Socio-economic Implications of Depleting Groundwater Resource in Punjab: A Comparative Analysis of Different Irrigation Systems

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The consequences of negative groundwater draft have mostly been viewed as an ecological disaster, but the externalities of groundwater depletion pose greater concern for socio-economic equity in the access to this resource. This empirical analysis signifies the concerns for the livelihoods of farmers, when the cost of depletion is disproportionately borne by the resource-poor farmers as they are unable to invest in capital and technology and are hence denied the benefits of groundwater irrigation that is subsidised by free electricity. This situation is perpetuated with further scarcity leading to unequal economic returns and, finally, takes the most exploitative form where the "large landlords" also emerge as "water lords" through surplus accumulation, forcing the small and marginal landholders to become landless agricultural labourers.

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The policy design revolving around food security of the country in the 1960s encouraged a "green revolution" through subsidised input use and high procurement prices. Punjab became the food basket of the country with an increasing area under rice and wheat by such subsidisation. The modern agricultural practices of high yield varieties (HYV) technology in Punjab also simultaneously ushered in the shift from canal irrigation to tube well irrigation as it was a more reliable and flexible source of irrigation (Kaul and Sekhon 1991). Thus, both the technological shift and the policy directions led to a wide development of groundwater to go in for a water-intensive rice-wheat crop rotation and to such an extent that at present groundwater mining has become a reality in Punjab and is showing alarming signs of overexploitation (Singh 1991; GOI 2007).

During the years of initiation of tube well irrigation, the literature mainly focused on the superiority of water extraction machines (WEM) which made groundwater the most efficient, reliable and productive source of irrigation (Dhawan 1982; Kaul and Sekhon 1991; Singh and Joshi 1989). The perspectives underlining these studies mainly focused on groundwater as an economic good, which with the introduction of HYV seeds switched its role from a "risk reducing role" to a "production augmenting role". Disillusioned by the poor efficiency of public tube wells, farmers resorted to private investment in groundwater technology to boost production, and thus the major development of groundwater irrigation (GWI) in Punjab happened under the aegis of private investment of farmers (Dhawan 1987). The initial increase in cost of cultivation due to investment in GWI was cushioned by the gains from the highly productive HYV (Dhawan 1975) seeds and it was also supported by state subsidies.[1]

In the late 1980s and early 1990s, stagnating yields, rising cost of cultivation and declining profit levels were debated as an emerging crisis in Punjab's agriculture (Chand 1999; Siddhu 2002; Singh 2000). One of the major concerns under this umbrella of discussion was that of increasing levels of groundwater mining due to the GWI which threatened the sustainability of agriculture in Punjab (Bathla 1997; Joshi and Tyagi1991; Sarkar et al 2009; Singh 1991). While these studies mainly associated with falling water tables in Punjab looked at the ecological sustainability, they failed to comprehend the rise in social and economic inequity in the distribution of the scarce groundwater resource. Although a very few micro level studies have highlighted the equity implications of groundwater exploitation with falling water levels

(Bhatia 1992; Monech 1992; Nagraj and Chandrakanth 1997), they mostly represent Gujarat and regions of southern India. However, these crucial aspects have been somewhat neglected in the recent literature, particularly in the context of Punjab, in spite of the fact that Punjab shows the maximum groundwater mining with the highest percentage of blocks (75%) in the over-exploited category (GOI 2007).[2]

In this broader context, the paper gives an insight into several deeper questions associated with groundwater depletion in Punjab. It explores the questions like – who owns groundwater resources? who benefits from their use? who overexploits and contributes most to groundwater depletion and who suffers from their over-exploitation? The present study reappraises the externality of GWI from both private and social angles. It analyses the external diseconomies in groundwater utilisation in terms of its accessibility to GWI to large farmers vis-à-vis the small and marginal farmers at different levels of groundwater depletion.

Methodology and Sample Design

Since groundwater depletion is a temporal phenomenon, different sample villages were chosen with variable depths of water tables representing different stages of groundwater depletion. Among the three selected villages, one is a mixed irrigation system and the other two are completely dependent on GWI. The tube well irrigated villages were categorised into two types – villages with major problem of groundwater depletion and villages with comparatively less serious problem of groundwater depletion. The idea of taking one mixed irrigation village was to show that in conditions of groundwater depletion when farmers lose access to tube well irrigation, they can at least avail canal water and continue irrigation.

