Understanding and Managing the Water–Energy Nexus: Moving Beyond the Energy Debate

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Abstract

Energy and water are key instruments for agricultural production and their interlinkages pose significant management challenges. Lack of appropriate energy policy and policy to deal with management of groundwater has not only contributed to over-exploitation of groundwater; it has also resulted into a nexus. Perverse incentives provided as part of the energy policies have led to economic inefficiency in the performance of the electricity utilities, playing havoc with the energy economy of the country and viability of the energy sector. Analyzing the growth in use of groundwater and energy for pumping coincides with India's overall development policy of attaining food security. However, much of the debate on water- energy nexus as an indirect approach for groundwater management has focused on the energy side of the nexus, ignoring the role of agriculture policy, especially those dealing with gaps in market linkages for agricultural products and role of minimum support price, which have greater influence on farmer's choice of cropping pattern and hence excessive groundwater use. Policies governing agriculture and energy are apparently dictated more by political populism rather than sound management strategies for sustainable resources development. Combined effect of these policies has resulted in the hydrological unsustainable over-exploitation of groundwater. In this paper, the authors argue that there is need to further the debate on water-energy nexus beyond the realms of those focused primarily on energy policies.

Introduction

Despite a decade and half of economic reforms in India, agriculture remains the backbone of the economy and a direct and indirect source of livelihood for India's vast rural population. The recent estimates show that the agriculture sector accounts for 22% of the Gross Domestic Product (GDP), and provides livelihoods to 58% of the population (584 million people, GoI, 2004). In fact, energy (electricity) and water (irrigation) have emerged as key determinants of economic growth and social development in the rural areas in India.

Groundwater has become the mainstay of irrigated agriculture in India. Energy, especially electricity, has contributed significantly to the development and exploitation of groundwater resources, improving productivity and providing livelihood and food security (Shah et al., 2003). While energy and water have strengthened economic opportunities in rural areas and ensured food security, these are also threatening this very livelihood option. Groundwater resources in India are largely unmanaged, resulting in high possibility for its over-exploitation, thus threatening people's livelihoods and endangered drinking water supplies. This is further aided by energy policies and perverse incentives created by energy subsidies, inefficient electricity distribution system involving unreliable, poor quality and restricted hours of supply. Lack of appropriate energy policy has not only indirectly contributed to overexploitation of groundwater, creating a water-energy nexus, the energy policies have also, resulted in economic inefficiency of electricity utilities (State Electricity Boards), playing havoc with the energy economy of the country and seriously affecting the viability and reform process of the energy sector.

Much of the debate on managing the water – energy nexus has focused on intervening on the energy side of the nexus as an indirect tool for arresting the depletion of groundwater, which is addressing only half of the problem (Shah et. al., 2003; Sharma et. al., 2005). The indirect approach in energy policy has a technocratic bias, rather than the appreciation of the other side of the problem, the associated policy issues and political nature of the problem. Energy policy intervention, especially those policy measures initiated since electricity sector reforms have focused on either economic – raising electricity tariff for agriculture users – and/or technical – installing meters and doing demand side management to improve the pump set efficiency. The standard electricity reforms prescriptions have witnessed little buy-in from the farmers, as well as politicians. While individual farmers have opposed metering; collective action, and lobbying by farmer's groups have been effective in blocking tariff increase and payment of arrears. These collective actions of farmers have also found support from the political groups, who have used the means of waiver of dues and subsidized to free power as an instrument for rural development and to win farmer's vote.

Energy and water are key instruments for agricultural production. Irrespective of the changes in the energy policy, the demand for groundwater depends upon what farmers grow, which in turn is influenced by the support price policy, agriculture (food security) policy, and, market linkages. Government policies in the agriculture sector are multi-faceted and inadvertently encourage the production of water intensive crops over more water efficient commodities. Indian agriculture suffers from a mismatch between food crops and cash crops. Domestic production of pulses and oilseeds are still much below the domestic requirements. A distinct bias in agriculture price support policies in favor of rice and wheat has distorted cropping pattern and utilization of different inputs. Besides this, market for farm produces continues to be dominated by heavy procurement interventions by the government agencies.

Analyzing the growth in use of groundwater and energy for pumping coincides with India's overall development policy of attaining food security through Green Revolution technologies. The nexus that is visible today is due to the fact these policies did not change with time. That brings to another external factor – political - affecting the nexus: the rise of farmer's movement coupled with political populism in the late seventies and early eighties. The farmer's movement in southern states of Andhra Pradesh and Tamil Nadu brought the political intervention of free power. Almost parallel movement of farm lobby in northern and western India brought more subsidies in the agriculture sector in form of inputs and minimum support price for food crop procurement. Combined impact of these policies has affected the water and energy sectors. Breaking the nexus would require not just policy changes at the level of farm input subsidies, but also a realistic and strategic shift from minimum support price policy, and developing alternate product markets essential for crop diversification.

