THE EFFECTS OF FINANCIAL INCENTIVES ON GROUNDWATER USE FOR IRRIGATION IN WESTERN KANSAS

by

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Chapter 1

Introduction

The economy of Western Kansas is based on agriculture, mainly on grain production, feeding and processing beef and the industries related to agriculture, such as farm equipment, seed and fertilizer businesses and farm service industries.

Irrigation started playing a major role in the Western Kansas agriculture in the 1950s, when several technical discoveries made it possible to tap the Ogallala Aquifer, the abundant groundwater reservoir underlying large parts of Western Kansas. Irrigated acreage, mainly for grain production, expanded significantly. The increasing supply of feed grains induced a substantial growth of the feedlot and beef processing industry.[1]

The growth in irrigated production came to an end in the late 1970s when it became more and more apparent that both the water and energy supply for irrigation were not unlimited and were available only at increasing costs. Since the natural recharge of the Ogallala Aquifer is almost negligible, the water pumped to the surface directly reduces the amount of water left in storage. The aquifer is essentially being "mined". The water table gradually declines, more energy is needed to lift the water to the surface and irrigation becomes more costly.

For most irrigators, rising energy costs have been the major reason to reconsider their irrigation practices. Because there is no price for groundwater, energy costs are the only costs directly related to the amount of water pumped to the surface. Since 1977, increasing energy requirements due to a declining water table, combined with rising prices for natural gas, diesel fuel and electricity, the main energy sources used to drive the irrigation pumps, led to reductions in the amount of irrigated acreage and irrigation water used.[2]

The declining water table caused concern among farmers as well as non-farmers,[3] who began to consider whether water conservation meaures should be induced by state and/or federal legislation. If such policy measures were considered necessary, the next question would be what kind of political instruments should be applied. One possible choice, economic policy instruments, are described in this paper. There are other ways to induce reduction of groundwater use: rules and regulations could be elements of another political strategy. However, this type of policy will not be included in this paper, which is focussed strictly on financial incentives as economic policy instruments.

As pointed out above, high energy costs have been and still are a financial incentive to conserve groundwater. In this paper, "artificial" financial incentives for groundwater conservation will be presented, incentives created by policy makers to enhance the tendency of reducing water consumption caused by the rising energy costs.

In the beginning of chapter 2, the inefficiencies of the market allocation of natural resources are described as an economic justification for this kind of policy interference.

Two different categories of financial incentives are described in the second and third chapter of this paper. Negative financial incentives, increasing the costs of water use and thereby reducing the profitability of irrigation, are presented in chapter 2. Different forms of groundwater taxes and their effects are described with special regard to efficiency aspects.

Chapter 3 discusses positive financial incentives, which increase the financial attractiveness of groundwater conservation. Different types of subsidies are described, and problems are mentioned that could emerge when positive financial incentives are used.

In the fourth chapter, suggestions are presented to establish an entire incentive system by using combinations of negative and positive financial incentives. This chapter also contains the idea of regional differentiation of financial incentives and a description of "water banking" as a special type of incentive system.

The combinations presented in the fourth chapter seem to be a more effective and more feasible political strategy than the use of positive or negative financial incentives alone. If the political authorities would decide to choose financial instruments to promote groundwater conservation, an incentive system which includes both positive and negative incentives seems to deserve serious consideration as a suggestion for an economic policy strategy.

Chapter 2

Financial Disincentives for Groundwater Use

Groundwater is a natural resource. In the case of the Ogallala Aquifer it is an exhaustible natural resource. Exhaustible means that the quantity of the resource in stock decreases by the amount taken by man until eventually depletion of the resource will occur. This process is often referred to as "mining" the exhaustible resource. Before financial disincentives, used to influence the allocation of this type of resource, will be discussed in detail, some general aspects of natural resource allocation in a market economy will be presented in order to clarify the overall context of the discussions in the following paragraphs.

The allocation of an exhaustible natural resource by the private sector in a market economy may not be optimal for society as a whole.[4] Two separate aspects have to be considered:

- misallocation of water resources within a single time period: external costs imposed by one resource user on other (contemporary) users and
- misallocation of the resource over time.