My conjecture is that, although tube wells contribute to maximum agricultural gains, failing in competitive deepening the farmers who lose access to water have difficulty in sustaining agriculture, or, in other words, groundwater depletion affects completely groundwater dependent agriculture more than the farming systems dependent on conjunctive irrigation. The categorisation (as given in Table 1) was done by a rapid rural survey and by interviewing the key informants regarding the depth of wells and intervals of well deepening in the last few years in the respective villages. Moreover, these villages were taken from the neighbouring blocks of Verka, Gandiwind and Ajnala of Amritsar district, so that they fall under the same agro-climatic zone with similar physical characteristics like soil and climate. Since it is difficult to incorporate important associated phenomenon like rainfall and soil at the household level, such sample design minimises the effect of these variables on agriculture at the village level.

The comparative analysis of these three sample villages thus gives a better picture of groundwater depletion and its associated phenomenon. Besides the structured questionnaire, recording of oral history and focus group discussions considering the homogeneity of the groups with regard to the social and economic class formed the basis of our conclusions. While the issues of economic accessibility are studied in the light of changing profitability and investment to harness groundwater, social accessibility is determined by institutional mechanisms and the terms of exchange of groundwater from the resource-rich tube well owners to the resource-poor small and marginal farmers.

Table 1: Profile of Sample Villages

Name of the Villages	Tohl Kalan	Gharinda	Ballab-e-Darya
Slope	gentle	gentle	gentle
Prevalent soil type	alluvial	alluvial	alluvial
Average depth of water table below (metre)	12	18	46
Type of irrigation	mixed	groundwater	groundwater
Sources of irrigation (%)	canals – 43 tube wells – 57	tube wells – 100	tube wells – 100

1 Costs and Returns to Agriculture

The decline in water table gives rise to technological externalities in terms of rising costs of installing new wells, deepening of existing wells and pumping and other maintenance activities (Moench 1992 and Shah 1993). The failure of dug wells, shift to water-intensive high value crops and policy instruments like free electrical power to lift groundwater have paved the way for the use of expensive technologies for rapid harnessing of groundwater in Punjab. Micro level studies demonstrate that the existing inequality in landholdings leads to an inequity in access to groundwater, which, in turn, widens the skewedness in assets and income distribution (Dubash 2002; Nagaraj and Chandrakanth 1997). The capital intensity of groundwater extraction, thus, makes it easier to exclude rival users, especially in the fragile resource regions, making the resource used largely by a few well-to-do households (Shah 1993).

Moreover, the declining water table may not only raise the marginal operational cost, but also give rise to a situation of diminished water availability, resulting in loss of farm output (Dhawan 1975) and lowering net returns. In the light of these arguments, the net returns per unit of cost are used as a measure of profit margins to compare the profitability of cultivation of the two major crops in Punjab across landholding size classes at different levels of groundwater depletion (Table 2).

Table 2: Ratios of Cost and Returns to Cultivation of Rice and Wheat

Particulars	Marginal Farmer	Small Farmer	Medium Farmer	Large Farmer
Landholding size (acres)	1 – 2	2 – 4	4 – 10	more than 10
Mixed irrigation village (Tohl Kalan)				
Return per unit of cost (Rs)	2.33	2.48	2.87	2.94
Tube well irrigation village (Gharinda)				
Return per unit of cost (Rs)	3.06	3.10	3.70	3.82
Tube well irrigation village with problems of depletion (Ballab-e-Darya)				
Return per unit of cost (Rs)	1.09	1.99	2.00	2.94

Source: Questionnaire surveys in various villages from May to July 2008.

The empirical analysis indicates two important findings. First, the returns to cost ratio increase with the landholding sizes indicating a higher profitability of large landholders than the small and marginal. Second, profit margins across all landholding classes decline with the decline in water table and the marginal and small landholding classes are the worst sufferers of groundwater depletion. This indicates the fact that the cost of natural resource depletion is disproportionately born by the resource-poor farmers because they are unable to invest in technology, and hence, remain excluded from its beneficial ambit. The inequality in the net returns, especially in the completely groundwater dependent agricultural economy, becomes inevitable with groundwater depletion for two reasons. First, the non tube well owning households have to buy water for irrigation which increases their cost, and second, the large tube well owning households get water for free as the running cost of tube wells is marginally zero on account of the supply of free electricity to agriculture.

