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Falling Water Tables - Sustaining Agriculture
The challenges of groundwater management in India

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Abstract

India has witnessed a groundwater boom over the last about three decades. Availability of groundwater coupled with remunerative prices for crop outputs and their assured procurement by government agencies has encouraged farmers to switch their cropping patterns in favor of water intensive crops even in regions of scanty rainfall and precarious groundwater conditions. The absence of any mechanism to monitor and regulate the extraction and use of groundwater has led to overexploitation of groundwater in large parts of India leading to fall in water tables. With marginal cost of pumping groundwater for a farmer close to zero, this has also resulted in inefficient use of irrigation water and low water use efficiency. Nonetheless access to groundwater did help in making India a food secure nation.

Like many other Indian states, the state of Punjab, the food basket of India, is witnessing a steep decline in groundwater tables and severe problems in sustaining its agricultural economy. In 80% of the blocks the groundwater is being over-exploited. While several technological, management and policy options are available to help slow down the rate of decline in water table, in practice these have been slow to be adopted by the farmers. The paper discusses some of the options and the way forward in promoting more sustainable use of groundwater in India in general and Punjab in particular.

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The growth of groundwater irrigation

India has, over the years, invested hugely in development and management of its water resources. These investments have contributed immensely to economic growth and social development of India. Investments in water infrastructure of all kinds (multipurpose, single purpose dams, canals, small check dams, tubewells and pumpsets) have generated direct and indirect benefits to the people in various regions of the country. Irrigation is the largest user of water resources in the country accounting for almost 80% of the total water use.

Despite being the largest user of water, irrigation only covers 45.2 of net sown are (NSA) and 45.4% of gross cropped area (GCA) of the country. Due primarily to access to availability of irrigation, India has been able to achieve food security. The food grain production has increased from 108 million tonnes in 1970 to about 265 million tonnes In 2014 [GoI, 2015]. Irrigation provides bulk (55 to 65 percent) of the foodgrains output and a substantial part of the output of commercial crops. Irrigated agriculture provides employment, incomes and livelihood to millions of farmers and agricultural labor in the country [Bhatia, 2007] and has contributed a great deal to reducing poverty in the countryside [Malik, 2007].

Over the years the irrigation scenario in India has undergone a significant change. Surface water, which used to be the predominant source of irrigation, has now been replaced by groundwater (Figure 1) [GoI, 2013]. Inadequate and untimely availability, and limited reach of surface water coupled with easy access to electricity in rural areas as a result of rapid electrification of the countryside, provision of highly subsidized power for irrigation pumping, and the availability of focused rural credit facilitated this shift in source of irrigation as also in extending irrigation to hitherto unirrigated areas. The convenience of access to a switch-on switch-off technology for access to water under farmer's own command and control encouraged huge private investment in groundwater irrigation thereby shifting the nature of irrigation water provisioning from pre-dominantly public sector responsibility to one of private sector, owned and managed individually by millions of small and large farmers. As a result, the number of electric pumpsets increased to 10.3 million in 1993-94 and to 12.5 million in 1999-2000. The number of diesel pumpsets are estimated to be around 6 million in the country. Thus, there are around 500 pumpsets per thousand hectares (ha) of area irrigated from groundwater [Bhatia, 2007a]. Electricity use in pumping groundwater constitutes more than one-fifth of the total electricity consumption in several states. Groundwater-based irrigation now provides irrigation[1] to 39 million ha. Thus, net area irrigated by private wells and tubewells is more than 2.3 times of the net irrigated area by canals (see Figure 1). Net Irrigated Area (NIA) under wells and tubewells as percent of total NIA is greater than 60 percent in Bihar, Gujarat, Punjab, Madhya Pradesh, Uttar Pradesh, Maharashtra and Rajasthan. In Haryana, Andhra Pradesh, Karnataka and Tamil Nadu, the share of net irrigated area by tubewells is between 50 and 60 percent, while in Orissa, Chhattisgarh, Kerala and West Bengal the share is less than 50 percent [GoI, 2014].