Implications of each aspect of misallocation will be explained.

External costs for contemporary resource users occur when an irrigator X pumps water from the Ogallala Aquifer and causes higher irrigation costs for neighbor irrigators by lowering the water table and thereby increasing their pumping costs.[5] These costs, imposed on other individuals and on society in general, are not considered in the cost function of irrigator X. X therefore has no incentive to reduce the external costs by using less water. He will continue drawing from the common source.[6] The neighbors of irrigator X also consider only their private costs of water use and cause the same kind of external costs for society. Every individual irrigator continues to irrigate as long as the current marginal value product of the water used exceeds the marginal private cost of pumping and delivering water to crops.[7] The marginal social cost curve (MSC), including the external costs, lies above the marginal private cost curve (MPC) in figure 1. The external costs are represented by the vertical distance between MSC and MPC. The marginal value product curve is labeled MVP in the figure. Consideration of the social cost curve leads to water use A, which is lower than water use B created by the private sector. The private sector therefore does not allocate groundwater in a socially optimal way for the contemporary society.

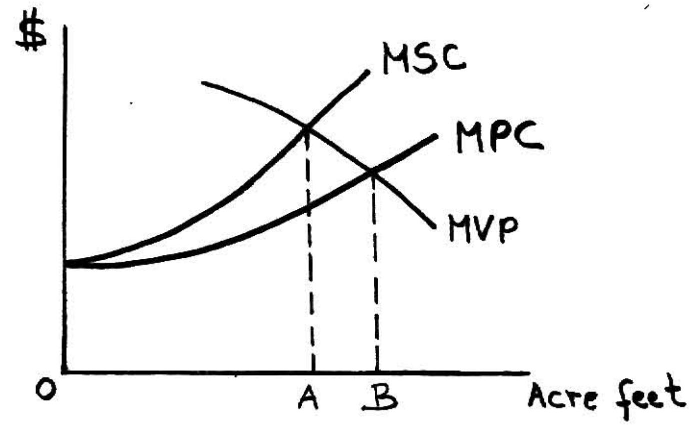

Figure 1. Illustration of the Divergence of Private and Social Costs and the Resulting Resource Allocations.

Source: H.P. Mapp and V.R. Eidman, An Economic Analysis of Regulating Water Use in the Central Ogallala Formation, p. 14

Misallocation of the Resource over Time will be explained next: In the free market solution, groundwater allocation is the outcome from each user's individual benefit maximization problem. To achieve a socially optimal solution, joint benefits over time have to be maximized.[8] In the private sector, individual users consider only their own private pumping costs in their decision and assign a zero opportunity cost to the groundwater in stock, thereby neglecting future uses and future value of the resource[9] This "myopic behavior"[10] of individual irrigators, not taking into account opportunity cost of foregone future use, results in an inefficient allocation of the water over time, because the effect of individual withdrawals on future water levels is ignored. (The economic loss due to the commonality of the groundwater reservoir has been estimated in a groundwater mining model by Lee, Short and Heady.[11])

Optimal groundwater use over time implies that water is pumped until marginal benefits equal marginal private pumping cost plus marginal user cost. Marginal user cost can be defined as "reduction in discounted future net benefits from a withdrawal of one additional unit in the current period."[12]

The interest rate used to discount the future net benefits obviously plays a crucial role in the calculation of the user cost. If a higher interest rate is applied to discount the future benefits, the future use of the resource appears less valuable to a contemporary water user. This user is therefore less likely to practice conservation. The interests of society, which can include the expected future use of those yet unborn, require that the use of future generations be incorporated in present value analysis. This could be achieved by using a lower discount rate. The rate of discount applied to future benefits of the groundwater under consideration of this social aspect has to be lower than the rate of interest that might be used to determine the present resource value by private investors.[13] Using a private discount rate which is larger than the the social discount rate leads to an allocation of groundwater that is not considered socially optimal: the water is used up too fast.

