

# How Politics and Economics Affect Irrigation and Conservation

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A growing population and rising incomes have challenged agricultural supply and led to drastic increases in irrigated agriculture. Globally, irrigated acreage increased by 76% between 1970 and 2012 (Food and Agricultural Organization of the United Nations, 2014). Irrigated agriculture can produce crop yields two to four times greater than rain-fed agriculture (Renner, 2012). Parallel to the increased demand for agricultural water, demand for municipal and industrial uses of water also rose. As overall demand for consumptive use water mounts, there are growing preferences for environmental preservation, concern for depletion of groundwater reserves, and, thus, calls for limiting the supply of water available for consumptive use (Organisation for Economic Co-operation and Development, 2015; Wada et al., 2010). There is a perceived crisis in water availability and a growing need to develop solutions that will increase supply and reduce water demand.

This article argues that much of the current water situation is a reflection of institutional and political arrangements. It further develops a political economics framework that explains the existing water allocation arrangement and suggests directions for institutional reforms. Since agriculture is responsible for more than 70% of consumptive water use in most countries, the analysis will concentrate on water resource allocation in the context of agriculture, specifically explaining the dynamics behind water products and water rights systems. We also address the challenges associated with introducing and adopting water conservation methods in agriculture and why their performance varies across regions. Finally, we provide policy recommendations and conclusions.

## The Emergence of Water Policies and Institutions

Research on the history of agricultural policies (Cochrane, 1979) emphasizes that government aims to design policies to achieve multiple objectives. In the context of agriculture, these include (among others) providing resources (e.g., land and water) and developing technologies to expand agricultural production and provide safe and affordable food, assuring security of the food supply given random events, protecting farmers' income, and developing mechanisms to protect the environment. Water projects were also established as a mechanism to control floods.

The weight given to different objectives may change over time, and government choices are made subject to constraints based on control and availability of resources and ability to tax and obtain credit. In the 19th century, expanding agricultural production and land base was a major priority in the United States. There was abundance of water and land, but at the same time, the government had limited financial resources. As a result, the government established a homesteading system that allowed farmers who settled frontier regions to receive land ownership as long as they remained on the land. Similarly, in the case of water resources, farmers and other water users (both as individuals and groups) were given the right to divert water for "beneficial use," and the seniority of water rights was based on time of diversion ("first in time, first in line"). These rights were maintained as long as they were used ("use it or lose it"). During the 19th century, water districts of farmers and miners established water diversion projects that were key for agricultural activities through the West. Farmers started to pump groundwater to a limited extent.

After the establishment of personal income tax in 1909, the federal government's income greatly increased, which led to the development of large infrastructure as a major policy objective. In the early 20th century, expanding agricultural capacity continued to be a major policy objective, but most of the arable continental United States was settled and utilized. Agricultural cropland reached its peak in 1919, so the government expanded research and development to increase productivity and developed major water projects through the Army Corps of Engineers and the Bureau of Reclamation, established in 1902. During the first part of the 20th century, the government financed major projects on the Columbia and Colorado rivers, in the Tennessee Valley, and in the Central Valley in California. Some of these projects were part of the government effort to provide public works in response to the Great Depression.

The decisions about water projects were heavily based on political considerations, and economists have criticized a few of the major projects, such as the Central Arizona Project, on a benefits-costs basis (Bush and Martin, 1986). Agencies like the Bureau of Reclamation and Army Corps of Engineers, as well as individual legislators, pushed for further expansion of environmental projects, and there were even proposals to divert water from the Great Lakes to Arizona and from Alaska to California (Reisner, 1993). But growing environmental awareness, as well as mounting budgetary pressures in the 1970s and increased awareness of economic inefficiencies of water projects, led to the requirement to use benefit-cost analysis to evaluate new water projects, where the criteria of evaluation (Water Resources Council, 1983) must account for environmental side effects. These criteria have been subject to criticisms and re-evaluation, but their introduction led to reduced expansion of water projects in the United States (Shabman and Stephenson, 2000). Parallel to the introduction of benefit-cost analysis to assess water projects in the United States, the use of this analysis to assess water projects around the world increased (e.g., Pearce, 1998).

