The Role of Agricultural Policy in the Water-Energy Nexus

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May 31, 2011

Abstract

Water and energy are interconnected. The water-energy nexus implies that energy policy effects water use and vice versa. Therefore, holistic water and energy policies are required for the efficient management of these resources. Water and energy are key inputs in the production of food through agriculture. However, many of the current energy and agriculture policies provide electricity and water at no cost to farmers, leading to over-use of water and energy. In many agricultural economies in the developing world, appropriate energy policies are cited as an efficient tool to manage scarce water resources. Agricultural policies are often overlooked although they impact water and energy use through subsidies that change farming practices. In developing countries, where agriculture provides livelihoods for a significant portion of the rural population, they can complement energy and water policies in achieving efficiency goals. This paper addresses the role of agricultural policy within the water-energy nexus.

Keywords: Water-energy nexus, Groundwater, Agricultural policy

Introduction

Water and energy are complementary inputs in the production of agriculture and thus food. In many countries, including the US, Mexico, China, and the Indian subcontinent, subsidies and price supports in agriculture influence farmer production decisions, which in turn effect water and energy use in irrigated agriculture. This is especially true for farming communities that depend partially or solely on groundwater for irrigation as vast amounts of energy are needed to lift the water for use.

Groundwater has allowed many Asian countries to meet their goals of food security and bring people out of poverty. It was a major contributer to the Green Revolution in the Subcontinent and to this day, more than half of the population depend on agriculture for their livelihoods making it essential for economic growth. However, the use of groundwater has developed in an unsustainable manner, where governments have not adapted to changing conditions of the resource base. In the first phase of use, the resource base must be promoted and incentives provided to farmers to use it. This phase has been reached in many of the economies in the US, Mexico, China and parts of Western India. In this phase the use of groundwater results in an agricultural boom and more and more farmers invest in pump sets. In the second phase of use, the resource starts to decline due to over exploitation and finally it is no longer viable which is seen by the drying up of wells (Shah et al., 2003a). The main problem lies in the fact that sustainable management policies are not developed quickly enough, during the first phase, and thus the groundwater tables are falling below acceptable levels and the problem is addressed too late. This is a problem, especially in the Asian context because the people who depend on groundwater for their livelihoods will fall back into poverty once they no longer have the resource to use in irrigation.

Water quality is another aspect in the nexus that is affected by agricultural policies. Declining quality due to increased fertilizer and pesticide use causing pollution, salinization of water bodies, and water logging are problems faced in groundwater economies and need to be addressed for sustainable management (Mayrand et al., 2003; Scott and Shah, 2004; Shah et al., 2003a).

Policies play an important role within the water-energy nexus by managing both the use of water and energy which can lead to the development of sustainable solutions in groundwater. Direct policies on water use, such as pricing and metering, have worked in the US and Australia where the economies are characterized by a small number of large farmers. However, in most of South Asia and China, the groundwater economy is characterized by large number of small farms. In India, this meant that metering and pricing policies were not politically feasible or easily implementable resulting in almost free water and energy for agriculture (Scott and Shah, 2004). More recently, energy policy has been cited as a means to control groundwater overdraft where direct policy intervention in water is not possible or is not enough. However, as agriculture is the output that determines the use of both water and energy, agricultural policies also have an important role to play.

This paper first discusses groundwater economies and their role and development within the water-energy framework. Second, it addresses energy policy and how it affects water followed by the role of agricultural policy. The following section discusses how agricultural policy fits into and can be used within the water-energy nexus. The final section concludes.

Groundwater

Although cultivated land worldwide has been increasing, the percentage is dwarfed by the change in land that has been irrigated. Irrigation is most prevalent in developing countries, especially those in Asia and was one of the major contributers of the Green Revolution. Irrigation technologies have allowed countries to reap productivity benefits in agriculture without tapping into new land (Whiting, 2011). Initially, in the 1970's and 1980's investment was undertaken in large, centrally managed systems that mostly used surface water. However, more recently, groundwater has become the major source of irrigation.