It is argued by Beattie[14] that finding socially optimal mining rates is the same problem for groundwater as for other stock resources like oil or minerals, and that therefore this problem does not deserve greater concern than any other investment on resource development. Plus, to determine the true socially optimal time distribution of a resource would require information about the future that is not available.[15] Therefore, the decision about how much slower groundwater depletion should be than the current rate of depletion has to be normative, just as the decision about profit maximization as the objective of the behavior of firms is normative.

When the concept of user charges is presented in the next paragraph, the assumption will be made that a reduction in groundwater use is desirable. (This assumption will also be used in chapter 3 and 4 about other water policy instruments.)

Pollution fees are applied to reduce air and water pollution by putting a charge on the "use" of the environment (Pigovian tax solution).[16] They are claimed to promote an efficient method of pollution abatement, because every firm reduces the emission of pollutants until the marginal costs of abatement equals the pollution charge.[17] This leads to a minimization of the sum of treatment costs; firms that can reduce emissions at low costs will do so to a greater extent (until they reach the amount of the pollution charge), than firms that have but very costly ways of pollution abatement. Thus, pollution abatement takes place at least cost.

Charges, used to reduce groundwater use instead of pollution, put a cost on the use of groundwater to internalize the social costs of groundwater depletion. This "price" on the water will lead to a reallocation of the resource. At the higher water cost, previously profitable resource use becomes inefficient (marginal costs exceed marginal benefits), waste will become more expensive. The task to find a new efficient groundwater allocation at new cost conditions is left to the market. As opposed to groundwater use regulation (quota solution or an upper limit to total water pumped from the aquifer per year and individual limits on each irrigator), a charge system leaves to the individual user the freedom of decision concerning what quantity of water he will withdraw from the aquifer. The user charge, by increasing the costs of water use, creates a financial disincentive to pump water.

Different forms of user charges will be presented next.

2.1. Tax Policy

If a water user charge is integrated in the tax system, the special tasks of the tax system have to be considered. Taxes are used to achieve several different goals in an economy:

- Resources are transferred from private to public use. Taxes provide the financial means to produce public goods.
- Taxes are used to promote a more equal distribution among individuals in a society by a special allocation of tax burdens.
- Taxation of a socially undesirable action is used as a financial disincentive (for example by taxes on cigarettes or liquor).
- Tax policy is used as a macroeconomic tool to raise or lower aggregate demand in the economy.

A tax system, set up in order to achieve the various goals developed in the political decision process, has to meet one more criterion: it has to be fair. Fairness in a tax system means that the criterion of equity is fulfilled. Equity is based on social and political consensus. The principle of equity has two aspects:

- Horizontal equity requires equal treatment for persons in substantially similar circumstances.
- Vertical equity means that persons in dissimilar situations are treated in a different way.

If the water issue is integrated into the tax system, the designers of the new element in the tax system have to keep in mind the above goals and the principle of equity.

Creating a tax consists of the definition of what is to be taxed and of the decision how high the tax rate will be. These decisions can be made at the national, state or local level of administration. If a water charge is planned to be integrated into a tax that already exists, the power to decide the tax rate will be at the level this special tax is administered. For example, an integration of a water user charge into the federal income tax would transfer the responsibility for the water charge to the national level. Whether or not this would be desirable will be discussed later in this paper.

If a water charge would be attached to an already existing tax, three other aspects have to be considered.

The first problem would be how to integrate the new element into an already existing tax, for example the federal income tax. The income tax has a certain structure that serves to reach the goals it has been assigned by policy makers. Water use as a new criterion has to be implanted into this structure by using different tax rates for groundwater users. This implies that another tax base has to be used in addition to income and that for taxpayers with that new tax base (water use) a whole new tax schedule has to be worked out that uses both income and water use as tax base. This would most probably be more complicated than creating a new tax just for water use. The addition of water use as criterion for an existing tax might be quite difficult, because, as mentioned above, the existing taxes, especially the "big" taxes like income tax, property tax and sales taxes, are already loaded with social and economic goals.

