POLICY INSTRUMENTS FOR GROUND WATER ALLOCATION IN DUTCH AGRICULTURE

Petra Hellegers

Ekko van Ierland

ABSTRACT

The economic efficiency of current and alternative ground water policies for Dutch agriculture and their impact on the adoption of modern irrigation technology have been investigated. The study shows that the current system of historical ground water extraction rights and sprinkling bans is inefficient and provides fewer incentives for the adoption of modern irrigation technology than does a system that considers externalities in the price of water or diverts water away from agriculture while encouraging trading. These inefficiencies may result in low-value use of ground water and the use of traditional irrigation technologies, which may cause desiccation.

Key words: agricultural ground water allocation mechanisms, efficiency, modern irrigation technology adoption

INTRODUCTION

Policy instruments for ground water allocation such as tradable extraction rights, sprinkling bans, and ground water extraction charges determine both the economic efficiency of ground water use and the distribution of ground water among users. They can "queue" users and restrict or encourage the transfer and trading of water and adoption of water saving technologies. The current ground water extraction rights system together with the low ground water prices encourage low-value agricultural ground water usage in The Netherlands. Extraction can result in desiccation of nature areas. Sprinkling bans in periods of serious drought and irrigation scheduling currently aim to reduce low-value use of ground water, but it is not clear whether these measures are efficient and whether they provide incentives for the adoption of modern irrigation technology.

Economic literature on mechanisms to allocate ground water in The Netherlands has been limited, especially with respect to agriculture. Wiersma (1998) investigated a more efficient ground water allocation procedure based on regional auctions for Dutch ground water extraction permits. He does not consider agricultural extractions in his analysis, because they are only temporary and will be reduced by sprinkling bans. There is, however, extensive literature available (e.g. Michelson & Young 1993; Dinar & Wolf 1994; Strosser, 1997) on the role of ground water allocation mechanisms in other countries.

In this paper we will investigate whether current and alternative mechanisms allocate ground water efficiently and whether they provide incentives for the adoption of modern irrigation technology. We addressed the following research questions:

1. Do current ground water policies allocate ground water efficiently in The Netherlands?
2. What kind of alternative policies can be used to achieve a more efficient allocation?
3. Do these policies provide incentives for the adoption of modern irrigation technology?

To answer these questions, Dutch ground water management problems and economic efficiency concepts are explained in more detail in Section 2. Section 3 studies the economic efficiency of current ground water policies. Section 4 studies the economic efficiency of alternative ground water policies. Finally, Section 5 contains the discussion and conclusions.

ECONOMIC INEFFICIENCY AND RELATED DUTCH WATER PROBLEMS

In The Netherlands, current ground water policies encourage both low-value agricultural ground water use, like the sprinkling of grasslands, and the use of traditional irrigation technologies with a low irrigation effectiveness. Extraction may reduce temporarily and locally the availability of water for environmental amenities. Plant species adapted to wet and moist environments disappear due to a lack of soil moisture. As a result biodiversity will decline. So, extraction may cause externalities. Private behaviour is inefficient from a social point of view in the presence of externalities that are not taken into account. Therefore we will evaluate the efficiency of various ground water policies. Two kinds of criteria to evaluate efficiency can be distinguished; allocative and technical efficiency (Perman *et al*., 1999):

- *Allocative efficiency* requires the marginal value of water to be the same for the last unit of water consumed by each user and equal to the marginal cost of supplying water. Transactions are interesting when differences exist between the marginal value of water for different uses.
- *Technical efficiency* is measured by the ratio between output and inputs. Technical efficiency can be improved by adoption of modern water saving technologies, which produce the same output with less inputs. Allocation mechanisms, which establish a higher water price provide incentives for the adoption of modern irrigation technology (Zilberman and Lipper, 1999).

CURRENT GROUND WATER POLICIES

In this section we will show that current ground water policies are in many situations inefficient. Alternative policies to improve the economic efficiency will be discussed in Section 4. Table 1 shows whether current (row *3a* until row *3d*) and alternative (row *4a* until row *4e)* policies achieve the socially optimal water price, an efficient allocation, and provide incentives for the adoption of modern irrigation technology; i.e. improve the technical efficiency. It also shows prerequisites for policy instruments to be effective.