[1]However, it should be recognized that irrigated area under tubewells is partly sustained by the seeped in waters from unlined canals. For example, according to available estimates, the natural groundwater recharge in Punjab could sustain half the existing number of tubewells in Punjab. In other words the investment in canal works has enhanced groundwater availability in Punjab by a factor of two [Dhawan 1993].

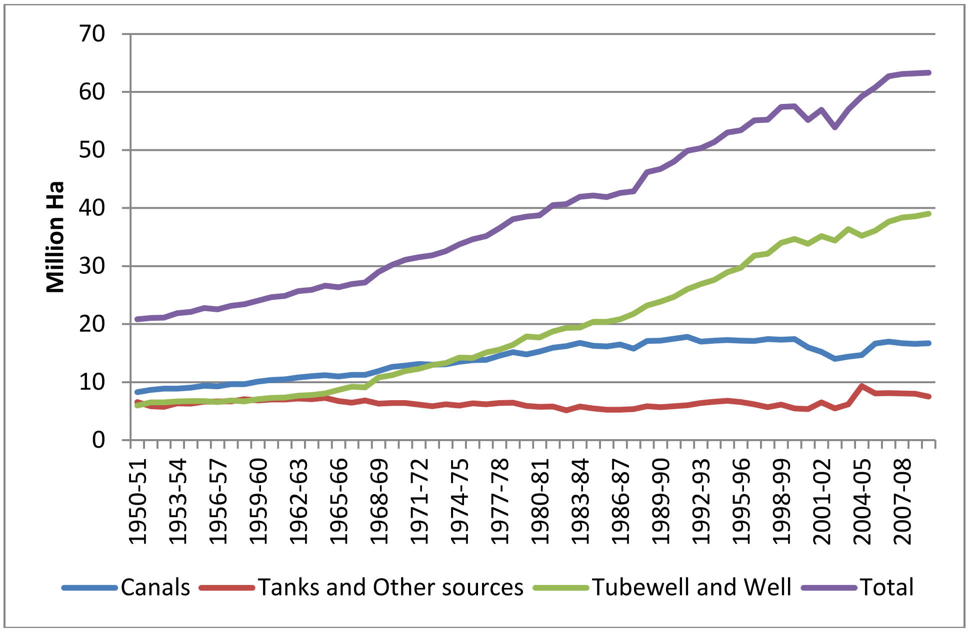


Figure 1: Growth in Net Area Irrigated (NIA) by different sources

Growth of groundwater irrigation: Implications for resource use

The annual replenishable groundwater resources of the country have been estimated at 433 BCM and the net annual groundwater availability at 398 BCM. The annual groundwater draft of the entire country for 2010-11 has been estimated as 245 BCM (62%). Given the pace at which groundwater irrigation has expanded, about 91% of total annual ground water draft i.e. 222 BCM is used for irrigation. The remaining 9% or 23 BCM is used for domestic & Industrial purposes [GoI, 2013].

While the overall stage of ground water development in the country at 62% is somewhat comfortable, there are significant variations across different states. The status of ground water development in the states of Delhi, Haryana, Punjab and Rajasthan is more than 100%, which implies that in these states the annual ground water extraction is more than annual ground water recharge. In the states of Himachal Pradesh, Tamil Nadu and Uttar Pradesh and UTs of Daman & Diu, and Puducherry, the stage of ground water development is 70% and above. In the rest of the states the stage of ground water development is below 70% [GoI, 2014a].

Out of 6607 numbers of assessed administrative units (Blocks/ Taluks/ Mandals/ Districts), 1071 units are categorized as over-exploited, 217 units are critical, 697 units are semi-critical, and 4530 units are safe. Apart from these, there are 92 assessment units which are completely saline (Table 1). Number of over-exploited and critical assessment units are significantly higher (more than 15% of the total assessed units) in Delhi, Haryana, Himachal Pradesh, Karnataka, Punjab, Rajasthan and Tamil Nadu, Uttar Pradesh and also the UTs of Daman & Diu and Puducherry.

