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Policy Instruments for Groundwater Management in the Netherlands

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Abstract. In the Netherlands agriculture and nature have conflicting interests with respect to groundwater management. Insight into the suitability of policy instruments to achieve optimal groundwater level and extraction management in the Netherlands is, however, missing. In this paper the suitability of policy instruments for groundwater management is studied. Changes in the institutional environment and voluntary agreements seem to be more suitable for groundwater level management than economic instruments. The current historical groundwater extraction rights systems together with the low groundwater prices encourage low-value agricultural groundwater usage, whereas sprinkling bans and irrigation scheduling currently aim to reduce low-value use of groundwater. These extraction instruments are less efficient than a system that considers externalities in the price of water or diverts water away from agriculture while encouraging trading.

Key words: agriculture, efficiency, policy instruments, water management

JEL classification: Q15, Q25, Q28

1. Introduction

In the Netherlands nature reserves are suffering from desiccation, due to falling groundwater levels. Intensification of agricultural activities contributed to the lowering of groundwater levels by intensified drainage of farmland and increased agricultural groundwater extraction. In the presence of growing conflicts between agriculture and nature with respect to groundwater management, there is a pressing need to have insight into the suitability of policy instruments to achieve optimal groundwater level and extraction management.

Economic literature on the role of policy instruments for groundwater management in the Netherlands has been limited, especially with respect to agriculture. There is, however, extensive literature available (e.g., Michelson and Young 1993; Dinar and Wolf 1994; Strosser 1997) on the role of groundwater allocation mechanisms in other countries.

As policy instruments have major impacts on the efficiency and effectiveness of water allocation as well as on the distribution of costs and benefits, which may affect the political feasibility, it is important to study both their current and

their potential role. *The aim of this chapter is therefore to test the suitability of various instruments for groundwater level and extraction management in the Netherlands*. We will study the suitability of three economic instruments, one regulatory instrument, one suasive instrument and a change in the institutional environment. To provide insight into the suitability of these policy instruments, they will be reviewed against six performance criteria: environmental effectiveness, economic efficiency, technical efficiency, administrative feasibility, equity and acceptability.

The structure of this chapter is as follows. In Section 2 current instruments for groundwater level management are discussed and the suitability of alternative instruments is tested. In Section 3 current instruments for groundwater extraction management are discussed and the suitability of alternative instruments is tested. Section 4 contains the conclusions.

2. Suitability of Policy Instruments for Groundwater Level Management

In this section we will test the suitability of instruments for groundwater level management. It is important to note that economic instruments are at present not used for groundwater level management in the Netherlands. We will first explain how current instruments work. Then we will discuss whether improvements are desirable and we will propose some alternatives. The performance of each of the instruments will be discussed separately. First we describe the prerequisites for instruments to be effective. After that we discuss whether it improves the economic and technical efficiency. Next we discuss the administrative feasibility. We also discuss whether the financial impact is equitably distributed among affected parties, which affects the acceptability. Finally, practical implementation problems will be addressed. The results of these tests are summarised in Table I.

Economic instruments

1A) Theoretically, a *tax* can be used to discourage farmers from lowering the groundwater level below a certain threshold. The effectiveness of a tax depends on the right estimation of the marginal tax level and on the risk attitude of farmers with respect to wet damage. A differentiated tax level has to be created where there are local differences in the value of reserves or the vulnerability of the environment to changes in the groundwater level. An advantage of a tax is that it improves both economic and technical efficiency. The financial impact on affected parties depends on the restitution of revenues. Usually serious resistance is raised against the introduction of a tax. Transaction cost will be high, since a differentiated tax is not easy to control and monitor and due to practical implementation problems. Firstly, it is hard to define a good tax base. For instance, it is not easy to measure the amount of drainage water. A tax on a change in the groundwater level is also complicated, because external factors also affect the groundwater level. Secondly, it is also complicated to take account of heterogeneity in vulnerability of areas to changes

Table I. Suitability of instruments for groundwater level management[1)]