The second problem deals with the taxpayers' perception of the new element in an existing tax. A "water-use addition" to the federal income tax would probably be perceived as just another way to raise the income tax. The relation to the water issue would be hidden. Since the goal of a water use charge is to reduce water use, the charge should stand out from the other taxes and have a very distinct relation to the water.

The water use tax revenue should be separated from other revenues to create a fund that would be available for other water policy measures, such as expenditures for water conservation practices. This aspect will be discussed in chapter 4 (combinations of different financial tools in a system).

Because of the above arguments, the integration of water charges into an existing tax does not appear to be a practical solution. Therefore, this report is focussed on a water charge as an independent tax and not as an addition to existing taxes.

A groundwater use charge as an independent tax called a water tax. can be constructed in various ways. Options for different tax bases and different tax rate schedules are described in the following paragraphs.

2.1.1. Linear Tax Per Unit of Groundwater Use

The linear tax per unit of groundwater use fits into the category of severance taxes that can also be used to tax firms extracting other natural resources, especially minerals. The rate of return on capital is reduced by the tax and investment in resource extraction is discouraged. Therefore, extraction will be postponed into future periods.[19]

This is the effect wanted by a groundwater tax. Figure 2 shows the influence of a tax per unit of groundwater pumped on marginal private costs (MPC) and on water use, measured in acre feet. The marginal private cost curve shifts to MPC' when tax EF is imposed; water use is reduced to level B. To achieve the socially optimal water use, the tax rate has to be DE per unit. With DE, MPC shifts to MPC'' and the socially optimal water use A is reached, private costs of water use are made equal to social costs.

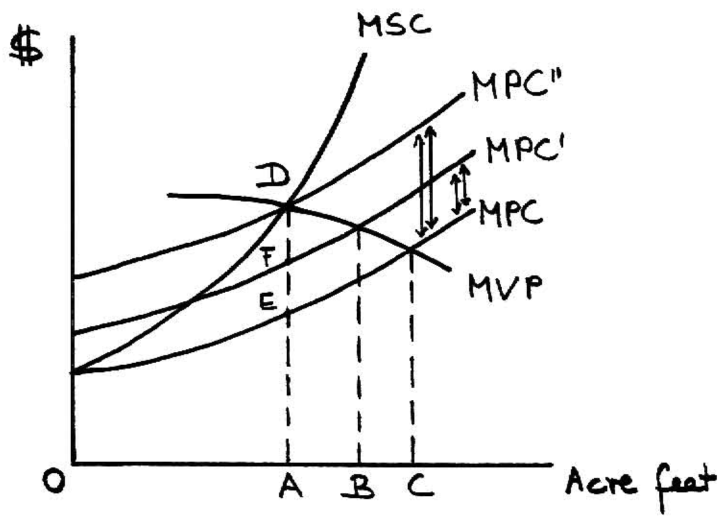

Figure 2. Effects of a constant tax per unit of groundwater pumped on marginal private costs and water use.

Source: H.P. Mapp and V.R. Eidman, An Economic Analysis of Regulating Water-Use in the Central Ogallala Formation, p. 17

The effect of the linear groundwater tax on the individual water user (irrigator) is shown with the help of production budgets set up by F.D. Worman for the Western Kansas area (appendix).[20] Worman calculated net returns per acre for different crops and irrigation situations using simulated crop yields from crop growth models for corn, wheat and grain sorghum. Basic budget material was provided for the year 1983 in the Farm Management Guides of the Cooperative Extension Service and was modified based on recommendations by staff at the Garden City

Branch Experiment Station.[21]

A tax per inch of irrigation water applied to the different crops can be introduced into the budgets by adding the tax payment (number of inches x tax rate = tax payment) to the variable costs per acre. One can then trace the effect of these additional costs on net return per acre (see appendix). The budgets of irrigated and dryland grain sorghum and of irrigated corn are presented to show how the net return situation changes in favor of dryland grain sorghum production after the introduction of the tax.