2 Equity in Access to Groundwater Irrigation

It is a well-established fact that the access to good quality reliable irrigation is important as it not only reduces risks faced by the rainfed agriculture; it also reduces the cost and increases the quantum of production (Dhawan 1988). But another important fact is the equity in access to GWI which is the most important factor of production, and scarce. Ethically being a common pool resource, the right to access this resource should be equal to all. However, this right is guided by two factors, "proportionate equality" and "prior appropriation". There is an inherent inequality in groundwater accessibility as the groundwater rights are attached to land rights, which make the landowners de facto owners of the groundwater pumped out from WEMS fitted onto their land. Since the land distribution is skewed in favour of large farmers, there is an inherent inequality in ownership and access to groundwater.

There is a positive correlation between the ownership of wells and depth of wells to the landholding sizes in all the villages under the study (Table 3). This is a natural phenomenon as the large farmers with more capital savings invest in new WEMS and are also able to adopt the best suitable technology as the water table declines. In the process, these resource-rich farmers steadily exploit groundwater and as a result the water table goes down.

Table 3: Ownership of Groundwater across Farm Size Classes

Particulars	Marginal Farmer	Small Farmer	Medium Farmer	Large Farmer
Mixed irrigation village (Tohl Kalan)				
No of farmers	18	26	38	18
Average no of operational tube wells	0.72	0.96	1.00	1.00
Average depth of tube well (metres)	45	58	70	98
Tube well irrigation village (Gharinda)				
No of farmers	4	6	32	58
Average no of operational tube wells	1.00	1.00	1.06	1.34
Average depth of tube well (metres)	37	56	74	96
Tube well irrigation village with problems of depletion (Ballab-e-Darya)				
No of farmers	32	15	32	20
Average no of operational tube wells	0.41	1.00	0.91	1.80
Average depth of tube well (metres)	46	58	67	109

Source: Questionnaire surveys in various villages from May to July 2008.

This proportionate inequality also leads to prior appropriation of the resource leading to greater inequity. This aspect has already been indicated by the comparative returns to cultivation in the previous section. Further, it is reiterated by the differential cropping pattern across landholding classes in the study area (Table 4). With greater accessibility to groundwater resources, the large farmers devote a larger proportion of area to rice cultivation and gain enormously with the government support in the form of the high minimum support prices (MSP) and free agricultural electricity. The small and marginal farmers facing problems of water depletion have either dry wells or low water yields. They have lower productivity of rice or are forced to grow maize, as they cannot access irrigation water. It is quite evident from the fact that only 15% and 28% of cropped area of marginal and small farmers in the most water depleted village of Ballab-e-Darya are devoted to rice cultivation as compared to around 47% in the case of large farmers. In this village, in the kharif season, these resource-poor farmers either cultivate maize (12%) or fodder or lease out their land.

Table 4: Cropping Patterns according to Landholding Size Classes (Percentage to total area under each category)

Particulars	Marginal Farmer	Small Farmer	Medium Farmer	Large Farmer
Mixed irrigation village (Tohl Kalan)				
Rice	32.33	38.74	41.56	43.86
Wheat	34.05	39.31	43.16	44
Others	33.62	21.95	15.29	12.14
Tube well irrigation village (Gharinda)				
Rice	31.96	40.91	42.89	45.86
Wheat	30.56	40.81	42.79	45.06
Others	37.49	18.29	14.33	9.08
Tube well irrigation village with problems of depletion (Ballab-e-Darya)				
Rice	14.9	28.31	33.68	46.77
Wheat	31.51	29.78	37.74	45.11
Maize	10.42	1.47	3.88	1.83
Sugar cane	26.37	27.21	13.76	0
Others	16.8	13.24	10.93	6.28

Source: Questionnaire surveys in various villages from May to July 2008.

In the mixed irrigation systems, the farmers who lose in the race of chasing water tables resort to canal irrigation, but in completely groundwater-dependent agro systems the farmers are compelled to buy water or change their crop combination to remain in cultivation. Thus, the resource-rich by virtue of having de facto ownership of groundwater, benefit from their use and in the process also exploit the scarce common pool resource and the resource-poor suffers because of their over-exploitation.

