TOWARDS EVOLVING GROUNDWATER RIGHTS: THE CASE OF SHARED WELL IRRIGATION IN PUNJAB

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Abstract

Operationally, the water allocation arrangements found in the shared groundwater irrigation systems in the Bist Doab area of Punjab are identical to a "crude form" of water rights. Here, the individual farmer's access to well water is restricted in terms of number of days for which they could use the well. Also, these rights to use "water" can also be leased out. Hence, these entitlements can be treated as "tradable". Another important feature of this arrangement existing in the shareholder irrigation system is that the amount of water which the farmer can access through the well is rationed by restricted power supply. Hence, they are analogous to tradable water rights, with rationing. The potential impacts of such a rationing on efficiency of groundwater use can be examined by comparing the productivity parameters such as cropping pattern, land productivity (yield and net returns) and water productivity in crop production under shared irrigation systems with that under individual irrigation systems.

The learning from such a study can be used in drawing inferences on the potential outcomes of instituting water rights in groundwater. The study shows that under conditions of rationed water allocation, the farmers have high motivation to allocate more water to crops that are economically more efficient, and also use it more efficiently for the chosen crops than the farmers who have unrestricted access to groundwater by virtue of having wells under individual ownership. They generate greater returns from every unit of water used, without compromising on the prospects of farming. Hence, we can conclude that in semi arid and arid areas, establishing water rights in volumetric terms with due consideration to safe yield of the aquifer under consideration, and enforcing it would help promote efficiency and sustainability in groundwater use.

1.0 INTRODUCTION

The past few years have seen extensive academic debate on the range of institutional measures for promoting efficient, equitable and sustainable use of groundwater use in India (see Kumar, 2007; Moench, 1995; Shah et al., 2004b). These regulations and market instruments concern introduction of top-down state regulations on groundwater withdrawal (Sharma, 1995); introduction of groundwater withdrawal permits (Sharma, 1995); cooperative management of groundwater (Singh, 1995); introduction of tradable property rights in groundwater (Kumar and Singh, 2001; Kumar, 2007); intelligent rationing of electricity supplied to farm sector (Shah, 2004); and pro-rata power tariff in agriculture (Saleth, 1997; Kumar and Singh, 2001; Kumar, 2005); and community-based ownership and management of groundwater (Shah et al., 1998). These debates are, however, characterized by diametrically opposite view on the equity and productivity impacts of most of these instruments.

Many argue that pro rata pricing would have positive impacts on efficiency, equity (Kumar and Singh, 2001; Kumar, 2005) and sustainability (Singh and Kumar, 2008) in the use of groundwater in semi arid and arid regions. Some argue that the operational issues associated with introducing metering and pro rata pricing are many that it is almost impossible to do agricultural metering of electricity in the farm sector without causing

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negative welfare effects (Shah et al., 2004a; de Fraiture and Perry, 2004). On the other hand, some scholars have argued that rationing of water allocation is the best way to achieve enhanced productivity in agriculture water use (Perry, 2001; de Fraiture and Perry, 2004). Saleth (1997) argued that even the crudest form of water rights would be more effective in achieving equity, efficiency and sustainability in groundwater use, than evolving energy pricing policy which can achieve the goals of efficiency, equity and sustainability. While Shah et al (2004b) argue that instituting and enforcing groundwater rights or enforcing any regulations on the use of groundwater would be practically infeasible due to millions of wells and pump sets, Kumar (2007) suggests an institutional framework for enforcing tradable property rights in groundwater, with a three-tier hierarchy of institutions from local (village) level to the aquifer level to overcome such operational difficulties.

Kumar (2005) had illustrated with empirical evidences from semi arid north Gujarat that rationing groundwater allocation with volumetric water prices or pro rata pricing of electricity for pumping water would lead to positive outcomes on efficiency and sustainability of groundwater use with no adverse effects on farm returns. Whereas, Singh and Kumar (2008) based on empirical data from three locations in India, shows that pro rata pricing alone could bring about positive outcomes on efficiency, equity and sustainability. But, there is very little evidence on the potential impacts of volumetric rationing of water, wherein farmers have restricted access to groundwater, but do not incur any marginal costs of using it. Though the shareholders of tube well partnerships in north Gujarat have volumetric entitlements, they are also confronted with positive marginal cost of using water (Kumar, 2000; Kumar, 2005). Internationally, the only developing country where evidences of efficiency and equity impacts of tradable property rights in groundwater is Chile, where positive impacts on equity and water use efficiency were seen (Rosegrant and Gazmuri, 1994; Thobani, 1997).