Two tax situations are shown in the appendix: $1.00 per inch and $2.00 per inch of irrigation water applied to the crops. In the case of corn the introduction of a $2.00 tax leads to returns over total costs, that are almost equal for 16 inch and 12 inch irrigation. At a tax level of $2.50 per inch, the net return in the case of 12 inches of irrigation water would exceed the net return with 16 inches of water. The farmer, trying to maximize net return, would switch to 12 inch irrigation and save 4 inches of applied irrigation water per acre.

For grain sorghum, a similar situation is created by taxation of water use. A $2.00 tax lowers the net return for 12 inch irrigated sorghum under the net return of dryland sorghum. If the farmer decides to switch to dryland production, 12 inches of irrigation water are saved. With a $1.00 tax, dryland sorghum production becomes preferable to the production of 12 or 16 inch irrigated corn. If the farmer switches from 16 inch irrigated corn to dryland sorghum, 16 inches of applied irrigation water are saved per acre.

These calculations give but a very rough idea of what could happen under groundwater taxation. In his validation of the model results, Worman points out that the sorghum model has a considerable tendency to overpredict yields.[22] Overestimated yields lead to higher than realistic net returns. The comparison between corn and sorghum is therefore not quite fair. But, although the numbers might not be correct estimates, the calculations show the type of reaction to be expected after the imposition of a per unit groundwater tax. To determine the tax rate that leads to a certain level of water savings, more exact data are necessary and special situations on individual farms have to be considered. Most models work with average values, but the situation on individual farms can be very much different due to a special production structure, soil conditions or the size of the farm.

The results of the comparison between corn and sorghum under different taxes are also highly sensitive to changes in crop prices. For example, if the corn price rises from $3.25 to $3.50, a $2.00 tax cannot provide incentive enough for a farmer to use less than 16 inches of water on corn. A switch to dryland grain sorghum is not attractive. The tax would reduce the farmer's net return but not initiate a change in water use.

2.1.2. Progressive Tax Per Unit of Groundwater Use

A tax is progressive when the tax rate increases with rising tax base. Progressivity can be achieved in different ways:

a) The tax rate rises with increasing water use. Example: Up to 8 inches of irrigation water applied a tax rate of $1.00 is used, from over 8 to 12 inches the tax rate is $2.00, over 12 a tax level of $5.00 is applied per inch.

b) No tax is charged up to a certain level of water use. Water use exceeding the limit is taxed by a constant tax rate, for example $3.00.

c) A combination of a) and b) is applied, for example: No tax for a water use under 8 inches per acre. For water use exceeding the limit, increasing tax rates are applied as described in a).

Figure 3 shows the effect of a progressive (graduated) tax on the marginal private cost curve MPC and water use. Solution a) is represented by MPC', b) is shown by MPC'', and MPC''' stands for solution c).

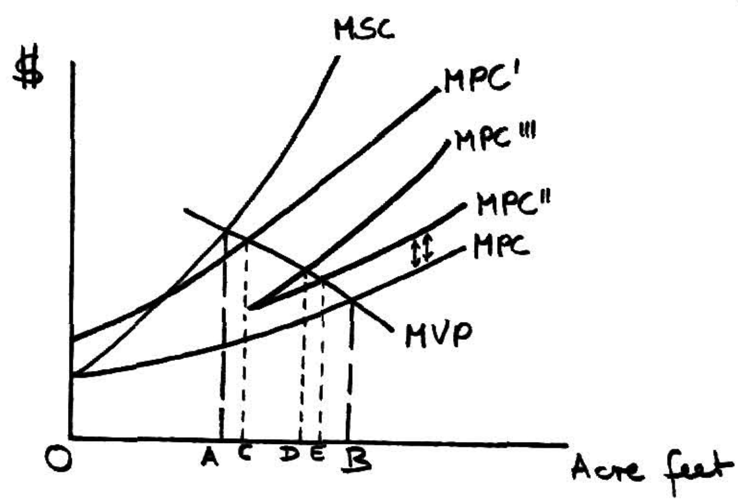

Figure 3 Effects of Progressive Per Unit Groundwater Taxes on the Divergence of Private and Social Costs

