $Average$)100

Vertical equity

For the purpose of capturing the vertical equity in order to access the groundwater to farmers of all size groups under all forms of water market, land by cob douglas production of the following form

Log $\frac{Y}{X}$ = b_0+b_i log X_i

Where,

Y= total crop output

X_i= size of holding

b_0= constant

b_i= elasticity of land

This type of equation was used because of the use and uniqueness of interpretation of regression parameters in bringing out the relationship between size of holding and productivity. A negative elasticity parameter bi indicates equal access to groundwater, in which level of productivity declines as the size of holding increases: a zero value for bi indicates a lack of association between farm size and access of groundwater. A positive value indicates some degree of inequitable access in which the productivity increases with the size of holding. Productivity of wheat, mustard, groundnut, tomato in semi arid region and wheat, mustard, cumin and isabgol was selected as an indicator for the fairness of equal access of groundwater, together with other inputs.

RESULT AND DISCUSSIONS

Equity consideration is of great importance in order to develop sustainable groundwater irrigation. As discussed earlier the level of input use and yield realized did not assessed the two dimensions of equity, viz., the horizontal equity with regard to access to groundwater and vertical equity in terms of yield differences among different farm sizes. Therefore, these issues were examined under different forms of water market for semi- arid and arid regions and discussed under separate heads.

Horizontal equity

Horizontal equity is defined as the condition of equal access to groundwater resulting in an even yield realization among the various forms of water market. Number of irrigations was taken as a proxy for actual volumetric measurement of groundwater, an important indicator taken into consideration to access the equity was the average yield under different forms of water markets. As mentioned in the methodology, coefficient of variation and analysis of variance (F- test) were used to examine these issues in major crops viz.; wheat, mustard, groundnut and tomato in semi-arid region and wheat, mustard, cumin and isabgol in arid region.

Semi arid region

The results of the analysis indicated the means of the factors, i.e. number of irrigation and yield of wheat, mustard and groundnut were not significantly different between forms of water markets.

Table 6.4a level of irrigation and yield achieved in different crops under different ground water regime in semi arid region (2015-16)

Particulars	Irrigation (numbers)	C.V.(%)	Yield(Qt/ha)	C.V.(%)
Wheat				
Self-users	7.2	15.52	40.3	4.54
Self-users + Sellers	7	15.84	41.1	4.17
Self-users + Sellers + Buyer	6.9	15.88	41.85	3.98
Self-user + Buyer	6.7	15.96	41.05	4.05
Buyer	6.2	16.1	41.9	3.89
Mustard				
Self-users	3.5	15.30	12.5	15.70
Self-users + Sellers	3.25	16.63	12.32	15.74
Self-users + Sellers + Buyer	3	15.45	12.15	18.33
Self-user + Buyer	2.9	16.98	11.8	15.95
Buyer	2.75	16.67	13	14.89
Groundnut				
Self-users	4	11.55	38.2	10.66
Self-users + Sellers	3.75	12.83	38.05	10.75
Self-users + Sellers + Buyer	3.75	12.83	37.9	11.04
Self-user + Buyer	3.5	12.95	37.2	11.56
Buyer	3.2	13.05	37.05	11.68
Tomato				
Self-users	12.95	2.75	255.5	1.39
Self-users + Sellers	12.75	3.67	248.5	1.48
Self-users + Sellers + Buyer	12.5	3.72	251.3	1.78
Self-user + Buyer	12.5	3.54	248.7	1.67
Buyer	13.25	3.90	234.8	1.90

*Non users' category was not included as they were not indulged in the groundwater marketing.
F- Values were significant only for tomato crop. Other crops were found no-significant.

Though, higher number of irrigations was applied by self-users in case of wheat (7.2 irrigations) and mustard (3.50 irrigations), groundnut (4.0 irrigations) and by buyers in case of tomato (13.25 irrigations) as revealed from table 6.4a. The yield differences, though buyers out-performed the other forms of water market in case of wheat (41.90 Qt/ha) and mustard (13.00 Qt/ha) than other forms of water market, were statistically significant except for tomato. In case of tomato, yield differences were statistically significant among the different forms of water market. For the groundnut self users perform well under conditions. The coefficient of variation shows that higher variation was observed among buyers for irrigation applied (16.10 Percent) as well as well as yield realized (4.62 percent) in case of wheat. In case of mustard, higher variation in number of irrigations was observed for self-users + buyers (16.98 percent) while for yield, higher variation was observed among self-users + sellers (12.32 percent). Buyer water market structure has the maximum variation among different form for groundnut crop in number of irrigation (13.05 percent) and yield variation (11.68 percent). For tomato crop, higher variation was observed for irrigation (3.90 percent) as well as for yields realized (1.90 percent) to buyer form of water market.