Water – Energy Nexus: Moving Beyond the Energy Debate

Water – energy nexus in India is a result of policy issues such as those dealing with groundwater, agriculture, and energy. Rapid development of high intensity of pump sets of smaller capacities scattered throughout the landscape makes water – energy nexus peculiar. Yet, another feature of the nexus is the existence of groundwater markets, where especially the small and marginal farmers depend upon the pump owners to buy water. Groundwater resources are largely unmanaged and the policies needed to deal with the problem are not yet in place. Agricultural policies, especially the procurement policies are such that they have encouraged farmers to continue growing more water intensive crops (rice, sugarcane etc.). Energy policies and economic incentives (or disincentives) for use of electricity for groundwater extraction, has resulted in almost zero incremental cost for the farmers. At the same time, inefficient electricity distribution system involving restricted hours of supply, with unreliable and poor quality has resulted in long hours of pumping by the electric pump owners.

The existing discussion on water energy nexus, attempts to capture a simple linear causal relationship between water and energy sector, as shown by the bottom part of the triangle in Figure 1. The causal effect for the energy-water nexus is not just due to inadequate energy policy or groundwater policy or the absence of any linkage between the two sector issues. Uncertainty of monsoon and existence of groundwater markets add further stress to the groundwater resources. This is a vicious cycle from the groundwater sector perspective. Energy sector policies provide electricity at a very low cost for agriculture and contribute to the socio-economic development of the rural areas. Due to shortages in electricity generation, and almost negligible return from supplying electricity to farmers (low/ nil tariff, non-payment), the utilities restrict the supply hours and provide it during off-peak hours. Lack of investments in strengthening the supply infrastructure by the utilities often results in frequent breakdowns and burnouts. Dispersed nature of electricity connections, means very little monitoring, and allows pilferages. This results in a vicious cycle, which the farmers mitigate by pumping for all the hours supply of electricity is available and in the process affecting the groundwater resources. These two vicious cycles are considered as the cause of the nexus. The nexus is complicated further by policies related to those of the agriculture and trade and procurement support policies, which influence the choice of crops grown.

Broadly, there are two approaches to arrest depletion of groundwater – direct and indirect. The direct approach for groundwater management has largely failed, as access to groundwater is through right of capture and the number of users is simply too large for effecting any regulations. In fact, despite being a common resource, inability to manage groundwater is a classical failure of common property resource management. In the absence of any effective legislation for groundwater management, indirect approach through energy policy intervention has been considered as an alternate option.

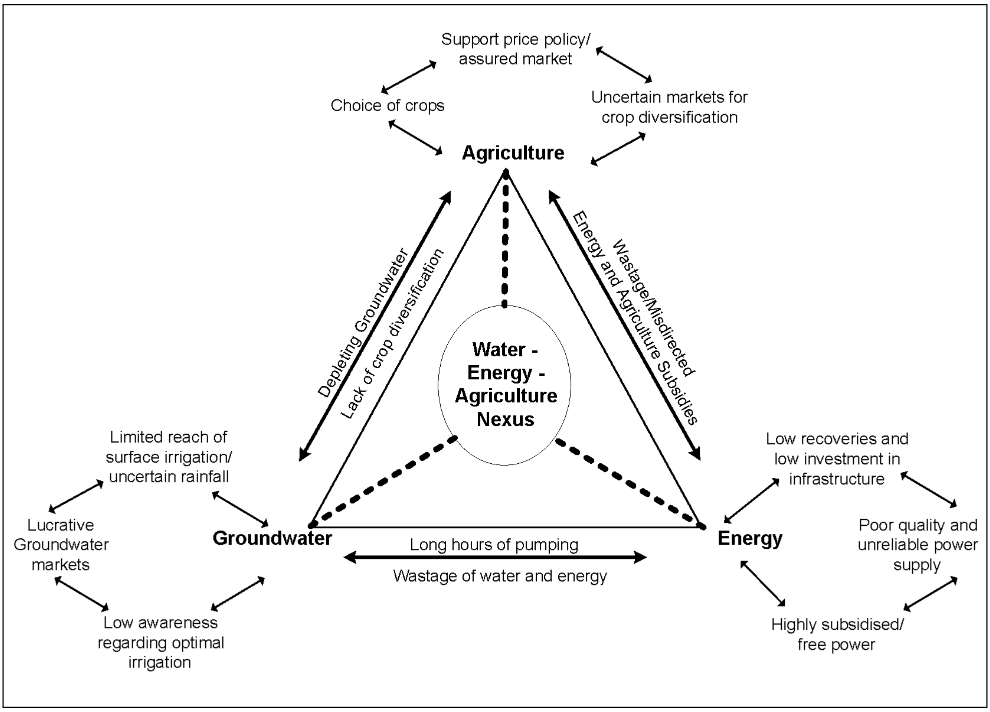

Figure 1. Water - energy nexus – moving beyond the energy debate

Energy policy as an indirect tool for groundwater management has twin advantages: one, it can be effective in arresting groundwater overexploitation, and, two, it will also lead to economic viability of the energy sector. The energy sector policies have focused either on technical solution of metering and demand side management, or through economic instruments of electricity tariff revisions. The policy prescriptions have emerged since the on-set of energy sector reforms, which views electricity supply to agriculture and poor recoveries as key factor for poor performance of electricity utilities in India. However, energy policy interventions have limitations, and given the standard prescription, they are more likely to benefit electricity utilities, than either the farmers or arresting groundwater depletion. It is therefore in context of these issues, that these energy policy interventions have seen little buy-in from the farmers (Dubash, 2005).