In addition to this exploitation, the large farmers by virtue of having the sole right over the groundwater resource also accumulate surplus from the resource-poor farmers, further adding to the dilemma of the small and marginal farmers. It is seen that with water tables receding, a larger number of marginal and small landholding households depend on groundwater markets for irrigation. The groundwater market is an arrangement through which the owner of a pump sells water to the others for a consideration, generally a pecuniary one (Mukherji 2007). The seller is typically a private owner of a modern WEM with surplus pumping capacity

Table 5: Households Participating in Groundwater Market

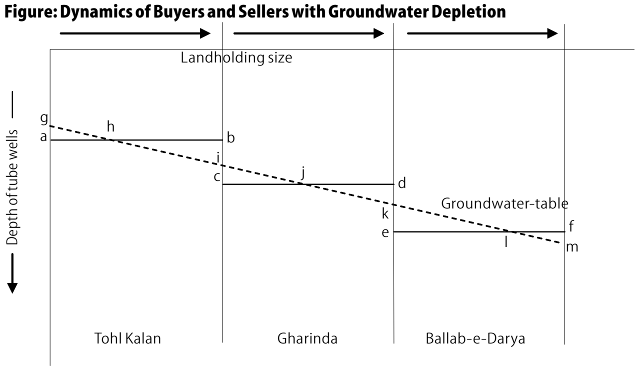
Size Class Category	Buyer	Seller	Buyer (%)	Seller (%)
Mixed irrigation village (Tohl Kalan)				
Marginal farmer	4	2	22.22	11.11
Small farmer	5	7	19.23	26.92
Medium farmer	9	6	23.68	15.79
Large farmer	2	6	11.11	33.33
Total farmers	20	21	20.00	21.00
Tube well irrigation village (Gharinda)				
Marginal farmer	4	0	100.00	0.00
Small farmer	6	0	100.00	0.00
Medium farmer	1	0	3.13	0.00
Large farmer	0	6	0.00	10.34
Total farmers	11	6	11.00	6.00
Tube well irrigation village with problems of depletion (Ballab-e-Darya)				
Marginal farmer	18	1	64.29	3.57
Small farmer	2	1	13.33	6.67
Medium farmer	12	11	37.50	34.38
Large farmer	1	12	5.00	60.00
Total farmers	33	25	34.74	26.32

Source: Questionnaire surveys in various villages from May to July 2008.

beyond what he can use on his own farm. The comparative proportion of households participating in groundwater markets shows a direct correspondence with groundwater depletion (Table 5, p 62).

It is an inevitable fact that more buyers in the groundwater market will be the owners of small and marginal landholdings those who do not have the capital to set up their own tube wells or those whose shallow tube wells have dried up. But it is interesting to note how groundwater depletion leads to increasing skewedness in groundwater ownership, which, in turn, raises the monopoly of WEM owners and exploitation of buyers (Figure). In the Figure, the comparative groundwater levels in the three villages are shown by ab, cd and ef. While the X-axis shows the landholding size, the Y-axis depicts tube well depth. The increasing tube well depths with increasing landholding size in the three villages are shown by ghi, ijk and klm, respectively. As the water table goes down, many tube wells become non-functional when owners fail in competitive deepening. These are mostly the

Figure: Dynamics of Buyers and Sellers with Groundwater Depletion



smaller landholding owning households as represented by triangles a-h-g, c-j-i and e-l-k, who lose access to irrigation water and are compelled to buy water to remain in agriculture. This to a large extent, exemplifies the fact that groundwater markets emerge with a demand of water for irrigation and further expand with rising scarcity due to depletion. Simultaneously, the farmers with access to groundwater, represented by triangles h-b-i, j-d-k and l-f-m also decline with depletion. In conditions of acute depletion when a few deep tube wells functions, there are a handful of WEM owners and a large number of buyers. In such situation, it is inevitable that the monopoly of water sellers increases as they can bid any price for water and the terms of transaction of water trade get dictated by the sellers.

3 Impact of Groundwater Markets

The emergence and expansion of groundwater markets cannot throw any light on its implications on the agrarian change and livelihoods of farmers involved in the water trade. The literature on the impact of groundwater markets on the socio-economic development of the agrarian societies ranges from highly positive ones that declare groundwater markers as the "vehicle of poverty alleviation" (Shah 1991) to that of accusing groundwater markets to be "creating water lords" (Ballabh 2003) and appropriating surplus from the poor. The impact of reliable access to groundwater in the water market is studied by comparing the cropping pattern and yield levels of different categories of farmers according to their role in the market (Tables 6 and 7).