Arid region

The results of coefficient of variation shows that higher variation in number of irrigations applied in wheat was among the buyer (8.05 percent) while for yield achieved in arid region was among the self-users + sellers (7.90 percent) forms of water market. In mustard crop, the higher differences in irrigation applied was observed among self-users (11.73 percent) form while in yield achieved high variation was reflected among buyers (15.05 Qt/ha) category whereas, in yield achieved the higher variation was observed among self-users + sellers (20.86 percent) form of water market. The higher variation in number of

irrigation applied and yield achieved of isabgol crop were observed among the farmers of buyers (9.78 percent) and (19.45 percent) forms of water market, respectively.

The analysis of variance indicated that the differences in number of irrigations applied in wheat, cumin and isabgol crops were not statistically significant but in mustard crop, the difference in irrigation applied was significantly different between the different forms of water market.

Table 6.4b level of irrigation and yield achieved in different crops under different ground water regime in arid region (2015-16)

Particulars	Irrigation (numbers)	C.V. (%)	Yield(Qt/ha)	C.V.(%)
Wheat				
Self-users	10	7.76	37.05	7.67
Self-users + Sellers	9.6	7.92	35.55	7.90
Self-users + Sellers + Buyer	9.2	7.94	35.22	7.56
Self-user + Buyer	9	7.98	37.55	7.82
Buyer	8.5	8.05	38.10	7.43
Musturd				
Self-users	3.5	11.73	14.20	20.78
Self-users + Sellers	3.2	10.63	13.85	20.86
Self-users + Sellers + Buyer	3.05	9.83	14.02	23.56
Self-user + Buyer	3.3	10.13	14.58	21.32
Buyer	3.6	10.43	15.05	20.08
Cumin				
Self-users	4.95	14.56	8.55	6.55
Self-users + Sellers	3.5	15.30	8.35	6.25
Self-users + Sellers + Buyer	4.2	14.43	8.10	6.11
Self-user + Buyer	4	14.02	7.88	5.98
Buyer	3.8	12.86	9.00	7.45
Isabgol				
Self-users	5.5	8.05	9.45	18.67
Self-users + Sellers	5.2	9.23	9.20	18.34
Self-users + Sellers + Buyer	5.1	9.34	9.00	18.05
Self-user + Buyer	4.8	9.52	9.10	18.23
Buyer	4.4	9.78	10.25	19.45

Non users' category was not included as they were not indulged in the groundwater marketing.

F Values were not statistically significant for number of irrigations applied in wheat, cumin and isabgol crops except irrigation applied in mustard crop.

Though, the buyers achieved higher yield level of wheat (38.10 Qt/ha), mustard (15.05 Qt/ha), isabgol (10.25 Qt/ha) and cumin (9.00 Qt/ha) crops. But the differences in yield realization were statistically non –significant between the different forms of water market.

From the foregoing discussion, it may be summarized that there was a reasonable degree of fairness in the distribution of water between the different forms of water and thereby, realized equal yield levels if different forms of water market and thereby, realized equal yield levels of different crops. Equity in access to water and yield realized, between categories, was also reported by Narayana, 1991; Sai, 1987; Shah and Raju, 1986 and 1988 and Shankar, 1992, Sharma and Sharma, 2006.

Vertical equity

The vertical equity examines the equity in access to groundwater among the farmers of different farm sizes within a particular form of water market. The analysis was carried out to observe the effect of landholding size on productivity of crops where yield was taken as

an indicator for access to groundwater together with other inputs.

Semi-arid region

The negative sign of estimated regression coefficient of land indicated an inverse relationship between farm size and yield of wheat, mustard, groundnut and tomato under all forms of water market in semi-arid region.

This relation was statistically significant under all forms of water market in case of wheat and mustard and under self-users + seller + buyer and self-users + buyers in case of groundnut and self user and self user + seller for tomato in terms of t-ratio. The r^2 values in almost cases were found to be differences in productivity were due to the differences in farm size. In other words, the accessibility of groundwater under specific form of water market do not varied across the farm size, thus variation in yield was on account of other than the variation in accessibility of groundwater. It is worth noting that

Table 6.5a Relationship between farm size and yield under different crops under different ground water regime in semi- arid region (2015-16)