The major users for groundwater are the US, Iran, Mexico, China and the Indian subcontinent (which include India, Pakistan, Bangladesh and Nepal) (Shah et al., 2003b). However, the difference in the groundwater communities across these regions lie in the number of users. The US, Iran and to a smaller extent, Mexico are characterized by pumps of larger capacity and thus there are less wells. In India there are many small wells with pumps that operate about 400-500 hours per year (Shah et al., 2003b). The North China

plains are also characterized by small pumps and groundwater is the sole method of irrigation (Mukherji and Thierry, 2009). The countries above also differ in the number of people that are dependent on groundwater with India and China relying most on it as can be seen from the table below.

Table 1: Groundwater Use by Country

Country	Annual groundwater use (km^3)	No. of groundwater structures (million)	Extraction/ structure (m^3/year)	% of population dependent on groundwater
Pakistan/Punjab	45	.5	90,000	60-65
India	150	19	7,900	55-60
China	75	3.5	21,500	22-25
Iran	29	0.5	58,000	12-18
Mexico	29	0.07	414,285	5-6
USA	100	0.2	500,000	<1-2

Source:B. Sharma, C. A. Scott, and T. Shah (2010). "Groundwater-Energy Nexus: Implications for Sustainable Resource Use". In: pp. 119–129

Surface irrigation infrastructure in Asia has been in decline leading to the boom in groundwater use. Also, groundwater allows farmers to have a reliable water source which is not dependent on the season. In Bangladesh, for example, irrigation, particularly groundwater irrigation has encouraged farmers to grow rice and wheat in the dry season where once, the land was left fallow (Alauddin and Quiggin, 2008). Groundwater use is more productive than surface water use per cubic meter because it does not need to be transported and can provide farmers with water when they need it (Shah et al., 2003a).

Fifty percent of groundwater use in agriculture is attributed to just two countries, India and China (Molden et al., 2007). In India, groundwater is responsible for irrigation of 60% of the irrigated area, while in China, by 1997, the provinces of Beijing, Hebei, Henan and Shandong each, at least 50% of the agricultural water use was from groundwater. It has been the underlying cause of economic growth in these developing countries and provided livelihoods and food security to the poor (Shah et al., 2003a). Thus, many of world's poor depend on the resource and its sustainable use is essential to these economies.

Energy Policy

Energy is vital to the groundwater economy in developing countries. Initially, in India, the government provided subsidies for diesel pumps and pump irrigation equipment leading to adoption. However, electric pumps now prevail with the spread of the electricity grid to rural areas and cheap electricity for the agricultural sector. The concentration of these electric pumps are in the drier Wester states of Punjab, Haryana, Gujarat and also Pakistan (Sharma, Scott, and Shah, 2010). Twenty five to thirty percent of the total electricity consumption in the country is in groundwater pumping although it only contributes ten percent to the GDP (GOI, 1998).

Energy policy for agricultural users has been an important factor that has led to over extraction of the resource base and also given rise to the bankruptcy of the state electricity boards in India. Many authors have argued that energy policy can be used as an indirect tool to manage not only energy resources but also the groundwater resource (Scott and Sharma, 2009; Scott and Shah, 2004; Shah et al., 2003a; Sinha, Sharma, and Scott, 2006). Provision of free electricity to farmers, which was implemented as a policy option by the states of Punjab, Madhya Pradesh and Tamil Nadu along with policies that waive electricity use to farmers have led to non-payment behavior (Sinha, Sharma, and Scott, 2006). Further, the farmers' dissatisfaction with the intermittent electricity supply and power fluctuations lead them to run their pumps non-stop irrespective of water needs (Sharma, Scott, and Shah, 2010).

Scott and Shah (2004) argue that energy supply and pricing can also be essential tools in Mexico to control over pumping of groundwater. In Mexico problems have arisen because farmers have a tendency to over irrigate as a risk mitigation strategy because irrigation costs (in terms of energy) are relatively small compared to total costs of production and do not reflect the externality costs of groundwater. In Mexico, as in India the government provides power subsidies to the agricultural sector increasing over draft. In the year 2000, these amounted to US$592 million and US$5.4 in Mexico and China, respectively (Scott and Shah, 2004).