Table 1: Categorization of assessment units based on stage of groundwater development

Stage of development	**Number of assessment units**	**Percent**
Overexploited	1071	16
Critical	217	3
Semi-Critical	697	11
Safe	4530	69
Saline	92	1
Total	6607	100

A perusal of the geographical distribution of the over exploited blocks indicate that the over-exploited blocks are concentrated in the North Western, Western and Southern Peninsular part of the country. While the primary reason for over-exploitation in the North Western part i.e. Punjab and Haryana is indiscriminate extraction of ground water mainly for irrigation purpose, in the Western part of the country viz. Rajasthan and Gujarat, over-exploitation is caused by arid climate resulting in scanty and irregular rainfall and consequent low recharge. In the southern part of the country i.e. Karnataka, and Tamil Nadu, large number of over-exploited blocks are caused because of hard rock terrain which permits less recharge and thus result in water stressed conditions.

As a result of unchecked extraction of groundwater, the groundwater tables have been falling in many parts of the country. An analysis of the pre-monsoon level of depth to water table for 2013 in the different regions of the country suggest that in major parts of North-Western states, depth to water level generally ranges from 10-40 m below ground level (bgl). In the western parts of the country deeper water level is recorded in the depth range of 20-40 m bgl. In North Gujarat, parts of Haryana and western Rajasthan water level more than 40 m bgl is recorded. Along the eastern & western coast water level is generally less than 10 m. Central part of West Bengal state recorded water level in the range of 5-20 m bgl. In north central India water level generally varies between 10-20 m bgl, except in isolated pockets where water level less than 10 m bgl has been observed. The peninsular part of country generally recorded a water level in the range of 5 to 20 m bgl depth range [GoI, 2014a].

Given that 91% of the groundwater is used for irrigation and that most of the groundwater overuse areas lie in the states which also produce bulk of the foodgrain output of the country, raises serious concern about sustaining current levels of food production by continuing with the business-as-usual scenario of groundwater extraction. Many differential factors have contributed to over- development as well as under- development of groundwater resources in different parts of the country and therefore there cannot be one- size- fits- all solution for the entire country. Groundwater management has been a difficult problem, not only in India but also other parts of the world, and attempts at formulating appropriate agreeable and implementable interventions have generally not been very successful.

In what follows we focus on the state of Punjab where the over-development of groundwater has raised serious concerns not only about the sustainability of its own agricultural sector but also for the food security of the entire country. We look at some of the experiences with and opportunities for managing groundwater that have been attempted in Punjab with a view to draw some general lessons for some of the other regions of the country placed similarly.

Falling water tables - sustaining agriculture: Evidence from Punjab

Agriculture sector has been central to the economic development of Punjab. The unprecedented growth of the agricultural sector in the State following the green revolution in mid- sixties significantly contributed to making it one of the richest states in the country. Although over the years the share of agriculture in GSDP has declined to 21%, about 36% of total workers depend on the agricultural sector. At present, 82% of the total geographical area of the State is under cultivation and the cropping intensity is around 191% with over 98% of the cultivable area being under assured irrigation. The State is among the highest ranking states in the country in terms of productivity of wheat and rice [GoP, 2014].

The hitherto vibrant agriculture sector in the state, of late, is showing signs of a serious slowdown over the past many years. The sector's growth rate has remained way below 2% in all the years from 2007-08 to 2013-14. The growth in agriculture sector is slowing down as cropping intensity and irrigation potential have already been fully exploited and the growth in productivity has also reached a saturation point as very few R&D advances have taken place over a long period of time. The state is facing serious challenges posed by deteriorating natural resource base, principally water resources; environmental pollution due to burning of straw; stagnation in yields of principal crops; declining farm incomes; growing shortages of labor; overcapitalization of agriculture and rising rural indebtedness.