Though theoretically not, practically, the water sharing arrangement in shared well irrigation of Punjab is quite identical to the crudest form of water rights. In this case, the farmers do not pay for well water on volumetric basis, neither their access to well water is defined in volumetric terms. But their access to the same is restricted in terms of number of hours/days for which they could use, which is directly linked to the size of share holding (Tiwari, 2007). Some scholars have argued that water rights without tradability would lead to wasteful use of the resource (Frederick, 1993; Howe et al., 1986), though this is not identical to the earlier case. Others fear that tradable water rights would lead to farmers allocating their water for high valued uses or using it for high valued crops, with negative consequences for equity, food security and water for basic survival needs (Rosegrant and Ringler, 1998). Understanding the potential impact of rationing water allocation can significantly contribute to deepening our understanding of crafting institutions and policies for sustainable use of groundwater.

2. OBJECTIVES

The study explores the impacts of rationed allocation of groundwater on efficiency and sustainability in groundwater use in agriculture. The specific objectives are to analyze the impact of volumetric rationing in water allocation on: 1] cropping pattern of the irrigators; and, 2] land and water productivity in irrigated crops.

3. THE STUDY AREA, METHODOLOGY AND SAMPLING

The area of our study was limited to the four districts of Doab region namely Jalandhar, Kapurthala, Nawanshahar, Ropar. This region falls between the two rivers Sutlej and Beas and as mentioned before, it is known as the heart of Punjab.

The district of Jalandhar is an intensively irrigated plain of Punjab between the Beas and Sutlej rivers. The district has semi arid climate. The mean annual rainfall in the district is 703.0 mm. The rainfall increases from the south-west towards the north-east, from 551.3 mm at Nakodar to 892.3 mm at Adampur. About 70 per cent of the annual normal rainfall is received during the period July to September, July being the rainiest month. The Nawanshahar district has a geographical area of 1258.33 sq. km with a population of 5.86 lac people. The average annual rainfall in the district is 700mm. About 70 % of the annual normal rainfall in the district is received during the period July to September.

Kapurthala District is situated in the Jalandhar Doab and comprises two non-contiguous parts, separated by a distance of 32 kilometres. According to the 1991 census, the population of Kapurthala District, covering a geographical area of some 1633 sq km., was 6.46 lac people. The district of Rupnagar falls between north latitude 30°-32' and 31°-24' and east longitude 76°-18' and 76°-55'. The district adjoins Nawanshahar, Mohali and Fatehgarh Sahib Districts of Punjab. The district comprises three Tehsils and 617 villages.

3.1 Methodology and Analytical Tools

The methodology used in the study involves comparing the cropping pattern; land productivity (yield and net returns) and water productivity (Rs/m3) under shared irrigation system with that of individual well commands. The efficiency impact of rationing water allocation is analyzed in terms of differences in water productivity of the crops in economic terms; and the cropping pattern. This approach is based on the premise that while the amount of water that can be accessed by individual well owners is unrestricted, it is restricted in case of shared well owners.

In order to collect detailed information regarding social dynamics of shareholders, history of system, dispute emergence and settlement, and to triangulate what information has been provided by the farmers, 15 Focussed Group Discussions were conducted with the farmers in all the study villages.

To estimate the land productivity (Rs/ha) the minimum support price has been taken as the price of output. It would help nullify the effect of any exaggeration made by the respondent or market volatility and only capture the effect of yield increase and change in cost of inputs. From the four districts in the Doab area, the villages and the respondents were selected using random sampling method for administering the structured questionnaire. The sample survey covered 81 individual well owners and 75 shared tube well systems from 20 villages in four districts. In case of shared tube wells, information about the entire tube well command was collected.

In order to understand how efficiently irrigation water is used for production of a particular crop, it is important to know the marginal productivity of irrigation water, wherein we should segregate the effect of soil moisture on crop yield or rain-fed component of crop yield. The detailed methodology for estimation of marginal productivity of applied water is provided in Kumar et al. (2008). However, it is assumed that the entire crop yield is due to the irrigation water, and rains do not contribute to the yield at all. The applied water productivity for crops in economic terms (θ_{crop}) was estimated by using the estimates of the total volume of water used for crop production (Δ_i) as the denominator against the net return from crop production (NR_i) in the numerator, as per equation 1.