The constraints on construction of new projects added incentives to increase the efficiency of utilization of water resources in agriculture. One approach is the transition toward relying on markets to allocate water resources. In many parts of the world, water allocation was based on water rights and trading these rights was prohibited. Ability to sell water at market prices would induce farmers to switch away from water-consuming crops and to adopt water conservation technologies. However, there has been significant resistance to introduction of water markets for several reasons. First, owners of water rights objected to proposals to introduce water trading by putting water rights to bid among potential users, and this led to a consideration of mechanisms of tradable permits. Second, reliance on market forces to price water may have negative equity effects, especially on poor consumers or subsistence farmers.

One approach to address this concern is tiered pricing, in which users are given a minimum amount of water at a low cost but must pay the marginal cost of water beyond a certain level of use. This approach is especially effective in allocating water within water districts and to small water users and can be designed to meet both equity and efficiency objectives for small water users (Schoengold and Zilberman, 2014). Third, there have been concerns about third-party effects (not all the applied water is used by crops, and the residues are used to serve environmental purposes) and about loss of income within regions as economic activities may move as water is traded. This led to some constraints on water trading; for example, farmers can sell only a portion of their allocation (Schoengold and Zilberman, 2005). In some western states, the environmental benefits of water were not considered a beneficial use of water resources, and federal water projects therefore distributed water rights only for industrial and agricultural use.

The Central Valley Project Improvement Act of 1993 was a political compromise that recognized environmental water use as beneficial, reallocated 10% of Central Valley Project water to environmental purposes, and at the same time approved the sale of water rights to municipalities. This reform was introduced after the drought of 1987–1991, and its introduction illustrates that water reform tends to occur after periods of crisis, major droughts or floods, when the power and influence of different groups are changing and the status quo becomes difficult to maintain (Fischhendler and Zilberman, 2005). Similarly, the large water reform in Australia that enhanced water trading occurred after the big drought of 2001–2009 (Young, 2010; Grafton and Horn, 2014). A crisis situation also leads to major public investment decisions. For example, Israel invested in recycling and reuse of water to address growing deficits (Tsur, 2015). After the 2011–2015 drought, California introduced the Sustainable Groundwater Management Act, which will require monitoring of groundwater and control against excessive pumping (Brown, 2017).

## Challenges and Possibilities of Water Conservation Technologies

One important strategy that has been proposed to address water shortages is the adoption of modern water conservation technologies. However, a growing literature suggests that adopting improved irrigation technologies does not necessarily save water. Thus, understanding the conditions under which irrigation technology adoption leads to conservation is a major challenge (Perry and Steduto, 2017).

There is a large literature on the economics of modern irrigation technologies. A key distinction is between applied water and effective water. The ratio of these two measures is water-use efficiency, which is affected by irrigation technologies as well as land quality. Irrigation efficiency is higher when water is applied on heavy soils and level land, while it is low on sandy soils and steep hills. Thus, irrigation technologies often serve to improve the water-holding capacity of soils. By increasing water-use efficiency, these technologies tend to increase yield (Caswell and Zilberman, 1985) and may reduce drainage and water logging. Shani et al. (2009) suggest that technologies like drip irrigation can also improve the timing of irrigation and maintain stable soil moisture, which both contribute to increased yield and may save water. Drip irrigation is also used as an effective mechanism for fertigation and chemigation, saving chemicals as well as reducing externalities. Generally, modern irrigation technologies (like drip irrigation) are costly compared to flood irrigation, and theory suggests that technologies are likely to be adopted on high-value crops and in locations with sandy soils or steep hills, high input prices, or concerns about environmental side effects. But while adoption of these technologies is likely to increase supply of output, they will not necessarily reduce demand for water, especially when their yield effect is substantial and in regions where demand for the final product is elastic.