Given the limitation of the changes in energy policy, there is a need to look at the problem from a holistic perspective. Energy and groundwater are inputs to support agriculture development and improving farm productivity. In fact, choice of crops by farmers are not determined alone by the quality and economic cost of different inputs such as electricity, but, the economic returns, market demand for commodities, and market linkages are dominant factors. The debate on water – energy nexus would remain incomplete and lead to inconclusive solutions, without looking at the role of agriculture sector policies.

Adding the agriculture component to the nexus as shown in Fig.1 modifies the water-energy nexus. The schematic diagram shows that there is a vicious cycle operating within-water, energy, and agriculture sectors - creating a nexus. In the absence of effective groundwater legislation to control over-exploitation of groundwater, and under the favorable condition of agriculture policy, which emphasizes on production of food grains through procurement support, there is excessive dependence on water intensive crops leading to depleting groundwater levels and lack of crop diversification. Perverse incentives provided as part of the energy policy coupled with poor quality and un-reliable electricity supply has resulted in long hours of pumping and leading to wastage of both energy as well as groundwater. Implementation of policies in the agriculture and energy sectors, have resulted in misguided targeting, as benefits of the agriculture subsidies are captured by agriculturally prosperous states and benefits of electricity subsidy are mostly retained by rich farmers, instead of poor states and small/marginal farmers.

Although Figure 1 shows the internal vicious cycles between agriculture, water and energy sectors, it does not show the coping mechanisms that farmers adopt in light of inefficient power supply. Rapid growth in groundwater wells is largely because of unreliable power supply. When power fails, the additional wells would have pumped enough to meet the requirements. When pump fails, the additional wells would be used to fill in. Surveys in Andhra Pradesh and Haryana also showed that most of the large and medium farmers had more than two wells per farmer. These are the ones that have the capacity to invest in additional wells and benefit from energy subsidies. The coping mechanisms adopted by the farmers add to increased pressures on both energy and water (Sharma et.al, 2005).

Groundwater

Groundwater irrigation developed towards early 1960s in India, and expanded rapidly after 1969 with the expansion of grid electricity to rural areas. At present, groundwater supplies water to 70% of the irrigated area (Shah et al., 2003). Over the last two decades, 84% of the total addition to the net irrigated area came from groundwater, and only 16% from canals (Figure 2). As it can be seen from the Figure 2, the net irrigated area by groundwater is about twice the area irrigated by the canals.

The current dependence on groundwater irrigation started as a viable alternate option largely due to certain critical changes that took place in the Indian agriculture and irrigation sectors. Surface irrigation sources such as canals and tanks required massive public investment and complex institutional set-up. Over the years public investments in irrigation infrastructure has declined and simultaneously the surface irrigation source suffer from poor maintenance leading to deterioration in quality and inadequacy of water supplies.

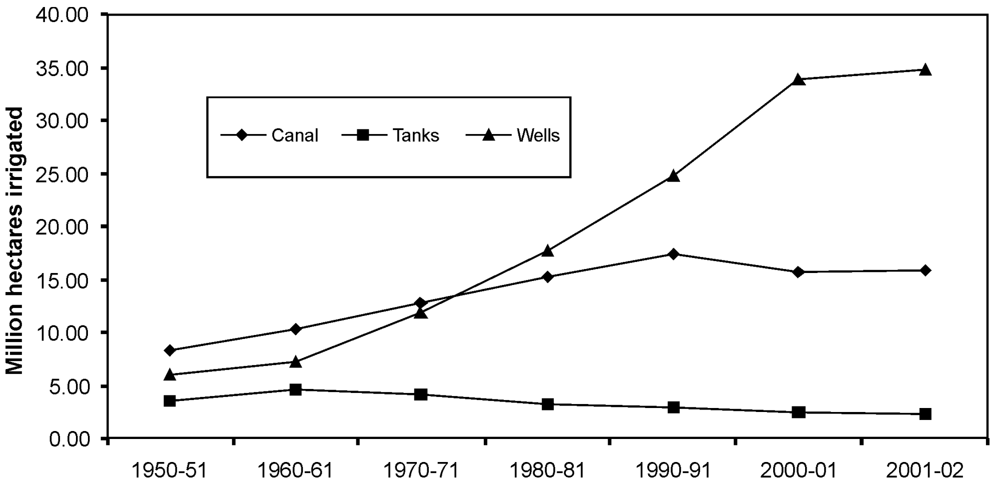

Figure 2. Source-wise irrigation development in India

With India's demand for food security becoming the primary objective of agriculture development, the demand for groundwater irrigation increased. Groundwater irrigation was also considered as a viable technical option to reduce water logging and salinity in certain areas of river basins. For the farmers, groundwater provided flexible option of applying right quantities of water when needed. Groundwater irrigation received further fillip due to increased availability of irrigation pump sets at affordable prices and ease in access to subsidized credit.