The volume of water applied for crop (Δ_i) was estimated for each crop on the basis of the number of irrigations; hours of watering per irrigation and the well output. In order to ascertain the discharge of pump sets, discharge measurements were made for sample pump sets under each horsepower category from each district using bucket and stop watch. The discharge for the rest of the pump sets was then extrapolated using the estimated values of pump efficiency for each category of pump set.

$$\theta_{crop} = \frac{NR_i}{\Delta_i} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

4. SHARED IRRIGATION SYSTEMS IN DOAB AREA OF PUNJAB

On the basis of ownership, irrigation systems can be classified into two major categories, viz., individual irrigation system, and shared irrigation system (Kumar, 2000; Tiwari, 2007). In shared irrigation system, the water extraction mechanism is owned or shared by at least more than one household. In simple terms, it is a type of arrangement where more that one household take water from a water source. These shareholders follow a specified system of turns to avail of the irrigation services. As found by Kumar (2000) in north Gujarat and later on by Tiwari (2007) in Punjab, generally, this mechanism of turns is based on the ratio of land owned by the particular household in the command area of the particular tube well. These shareholders do not have the liberty to avail of the irrigation services as per their wish. Instead, they need to plan about the selection and water requirement of crop keeping water availability in mind, and at times they do undertake discussions and mutually decide about the crops to be taken in command area.

There have been cases where shareholders take water intensive crops alternatively. However, this situation prevails only in limited number of cases. In majority of the cases, shareholders do protect themselves by taking only those crops which are less water-consuming and can provide better returns coupled with lesser risk with regard to water availability. In case of individual tube wells, owner enjoys full control over water application. Therefore, the availability of water does not become a constraint in crop selection.

The turns for irrigation are allocated on daily basis wherein during each turn water is available to the shareholder at least for a day. Those who have larger holdings (and share) would get each turn for proportionately more number of days. This is different from what was found in the case of north Gujarat where the allocation is on hourly basis for each watering. Except for Ropar, where there is electricity for 24 hrs, in other three districts electricity is available for about 8 hours in kharif and about 4 hours in winter. So if a farmer decides to grow rice then he has to se generator to fulfil the water requirement of the crop which increases the cost of cultivation to a very high level.

4.1 Illustrative Case Study

A clear illustration of shared groundwater irrigation system, and its operating principles and rules is provided below. Satnam singh had total land of 8 Acres which got divided between his two sons Raj and Banta in two equal parts. Their land was further divided in the next generation. Earlier both Raj and Banta singh were taking water on every alternate day. But, now with their off springs, Amar Singh's turn comes once in every 4th day, and similarly for other shareholders.

Figure 1: Demonstration of Shared irrigation system

	Satnam Singh (8 Acres)			
	Raj Singh		Banta Singh	
Land ←	4 Acres		4 Acres	
Turn ←	1 day		1 day	
	Amar Singh	Sohan	Pukkar	Kasmir
Land ←	2 Acres	2 Acres	2 Acres	2 Acres
Turn ←	1 day	1 day	1 day	1 day

Now if Amar singh decides to migrate abroad or to a city, then he can lease out his land to his brother or third party. In case he leases out his land to Sohan then, the turn earlier allotted to Amar gets transferred to Sohan Singh as shown in Figure 1. Now, though the command area remains the same, Sohan gets two consecutive turns.

Figure 2: Shared irrigation system in case of farmer leasing out land to his brother

Satnam Singh (8 Acres)			
Raj Singh		Banta Singh	
4 Acres		4 Acres	
1 day		1 day	
Amar Singh	Sohan	Pukkar	Kasmir
Lease out to Sohan	2 Acres + 2 Acres	2 Acres	2 Acres
	1 day + 1 day	1 day	1 day

Another possibility is that Amar Singh leases out his land to a third party and in that case the turn for water gets transferred to the lessee (Figure 2). In all the three cases discussed above, the command area of the tube well remained same. Also the irrigation schedule for the other three shareholder farmers remains the same. If Amar singh decides to cultivate crops in more area, then he will have to manage water to meet the crop water demand from his own fixed entitlement, decided earlier. But generally this does not happen as all the “leasing in” and leasing out” transactions in land occur along with transfer of water entitlements.

But, it is important to note that the farmer can use a generator or any other water extraction device for pumping water from the tube well to irrigate the extra piece of land within the allocated day. In this case, the command area of the tube well increases forms eight acres to nine acres. This clearly means that the farmers' "entitlement" is not defined in volumetric terms, but in terms of number of days for which he can use water from the tube well.