Table 6: Cropping Pattern (Area under each crop, %)

Crops	Self-user	Self-user + Seller	Self-user + Seller + Buyer	Buyer	Self-user + Buyer	Total
Mixed irrigation village (Tohl Kalan)						
Rice	60.60	23.11	4.82	4.61	6.86	100
Wheat	60.81	23.18	4.73	4.53	6.74	100
Total	61.45	22.11	4.78	4.33	7.33	100
Tube well irrigation village (Gharinda)						
Rice	87.00	11.21	0.00	0.00	1.79	100
Wheat	87.00	11.21	0.00	0.00	1.79	100
Total	87.49	10.42	0.08	0.50	2.05	100
Tube well irrigation village with problems of depletion (Ballab-e-Darya)						
Rice	46.65	45.04	5.73	0.69	1.89	100
Wheat	45.74	40.52	4.61	6.69	2.44	100
Maize	33.04	8.26	0.00	49.26	9.44	100
Sugar cane	25.00	65.38	3.85	0.00	5.77	100
Total	44.56	39.74	4.45	8.15	3.03	100

Only the main crops are considered.
Source: Questionnaire surveys in various villages from May to July 2008.

Table 7: Yield Levels of Different Crops (Kg/msq)

Particulars	Self-user	Self-user + Seller	Self-user + Seller + Buyer	Buyer	Self-user + Buyer
Mixed irrigation village (Tohl Kalan)					
Rice	.40*** (B) **(S+S+B)	.44***(B)	.47** (B) ** (S)	.37***(S) *** (S+S) **(S+S+B)	.40** (S)
Wheat	.44*** (B) *** (S+B)	.47***(B)	.52** (B)	.35***(S) *** (S+S) **(S+S+B)	.42*** (S)
Tube well irrigation village (Gharinda)					
Rice	.53**(S+B)	.53***(S+B)	0	0	.54***(S+S) **(S)
Wheat	.44	.44	0	0	.47
Tube well irrigation village with problems of depletion (Ballab-e-Darya)					
Rice	.49***(S+S+B) ***(S+B)	.53***(B) **(S+S+B)	.44***(B) ***(S+S)	.37***(S+S) ***(S+S+B)	.47***(S)
Wheat	.44*** (B)	.47***(B)	.49*** (B)	.35***(S)	.42***(S)
Maize	.12	.01*** (B)	0	.12***(S+S)	.15

***Significant at the 0.01 level, ** Significant at the 0.05 level.
S – Self-user, S+S – Self-user + Seller, S+S+B – Self-user + Seller + Buyer, B– Buyer, S+B – Self-user + Buyer.
Source: Questionnaire surveys in various villages from May to July 2008.

For a meaningful comparison, the selected farmers were classified into five categories of participants in water markets, viz, buyers: (1) the farmers who buy water for irrigating their crops, self-users + buyers, (2) the farmers who have their own WEMs but also buy water, self-users + buyers + sellers, (3) the farmers who have their own WEMs and also buy and sell water, self-users + sellers, (4) the farmers who have their own WEMs and also sell surplus water, and self-users, and (5) the farmers who have their own WEMs with which they irrigate their own land.

Although the groundwater market did not exist in the case of self-users, for a meaningful comparison, they were also included in the study.[3] It was noticed that the sellers devoted a much larger area to the most profitable as well as the most water-intensive crop rice than the water buyers, whereas in the most water-depleted village, the buyers grew the less water-intensive and much less profitable maize crop. It was widely noticed that when a seller irrigated his own land, the spacing between water turns was less than that of the buyers. Moreover, the existence of a time constraint in irrigation – all farmers tend to demand water at the same time and place a heavy stress on the effective functioning of a groundwater market.

The perception of buyers and sellers was that the direct control over water enhances the output. This perception was also supported by the empirical study on the comparative yields of buyers and tube well owners (Table 7). It was seen that among all categories of participants in the water market, the buyers had significantly lower yields for both rice and wheat in all the three sample villages. Whereas for both these crops, there was a statistically significant difference in yields obtained in favour of WEM owners, be it sellers and self users or only self users. Although it can be argued that there is no statistical evidence to justify the claim that higher yields are the direct outcome of control over water and that the results could also be explained by other attributes of tube well owners which we do not have information to control for, such as the likelihood that they have greater access to other commercial inputs than buyers. But micro level studies in Punjab have also empirically concluded that the input use, and, hence, the consequent productivity increase with greater control over water assuring the "flexibility and reliability" of irrigation to crops (Kaul and Sekhon 1991).

Thus, the results are indicative of a productive advantage derived from tube well ownership rather than buying water. These findings, as a result, also cast doubt on a popular argument that water markets function so well as to neutralise the irrigation benefits of tube well ownership (Shah and Ballabh 1997). As a result, these empirical findings indicate that the groundwater markets do not provide equal access to reliable irrigation across all farmers and rather the water sellers gain much from water selling.