Groundwater exploitation in India has contributed to irrigation, poverty reduction, and rural development benefits. However, its utilization pattern and heavy dependence have raised sustainability concerns. Groundwater estimates indicate that more than 9% of the administrative blocks/watersheds/*talukas* are over-exploited, and nearly 5% of them are in critical stage (Romani, 2005). These estimates are based on assessment conducted around 1999. The situation has aggravated since then. For example in Karnataka, the 1999 estimates identified a Doddaballapura *taluka* as "safe" and only parts of the *taluka* were semi-critical (GoK, 2004). However, the recent assessment by the state government department shows that the entire *taluka* has now been classified as "critical"(Venugopal, 2005). The change in the availability of groundwater in this area has been largely due to increase in number of bore wells, increase in depth of bore wells, and poor maintenance of tanks. Anecdotal evidence from the area also suggests that the well failure rate is extremely high, and existing bore wells have started to dry.

Agriculture

Agriculture has been the mainstay of the economy and its growth is pre-requisite for economic and social development of the Indian economy. As noted earlier, agriculture sector accounts for 22% of the GDP, but at the same time, it supports livelihoods of 58% of the population. The Xth Five Year Plan (FYP) has targeted an average annual growth rate of the agriculture sector at 4 per cent

(Planning Commission, 2002b). However, monsoon plays a critical role in the growth rate of the sector. Severe drought in 2002 resulted in negative (-7.0 per cent) growth rate, as deficient rainfall significantly affects *Kharif* (rainy season) food grain production (GoI, 2005a).

Post independence growth of agriculture owes much to the conscious and proactive government policy to promote agricultural productivity and overall development. These could be largely ascribed to measures such as public investments in irrigation, rural electrification, research and development and transfer of knowledge to field to improve crop productivity, development of credit networks and extension services, guaranteed support prices for outputs and subsidized inputs. Annual growth rate of 2.7% for all crops achieved during 1949-1995 was considerably higher than insignificant growth of 0.3% per annum registered during the first half of the century. Accordingly, food grain production has grown from 50.8 million tonnes in 1950-51 to about 212 million tonnes in 2001-02.

However, in striving to achieve food security, the basic principle of rational pricing and sustainable management of natural resources were neglected in India. The magnitude of un-recovered costs on subsidized inputs has been rising at a much faster rate than public investment in the sector. Apart from rising input subsidies, subsidy provided by the government as output subsidy in the form of food subsidy has also been increasing and contributing to the rising subsidy bill for the government. Food subsidy in India comprises of subsidies to farmers through support price and purchase operation of the Food Corporation of India (FCI), consumer subsidies through the public distribution system, and subsidies to FCI to cover all its costs. Food subsidies are mainly on account of food grains - paddy and wheat - both being water intensive crops and rely on groundwater.

Food subsidy, especially the minimum support price (MSP) has asserted in improving food security through affordable prices for the consumers and incentives to the farmers in form of assured market and thus keep food grains production at a comfortable level. However, these policy measures have also created a lock-in situation, where food grains production dominates and domestic production of other cereal crops and oil seeds have suffered because of food security. Analyzing the food subsidy bills in India for the period between 1990-91 and 2003-04, shows a ten times increase in the food subsidy (Table 1). In 1990-91, the food subsidy was Rs 245 billion (1 USD ~ INR 45) and it increased to Rs. 2580 billion in 2003-04. In fact, after 1994-95, the annual growth in the food subsidy bill has registered a growth, due to increase in MSP and open-ended procurement. Food subsidy is further increased by the low off-take of food grains for distribution and build-up stocks.

Higher food subsidy bill in the last five years has been on the account of open-ended procurement policy with no upper bounds on procurement levels. Under this procurement scheme, the government buys whatever is offered to it at the 'going' MSP. Analyzing the food subsidies in India indicates that a large part of the recent problems arise from the relatively high MSPs (Table 2). Not only the MSP is higher, it is also at levels higher than the price recommended by the Commission on Agricultural Costs and Prices (CACP). The declared MSP has had several negative fallouts. Significant from the water-energy nexus perspective, is the fact that the exclusive attention to wheat and rice has distorted the cropping pattern of

Table 1. Growth of food subsidies in India

Year	Food subsidy (Rs.,billion)	Annual growth (%)
1990/91	245.0	—
1991/92	285.0	16.33
1992/93	280.0	-1.75
1993/94	553.7	97.75
1994/95	510.0	-7.89
1995/96	537.7	5.43
1996/97	606.6	12.81
1997/98	790.0	30.23
1998/99	910.0	15.19
1999/2000	943.4	3.67
2000/01	1206.0	27.84
2001/02	1749.9	45.10
2002/03	2417.6	38.16
2003/04	2580.0	6.72

Source: (Ministry of Finance, 2004).