5. RESULTS AND DISCUSSION

5.1 Type of Tube Well

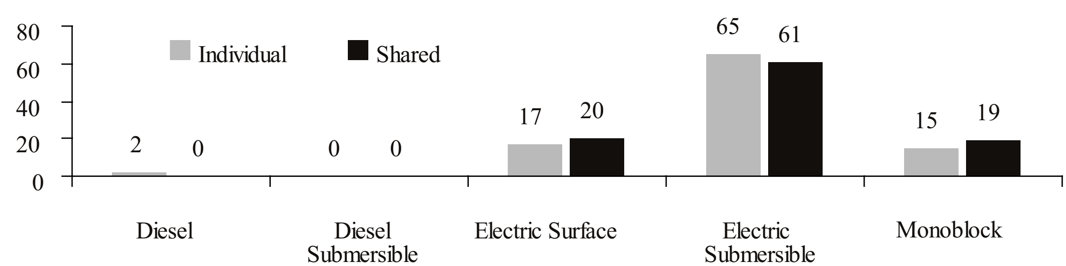
Figure 3 shows the percentage of farmers under the two categories, who own different types of water extraction devices. As regards pump ownership, nearly 60% of the tube wells both in shared and individual tube well systems were reported to have submersible pumps. One of the reasons for such a high percentage of submersible pump sets for tube wells was the prevalence of rice-wheat cropping pattern. Since irrigated paddy needs frequent heavy dozes of irrigations, farmers switch over from mono-block pumps to submersible pumps. One of the reasons for this is the drop in water table, experienced particularly during summer, due to which the outputs obtained from wells through the use of mono block pump sets are inadequate.

During the survey, it was found out that there was a trend of shifting from mono block pumps to submersible pumps. While mono-block pumps could operate at a depth of about 50-60 ft, a submersible pump can work at much higher depth with higher pump capacities. Also farmer makes a cushion for future and installs the pump at a greater depth considering the rapid decline in water table, which the region is experiencing. Table 1 shows the percentage of farmers under the two categories who have not shifted, and the percentage of farmers who have shifted due to one of the three reasons.

Table 1: Percentage of Farmers Shifting from Mono-block to Submersible Pump sets and the Reasons for Shifting

Particulars	Shared Wells (%)	Individual Wells (%)
No shift in pump sets	44	32
Increasing water table depth	23	41
Rice cultivation	17	21
Summer water shortage	16	6

Figure 3: Ownership of Groundwater Extraction Mechanisms by Different Categories of Farmers



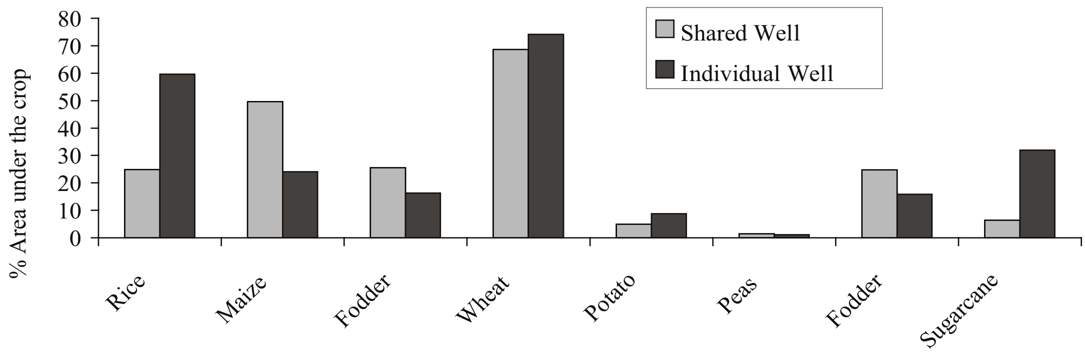
1. **N**o Shift in Pump Sets: Forty Four per cent of the shared wells and 31% of the individual wells did not change the pump sets due to the following reasons: 1] they are growing crops that do not require much water like maize, sugarcane. Water currently available is sufficient for these crops except rice; 2] water table at that particular place is still good enough for cultivation; 3] in shared well, since every decision regarding expenditure on the tube well is made with consensus of all the shareholders, many a times change of tube well is not supported if proposed by only one of the member because the cost of shifting is quite high approximately Rs. 87000.
2. Depth to Water Table: Water table depth is declining at an average annual rate of nearly 0.2 m. So, in the course of time, shift in pump sets become imperative. This phenomenon was more prominent in Ropar as the average bore depth was around 300 ft. In Ropar, all the pumps were submersible.
3. Rice Cultivation: In many areas such as Punjab (India), a traditional wheat belt, where rice-wheat is intensively grown, the water table receded on average 0.2 m per year during 1979-1991 (Singla 1992)[4] . The area under the critical water table below 10 m in central Punjab increased from 3% in 1973 to 25% in 1990 and 53% in 2000. Due to this decline in groundwater levels, there has been a shift from surface pump sets to submersible pumps.
4. Shortage of Water in summer: In summer, the temperatures soar up to 50^{o}C in Doab area. The water requirement for paddy, which is transplanted in May-June, is very high during these months. Due to this reason, there is heavy pumping of groundwater. As a result, water table goes down, resulting in lowering of well yields. The crops suffer due to shortage of water. Hence, the farmers are forced to increase the depth of the tube well, to raise the well yields.