Besides the economics of water buying, there is the hidden exploitation in the groundwater markets. In the initial stage of groundwater market evolution, water was exchanged with farm labour in which the buyer was expected to do all kinds of labour as and when required by the seller. Land and labour linkages were common in the rural economy, but the groundwater dependent rural economies show linkages of the three most important components of agricultural production – land, labour and water. This bilateral bargaining between the buyer and the seller is subjected to personal affinities and kinship ties, and, thus, the degree of exploitation varies from one buyer to the other. But with falling water tables the non-standardised terms of transactions change into standardised cash contracts, which are either seasonal or hourly. It was noticed that with rising water scarcity, the sellers leased in buyers land for the kharif season when the scarcity was acute because of rice cultivation. The leased in amount was very little varying from Rs 6,000 to Rs 8,000 per season and the contract also implicitly meant that the seller was going to give water free of cost in the Rabi season when all the farmers grew wheat which required only three to four waterings. In these land-leased contracts, all the inputs were provided by the landowners and the water was provided by the tenant and the grain produced was equally divided between the two.

This implies two important emerging concerns. First, water has become the most important input in agriculture, surpassing of land. This is implicit in the fact that the bargaining power in the production decision remains with the (de facto) owner of water and not the owner of the land. Second, along with the bargaining power of the landlord, the value of land declines if it does not have any source of irrigation, especially a functioning tube well, which is evident from the lease-in amount. It was also noticed that with further lowering of water tables, the sellers of water imposed a yearly lease-in contract on the buyers when they do not give them water in the rabi season also. The farmers consider leasing out land as more profitable than rainfed maize cultivation. This fact was also reiterated by the empirical evidence of the incidence of lease out land by the farmers in the three villages where reverse tenancy was positively correlated with groundwater depletion and negatively with the size of the landholdings they own (Table 8).

Table 8: Incidence of Tenancy by Landownership in Different Irrigation Systems

Land Owned (Acres)	% of Households in Each Group	% of Households Leasing in	% of Households Leasing Out	Leased in Area as % of Operated Area	Leased Out Area as % of Operated Area
Mixed irrigation village (Tohl Kalan)					
Marginal farmer	18	11	6	9	21
Small farmer	26	23	0	11	0
Medium farmer	38	13	0	6	0
Large farmer	18	50	0	28	0
Total	100	22	1	18	2
Tube well irrigation village (Gharinda)					
Marginal farmer	4	0	0	0	0
Small farmer	6	0	0	0	0
Medium farmer	32	9	0	5	0
Large farmer	58	17	2	5	9
Total	100	13	1	5	7
Tube well irrigation village with problems of depletion (Ballab-e-Darya)					
Marginal farmer	32	0	28	0	29
Small farmer	15	0	7	0	9
Medium farmer	32	13	0	5	0
Large farmer	20	20	0	16	0
Total	100	8	10	10	2

Source: Questionnaire surveys in various villages from May to July 2008.

It was seen that in this land – labour – water locked relationship, the credit also gets its place when the buyers mortgage their leased in land to the water sellers, who are more than often large landlords. The debt burden rises to enormous extent and in the process of surplus accumulation by the large landlords; the small and marginal farmers are compelled to sell out their land at distress prices. It is a serious issue of the emerging rural economy of the completely groundwater dependent societies, where farmers losing access to groundwater irrigation, and their rights to land and in the process turn into landless labourers from cultivators.

It is pertinent here to note that skewedness of ownership of land could not be corrected through land reforms due to many socio-political reasons, but this skewedness leads to proportionate inequality and facilitate prior appropriation of the common pool resource of groundwater to such an extent that it seizes the land rights of the small and marginal landholders. With no well-defined right of groundwater, the rights of the resource-poor to this scarce resource is not protected, and without access to water they are forced out of farming and pushed to further deprivation and impoverishment.

4 Conclusions and Policy Implications

The study brings to light the fact that profitability in agriculture declines with falling water tables and the cost of depletion is disproportionately borne by the resource-poor farmers as they fail to invest capital in changing technology and well deepening. In the process they also get excluded from the state-financed free electricity in agriculture. While in mixed irrigation systems, these marginalised farmers can avail of canal irrigation and sustain agriculture, in completely groundwater dependent irrigation systems the farmers are forced to buy water to sustain agriculture or lease out land and sell their land. Thus, with continuous depletion, the skewedness in the distribution of land facilitates a prior appropriation of irrigation water transforming the landlords to powerful "water-lords" in the rural economy. Tube well technology, being capital biased, strengthens the process of social deprivation as increasingly small and marginal farmers in groundwater dependent rural economy sell their land and turn into agriculture labourers, when they lose access to groundwater irrigation.