Most of the past glory and the current malaise in the agriculture sector in Punjab has been attributed to large scale cultivation of rice-wheat monoculture year after year. The popularization of this cropping pattern can in large part be traced to the conducive policy environment and institutional support that has been provided over the years by the Central and state governments to encourage cultivation of these two crops in order to achieve food security for the country. Initially highly subsidized and later free and unmetered supply of power for irrigation pumping has not only led to excessive withdrawal and inefficient use of groundwater leading to steep fall in groundwater tables (Figure 2) and in posing serious threat to the sustainability of rice-wheat system , it has severely impacted the economy of the state. As against total water demand of 4.45 million hectare meters (ha-m) the currently available water resources are 3.04 million ha-m. While 80% of the blocks in Punjab are overexploited, this proportion rises to 96% in central Punjab. On an average the water table in Punjab is falling at the rate of more than one meter per year while in some blocks this decline is about 2 meters per year.

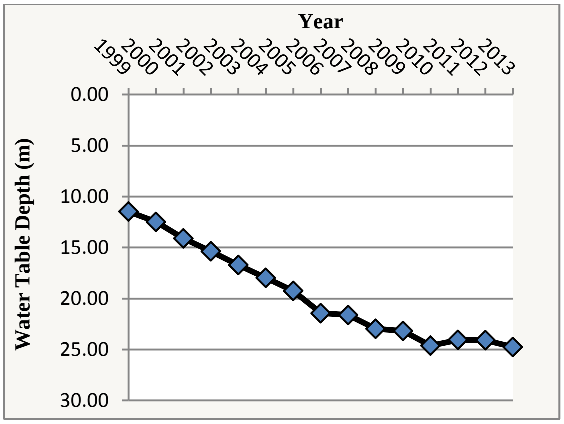


Figure 2 : Depth to Water Table - Punjab

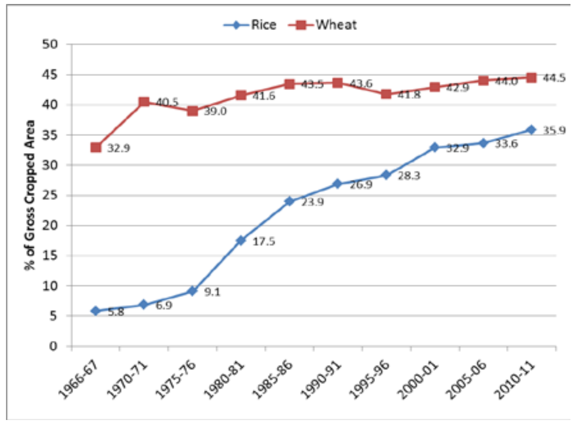


Figure 3: % GCA allocated to Rice and Wheat

Bringing groundwater withdrawal in line with its recharge and promoting a more sustainable pattern of groundwater usage and agricultural production require taking concurrent action on several fronts. The important of these include diversification of at least a part of the area from under water intensive paddy cultivation to an alternative crop which requires less water; efficient management of groundwater-energy nexus; technological interventions to improve water use efficiency and crop water productivity and; regulatory and legal interventions aimed at restricting the amount of groundwater withdrawals.

Diversification of cropping pattern

There is a strong belief in the State that the only way to deal with declining groundwater tables and promoting a more sustainable pattern of groundwater usage lies in diverting at least a part of the area away from rice-wheat cropping system. Policy makers and scientists unanimously subscribe to this view. Shift area out of paddy forms an important constituent of agricultural policy of the state. The Agriculture Diversification Policy prepared by state government envisages diverting at least 1.2 million hectares of land from under paddy cultivation [Johl, 2002, 1996]. For diversification to succeed, the experts have suggested putting in place a level playing field for new crop at par with that of paddy. Specific suggestions include:

1. Provision of assured MSP for the intended crop and fixing it at a 'remunerative' level
2. Setting in place a system of assured crop procurement by government, similar to that existing for the paddy.
3. To obviate need for such a system of crop procurement and price fixation, some experts have also suggested institution of an alternative institutional arrangement of contract farming. Some others have suggested paying cash compensation to those farmers, who diversify their cropping pattern, so that they are financially not disadvantaged.