[4] Singla, T. L (1992) Groundwater recharge programme: present status and scope. Water Resources Day, Vol. I, Punjab Agricultural University. p 1169-1173.

5.2 Cropping Preferences in Shared and Individual Systems

Comparative analyses of cropping pattern of individual irrigation systems and shared irrigation systems show remarkable difference in the cropping pattern adopted in their command areas. In kharif, farmers in the commands of individual irrigation system are more inclined towards rice cultivation whereas in shared irrigation systems, majority of the cropped area in kharif is under maize (Figure 4). It should be kept in mind that maize grown during kharif takes much less water as compared to kharif paddy, which needs to be irrigated before the onset of monsoon, which arrives in the start of July. Though the cropped area figures of winter season do not differ much, the percentage area under wheat and potato, which are dependent purely on irrigation water, are slightly less in the shared irrigation system commands as compared to individual well commands. More interestingly, the percentage area under sugarcane is much less in shared irrigation commands (i.e., 32 per cent against 6.4 per cent). Here again, the tendency to go for highly water-intensive perennial crop is more among farmers having individual wells.

Figure 4: Cropping Pattern of Different Farmer Categories in Different Seasons



5.3 Crop Yields in Shared and Individual Irrigation System

Farmers mainly take two crops in a year in addition to the annual crop of sugarcane. These crops primarily include rice and maize in kharif and wheat in winter. There were instances, where vegetables such as potato and peas are also grown in winter. Water availability seems to have the biggest impact on the cropping pattern, and not on the agronomic inputs. Majority of the farmers follow the same agronomic practices suggested by the Agriculture University, irrespective of the amount of water they could access. The farmers who are members of shared irrigation systems manage their crop water demands by allocating less area for crops that are water intensive. This approach ensures optimum inputs, leading to more or less same level of crop yields. As Table 2 indicates, there is marginal difference in yield of crops, showing higher values in favour of individual well commands.

Table 2: Productivity of various crops in shared as well as individual system (qtl/acre)

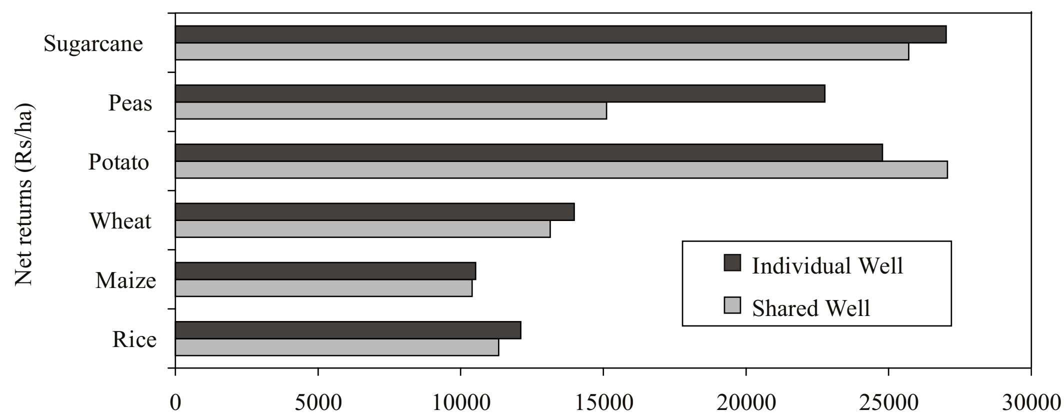
Crop	Shared Wells	Individual Wells
Rice	23.40	24.02
Maize	18.11	18.61
Wheat	20.17	19.80
Potato	65.00	64.79
Peas	25.29	29.75
Sugarcane	315.56	

Source: Authors' own estimates based on primary data

5.4 Net Returns from Crops in Shared and Individual Irrigation System

There was not much difference in both the systems as farmers irrespective of the tube well system adopt standard practices as recommended by Punjab Agricultural University, Ludhiana. The productivities as shown in the figure below (Figure 5)

Figure 5: Net Returns from Crops for different Categories of Farmers



Relatively higher values for returns from rice in the case of individual wells is mainly due to difference in use of generators. As discussed earlier, kharif rice in Punjab is a water intensive crop requiring daily irrigation till the onset of monsoon. If the field under rice gets dried then the productivity can fall drastically. At times, this can result in total loss of the crop also. In order to avoid such situations, farmers use generators to irrigate their land. Due to restricted availability of water and lesser control over timings, usage of generator is relatively higher in the shared irrigation systems in comparison to the individual systems.