Table 2. Minimum support price(MSP, Rs. per 100 kg) of wheat and paddy

Crop Year	Paddy (Common)		Wheat	
	MSP	% Change	MSP	% Change
1990-91	205		225	
1995-96	360	5.9	380	5.6
1996-97	380	5.6	475	25.0
1997-98	415	9.2	510	7.4
1998-99	440	6.0	550	7.8
1999-00	490	11.4	580	5.5
2000-01	510	4.1	610	5.2
2001-02	530	3.9	620	1.6
2002-03	530	—	620	—
2003-04	550	3.8	630	1.6
2004-05	560	1.8	640	1.6

Source: (Ministry of Finance, 2004; GoI, 2005b).

farmers in the favor of these two food grains alone. The higher water intensity of these two crops in turn has had adverse environmental impacts.

The other negative impact of the MSP is the inequitable distribution of subsidies due to concentration of procurement in just two food grains and selected states. In 2003-04, nearly 95% of the wheat was procured from Punjab, Haryana and part of Uttar Pradesh. Similarly, nearly half of the paddy procurement was from the states of Haryana and Punjab, followed by Andhra Pradesh and Chattisgarh. Not only farmers in these selected states draw the benefits of the subsidies, within these states the large farmers, leaving out small and marginal farmers, mostly enjoy these benefits. Study in Andhra Pradesh has shown that farmers, notably small and marginal, face several hurdles in realizing the MSPs offered by the government.

In summary, food subsidies have not only resulted in being mis-directed and leading to wastage of subsidies, they are responsible for excessive dependence on two food grains – paddy and wheat. This has not only affected the cropping pattern, it has also resulted in over-exploitation of groundwater.

The Energy Angle

Improving access to electricity for social and economic development in the rural areas has been the mainstay of the energy policy in India. Energisation of irrigation pump sets was integral to the rural electrification program with the objective of creating economic opportunities in the agriculture sector along with creating agro-processing units. At the time of independence, there were approximately 6500 irrigation pump sets. In the interim period of 1966-69, between the IVth and the Vth FYPs, about one million pump sets were installed. However, after 1969, there has been an exponential growth in number of energized pump sets (Figure 3). As it can be seen from Figure 3, after 1969, the number of energized pump sets has substantially increased during each plan period. This was possible due to expansion of grid electricity in the rural areas, mostly on the back of multi-purpose irrigation projects, easy availability of pump sets and affordable drilling services in the market, access to subsidized credit, for realizing potential of groundwater for irrigation. The trigger point was the consecutive years of drought between 1966-68, which changed the face of Indian agriculture, irrigation, and role of electricity in supporting irrigation and agriculture for attaining food security.

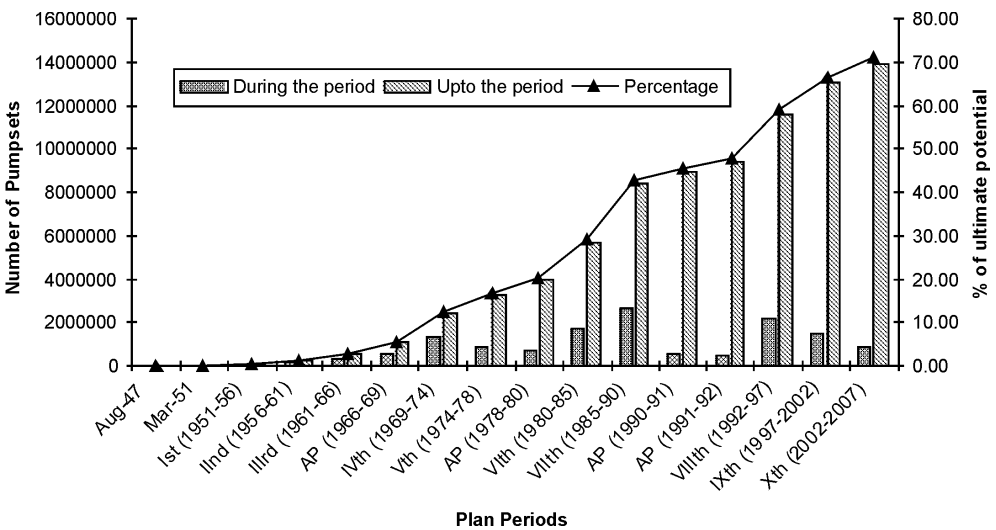

Figure 3. Progress in pump set energization in India 1947-2003 (Source: Sinha (2005)

As it can be seen from Figure 3, 70% of the groundwater potential has already been utilized. Groundwater estimates based on the available resources, indicate that approximately 19 million pump sets can be installed in India. The decline in pace of pump set energization in the last two Five Year Plans is largely due to saturation in most of the agriculture prosperous states, denial of new pump-set connections and subsidized credit in the 'over-exploited' or 'critical' administrative units. In the states such as those in the eastern India, where high potential for groundwater exploitation is possible, then these states are affected by low density of rural electricity grid, poor availability of electricity supply, high incidence of poverty making access to individual ownership of pump set difficult, and these problems are further complicated by bureaucratic inefficiencies in these states.