Diversification is however easily said than done. More than thirty years after the debate on diversification started and efforts initiated by the state to diversify its agriculture, no positive outcomes have been reported. On the contrary, the area under paddy has actually increased (Figure 3). The farmers are unlikely to diversify away from rice so long as the prevailing production conditions for the proposed crops/ activities set to replace paddy are either better than or at least at par with the cultivation conditions for paddy. While some farmers did try to diversify away from paddy to sunflower, however in the absence of crop output procurement support the sunflower market crashed and farmers switched back to paddy. In some areas farmers diversified to horticultural crops. Recent reports suggest that in the absence of post harvest support in the form of procurement prices and lack of investment in value chains, farmers are switching back from cultivation of 'kinnow' to paddy. The experience with contract farming has also not been very encouraging [Singh, 2005].

The diversification attempts have in large part failed because all the suggested pathways for development were dependent on government support for results, which the State government could not provide either because it was not under its jurisdiction (such as fixation of Minimum Support Prices), it has no money to invest in value chains, the usual lackluster approach or, because of political compulsions. The diversification has always been optional and there is no compulsion, direct or indirect, for the farmers to diversify. Given the tension free production environment and assured procurement arrangement for paddy-wheat, there is no reason for the farmers to diversify voluntarily. Having failed to bring about any shifts through voluntarily diversification, there have also been some suggestions of creating conditions for farmers to force them to diversify away from paddy. However this has not been attempted.

Managing Groundwater-Energy Nexus

The overdevelopment of groundwater in Punjab has largely been attributed to the specific modality of providing subsidized unmetered power for groundwater irrigation. This has introduced severe distortions in both the power and water sectors, and its use as a tool in electoral politics has become so entrenched that the problem, referred to as the “groundwater-energy nexus”, seems almost inseparable. Suggested attempts at managing groundwater-energy nexus have revolved around three pillars : (i) restricting the supply of electricity for groundwater pumping, (ii) removing subsidies on electricity for groundwater pumping and, (iii) a combination of supply restriction and subsidy reduction.

Punjab has experimented with unscientific and ad-hoc restrictions on the supply of power to the agriculture sector. While some of these restrictions were driven by compulsions of non-availability of sufficient power in the face of increasing demand for power from non-agricultural sectors of the economy, other concerns which contributed to putting in place some of these supply restrictions included concern for slowing down the rate of groundwater depletion and, to reduce the subsidy burden on the exchequer due to supply of free/ subsidized power to the agricultural sector. These restrictions have however failed to bring in the desired impacts either on electricity use or groundwater withdrawals. To meet the shortfall in electricity supply, farmers have invested in diesel pumping sets as a coping strategy leading to overcapitalization of the farm economy. Restricted supply of power encouraged farmers to invest in higher than required size of the pumping equipment to withdraw more water in the limited time period during which electricity supply was available. Restricted and untimely supply of power led to installation of automatic power switches resulting in wastage and inefficient use of both power and irrigation water. Poor quality of power supply led to more frequent burning of the motors causing increasing expenditure for the farmers.

Restricting the supply of electricity for the agriculture sector also had an unintended impact on the non-agricultural rural economy and social life of rural Punjab. Since the common electricity feeders supply electricity for tubewells, rural industry, rural households, schools etc, switching off of the power supply for tubewells also meant switching off of the rest of the rural economy. Learning from the experience of Gujarat, where under the Jyotigram program electricity feeders supplying electricity to rural areas were segregated in to two - one supplying three phase electric current for tubewells for restricted number of hours and the other supplying single phase current for domestic and non-agricultural sector on near continuous basis [Shah and Verma, 2008], Punjab invested huge amounts of money in segregating its rural electricity supply feeders. While no evaluation of impact of feeder segregation in Punjab is available, the ground level reports suggest that Punjab has not been able to put the built infrastructure to any significant productive use either in managing its electricity distribution more efficiently or in controlling groundwater extraction. Faced with acute transmission and distribution losses and to improve the quality of electricity supply to farmers, Punjab has gone one step further and experimented with installation of High Voltage Distribution System (HVDS), LT capacitors on 11 KV feeders and all tubewells.