Table 1. Overview of the characteristics of various ground water policies

Instrument	Socially optimal water price	The value of the marginal product is equal among all			Incentives for adoption of modern technology	Prerequisites for policy instruments to be effective
		users	farm land	land at the farm		
Current policies						
3a Current price of water use	N	N	Y	Y	N	
3b Current extraction rights	N	N	Y	Y	N	
3c Current sprinkling bans	N	N	N	N	Y	Penalties
3d Irrigation scheduling	N	N	N	N	Y	Adoption
Alternative policies						
4a Water pricing reform	Y	Y	Y	Y	Y	Negative price elasticity
4b (non)tradable extraction rights:						
Quota: -proportion current use	N	Y	N	Y	Y	Penalties, efficient
-per crop	N	Y	Y	Y	Y	assignment of quota
Markets:-without restriction on use	N	N	Y	Y	N	Efficiency gains have to
-with restrictions on use	Y	Y	Y	Y	Y	exceed transaction cost
4c Fine-tuned sprinkling bans	N	Y	Y	Y	Y	Penalties, fine-tuning
4d Persuasion	N	N	N	N	Y	No myopic behaviour
4e Subsidy: -proportion current use	N	Y	N	Y	N	Participation in subsidy
-per crop	N	Y	Y	Y	N	schemes

1) Y means that the price is equal to the socially optimal water price or that the value of the marginal product of water is equal among all users or farmland or land at the farm or that incentives exist for the adoption of modern irrigation technology; N means that this is not the case

3a) Current Price of Water Use

Since it was introduced in January 1995, Dutch ground water extraction is subject to a charge of € 0.08 per m^3 (to be increased to € 0.15 per m^3), but the current charge is restricted to farmers withdrawing more than 30,000 m^3 of ground water per annum. Only a small percentage of farmers (about 1 to 2 percent) exceed this charge-free threshold, and are subject to this charge (Staalduinen *et al*. 1996). Most farmers currently only pay the energy costs of lifting water from the stock to the field (i.e. about € 0.04 per m^3).

The current pricing system of water implies that externalities, which arise due to agricultural ground water extraction, are not yet fully internalised in the price of applied water. Marginal values of the last unit of ground water applied are not equal among users, since farmers maximise individual (instead of social) current (instead of future) profit each period. In the absence of sprinkling bans, it seems reasonable to assume that they pump water until its marginal net benefit is zero. The value of the marginal product is therefore equal among all farmland irrigated. Such a low water price does not provide incentives for the adoption of modern irrigation technology (see row *3a* in Table 1).

3b) Current Extraction Rights

In The Netherlands, ground water extraction is currently determined by free extraction licences granted by local authorities (provinces) in the past. These licences can be considered as historical extraction rights ("grand-fathering rules"). An extraction right was only refused when the extraction could damage other users, while damage of extraction to ecosystems was until very recently not taken into account. Under such a ground water extraction rights system nature is jeopardised, since it encourages agricultural ground water extraction.

The current ground water extraction rights system is not efficient, since current allocation rules are based on a "queuing" system that restricts the transfer and trading of water rights. The water price which is equal to the extraction costs, will be below the socially optimal water price, which provides fewer incentives for the adoption of modern irrigation technology. Current allocation rules "queue" in particular users who are interested in the maintenance of stream flows like nature. Marginal values of the last unit of ground water applied are not equal among users (see row *3b* in Table 1).

3c) Current Sprinkling Bans

Low-value agricultural use of ground water by agriculture is currently reduced by imposing sprinkling bans, diverting water away from current agricultural use to non-agricultural and/or future use. These bans differ per province and vary with respect to the source of water used (ground water versus surface water), crop grown (grass versus arable), soil type (sandy versus clay), and time period (part of the year and day). Bans especially aim to reduce ground water use for sprinkling of grass on sandy soils in areas sensitive to desiccation during dry periods.

Current bans are only rough restrictions and are not efficient. There are for instance no arable crop-specific sprinkling bans, while marginal values of water vary among arable crops. If bans reduce current ground water usage, they will increase the shadow price, which will provide incentives for the adoption of modern irrigation technology (see row *3c* in Table 1).

3d) Irrigation Scheduling

In response to the resistance the bans raised, a management tool for irrigation scheduling was developed and tested in 1995, often referred to as the irrigation planner. It gives farmers a better insight into the moisture regime of their plots, the best timing to start irrigation and the best water dose, and prevents over-irrigation and thus increases the irrigation effectiveness. It does not only have *a water-saving effect* but also has a variable *cost-saving effect* with respect to extraction cost. The irrigation planner is a *disembodied innovation*, which means that it is not embodied in a physical item. It is practical knowledge that can be shared by many users. It is an *unshielded innovation*, since the ability of private firms to appropriate some of the benefits associated with the use of it is limited (Sunding & Zilberman, 1999). The development of the irrigation planner was therefore a public funded R&D effort.