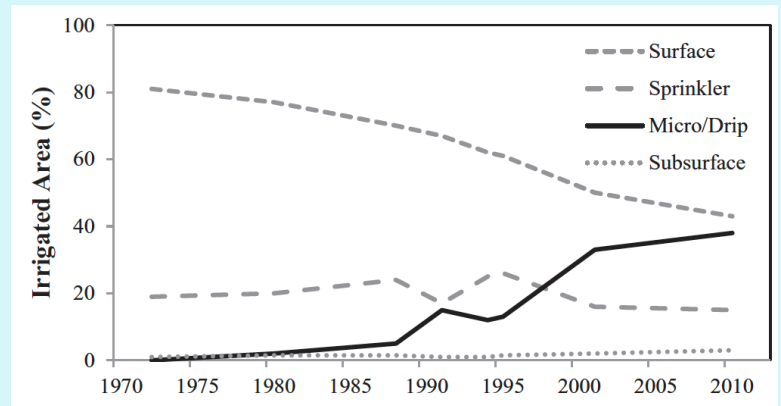
For example, Dagnino and Ward (2012) provide evidence that increased adoption of conservation led to additional water demand due to increased land cultivation as a result of improved profitability of farming. Furthermore, some suggest that adopting water irrigation can be used as a mechanism to reduce storage. Xie and Zilberman (2017) provide numerical analyses to show that water storage and modern irrigation technologies are not necessarily substitutions but instead may serve as complements in situations where water conservation technologies increase demand for water or conservation may increase the probability that water storage capacities are exhausted and thus more storage is needed. Thus, adoption of water conservation technologies is not necessarily a means to reduce water use but rather provides economic incentive to enhance water projects, and can be an effective mechanism to increase the economic performance of the agricultural sector. Of course, with a given amount of water capacity, conservation technologies can increase significantly the value of agricultural production.

Studies have found that adoption of conservation technologies like drip and sprinkler systems led to significant economic benefits in terms of increased yield as well as water savings in California, Israel, Spain, and Greece (Taylor and Zilberman, 2017). In all cases, diffusion was gradual in high-value crops and frequently occurred after periods of crisis. Successful adopters tend to have a high degree of human capital and strong support from industry. Failures and subpar performance of modern irrigation technologies in some developing countries were frequently due to lack of maintenance and support and an unreliable water supply.

The importance of timing and institutional and economic considerations in introducing conservation technologies is illustrated by the diffusion of drip irrigation in California, which was first introduced from Israel in the 1960s. The Israeli version was adopted on tree crops in Southern California, and joint public-private efforts led to the introduction of plastic tapes that were then adopted with strawberries. As Figure 1 shows, adoption rates were low until the drought of 1976–1978. The diffusion rate was still low after the drought due to uncertainty regarding quality and performance of the technology, which were—to some extent—partially addressed by establishing strong public sector activities to provide outreach and certification. The second boost to diffusion was the drought of the 1987–1991. Much of the diffusion was a result of reduction of surface water delivery by the state and increased reliance on expensive groundwater. Additionally, trading was enhanced as the state introduced “water bank,” a state-run exchange between farmers in different regions and that enabled farmers to sell water rights and provide them incentives for conservation, beginning with the 1993 passage of the Central Valley Project Improvement Act. Furthermore, political consensus on the need to conserve water in agriculture led to state investment in weather information stations (CIMIS – California Irrigation Management Information Services) and public research and extension efforts.

Cooperative Extension efforts contributed to the adoption of agricultural practices and crop varieties compatible with modern irrigation. Combined with continuous improvement in technology, these changes led to the adoption of processing tomatoes and other crops that had not previously been profitable (Taylor and Zilberman, 2017). Currently, 60% of irrigated agriculture uses drip/micro sprinklers (40%) and sprinklers (20%); surface irrigation has declined to below 50% and is mostly used on relatively low-value field crops in regions with heavy soils (Figure 1). Annual gains from yield increases and water saving associated with the adoption of drip irrigation in California are computed to be between \$313 million and \$1.13 billion (Taylor, Parker, and Zilberman, 2014).

**Figure 1. Trends in Irrigated Area (%) by Irrigation System Category in California**



Source: Tindula, Orang, and Snyder (2013).

## Conclusions

Water resource management reform may increase the environmental and economic benefits of water resources. Increased demand for agricultural products may increase reliance on irrigation, but water use sustainability is likely to be achieved by effective policies that lead to reduced pollution and over-pumping, increased water trading, and the adoption of conservation technologies. However, water policies are evolving, reflecting changing political and economic circumstances. Over-investment in water projects and restriction on water trading in the past were a result of perceived water abundance and a desire to accelerate development, ignoring environmental side effects. Recognition of scarcity and environmental considerations led to reforms mostly motivated by crises. There is a growing reliance on benefit-cost analysis in assessing water projects and on water trading, but much needs to be done, including improved regulation of groundwater pumping and water pricing schemes to balance equity and efficiency considerations.

Technology—including conservation, desalination, and reuse—can address some of the challenges facing water resources. Government agencies and the private sector can enhance the implementation of effective policies by supporting public research and Extension to improve technologies and adapt them to local conditions by providing regulations to ensure product quality and by enhancing farmer actions through effective education.

## For More Information

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