Thus while some attempts, howsoever successful these may have been, were made to manage groundwater-energy nexus through supply restrictions, however due to perceived high political cost of tinkering with electricity and water pricing, or moving out of free electricity supply regime, Punjab has restrained itself from making any serious attempts at removing subsidies and in reforming electricity and water pricing.

Given that Punjab, and many other states in India, is unique worldwide in providing a significant proportion of electricity to agriculture sector free and unmetered, it requires a unique and tailor-made solution to release farmers, power utilities, consumers and governments from the inefficiencies of the existing groundwater- energy nexus. A unique scheme which provides for direct delivery of power subsidies to farmers was recently tested in a study undertaken by ESMAP of The World Bank and International Water Management Institute (IWMI) [Gulati and Pahuja, 2015]. The scheme offers farmers an improved delivery of electricity service, as well as incentives to use electricity and groundwater efficiently despite receiving free power. The proposed scheme provides an attractive and politically feasible method—transparent and efficient—to deliver power subsidies; it provides incentives for power utility employees to improve operational and financial performance, and creates enabling conditions to improve rural power supply without increasing Government's fiscal burden.

Under the proposed scheme, farmers can choose *either* to continue with the current system of limited hours of free/subsidized power supply, *or* to adopt the new system of longer, more convenient, hours of supply—still free/subsidized—but the subsidy would be denominated in quantity of electricity instead of hours of supply. The scheme does not impinge on Government public policy choices to provide free or subsidized power nor does it seek to reduce the benefits currently being provided to the farmers. Its focus is on improving efficiency, equity and cost-effectiveness of delivering power subsidy to farmers. If direct delivery of the power subsidy to farmers were coordinated with ongoing complementary schemes for groundwater and agriculture improvements there is potential to significantly enhance the impact and effectiveness of the proposed scheme [Gulati and Pahuja, 2015]. While the proposed scheme has the potential to enable more efficient management of groundwater-energy nexus, and likely to have high political acceptability, it has yet to be piloted and field tested.

Technological Interventions for conserving water

Technological interventions provide immense scope for conserving water and in improving crop water productivity. In the case of such crops such as rice, the high irrigation input to rice fields is because of the cultural practices commonly used for irrigated rice production – puddling (involving saturation of the soil followed by intensive tillage in shallow-flooded conditions), followed by continuous or prolonged periods of flooding until shortly before harvest. However, puddling and prolonged flooding are not essential for achieving high rice yield. Available technologies for improving crop water productivity have essentially focused on safe alternate wetting and drying (AWD) water management for rice; dry seeded rice (DSR) with alternative wetting and drying water management; the system of aerobic rice; cultivating rice, wheat and maize on raised beds; system of rice intensification, conservation agriculture etc. (see amongst others Sudhir-Yadav, 2011; Laik et al, 2014; Jat et.al, 2014; Choudhury et al, 2006).

Concurrently with these interventions many technologies to help improve water productivity at the farm level are also available. These farm level interventions include technological interventions such as the use of micro irrigation technologies (drip and sprinkler), use of tensiometers for irrigation scheduling and; use of laser land levelers (see Naryanamoorty, 2009, Palanisami et al, 2012; Malik and Rathore, 2012; Jat et.al, 2006; Kukal and Sidhu, 2008). While efforts at improving water productivity through these available technologies at the farm level have been attracting significant attention of policy makers and practitioners, to date there has however been little adoption of such technologies by farmers in Punjab, except for significant levels of adoption of laser land leveling. Field experiments of laser land levellers in rice-wheat systems of the Indo-Gangetic Plain report 10-30% irrigation water savings, 3-6% effective increases in farming area, 6-7% increases in nitrogen use efficiency, and 3-19% increases in yield [Jat et al, 2006]. Discussions with farmers from the Bhatha Dhua village near Ludhiana (Punjab) revealed that laser levelling after the first year led to a decline in yield probably due to disturbance of the soil, but from the second year onwards the yield of both rice and wheat were higher by 2 to 4 quintals per acre (personal discussion with Kuljeet Singh Bhangoo). The large farmers in Punjab, who level their land at least once every year report huge water savings, to the tune of 30-40% [Kahlown et al., 2006].