If irrigation scheduling is adopted, it will improve the technical efficiency. The water price will, however, still be below the socially optimal water price. The value of the marginal product will not be equal among land at the farm, since the irrigation planner gives only rough indications to reduce usage (see row *3d* in Table 1).

Alternative Ground Water Policies

In Section 3 it became clear that current ground water policies are indeed inefficient. The efficiency of new options and their impact on the adoption of modern irrigation technology are studied in this section. We discuss the pros and cons of 1) three economic instruments, water pricing reform, agricultural water markets and subsidies; 2) two command and control based instruments, quota and fine-tuned bans; and 3) a social instrument, persuasion.

4a) Water Pricing Reform

The extent of divergence between the private and social price of water, represents the optimal volumetric charge that induces the individual farmer to behave in the socially optimal way. Not only extraction costs but also environmental and resource costs have to be considered in the socially optimal price of water. This increases the price of water and consequently creates incentives for the adoption of modern irrigation technology (see row *4a* in Table 1).

The theoretical framework of efficient water-pricing schemes is clear, but there are some problems. Firstly, it is hard to determine the level of charges, since monetary values have to be attached to the damage due to excessive use of ground water, whereas perpetrators of externalities usually evaluate damage less severely than other interest groups. Secondly, water pricing schemes often ignore information needed for implementation. Implementation problems are linked to enforcement, monitoring, institutional limitations, conflicting policies, and welfare implications. Thirdly, the introduction of price reform is conditional upon the size of the social gains relative to the transaction costs. Additional costs will be low, because only the charge-free threshold has to be reduced under the current ground water tax system. Finally, water-pricing reform only has a positive influence on water conservation if the price elasticity of water demand is significantly different from zero and is negative. Agricultural water demand is usually inelastic only up to a given price level (Garrido, 1999). This "price threshold" depends on the productivity of water, the set of alternative production strategies, the proportion of land devoted to permanently-irrigated crops, and the irrigation technologies.

4b) (Non)tradable Extraction Rights:

Ground Water Extraction Quota

Ground water extraction rights have to be divided among farmers with the intention to allocate a restricted amount of supply in a most efficient and equitable way, which is not easy to establish. Quotas can be assigned in proportion to ground water extraction by each farmer in a certain base period. In that case the marginal value of the last unit of water applied becomes equal among land at the farm, but not among all farmland. Alternatively, quotas can be assigned per crop in such a way that the marginal value of the last unit of water applied becomes equal among all farmland, which is more efficient. The first assignment seems to be more socially equitable, because the latter assignment will target some farms, mainly with low-value use, more seriously than others. Economists provide, however, only insight into alternative allocations of rents. Policy makers have to judge whether this is socially equitable. The shadow price of agricultural ground water use will increase if ground water is diverted away from current agricultural use to non-agricultural and/or future use by means of a quota, which will provide incentives for the adoption of modern irrigation technology. Adequate penalties have to be imposed, which involves monitoring and control costs.

Agricultural Ground Water Extraction Rights Markets

The efficiency gains of agriculture associated with the transition from "queuing" systems to agricultural extraction rights markets result from an increase in the area of land that the amount of ground water available for agriculture can serve (Zilberman et al., 1994). Moving water that has a relatively low marginal productivity to land that has not been irrigated before increases water productivity (Shah & Zilberman, 1992). Because water availability per hectare is currently relatively large on all farmland on which irrigation is desirable in The Netherlands (although not during all seasons), transition to agricultural extraction rights markets is less interesting. Efficiency gains will be small relative to the transaction costs. Agricultural extraction rights markets will become more interesting if agricultural water availability is restricted to the socially optimal level. Transition to agricultural water markets while diverting water away from current agricultural use may decrease agricultural sector's well-being to some extent, but is desirable from a social point of view. A possible efficiency gain of agriculture is associated with the adoption of modern technologies, which result from incentives created by higher water prices established under agricultural water rights markets.

An equitable introduction of water markets is hard to establish. Rights can, for instance, be auctioned off so that the authorities reap all the rent from new entitlements. An alternative is to allow senior rights owners to sell their water to buyers and benefit from the revenues of the sales. It is important to avoid transfers of extraction rights to regions sensitive to desiccation.

4c) Fine-Tuned Bans

If bans are fine-tuned to resource, region, soil, crop, and time specific circumstances and set to achieve the socially optimal agricultural ground water use level, they will allocate water efficiently. Such bans increase the shadow price, which provides incentives for the adoption of modern irrigation technology. There is a high demand for technical knowledge to fine-tune the bans. Nevertheless, they are suitable to restrict extraction under specific circumstances. Transaction costs will be low; it is only a refinement of current bans (see row *4c* in Table 1).