The widespread increase in utilization of groundwater from 1970s onwards was supported by incentives from the state electricity utilities through provision of subsidized tariff. While 1970s were the peak period for rapid increase in groundwater irrigation, two policy interventions in the energy sector during this period, resulted in their over-exploitation in coming years. One intervention was in the form of change in the billing of agriculture consumers. Agriculture consumers were billed based on energy used as per the energy meter. The billing was changed to load-based tariff (per horsepower [hp]) of the installed pump set capacity. Utilities felt that the change was necessitated to reduce the transaction cost involved in meter reading and bill distribution to the thousands of scattered pump set users in the rural areas. The negative implication of such a move resulted in under-reporting of pump set load used by the farmers, contributing to commercial losses for the electricity utilities.

Second policy intervention came from the government as part of larger political populism. Under pressure from rising farmer's movements in parts of southern Indian states, followed by similar movements in northern India, state governments introduced highly subsidized tariff and subsequently many states offered free electricity for the agriculture sector. Free electricity was introduced in Andhra Pradesh towards the end of 1970s and was followed by Tamil Nadu and Punjab. This political populism soon spread to other neighboring states.

The combined effect of these policy intervention resulted in poor performance of state electricity utilities, which over a period due to under-recoveries, became financially insolvent. While the agriculture sector share in total electricity sales increased, revenue realization remained extremely low. As it can be seen from Figure 4, during the period of 1994-95 and 2001-02, total sales of electricity to the agriculture sector was more than 30%, but revenue realization was less than 5% (Planning Commission, 2002a). The high commercial losses meant that the investment by the utilities in electricity distribution infrastructure declined over the years. As a result quality of power supply was characterized by low voltage and frequent outages and reliability of supply further deteriorated. At the same time power supply was scheduled during off-peak demands, therefore resulting in supply during night time. Farmers coping mechanism to counter low voltage power supply and frequent interruption during scheduled supply was to use phase splitters to run pump sets from single-phase power supply. To counter the nighttime power supply and unscheduled supply, farmers adopted auto-switch to run pump sets. Implication of such pump set utilization pattern negatively affected groundwater utilization.

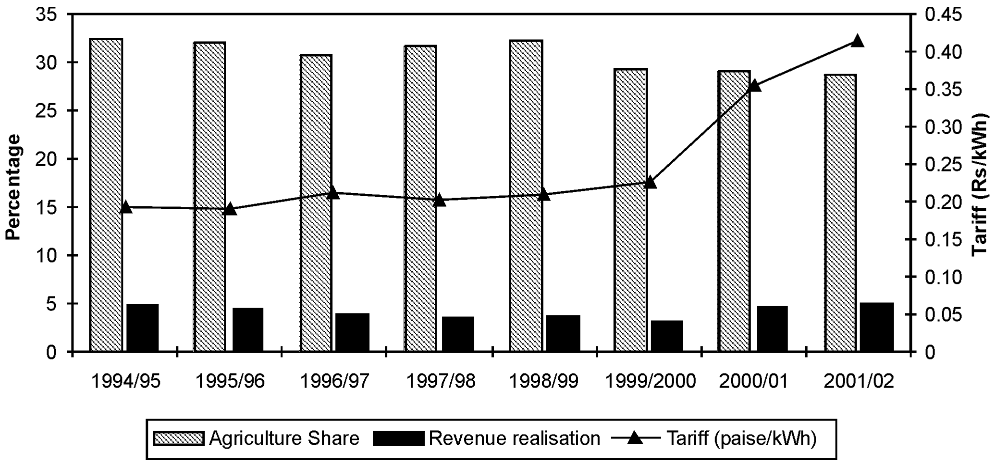

Figure 4. Electricity for agriculture consumers in India – agriculture share (%), revenue realization (%) and changes in average agriculture tariff 1994/95-2001/02 (Source: Planning Commission 2002(a)

Not only these policy interventions created unfavorable utilization of groundwater, they also contributed towards rising subsidy bills. Cumulative subsidies provided by all states for agricultural consumers increased from Rs. 593.8 billion in 1991-92, when energy sector reforms were started, to Rs. 2380.6 billion in 2004-05 (Table 3). This increase in subsidies has been despite the adoption of minimum tariff of Rs. 0.50 per unit under the common minimum plan for power sector reforms. The rising subsidy bills have largely been on the account of political interference in pricing of electricity for agricultural consumers, and it has been in the form of either free electricity or waiver of electricity dues.

Table 3. Growth of electricity subsidies for agricultural consumers in India

Year	Subsidy (Rs. billion)	Annual growth (%)
1991-92	593.8	
1992-93	733.5	23.53
1993-94	896.6	22.24
1994-95	1094.1	22.03
1995-96	1360.6	24.36
1996-97	1558.6	14.55
1997-98	1902.1	22.04
1998-99	2247.3	18.15
1999-00	2417.8	7.59
2000-01	2407.4	-0.43
2001-02	2401.3	-0.25
2002-03	2184.5	-9.03
2003-04	2334.6	6.87
2004-05	2380.6	1.97
2005-06	2537.7	6.60

Source: (GoI, 2002; Planning Commission, 2002a; GoI, 2004; GoI, 2005a).