Regulatory and Legal Measures

Groundwater being a common property resource with groundwater rights linked to the land rights, management of groundwater through legal interventions has always been a challenge. Based on Model Groundwater Bill prepared by the Central government, Punjab did prepare the Punjab Ground Water (Control and Regulation) Act 1998. However this could not be passed and implemented due to strong stakeholder resistance. Punjab has however successfully demonstrated implementation of regulatory measures to save groundwater through forcing shifts in paddy transplanting date.

The general tendency of farmers in Punjab has been to go in for early transplanting of paddy, during the month of May or early June. With relative humidity lowest, wind speed highest and temperature maximum during this period, the water evaporates very fast and the ET requirements are very high. Evaporation accounts for 60% of the total water depletion (ET) for rice during the crop growth period [Sharma et.al. 2010]. Some of the available research results indicated that the evapo-transpiration (ET) of paddy transplanted on May 20 is 76 cm, on June 10 is 60 cm, and on June 30 is 52 cm [Hira, 2013, 2009]. During 1998-99, the proportion of rice area transplanted before mid-June reached its peak at 66%. Given the high proportion of area transplanted before mid- June and high ET requirements of crop transplanted before mid-June, it was recognized that real water savings are possible by reducing this non-beneficial water loss through rescheduling the transplanting dates [Sharma et.al. 2010; Ahmad et.al, 2007].

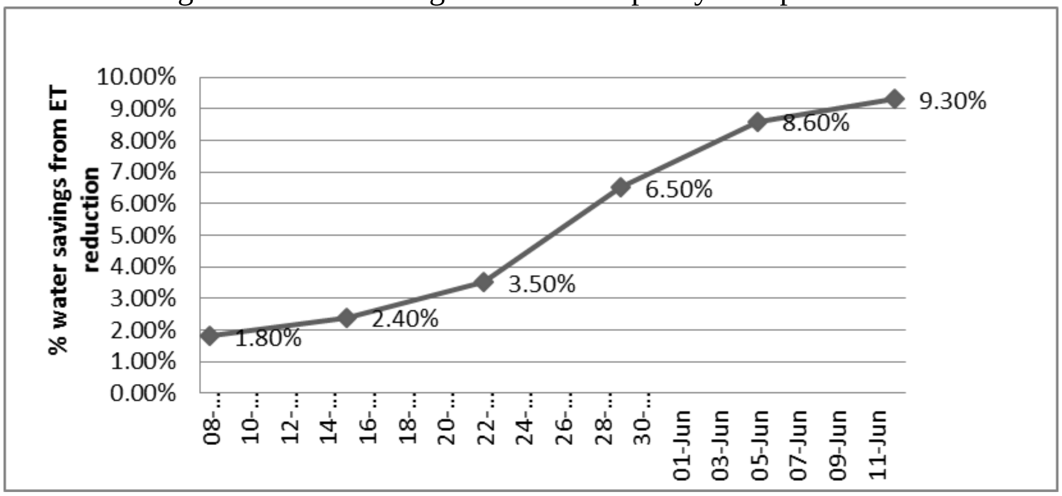
Efforts made by state administration and agricultural scientists to dissuade farmers from early transplanting met with little success. This is despite the fact that the available evidence showed that shift in date of transplanting have had no adverse impact on yield of paddy [Hira, 2009]. Restricting the supply of electricity did not make any significant impacts. The Punjab government in 2008 brought in legislative measures mandating farmers not to go in for early sowing of paddy. “The Punjab Preservation of Sub Soil Water Act, 2009” provides for a stringent penalty clause for defaulting farmers – a fine of INR 10,000 per hectare of transplanted field plus the cost of uprooting the crop [Government of Punjab 2009]. For enforcing the provisions of the Act a relatively simple institutional arrangement was put in place and the Chief Agriculture Officer at the district level empowered to ensure its implementation.