Due to this reason, percentage of farmers taking rice in kharif is only 25% in shared irrigation system, as against 60% in individual well owners. Majority of the farmers under the shared irrigation system are inclined towards maize, percentage of farmers taking up maize is about 50% whereas same under individual is about 24% only. The focused group discussions revealed that this difference was due to differential water security. While individual owners were having greater water security, same is not the case with shared irrigation systems.

In cases where there were only two shareholders in the system, farmers were found to be growing rice as they could manage to provide watering at all critical stages of crop growth. However, in cases where shareholders were three or more, they prefer to grow maize only as taking rice in such circumstances would increase the cost of cultivation to a great extent, making it economically less viable as compared to other available options for the season. Also with large number of shareholders, the risk of yield reduction due to insufficient irrigation also increases.

5.5 Water Productivity

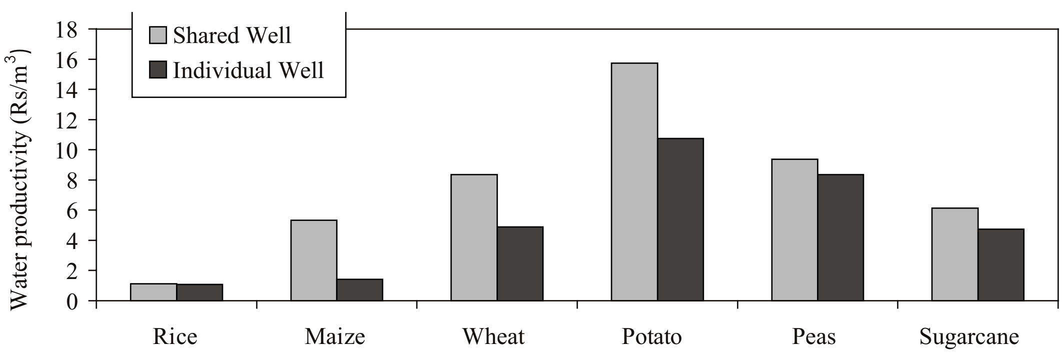
Water productivity in crop production can be defined as net return on per unit volume of irrigation water applied for crop production; in simpler words, it shows the average return on the applied water.

An analysis of water productivity can show the efficiency with which water is used in a particular crop. This analysis is relevant for areas where scarcity of water exists. However, Doab area of Punjab is a water rich region, and as a result generally farmers do not care about water use efficiency. While the electricity prices could motivate farmers to use water more efficiently, this is also available free of cost. Farmers do not have any special incentive to use electricity more efficiently as it won't help them cut down the cost of irrigation. But, in the case of shared irrigation systems (tube wells), the amount of water farmers are entitled to use in a season is limited.

Hence, ideally, they should have incentive to allocate their water for uses that yield higher returns, and as a result should obtain higher water productivity in crop production.

Figure 7 shows the difference in productivity of water for different crops between the two categories of farmers. It shows that there is no big difference between the water productivity of rice under both the systems. It is because of the natural tendency of farmer to keep the rice field submerged so that land does not get dried and risk with respect to loss in crop yield can be minimized. But for other crops, difference in water productivity figures between individual farmers and shareholders is significant. It shows the efficient utilization of water under the shared irrigation. These results were expected as under resource constraints, careful and judicious usage is resorted to. In this case, as the share holders get limited water, he/she plans irrigation schedules properly and provides only optimum dosage. Therefore, per unit return on water applied is higher in case of shared irrigation system.

Figure 6: Crop Water Productivity under different Irrigation Systems



5.6 Leasing of Land

There is a common trend in the area of leasing in or out the land because of many reasons. Some of the prominent reasons being: migration1[5] ; demise of the kin; and, outstation posting or government service. With the leasing of land in the shared system command, a farmer's entitlement for water also goes to the person who takes the land on lease. The rates of leasing out vary greatly, depending on whether the rights to use water from the well also get transferred or not. The lease charges may range from Rs. 16,000 to Rs. 17,000 per acre per annum. There were one or two cases where we found leasing out of land without rights to use water from the well. The rates in those cases were about Rs. 9000-1000/acre/annum.