Political populism in the energy sector can be classified into two categories – one, pertains to provision of free electricity, a policy which was followed by states such as Punjab, Madhya Pradesh and Tamil Nadu and were reintroduced by states such as Andhra Pradesh and Tamil Nadu after 2004 state assembly elections. Maharashtra also provided free electricity for short period in wake of 2004 state assembly elections and withdrew the scheme within six months of returning to power. Punjab, which gave free power in 2002, also withdrew in six months, but recently in 2005, the state government has reintroduced free power in view of forthcoming state election. Second, measure is in form of waiver of electricity dues, a policy that has been continuously followed by many states and in recent years, states such as Madhya Pradesh, Karnataka, and Maharashtra in 2004 gave waiver of electricity dues just before state assembly elections. Haryana offered waiver of arrears with a rider that with regular payment of 10 bi-monthly bills, arrears shall be reduced by 10% with each payment. While waiver of arrears is not same as providing free power, but instead is an interim measure of providing relief to farmers. However, this has resulted in creating a non-payment behavioral pattern by the farmers, who expect another round of waiver to come in future. For example, empirical evidence from Karnataka shows that farmers have stopped paying electricity bills after a waiver was announced before state assembly elections in 2004.

Discussion

Analysing the scenarios of groundwater, agriculture, and energy sectors and the implications of the policies on groundwater over-exploitation, policy and program intervention in the water sector needs to be supported by appropriate policies of the energy and agriculture sector. Direct management of groundwater suffers largely due to lack of legislative instruments including low opportunities for effective implementation of legislative controls (even in states where such legislations are existing), development of groundwater through right of capture, political sensitivity associated with its use for agriculture, food security and livelihoods, and the fact that much of the groundwater development actually takes place through private capital investments of the farmers. Even in states such as Andhra Pradesh, which enacted an Andhra Pradesh Water, Land, Trees Act, has run into institutional barriers and lack of teeth to restrict over-exploitation of groundwater (Narayana et al., 2005). Given this broader context of the groundwater, specific intervention can be focused on recharging the aquifers by managing run-off water from surface irrigation sources and rainfall. These interventions can provide positive benefits, however, the rate of recharge varies and rate of extraction is influenced by crop choice and density of pump sets. Energy sector policies and agriculture policies have to support groundwater interventions. Anecdotal evidence from watershed management in Madhya Pradesh showed that once the three-year restriction on digging new bore wells was removed, irrigation pump sets mushroomed. Even under other watershed management programs, benefits of groundwater recharge efforts by the community upstream were captured by few influential farmers downstream (Sharma et al., 2005).

Energy Options

The current approach in the energy sector has focused on technical and financial fixes to the problems. However, energy policies are concerned until the meter side of the pump set. Metering is the most debated aspect, as energy sector reforms proponents have argued that metering may not only reduce distribution and commercial losses for the utilities, but also induce efficient pumping and adoption of efficient pump sets by the farmers (Padmanabhan, 2001). The latter is assuming that farmer's would be rational in their approach, and is not likely to take place unless an overall change is brought in the distribution of electricity supply – quality, reliability, and time of supply (Reddy, 2000). Benefits of metering will be largely drawn by the electricity utilities, as it will improve accountability in the sector, however, there is little buy-in from the farmers. Farmers look at metering with distrust, as they expect that the otherwise flat tariff would increase in near future. Farmer's opposition to metering also stems from the fact that metering would not allow them to pilfer by under reporting pump capacity.

Pricing of electricity closer to the cost of supply is another common prescription. Appropriate tariff is the most prudent option, however, electricity pricing for the agriculture sector follows political logic rather than sound economic principles. The common quote from an influential politician states that " Pricing is not just a matter of people's willingness to pay. It's also a matter of politicians' willingness to charge". At the same time, there are other sets of arguments related to pricing of electricity. Electricity supplies to farmers are in fact, off-peak and highly un-reliable, and thus does not cost the electricity utilities even the average cost of supply (Bhatia, 2005). At a larger policy level, since electricity pricing are linked to political outcomes, tariff rationalization is not likely to be achieved in many states. The problem is not such much of appropriate tariff, but the inability of the utilities to do collection. In the recent past, there has been lot of outcry related to provision of free power. Free power sop runs contrary to the Electricity Act, 2003, which prescribes a gradual phasing out of cross-subsidies. However, there are several states which give waiver of electricity dues, and in the absence of revenue collection, electricity supply virtually becomes free. For example in Karnataka, where the utilities are not collecting any revenue from agricultural consumers, and at the same time the farmer are unwilling to pay and hoping for waiver of dues.

In this context, three options of energy side need to be explored further:

- The first is the analysis of the scheme introduced by the State Government in Haryana in 2005. Instead of giving a one-time waiver of electricity dues, the government introduced an "Arrear Waiver Scheme." As per the scheme, 10% of the arrear would be written off with the continuous payment of each of the next ten electricity bills on a two-month cycle. If the farmers miss any of the current payments, the scheme will start all over again. Preliminary observations indicate that scheme has been quite successful as more than 90% of the farmers in Bhiwani and Jind districts – districts with highest incidences of default - have utilized the scheme.
- The second option pertains to adopting a different system for setting electricity tariff for groundwater utilization. At present, the State Electricity Regulatory Commissions (SERCs) or State Electricity Boards (SEBs) sets tariff (per HP or