Energy policy that affects groundwater extraction are spatially varied both within and outside country borders. Along with the spatial variability of energy policy, the differences in groundwater characteristics must also be taken into consideration when determining appropriate policy measures. For example, in India much has been written about the electricity-irrigation nexus but less so about the diesel-irrigation nexus. Diesel pumps are still the the predominant technology in parts of Eastern India and Bangladesh. They account for 85% of the water extraction mechanisms in the region (Mukherji, 2007). These regions are home to half a billion of the world's poorest people who could benefit from further development of groundwater resources (Scott and Shah, 2004). As a result of high diesel prices that affect the ability of farmers to afford pumping, a situation of "economic" water scarcity has emerged (Mukherji, 2007). In West Bengal, Mukherji (2007) contends that a flat rate tariff will not lead to financial loss nor groundwater depletion because of the recharge potential in this region. This will also help to create groundwater markets where marginal users can buy from those who own pumps.

Agricultural Policies

Agricultural policy has an important role within the water-energy nexus because crop production decisions are what determine the use of both resources. These policies take many different forms across different countries. In the US, they are outlined in the Farm Bill. Agriculture is a sector within the US where subsidies are extensively used resulting in artificially distorted production choices (Mayrand et al., 2003). Market Price Support, output and input subsidies, supply and payment limits, and farm-based payments are some of the subsidies that affect agricultural output in the US (Mayrand et al., 2003). Each of these has a different affect on the environment. Market Price Supports give producers higher prices for their products than that of the world price thus increasing production by farmers. Output subsidies are payments that are made directly to the production of particular commodity and unambiguously lead to higher levels of production. Input subsidies are payments made to the inputs in the production of agriculture such as the technology or resources used. Their effects are twofold, changing the mix of inputs used and also the combination of products that are finally produced. Supply payments and limits are policies that affect large producers by limiting the amount of direct payments and hectares eligible for direct payments. Farm-based payments are those that are made based on previous/historical attributes of farms and thus are not seen to affect current production. However, because they increase farmers wealth and change risk attitudes, they also may intensify production (Mayrand et al., 2003).

In India, agricultural policies that affect production include the Minimum Support Price (MSP) for food grains and an open ended procurement policy whereby farmers can sell, to the government, all their excesses, at the going minimum support price. These supports are provided for wheat and rice raising production levels of both of these crops which have larger water requirements than what would be grown in the absence of the policy (Sinha, Sharma, and Scott, 2006).

Agricultural polices around the world are now also heavily focused on biofuel policy. With growing concerns about the Green House Gas emissions of traditional fuels sources and energy security, biofuel crops are becoming an important player in agriculture. Biofuels, to date, consist of two generations. The first is ethanol produced maize and sugarcane and biodiesel produced from palm oil, rapeseed, jatropha, etc. The first generation of biofuels have already received huge subsidies and are not feasible without these. The second generation of biofuels consists of ethanol that is derived from cellulosic sources such as woody biomass, wheat straw, corn stover and perennials like switchgrass and miscanthus. The technology for producing ethanol from these sources have not been perfected and it remains to be seen whether they will be viable. However, many countries are already implementing policies and targets for production of both generations of biofuels without taking the water and energy considerations into account.

The US can provide some insights where biofuel policy has been set forth where water concerns may have not been addressed. The demand and production of liquid biofuels has been encourages with the Clean Air Act Amendments of 1990, the Energy Policy Act, and the Energy Conservation Reauthorization Act. More recently, the Energy Security and Independence Act of 2007 further mandated that 36 billion gallons of biofuels be produced within the country. Only fifteen billion of this can be from current corn ethanol, the rest must come from the second generation of biofuels. Thus, there is a problem when policies are being put in place to implement a technology that may cause more damage then good in terms of at least one resource, water. Current production is also being promoted with subsidies to corn growers and tariffs on imported sugarcane ethanol from Brazil (Gorter and Just, 2008).

There may also be secondary impacts of agricultural biofuel policy. Water quality may be affected with increased use of fertilizers and pesticides (Doornbosch and Steenblik, 2007). Nitrogen and phosphorous run off can contaminate groundwater aquifers and are a likely side effect of increased maize and soybean production for fuel (Meijerink, Langeveld, and Hellegars, 2008). Although, it is unlikely that the water diversion to biofuels will cause concern at a global level, regional impacts could be significant, especially in India and China where water scarcity problems are already a problem (Fraiture and Berndes, 2008; Fraiture, Giordano, and Liao, 2008).