Instrument	Effectiveness	Economic efficiency	Technical efficiency	Administrative feasibility	Equity	Acceptability
1A Tax	+/–	+	+	–	+/–	–
1B Tradable rights	+	+	+	–	+/–	+/–
1C Subsidy	+/–	–	–	–	–	+
1D Standard	+	–	–	–	+/–	–
1E Agreements	+/–	+	+	+	+	+/–
1F Responsibilities	+	+	+	+	+	+

[1)]Three categories are distinguished: '+' stands for a positive impact, '–' for a negative impact and '+/–' indicates the possibility of a positive as well as a negative impact. A '+' can be interpreted as follows:
'+' for environmental effectiveness means that the instrument reaches its environmental objective;
'+' for economic efficiency indicates that the value of the marginal product of water is equal among users;
'+' for technical efficiency means that the instrument provides incentives to adopt modern technologies;
'+' for feasibility means that the instrument is easy to implement, monitor and enforce against low cost;
'+' for equity means that the costs and benefits are equitably distributed among affected parties;
'+' for acceptability means that affected parties accept the instrument without serious resistance.

in drainage. Finally, the internalisation of externalities in the price of groundwater levels is very complicated, if not impossible, because it is hard to exclude farmers from changes in groundwater level management. Groups of farmers will be affected by changes in groundwater levels. This implies that a change in the behaviour of one farmer with respect to groundwater level management, in response to an economic incentive, may affect adjacent farmers. Due to these interdependencies, third-party effects may arise. Charging water boards for lowering surface water levels will not influence individual farmer's behaviour, although it will affect the strategy of groups of farmers represented in the governing body of water boards.

1B) *Tradable rights* to lower the groundwater level are ceilings on lowering that, once initially allocated, can be traded subject to a set of prescribed rules. The environmental objective is the starting point. Tradable rights improve economic and technical efficiency, since the market determines the price of the right in a dynamic way (Pearce and Turner 1990). The high transaction costs are a major disadvantage. The financial impact on affected parties as well as the acceptability depends on the initial allocation of rights. The use of tradable rights seems to be complicated in practice, since the impact of changes in the groundwater level on agriculture and nature depends on location-specific circumstances. To avoid the transfer of rights to areas sensitive to desiccation, trading among areas has to

be restricted. Here we face a dilemma: on the one hand the market approach is embraced, but on the other hand we need a trade institution for guided trading (Kruitwagen et al. 2000).

1C) A *subsidy* is a reward for meeting a certain groundwater level, which is higher than the desired standard. Subsidies are not economically efficient, they are disturbing and do not provide incentives to adopt modern technologies. The acceptability is no problem, since participation in subsidy schemes is voluntary and because of the financial implications. Implementation problems are similar to those of a tax. Farmers currently receive payments for drastic income losses due to higher groundwater levels. These payments are called subsidies, which is a misleading, since these payments do not provide incentives to lower the groundwater level, but are intended to balance the financial impacts on affected parties. Whether this is justified depends on the allocation of rights to lower groundwater levels. Since farmers currently receive financial compensation for the private benefits they have foregone, the rights to lower groundwater levels have so far been ascribed to agriculture. These payments prevent farmers leaving the region due to income losses. In that respect it provides incentives to individual farmers.

Regulatory instruments

1D) A legal groundwater level *standard* can be introduced. Such standard will be effective if farmers face substantial monetary penalties for lowering the groundwater level below this standard. The standard does not improve the economic efficiency and does not provide incentives to innovate. The financial impact is not always equitably distributed among the affected parties, since there are differences in the vulnerability of areas. The transaction costs of a standard are low. Usually there is serious resistance to the introduction of standards.