The policies of the government which affect the groundwater development in agriculture of the state include subsidised input prices, remunerative prices for output (high MSP for rice and wheat), and most importantly, free electricity in agriculture. In the absence of a clear legislative framework, state's indirect forms of regulation of groundwater have led to miserable consequences for the farmers. Regulations stipulating the minimum space between wells have become an opportunity for graft, and have served to exclude the least well connected and the poorest. The limits on access to formal credit for drilling wells and for applications for new electricity connections have suffered the same fate. On the contrary, the use of electricity tariffs to regulate groundwater depths is completely missing in the Indian scenario which is well-documented in the relationship between electricity tariffs and the level of groundwater overexploitation in different states of India (Mukherji et al 2008). States with higher levels of groundwater overexploitations have either free electricity or very cheap flat rates of electricity in agriculture like Punjab and Haryana.

Suggesting an appropriate electricity pricing policy to regulate groundwater draft has been a matter of debate for both scholars and policymakers. While Shah (1991) argues a progressive flat rate of electricity tariff, Dubash (2007) suggests that the states should certainly stop free electricity to farmers and shift to prices based on units of electricity consumed. But volumetric pricing aimed at curbing groundwater draft certainly has significant consequences for the farming community. Rationally, one can argue that with volumetric pricing, the well owner will have an immediate incentive for more efficient and more careful irrigation, reducing the pressure on groundwater over draft, and, in the long run may also lead to a cropping pattern shift.

On the contrary, the immediate effect would most likely increase water prices to pass on the high electricity tariff to the buyers. In most cases, the WEM owners justify selling water by saying that they need to compensate for the money they have invested in setting up the submersible pumps.[4] Thus, it is quite inevitable that the tradition of non-standardised labour transactions for water trade will get converted to cash transactions leading to a steep rise in prices. But it is also noteworthy to mention that where the exchange is institutionalised, as in Ballab-e-Darya, the magnitude of the increase in water prices for the village will depend on local norms of legitimate price increases, and on the local power differentials between the buyers and sellers. So in the long run, the farmers and communities may adjust water investments and institutions in response to the shift in the electricity provision (Dubash 2002).

In response to the dilemma of groundwater mining, in 2008, the Punjab government passed an Act where summer paddy would not be allowed to be transplanted before 15 June. The Act was aimed at preserving sub soil water and improving groundwater situation. This implicitly means that no GWI will be done before the monsoons.[5] Wage rates are already very high in Punjab and the rice transplantation is done by hired labourers that mostly migrate from eastern UP and Bihar.[6] After the initiation of the Mahatma Gandhi National Rural Employment Guarantee Act,[7] the availability of agricultural labour in Punjab will become a challenge as farmers now get employment opportunities in their own village and will not migrate. The farmers fear that with the transplantation law strictly adhered to, all transplantation needs to be done within a short span of 15 days and this will lead to an enormous shortage of labour in the peak season of rice transplantation and the wage rates are going to further shoot up. The labour crunch is, thus, likely to fuel the demand for expensive mechanical sowing devices, known as transplanters, among the already capital-intensive farmers of Punjab, making agriculture further unviable.

Having witnessed the adverse impact on paddy sowing operations due to acute labour shortage during the 2008 season, the Punjab Government decided to focus on mechanical ways of crop sowing exercise by making available 700 paddy transplanters to the growers in the 2009 kharif season and also providing subsidy on purchasing the same (*The Hindu* 2009).

It is an irony that the Punjab government first launches policies to curb groundwater depletion and simultaneously encourages rice transplantation through further mechanisation to boost its yield. In fact, such antithetical policies have been frequent in Punjab. The successive Johl Committee reports[8] and the contract farming programmes[9] aimed at agricultural diversification to move away from the wheat-paddy monocultures did not lead to much positive result, because the policy of diversification was negated by the policy of high procurement price of rice and wheat on one hand, and supply of free electricity on the other. The reduction of price risk through high procurement prices of rice and wheat encouraged the crop specialisation in the state, which in turn, accentuated the demand for groundwater (Sarkar 2006).