per unit) for different consumers across the state and based on pooled average cost of supply. There is no differentiation in the tariff for different regions. Instead of this pooled average cost of supply, electricity tariff could be fixed based on the groundwater classification as over-exploited, critical and safe. This will not only bring two sectors to work together, it will also provide some accountability towards how groundwater has to be utilized. As part of the distribution reforms in the electricity sector, multiple distribution utilities either have been formed or are in the process, which makes it possible to have groundwater classification based electricity tariff. Regions that are classified as over-exploited can have higher electricity tariff (flat or metered), when compared to regions, which are classified as safe. High electricity tariff rate would act as a deterrent for farmers to grow water intensive crops in over-exploited and critical areas. In other terms, higher tariff for the over-exploited and critical areas would be equivalent to an environmental cess, which the farmers in such regions would have to pay to utilize groundwater. However, implementing such tariff system requires maturity to think out of the hat by the SERCs/SEBs, which set the tariff. This will also require a political vision to introduce such differential tariff system.

- The third option relates to matching energy supply with the irrigation needs of the farmers. Crop water needs are generally not linear in nature but follow a pattern closely dictated by crop growth patterns with high water/ energy requirements during planting and high vegetative growth (Sharma et. al, 2005). At the core of the nexus, is the mismatch between irrigation needs and energy availability. Power supply is good and reliable, when the irrigation needs of the farmers are low, and of inferior quality and in short supply when the irrigation needs are higher. When the irrigation needs are higher and power supply is unreliable, farmers are frustrated and opt for options such as excessive pumping of groundwater, power pilferage and default. These pumping patterns not only stress the electricity distribution infrastructure, but also increase commercial losses for the utilities. Matching energy supply with irrigation needs of the farmers would result in a win-win scenario, as farmers would be happy and the volume of subsidy would be controlled. However, this would require significant work at the electricity feeder level by developing local intelligence mechanisms. Shah et al., (2003) also suggested 'intelligent power supply' in which energy supply pattern is matched with crop water needs.

Agriculture Options

While managing input subsidies such as those provided by electricity can result in, to some extent, in efficient utilization of groundwater, but a more direct approach would come through policy interventions from the agriculture sector. There are two inter-linked policy issues, which can have direct bearing on groundwater utilization as well as equitable distribution of food and energy subsidies. First, policy issue deals with the restructuring of the MSP mostly targeted to paddy and wheat. Second, policy issue is the procurement policy for the food grains, which is inter-linked to MSP. Both these policy options have to be reviewed and implemented concurrently.

- As argued under the agriculture sector, MSP associated with paddy and wheat accounts for bulk of the food subsidy bill. In the last five years, the MSP prices for paddy and wheat have increased marginally, but open-ended procurement norms distort subsidy allocation, as well as encouraging paddy and wheat cultivation in states, which are increasingly becoming water scarce regions. The government needs to intervene either by freezing the MSP or by introducing a time bound phase out of the MSP. This is likely to trigger cropping pattern shift by the farmers, if the economic returns are no longer attractive. From a policy perspective, this option again has political implications. MSP restructuring would be effective, if it is accompanied by providing incentives for alternate crops, which provide at least similar economic returns as those from paddy and wheat. It would also require government to strengthen MSP as well as support them with market access in either domestic markets or international trade for other cereal crops and oilseeds.
- Restructuring the procurement norms for food grains is inter-linked with the restructuring of MSP. The current procurement policy is open ended, as there is no upper limit set. This has distorted procurement from states, which are increasingly becoming water scarce (Punjab, Haryana, western Uttar Pradesh). In the last two years, FCI, has made some changes in procurement and it is now focused on eastern Indian states for procuring paddy (GoI, 2005a). However, they account for approximately 10% of the total procurement. In order to restructure the procurement policy, the government might put upper ceiling of procurement. In other words, the government needs to introduce fixed quota for each food grain to be procured and gradually reduce the quota from states such as Punjab and Haryana. Imposing such quota limit is likely to influence farmer's decision to undertake cropping pattern change. However, the government needs to introduce safeguards through incentive and market linkages to grow other crops.

Conclusions

This paper has discussed role of indirect options pertaining to energy and agriculture policies simultaneously for efficient utilization of groundwater. While some of these policy interventions are already under review and implementation, they require rigorous public debate to find the appropriate balance. Given the groundwater realities in India, and likely future scenario, it is critical to understand, that no single policy intervention can solve the problem. Energy policies can play a role, but their implementation is fraught with political compulsions and their inherent limitations as a solution in sectors other than energy. Thus, the energy policies will be able to find solutions for the energy side of the nexus; the energy policies on their own will have little to offer for the groundwater.

Farmer's choice of crop is certainly influenced by input subsidies, but they are influenced by assured prices and market, both of which are provided by the government's food subsidy and procurement policies. Procurement policy and MSP needs to be revamped, not just from reducing fiscal burden on the exchequer and from equity perspective, but long term environmental benefits and livelihoods security that can be achieved from efficient utilization of groundwater. Both the indirect policies of energy and agriculture sector needs to be concurrently approached to bring diversification of agriculture and therefore arresting groundwater depletion, and safeguarding livelihoods and food security.

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