Suasive instruments

1E) Currently *voluntary agreements* concerning drainage control are established between farmers and governmental organisations representing the interests of nature. Participation in drainage control programmes is encouraged by means of positive incentives (a restitution of taxes). Under such programmes, educational activities are started to convince farmers of the advantages of fine-tuned drainage control. Less drainage leads, for instance, to a better utilisation of minerals by the crop, which encourages the adoption of sophisticated drainage management tools, e.g., adjustable weirs. Voluntary agreements concerning drainage control seem to be very suitable since they involve the participants' specialised knowledge of local conditions. They are only effective, however, if such agreements are really established. The size of the transaction costs depends on the kind of agreement reached. When costs and benefits are not equitably distributed among the affected parties, both parties can bargain about compensation payments. The

allocation of such payments depends on the assignment of rights. The acceptability is no problem as long as participation is encouraged by positive incentives. Because of these advantages, voluntary agreements for drainage control are highly recommended. The participation of farmers in decision-making at the local level is becoming more common. The principle of allowing individual members of agricultural organisations and water boards to make decisions on issues that affect them rather than leaving decisions to be made by the whole group (the so-called principle of subsidiarity) is widely accepted.

Change in the institutional environment

1F) Institutional change refers here to a change in the system that balance the interests with respect to water level management. Until 1992, agricultural interests dominated within the governing body of water boards due to the strong financial interest of this sector. Since 1992, environmental and nature organisations have been better represented in these governing bodies, which implies a transition to a multi-interest management system. Interests of nature with respect to groundwater level management have often been ignored in the decisions about surface water levels, which directly affect groundwater levels. If water boards become *responsible* for groundwater level management and if multi-interests are represented within the water boards, interests with respect to groundwater levels will be better balanced and can become guiding for surface water level management. This might improve the economic and technical efficiency in an equitable manner. Transaction costs seem to be low, although such changes are generally not so easy to implement. The acceptability seems no problem as long as the basic principle of water boards ("interest, payment and authority") is maintained.

In conclusion, Table I shows that most instruments are more or less effective as long as they are properly applied. A subsidy and a standard, however, do not achieve the objectives in an efficient way, while the introduction of a tax and a standard score low on acceptability. The suitability of a tax and tradable rights depends on the size of the efficiency gains relative to the transaction costs. The transaction costs of economic instruments for groundwater level management seem, however, to be high due to various practical implementation problems. Changes in the institutional environment and voluntary agreements between groups of farmers and nature organisations seem to be promising for groundwater level management.

3. Suitability of Policy Instruments for Groundwater Extraction Management

In this section the suitability of policy instruments for groundwater extraction management will be tested in the same way as instruments for groundwater level management in Section 2. Table II shows the test results of instruments for groundwater extraction management.

Table II. Suitability of instruments for groundwater extraction management[1)]

Instrument	Effectiveness	Economic efficiency	Technical efficiency	Administrative feasibility	Equity	Acceptability
2A Tax	+/–	+	+	–	+/–	–
2B Tradable rights	+	+	+	–	+/–	+/–
2C Subsidy	+/–	–	–	–	–	+
2D Ban	+	–	–	–	+/–	–
2E Agreements	+/–	+	+	+	+	+
2F Change rights	+	+	+	+/–	–	–

[1)] See Table I for the explanation of the '+' for the various performance criteria.

Economic instruments

2A) Extraction is currently regulated by two acts:

- Under the 1995 *Taxes on an Environmental Basis Act*, extraction is subject to a *tax*, which has to be paid to the central government. It is not a regulating tax, since the main aim is not to reduce water use, but to generate revenues. There are two tariffs: €0.15/m^3 for waterworks and €0.08/m^3 for other extractors. There is a tax-free threshold of 40,000 m^3/yr for extractions that are used for sprinkling. Extractions with pumps with a capacity of less than 10 m^3 an hour and extractions returned to the resource are also exempt from the tax. As extractions of waterworks are not exempt from this tax, the price of tap water has increased. This provided farmers with the incentive to sink their own wells, which means that such a tax is not very effective. On top of that, such diffuse extractions affect groundwater quality. We should therefore be careful with the creation of exceptions.
- Under the 1983 *Groundwater Act*, extraction is subject to a *levy*, which has to be paid to provinces. The tariffs and the levy-free threshold vary among provinces due to local differences and are subject to change. Tariffs are relatively small, for instance €0.0136 per m^3 in the province of Noord-Brabant in 2001.