Strict enforcement of the Act, made possible with backing of the political establishment, ensured that the violations were minimal. In a small number of cases where the provisions of the Act were not abided to, notices were issued and penalty imposed on violators. The fact that in the summer of 2008, only 0.6% of the paddy area was transplanted by end-May is a testimony to the success of the provisions of the Act. Even by mid-June, transplanted area was just about 22 per cent, which too was transplanted mostly after the stipulated date of June 10th [Sharma et al. 2010].

While it is difficult to isolate the impact of the Act *per se* to changes in groundwater usage in Punjab from other measures undertaken, an attempt was made to assess the impact of aforementioned efforts in halting the fall in water tables using the data of groundwater observation wells collected by the Directorate of Irrigation and Environment, Punjab. On an average, the water table fall in Punjab, prior to beginning of these efforts (1998-2005) was 54 cm per year, the fall in water tables declined to 32 cm per year during 2006-11. Delaying the rice transplanting to June 10 arrested the fall in water table by 22 cm per year, without any reduction in area under rice. Further while during 1998-2005 the water table fall was observed in near total area (99%) of Punjab, the area of falling water table declined to 75 per cent during 2005-11. Thus these efforts have resulted in reducing pressure on groundwater resources thereby preserving fresh water. In more recent years, the groundwater table has started rising in 25 per cent of Punjab, which earlier was only 1.5 per cent [Hira, 2013]

Savings in ground water withdrawals across various districts of Punjab as a result of delaying paddy transplantation to June 10^{th} were in the range of 3.7% to 12.7%, with a State average of around 7% [Sharma and Ambili, 2009). Savings in ET from delayed rice transplantation, using data from 17 districts of Punjab, reveal water savings of more than 9% when paddy is transplanted after June 12 (Figure 4). Simulation studies indicated increases in mean water productivity by around 10% and 21% for paddy transplanted on June 1 and June 16 respectively, as compared to May 16 [Sharma et al. 2010].

Figure 4: Water savings from date of paddy transplantation



In addition to water savings there were other incidental benefits. Singh [2009] estimates the savings in electricity consumed in agriculture because of fewer number of irrigation required for paddy cultivation. According to electricity utility (PSEB), in 2008-09, there was a saving of 276 million kWh in Punjab due to the implementation of the Act in spite of an increase in area under rice cultivation and in the number of tube-well connections. Further a 10-15 percentage point reduction in relative humidity has been noticed, which lowers the chances of crops being infected by pests and insects.

Summing up and the way forward

Groundwater-based farming currently is and is likely to continue to be not only the main source of foodgrain production but also a powerful engine of India's rural economic growth with very strong direct and indirect multiplier impacts both for the rural as well as urban economy. It is however clear that the way in which the groundwater is currently being managed, these benefits of groundwater could be short lived unless immediate steps are initiated to put groundwater management on more sustainable footing. In a country in which groundwater rights are inextricably linked with land rights, millions of small and large farmers spread across the length and breadth of the country take their own independent decision on when and how much groundwater to extract from millions of individually owned and operated underground structures using varying sources of energy. While fully realizing that managing groundwater in the prevailing scenario is a difficult task there are many opportunities, avenues, and instruments available for improved groundwater management. The institutional and policy divides in governance coupled with political exigencies that have often frustrated efforts at more scientific management of groundwater need to be overcome. The Punjab example of legislative intervention clearly demonstrates that despite all odds, concern about declining water tables, coupled with strict energy management, armed with scientific evidence of impact on crop yields, a strong political will to act and meticulous enforcement of the legal provisions by field officials can make the things happen on the ground and help reap rich dividends. Different stakeholders-state governments, utilities, and farmers urgently need to address the groundwater management through a set of politically and financially feasible and socially acceptable alternatives.

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Personal Discussions:

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Mr. Kuljeet Singh Bhangoo, farmer in Bhatha Dhua village – cultivates 70 acres of land; 30 acres own land and 40 acres leased-in.