In case of shared tube well systems, about 70% of the cases were of leasing of the land within the family i.e., between two brothers. As demonstrated earlier, if the lease out is to one's own brother, the person gets two consecutive turns. Whereas if the land is leased out to an outsider, the irrigation schedule for the kinship partners remain un-altered.

5.7 Mechanization

Mechanization is an important feature of Punjab's agriculture. Historically Punjab has been a region where modern agricultural practices have been followed; same is evident by proactive role and participation of

[5] Migration is very common in this region and because of that, the person migrating generally leases out his land to either his own brother or third party in the village itself. Earlier, people from the region used to migrate to Canada and USA but now they have started migrating to France, Britain and Spain. Also with the price of the land sky-rocketing, people do not sell off their land and therefore "land leasing" phenomena is on the rise.

the region in making green revolution a big success in India. Farmers in this region (mainly Doab region) are progressive, and with the support of Agricultural Universities, they have been able to achieve commendable crop yields and returns. These are clearly visible in the living standards of the inhabitants of the region.

In general, subsistence agriculture is characterised by low level of use of modern equipments or machinery and opposite is true for the commercial farming. In that respect, anything "shared" means a compulsive arrangement where the shareholders are seen to be under some kind of resource constraint, mainly financial. However, the same argument does not hold good for the members of shared well irrigation systems in Doab region. The farmers who are part of the shared irrigation system are well off and undertake all the modern agricultural practices as prescribed by Punjab Agriculture University. Concentration or usage of modern machinery is also very high. Table 3 shows the figure of farmers owning tractors and other kind of heavy agricultural machinery.

Table 3: Ownership patterns of farm equipments in both shared and individual systems

Particulars	Shared Wells	Individual Wells
Tractor owned	62.70	96.29
Tiller owned	64.32	98.76
Harvester	19.45	19.75

Source: Authors' own estimates based on primary data

As Table 3 shows, there is a significant difference in the percentage of farmers owning tractors and tillers falling under shared and individual irrigation systems. Although, figures of shared are relatively low, but these are higher in comparison of other states. This arrangement provides a clear indication that shared well irrigation is no where associated with subsistence agriculture, but is equally commercial like. The difference in ownership can be due to the smaller land holdings in case of farmers under shared irrigation systems. Those farmers, who do not own the farm machinery, rent or borrow them in to do the agricultural operations.

6. FINDINGS

1. In shared irrigation systems, farmers have greater motivation to grow less water consuming maize and peas as compared to water-intensive rice and sugarcane found in individual systems. The percentage of farmers growing rice under shared irrigation systems was about 25 as compared to 60 in the case of individual wells.

2. The income returns from unit area of the crop were slightly higher for farmers with individual irrigation systems. Such differences could be attributed to the higher yield these farmers get and the lesser cost they incur for irrigation.

3. Water productivity figures for all the major crops were higher for shared irrigation systems than that of individual systems. Overall, water productivity was higher for potato, peas, maize and sugarcane across the board. Though there wasn't much difference in water productivity of rice, in the case of wheat the difference was major. It was Rs.5.3/m^3 in shared systems, as against Rs.1.4/m^3 in individual systems. For maize, it was Rs. 8.36/m^3 in shared systems as against Rs. 4.89/m^3 in individual systems. This is in spite of the lower net returns from land, indicating lower dosage of irrigation water. Also, in the case of other crops viz., potato, peas, sugarcane it was higher in shared systems, though the differences were marginal. This improvement in productivity comes from careful and judicious use of irrigation water.

4. The farmers under shared irrigation systems tend to grow crops that give higher water productivity such as potato, peas and maize, and avoid crops that yield very low returns from every unit of water used. Hence, it could be inferred that these farmers secure much higher water productivity in rupee terms as

compared to individual well owners. Thus, under a regime of volumetric rationing of water, farmers maximize their returns from every unit of water used rather than land through careful use of irrigation water for a particular crop and careful selection of crops that give higher returns (in rupee terms) from every unit of water. Also, the limited access to water which the shareholders have, do not seem to have any impact on farm mechanization and land leasing.