Currently only a small percentage of farmers (about 2%) exceed the tax-free threshold and are therefore subject to the tax (Van Staalduinen et al. 1996). The main part of agricultural extraction is also not subject to the levy under the *Groundwater Act*. Most farmers currently only pay the energy costs of lifting water from the stock to the field (which is about €0.04/m^3). The current price of water implies that externalities, which arise due to agricultural groundwater extraction, are not yet fully internalised in the price of water. This is not efficient, since farmers maximise individual (instead of social) current (instead of future) profit and pump water until its marginal net benefit is zero (in the absence of bans).

An alternative is to impose a higher tax, which can be considered as a kind of water pricing reform. Whether such a tax is justified depends on the allocation of property rights for extraction. It is, however, not clear who owns currently these property rights. The theoretical framework of the optimal tax level is clear (the Pigouvian tax on the activities of the generator of an externality has to be equal to the marginal externality cost produced by that activity), but difficulties emerge if a proper tax level has to be determined in reality. In case of local differences in the availability and quality of groundwater and the role groundwater plays with respect to terrestrial ecosystems, a differentiated tax system has to be created. The effectiveness depends on the risk attitude of farmers and price elasticity of water demand. This price elasticity seems to be too low to do an effective job, because even now sprinkling is not always economically profitable. Other aspects, like peace of mind, also play a role.

A tax is easy to adjust and increases flexibility. It reduces extraction where it is most efficient and improves the technical efficiency, since it raises the water price. The financial impact depends on the restitution of revenues. Usually, there is serious resistance to the introduction of a tax and transaction costs will be high. The abolition of the tax-free threshold of agricultural groundwater extraction under the *Taxes on an Environmental Basis Act* seems, however, to be promising for price reform against low transaction costs.

2B) Currently the transfer of rights to extract groundwater is already possible in the province of Brabant. *Tradable rights* are a restricted number of agricultural extraction rights that, once initially allocated by authorities, can be traded subject to a set of prescribed rules. Transition to agricultural water markets while diverting water away from agricultural use, may decrease agricultural sector's well-being to some extent, but is desirable from a social point of view (Shah and Zilberman 1992). Tradable rights improve the economic and technical efficiency, since the market determines the price of the right in a dynamic way. The high demand for administrative institutions is a disadvantage of water markets. An equitable introduction of water markets is, however, 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. The financial impact on affected parties is determining for the acceptability. The use of tradable rights for groundwater extraction seems to be complicated in practice, since the impact of groundwater extraction on the desiccation of nature depends on location specific circumstances. To avoid the transfer of extraction rights to regions sensitive to desiccation, guided trading is required. As the market will not take differences in susceptibility of nature reserves to desiccation into account, it is necessary to intervene in the market to safeguard the environmental targets. The price of extraction rights is closely related to the heterogeneity criterion of water, geographic area, characteristics of the local market, the size of the transaction, the number and size of potential traders and the information and searching costs of transactions (Colby et al. 1993).

2C) *A subsidy* can be provided for meeting a certain volume of extraction, which is smaller than the desired standard. Subsidies fail to give a clear sign of real scarcity to farmers and provide no incentives for adoption of modern technologies. Administrative costs are high. The acceptability is no problem, since participation in subsidy schemes is usually voluntary.

Regulatory instruments

2D) Sprinkling *bans* currently aim to reduce low-value agricultural groundwater extraction. They divert 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 (groundwater versus surface water), crop type (grass versus arable), soil type (sandy versus clay) and time period (part of the year and day). Bans especially aim to reduce groundwater use for sprinkling of grass on sandy soils in areas sensitive to desiccation during periods of drought. Farmers are not compensated financially for income losses due to sprinkling bans, which means that the extraction rights are not implicitly ascribed to agriculture. Current bans are only rough restrictions. There are for instance no arable crop-specific sprinkling bans. Rough bans are suitable for a quick reduction in extraction and to ban a certain extractor.