Particulars	Constant	Coefficient	r^2	t-value
Wheat				
Self-users	5.02	-0.548***	0.621	56.74
Self-users + Sellers	1.53	-0.322***	0.596	25.67
Self-users + Sellers + Buyer	3.32	-0.478***	0.690	40.28
Self-user + Buyer	1.25	-0.571***	0.514	17.65
Buyer	2.32	-0.389***	0.437	15.33
Mustard				
Self-users	2.21	-0.432***	0.546	9.67
Self-users + Sellers	4.07	-0.339***	0.497	23.88
Self-users + Sellers + Buyer	5.13	-0.381***	0.467	20.56
Self-user + Buyer	1.15	-0.319***	0.498	27.89
Buyer	0.30	-0.458***	0.435	25.12
Groundnut				
Self-users	3.20	-0.562	0.332	1.16
Self-users + Sellers	1.23	-0.391	0.265	1.32
Self-users + Sellers + Buyer	6.35	-0.406***	0.436	51.33
Self-user + Buyer	2.08	-0.392***	0.540	59.20
Buyer	1.14	-0.364	0.342	1.27
Tomato				
Self-users	2.24	-0.433***	0.675	9.71
Self-users + Sellers	1.33	-0.421***	0.592	8.33
Self-users + Sellers + Buyer	0.26	-0.439***	0.605	5.41
Self-user + Buyer	1.16	-0.376	0.157	1.08
Buyer	2.15	-0.331	0.121	0.06

*** and ** indicates significance of factor at 1 percent and 5 percent level, respectively.

Table 6.5b Relationship between farm size and yield under different crops under different ground water regime in arid region of Rajasthan (2015-16)

Particulars	Constant	Coefficient	r^2	t-value
Wheat				
Self-users	1.14	-0.670***	0.675	51.51
Self-users + Sellers	1.02	-0.362***	0.528	20.44
Self-users + Sellers + Buyer	2.33	-0.456***	0.481	35.05
Self-user + Buyer	1.22	-0.712***	0.440	12.42
Buyer	4.42	-0.801***	0.562	10.1
Mustard				
Self-users	5.74	-0.641***	0.447	15.72
Self-users + Sellers	0.93	-0.346*	0.194	1.78
Self-users + Sellers + Buyer	0.98	-0.259***	0.112	1.12
Self-user + Buyer	1.08	-0.341***	0.433	33.94
Buyer	0.89	-0.421***	0.542	31.17
Cumin				
Self-users	2.54	-0.225***	0.522	30.56
Self-users + Sellers	0.69	-0.367***	0.547	36.12
Self-users + Sellers + Buyer	1.05	-0.580***	0.658	36.33
Self-user + Buyer	3.22	-0.322***	0.445	34.2
Buyer	0.77	-0.432	0.110	1.21
Isabgol				
Self-users	2.81	-0.344***	0.447	40.28
Self-users + Sellers	0.85	-0.289*	0.267	1.78
Self-users + Sellers + Buyer	0.65	-0.456	0.122	1.67
Self-user + Buyer	2.16	-0.367	0.118	1.55
Buyer	0.71	-0.435	0.05	0.016

***,** and * indicates significance of factor at 1 percent, 5 percent and 10 percent level, respectively.

The farm size effect in these regression equations was negative implying thereby the equity accessibility of groundwater (Table 6.5a). Similar results were observed in field study by Rajivan[3], Sharma and Sharma[1] and Singh and Singh[4].

Arid region

The similar results were obtained in arid region also. The estimated regression parameters showed an inverse relationship between farm size and yield of wheat, mustard, cumin and isabgol under all forms of water market in arid region. This relationship was statistically significant under all forms of water market for wheat and cumin except buyer category in cumin and under self-users, self- users + buyers and buyers for mustard and self-user in isabgol in terms of F-ratio. The r^2 values in most cases found to be high (Table 6.5b). This explained the variation in yield level were due to the differences in farm size. In other words, the accessibility of groundwater under specific form of water market do not varied across farm size, thus variation in yield was on account of other than the variation in accessibility to groundwater. It is worth nothing that the farm size effect in these regression equations was negative implying thereby the equal access to groundwater.

CONCLUSION

It may be concluded from above discussion that mustard and wheat in winter season and bajra and guar in summer season were the major crops. Farmers of the study area were growing less water intensive crops. Other high value crops were cumin, isabgol, groundnut, green gram and tomato. Buyers being the small and marginal farmers, preferred to grow food crops like wheat and bajra in higher proportion of GCA to fulfill their food and fodder requirement. Owners of WEMs preferred to grow mustard in higher proportion of GCA. Buyers in assured irrigation water were growing high value crops. Non users, in the absence of access to irrigation water were

growing unirrigated mustard in winter and bajra and guar in summer season. The cropping intensity was highest for buyer and other categories were almost similarly low respectively.

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