4d) Persuasion to Adopt Irrigation Scheduling

It is not likely that farmers will adopt irrigation scheduling under the low water prices they currently face. Motives for adoption of the irrigation planner are saving in costs, government-supported incentives, and persuasion. Motives for not using it are the investment costs that it entails, its complexity and the effort that its use will require. Practical test results showed that indeed only a small group of farmers would start using the irrigation planner of their own accord (Boland et al., 1996). Farmers are therefore subsidised and extension and education activities were started to encourage adoption. Besides, farmers were persuaded that bans would be abolished in the region, if a certain diffusion rate was met, i.e. if a certain number of farmers adopted the irrigation planner. Those who do not adopt also benefit from abolition. They can be considered as "free riders." It is hard to persuade farmers that extraction has a negative impact, because they often behave myopic (see row *4d* in Table 1).

4e) Subsidies to Reduce Agricultural Water Use

Subsidies can be provided to reduce ground water use to the socially optimal application level. A reduction in extraction is, however, not guaranteed, since participation is often voluntary. Besides, no increase in the water price will be established. Various possibilities to integrate water subsidies in Common Agricultural Policies are described below:

- An option is to design agri-environmental programmes under regulation 2078/92, that can be used to compensate farmers for the damage due to a reduction in ground water extraction; for instance, wetland recovery like in Spain (Varela & Sumpsi, 1999). Payments can be based on proportional reductions of current extraction or on crop specific reductions.
- Another option is to attach environmental conditions like less ground water extraction to direct income payments and to withhold payments to farmers who do not fulfil environmental conditions like defined in the Codes of Good Agricultural Practice; i.e. to use the instrument of cross-compliance. No additional subsidy is received. Money saved can be re-allocated to increase agri-environmental programmes for the protection of ground water resources.
- Finally, farmers and nature conservationists can make commitments on the use of ground water in a voluntary agreement and negotiate about compensation payments.

DISCUSSION

This study shows that current policies do indeed allocate ground water inefficiently in The Netherlands. We found that the current system of water prices, extraction rights, sprinkling bans, and irrigation scheduling did not equalise the value of the marginal product of water among all users and that nature may consequently be desiccated.

The study also shows that various alternative mechanisms can be used to achieve a more efficient allocation of ground water, but that each has its own prerequisites which have to be fulfilled. Whether the command and control based instruments studied here will allocate ground water efficiently depends on the penalties imposed, the way quotas are assigned, and the way bans are fine-tuned. Economic instruments like subsidies and pricing reforms will only reduce usage if farmers participate in subsidy schemes and if the price elasticity of water demand is negative. The theoretical framework of efficient water pricing is clear, but there are implementation problems. Persuasion only works if farmers do not behave myopically. Introduction of instruments is conditional upon the size of the social gains relative to the transaction costs. The high transaction costs of agricultural water markets are especially a problem when water availability per hectare for irrigation is large, which is currently the case in The Netherlands. In that case there will be efficiency gains if availability is restricted.

Allocation mechanisms that increase the price or shadow price of water provide incentives for the adoption of modern irrigation technology; i.e. improve the technical efficiency. We found that volumetric charges and water markets with a restriction on usage increased the water price, while quotas and sprinkling bans increased the shadow price of water and therefore create incentives for the adoption of modern irrigation technology. Since current water prices only reflect extraction costs under current extraction rights, they do not create incentives for the adoption of modern irrigation technology.

We should be careful with exceptions when allocation mechanisms are being designed as illustrated by the charge-free threshold for agricultural ground water extraction, which is only exceeded by a small percentage of farmers. This charge on ground water extraction is not a very effective policy instrument to reduce low-value agricultural ground water extraction.
In this paper various ground water policies are discussed separately, whereas they can be combined in such a way that they reinforce each other. The irrigation planner, for instance, seems to be a very useful instrument in combination with other instruments. An empirical analysis can provide insight into the optimal instrument mix.

According to the farmers irrigation of grassland is not a low-value application, because benefits other than changes in output should be calculated as well. If soils are very sensitive to drought, irrigation may be essential for good farm management to avoid a long recovery period of the crop due to drought damage to the roots. Besides, irrigation leads to better mineral utilisation, which is beneficial to the environment.

The study shows that the current system of historical ground water extraction rights and sprinkling bans is inefficient and provides fewer incentives for the adoption of modern irrigation technology than does a system that considers externalities in the price of water or diverts water away from agriculture while encouraging trading.

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