An alternative is to fine-tune bans to resource, region, soil, crop and time specific circumstances in such a way that they will allocate water efficiently. Bans provide incentives to change farming practices (like the cropping pattern), but it does not provide incentives to adopt modern technologies. The financial impact is not always equitably distributed among affected parties, since there are differences in the vulnerability of areas to extraction. Differentiated bans will pose a large burden on the administrative capacity.

Suasive instruments

2E) *Voluntary agreements* currently induce participation in irrigation scheduling programmes. A management tool for irrigation scheduling was developed and tested in 1995, often referred to as the sprinkling planner. Irrigation scheduling 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 is not likely that farmers will adopt the sprinkling planner under the low water prices they currently face. Motives for not adopting it are the investment costs 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 adopt the sprinkling planner of their own accord (Boland et al. 1996). Farmers are therefore subsidised and education and persuasion activities were started to induce participation (carrot approach). Persuasion is hard since farmers often behave myopic due to the competition in the sector. Besides, there will be no sprinkling bans, if a certain diffusion rate will be met

(stick approach), i.e., if a certain number of farmers adopt the planner within a certain time period. Those who do not participate also benefit from the absence of bans. They can be considered as "free riders". Another very promising voluntary agreement we recommend is a commitment between farmers and nature conservationists on the extraction of groundwater. It is only effective if such agreements are really established. It reduces extraction in an efficient and equitable way against low administrative costs. The acceptability is no problem, since it is a voluntary compliance regime.

Change in the institutional environment

2F) Institutional *change in the assignment of extraction rights* seems interesting to reduce extraction in an efficient way. The current extraction rights system is based on free extraction permits granted by local authorities (provinces) in the past. These permits can be considered as historical extraction rights ("grandfathering rules"). The system only refused an extraction right if the proposed extraction could damage other users (Perdok and Wessel 1998); damage to ecosystems was not taken into account until very recently. Nature is jeopardised under such a system. The current groundwater extraction rights system is not efficient, since current allocation rules are based on a "queuing" system that restricts the trading of rights.

Changes in the assignment of the extraction rights can reduce extraction in an efficient way in areas sensitive to desiccation. A restricted number of groundwater extraction rights have to be redistributed among farmers with the intention of allocating rights in an efficient and equitable way, something which is not easy to establish. Differences in the vulnerability of ecosystems to extraction should be taken into account when extraction rights are assigned. Changes in rights are not so easy to adjust. Besides, the involved parties are generally very sensitive to changes in the rights system and it may therefore encounter serious resistance.

In conclusion, Table II shows that most instruments are more or less effective in reducing groundwater extraction if they are properly applied. However, a subsidy and a ban do not achieve the objectives in an efficient way, while a change in the assignment of groundwater extraction rights and the introduction of a tax and a ban score low on acceptability. The suitability of a tax and tradable rights depends on the size of the efficiency gains relative to the transaction costs. The size of the transaction costs depends among others on the costs of registration of the large number of small-scale diffuse and irregular agricultural groundwater extractions. Voluntary agreements also seem to be promising.

4. Conclusions

Unambiguous statements about the suitability of policy instruments are hard to make without local empirical analysis, since the suitability differs due to region-specific circumstances. Nevertheless, our theoretical analysis shows that the use

of economic instruments for groundwater level management will be complicated in practice for several reasons. Changes in the institutional environment and voluntary agreements seem to be more suitable. It is for instance recommended to make water boards responsible for groundwater level management. Voluntary agreements between groups of farmers and nature organisations also seem to be promising. Such agreements are, however, difficult to establish if rights are poorly defined.

The current historical groundwater extraction rights system together with the low groundwater prices encourage low-value agricultural groundwater usage, whereas sprinkling bans and irrigation scheduling currently aim to reduce low-value use of groundwater. These extraction instruments are less efficient than a system that considers externalities in the price of water or diverts water away from agriculture while encouraging trading. Economic instruments seem therefore very promising for groundwater extraction management. They provide the correct incentives to use water more efficiently. In practice policy reform is usually conditional upon the size of efficiency gains relative to the transaction costs.

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