5. Under shared irrigation systems, there is optimal use of farm machinery through renting and borrowing.

7. CONCLUSIONS

In the recent years, discussions on the management of groundwater in arid and semi arid areas have focussed on institutional interventions that influence the way groundwater would be accessed and used by the users (Kumar and Singh, 2001; Kumar, 2007; Shah et al., 1998). Enforcement of tradable property rights in groundwater is one of them, the others being community based management of groundwater (Shah et al., 1998) and cooperative management (Singh, 1995). This marks a major departure from quick fix solutions to deal with groundwater over-draft such as water harvesting and artificial recharge of aquifers. It is being argued that enforcement of tradable property rights in groundwater would promote efficient water markets, raise the price of water in the markets, and encourage farmers to use water more efficiently in their fields, and transfer the saved water to economically more efficient uses (Kumar and Singh, 2001; Kumar, 2007). There is hardly any empirical evidence available from within India on the outcomes of introducing water rights.

At the operational level, the shareholder irrigation systems in Punjab are identical to a crude form of groundwater rights, wherein the individual farmer's "entitlement" for well water are allocated in terms of number of days for which wells can be run, and also schedules pre-determined. Also, these rights to use "water" can also be leased out. Hence, these entitlements can be treated as tradable. Another important feature of this arrangement existing in the shareholder irrigation system is that amount of water which the farmer can access groundwater through the well is rationed by restricted power supply, given the high cost of obtaining diesel generators. Hence, they are analogous to tradable water rights, with rationing. Hence, the learning from such a study can be used to draw inference on the potential outcomes of instituting water rights in groundwater. The study shows that under such conditions, the farmers have high motivation to allocate more water to crops that are economically more efficient, and also use it more efficiently for the chosen crops than the farmers who have unrestricted access to groundwater by virtue of having wells under individual ownership. They generate greater returns from every unit of water used, without compromising on the prospects of farming.

That said, one needs to see whether the learning drawn from Punjab study can be extended to other semi arid regions of India. For that we need to understand the groundwater socio-ecology in other dry regions as against Punjab. In Punjab, owing to the good resource endowment and the good economic conditions of the farmers, access equity in groundwater is good. Due to this reason, the extent of water trading is extremely limited. Whereas in other semi arid and arid regions such as north Gujarat, north Karnataka, western Rajasthan and parts of Andhra Pradesh, Madhya Pradesh and Tamil Nadu, groundwater is really scarce, and the equity in access to the resource is very poor (Kumar, 2007). With the introduction of water rights, many farmers who were earlier having unlimited access to the resource would have to manage with limited rights due to re-distribution of rights. This would increase the need for water trading, thereby increasing the price of water in the market. For the water using well owner, this would indicate the opportunity cost of using it, and therefore he/she would have stronger incentive to enhance the productivity of water use to get returns higher than the market price of water. Hence, we can conclude that in semi arid and arid areas, establishing water rights in volumetric terms with due consideration to safe yield of the aquifer under consideration, and enforcing it would help promote efficiency and sustainability in groundwater use. This might eventually result in large-scale shift from cereals that give low returns per unit of water to high valued cash crops. This can create problems of and regional food security and rural employment depending on the type of crop which replaces the traditional ones.

But, the opportunities for such crop shifts and the extent of real shift in cropping pattern would depend on the agro-ecology of the region in question. For instance, sweet lime orchards were common in Nalgonda district for quite some time. But, with drip irrigation becoming very popular and the heavy subsidy made available from the government in the recent years, the area under orchards had also increased remarkably. Paddy has been the major traditional crop in the region prior to large-scale introduction of orchards. But, in spite of the fact that sweet lime gives much higher returns as compared to paddy, farmers still grow the wet land paddy though in slightly smaller area. This is because the land used for paddy cultivation (low-lying wetlands) is not suitable for cultivation of sweet lime. Hence, the impact of expansion in area under orchard on cereal production and local food security is almost negligible, and this growth has mainly comes at a cost of traditional rain-fed pulses such as gram. Here, the limited opportunities for farmers to divert the water to more efficient uses would also reduce the monopoly price of water in the market.

Hence, the concerns being raised by researchers about the impact of water trading are equity, access to water for basic survival and food security (Rosegrant and Ringler, 1998) become real only when there is large-scale transfer of water from rural areas to urban areas. But, it is important to keep in mind that such transfers take place during droughts when urban areas face water shortages. At these times, rural areas also face shortage of water to produce sufficient food. Hence, it would give opportunities for all segments of the farming community to earn good income from sale of water to urban areas, by which they could take care of their cash needs to purchase food. Hence, the negative effect will be on those in villages, who do not have access to land and water resources, but depend on farm labour. The effects would be lack of water for drinking and domestic uses within rural areas. This leads us to the need for allocating water rights also to those who do not have land. But, more important than creating water rights are the institutional structures for enforcing it. Future research on evolving institutional structures for enforcing water rights in arid and semi arid regions that are embedded in the specific groundwater socio-ecology of the regions is needed.

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