Since electricity pricing poses political dilemmas and also threatens to raise prices in the water market, which invariably hits the poor harder, there is a greater need to focus on separating the MSP and procurement prices which, at present, are the same in Punjab. There is an urgent need to divert procurement of foodgrains (especially rice) considerably towards eastern India which is the traditional area of rice cultivation and is also not threatened by low water tables. So strengthening agricultural production in eastern India can boost agricultural yield contributing to the public distribution system (PDS), and simultaneously, can reduce the water stress in north western India and help in replenishing groundwater. The current argument of providing minimum support to benefit small and marginal farmers does not hold true in the current situation of groundwater depletion in Punjab. It has been seen that the farmers who can afford to grow rice are the wealthy farmers with large landholding and deep submersible pumps. The resource-poor, on account of no or very less water supply, have shifted to maize cultivation or have sold their land. Most of the small and medium farmers continue to grow wheat even without state provision of MSP, as they grow for self-consumption and not for selling in the market. Thus, the best possible option could be to direct the MSP towards less water-intensive crops like oilseeds and pulses to an agro-climatically suited MSP-driven crop shift for a sustainable agriculture.[10]

Though the MSP regulation can result in more efficient use of scarce groundwater and potentially slow down the rate of groundwater depletion, a long-term solution to groundwater depletion rests in creative and effective direct regulation of groundwater by defining rights to groundwater through effective legislation. Since more than 60% of irrigated land is under GWI, and depletion is an inevitable phenomenon, the challenge is to establish a broad framework which addresses the problem of depletion, while enabling the local institutions to play a positive role within a broader regulatory context to positively affect the livelihood of those which continue to be shaped by dependence on groundwater. Since the right to livelihood is getting increasingly dependent on the right to water, there is a greater need to find legislative solutions to delineate land and groundwater rights. In the coming decades an equitable distribution of water rights will pose as the major challenge for reducing agrarian inequalities, and if available water resources are more equitably distributed, it will have a marked impact on the income distribution.

NOTES

1 Institutional finance for farm equipment at liberal terms encouraged adoption of new water extractions machines in the canal irrigated tracts of western India to curb the problem of water logging. There was a massive extension of rural electrification which also reduced unit operational cost of pumping water.

2 The states which show very high level of groundwater development are Punjab (145%), Rajasthan (125%), Haryana (109%), Tamil Nadu (85%) and Uttar Pradesh (70%).

3 Out of the sample of 299 farming households only four (1.3%) were non-users who neither enters into the groundwater market nor they have their own tube wells. Because of their insignificant proportion they are left out in the comparisons.

4 In the focus group discussions with the farmers, it was learnt that they would increase the price of water according to the electricity tariff. Shah and Ballabh (1997) in their study in villages in north Bihar have shown that changes in water prices occur with the changes in diesel prices. Every time the diesel prices rose, water cost rose by three times the rise in the diesel cost.

5 The State Framers Commission had earlier sent a proposal to the state government to this effect. The proposal also sought that no farmer shall sow nursery of paddy before 10 May and recommended penalty on the farmer who committed breach of any of the provisions. The fine was to be in addition to the recovery of the charges actually incurred for destroying the crop sown/transplanted before a prescribed date.

6 Across Punjab, rice transplantation is only done with the hired labourers, irrespective of the farm size. It varies from Rs 1,000 to Rs 1,200 for transplanting rice in one acre of land from village to village. During the focused group discussions, the farmers revealed that rice being a non-traditional crop in Punjab, the Punjabi farmer is not habituated to stand in the hot waters of paddy fields to transplant rice seedlings in the hot months of May and June.

7 The National Rural Employment Guarantee Act (NREGA) came into force in 2006. It is an Act to provide for the enhancement of livelihood security of the households in rural areas of the country by providing at least 100 days of guaranteed wage employment in every financial year to every households whose adult members volunteer to do unskilled manual work.

8 In the mid-1980s when Johl Committee (1986) recommended diversification within farming away from wheat-paddy rotation to the extent of 20% in favour of fruit and vegetable, fodder and oilseeds crops, no crop could compete with wheat-paddy on assured profitability grounds. A second Johl committee was set up in 2002 which again recommended the same strategy of diversification which recommended 10 lakh hectares of rice and wheat cultivation to be replaced with higher value crops such as oilseeds and pulses. It also proposed a crop adjustment programme to compensate farmers who make the switch.

9 The contract farming programme launched by the Punjab government in October 2002 was aimed at reducing 10 lakh hectares under wheat-paddy rotation over the next five years.

10 In order to increase the production of pulses and oilseeds, Union budget has provided Rs 300 crore for organising 60,000 Pulses and Oilseed Villages in rained areas during this year.

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