Discussion

We have seen that water, energy, and agricultural policy are all closely linked. The water-energy nexus is cyclical in nature, where saving water can save energy and vice versa. As a result, energy policy, especially in groundwater, has been acknowledged as a powerful tool to control groundwater overdraft. Ultimately, however, the use of these two inputs is dependent on the crops produced. Agricultural policy has a direct impact on crop choices and as a result can be used to manage both water and energy.

Agricultural policy has direct effects on production and indirect effects on the environment including water and energy. In the Organization of Economic Co-operation and Development (OECD) countries, agricultural subsidies usually lead to intensification of production and increased use of fertilizers and pesticides which are detrimental to the environment, including water quality (Mayrand et al., 2003). However, the relationship is not proportional and thus a policy to remove subsidies has to be analyzed carefully. This is because the incentives that lead to intensification in production may not be automatically removed when the subsidy is removed. Similarly, policies that target use of fertilizers and pesticides may not lead to direct beneficial outcomes in terms of reduction in the amount of run-off in groundwater because the application rates do not translate as such (Mayrand et al., 2003). Therefore, subsidies or removal of subsidies must be further studied to analyze what effects actually occur.

Inputs in agriculture consist of more than just fertilizers and pesticides. The technology implemented can also be considered as an input and policy can target the technology used by farmers. In India, this has been the case with groundwater irrigation. Pump sets were implemented because they were highly subsidized by the government. Policy could provide incentives for the use of low energy precision application (LEPA) center pivot and other type of drip, tickle and low-flow micro sprinklers. These technologies require not only less water but less energy per unit of production (USDA, 2006). Further, sprinkler irrigation can be of high, medium, or low pressure and USDA (2006) found that in the US, changing the area under medium pressure to low pressure would result in energy savings of $40 per acre and translates to a 560 Kwhr reduction in energy use. Therefore, policies that target adoption of lower pressure irrigation systems in the US can reduce both water and energy use in agriculture.

In China, rice production has fallen due to lower world prices and higher costs of electricity. Rain fed maize is the alternative crop being grown and as a result, groundwater use is falling (IWMI, 2006). In comparison, in India, although rice and wheat production may have fallen due to depressed world prices, the MSP and procurement policies in agriculture prevent this from happening resulting in continued groundwater extraction (Sinha, Sharma, and Scott, 2006).

It should also be noted that the spatial distribution of water resources must be taken into account in agricultural policy design. In the Indian subcontinent, the Western states, that are drier are those that have current policies that are geared towards more agricultural production. However, the eastern states, Nepal

terai, and Bangladesh, where rainfall is greater and groundwater is at shallower depths, agricultural policy could be used to further stimulate growth in water intensive crops. Development of groundwater in this region could also help to alleviate problems of flooding and water logging (Shah, 2001). Technology based agricultural policy solutions, such as the promotion of smaller diesel pumps and manual irrigation technologies have the potential to create greater use of the groundwater. Further, there is pump-capital scarcity, which can be addressed by changing the pump subsidy schemes that exist (Shah, 2001).

Conclusion

Decreasing water and energy resources coupled with a rise in demand for both has created a nexus where policy in either sector can effect the other. Water and energy are also important resources in the production of agriculture. Therefore, agricultural policy in having a role on what is eventually produced can also contribute to the better management of both water and energy resources.

This is especially true in the groundwater economies of South Asia and North China where many of the world's poor depend on agriculture for their livelihoods. Here, it is especially important to strike a balance in the development of water, energy, and agricultural policy and that institutions that create these policies do so together. Often times, policies are put in place to achieve the goals in one sector without thinking about the effects on another. Yet, it has been shown that energy policy has had substantial impacts on groundwater use in India.

Agricultural policy can play a complementary role along with energy policy. They can target crop choice, the inputs/technology in production, and can contain a spatial aspect that accounts for regional variability in water and energy resources. A holistic approach, which is currently lacking in most of the developing world, is what is needed to manage water and energy resources while maintaining the livelihoods of the agricultural communities and meeting food demands.

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