Source: H.P. Mapp and V.R. Eidman, An Economic Analysis of Regulating Water-Use in the Central Ogallala Formation, p. 19

In principle, the effects of the progressive tax are comparable to those of the linear tax. When the net returns of production with less water exceed the net returns of highly water intensive production due to the tax, the farmer will switch to the lower irrigation level and save groundwater. But solution b) and c) leave low water use levels untaxed and tax rates in a) and c) could theoretically reach a prohibitive level, making the use of 16 inches of water per acre unprofitable in every case.

It will be a political decision whether progressivity is applied in groundwater taxation or not. If low levels of irrigation are considered desirable and high levels totally undesirable, the progressive groundwater tax can be the right tool.

2.1.3. The Use of Different Tax Bases

Taxation of groundwater pumped is the most direct and probably most effective way to achieve a reduction in groundwater use. But for reasons of completeness, a number of other possible tax bases are discussed below.

A charge could be placed on irrigated acreage instead of water use. An advantage to this solution would be that water meters would not be needed in this case. On the other hand, water use might not even fall under this solution. Irrigated acres could be reduced to avoid the tax, but water use on the remaining irrigated acreage could be increased so much that the net effect of the tax would be small or equal to zero. This tax would not reward farmers who install water conserving irrigation equipment on their land, because they would still have to pay the whole tax for their irrigated acreage. In short, the tax on irrigated acreage could create an allocation of the water that includes waste of water or less productive water use practices than those applied before the introduction of the tax.

A tax could be levied on the installation of new groundwater pumps as a kind of property tax. If this tax is high enough, it provides the incentive to conserve water in order to maintain the water level, so that new pumps are not needed or needed at a later time. Since the water table under one farm might be affected by the water extraction on neighboring farms, a tax on new pumps could make one farmer pay for the water use of his neighbors. The problem caused by the common pool character of the groundwater reservoir is not appropriately addressed by a tax on new pumps.

Finally the production of highly water consuming crops could be taxed; for example corn could be charged with a tax per bushel that has to be paid at the time the crop is sold. For this tax to be effective, the incidence must fall on the farmer, which it would do under the current market situation for farm products. Nevertheless, this tax, like the other options mentioned in this paragraph, would not necessarily create an efficient water allocation. Farmers might plant less corn, but they can still waste water on it due to inefficient irrigation strategies.

The conclusion of this section is that the easiest and most efficient way to reduce groundwater use by taxation is to impose a per unit tax on water pumped, thereby creating a negative incentive that is directly related to the objective: reduce usage of water for irrigation. The amount of water conserved is directly related to the tax rate. As mentioned earlier, the optimal tax rate can only be found with information about the exact social costs of groundwater depletion. The social costs cannot be accurately calculated[23] because of a lack of information about the future. Policy makers have to set up a water conservation goal and a process of trial and error will be necessary to find a tax structure with results that come as close as possible to this political goal.[24]

Also a transition period should be allowed for farmers to adjust to groundwater taxation. Time is needed to change the production structure (plant crops that are less water intensive) and to adopt different production techniques, for example more efficient irrigation methods.[25]

2.2. Fees Related to Groundwater Use

The difference between a tax and a fee is that a fee is usually paid for a service rendered, whereas a tax can be levied without direct relation to a service. Income tax, for example, is not paid for a service related to the taxpayer's income. Income taxes end up in a pool of tax revenues (general fund) that is used to finance a bundle of services, for example the services of the institution "government". A fee is paid for one well defined service like the maintenance of a public facility, for keeping the facility from being overcrowded or for compensation for discomfort of persons affected by the action of the feepayer.[26] Thus, a fee does not end up in a general pool of revenues, but it is collected to provide the service and cover all costs related to that service.

At present, farmers have to pay a fee to get a permit to pump groundwater,[27] but it is not related to the amount of water pumped. It is an administrative fee.

To create a negative incentive on groundwater use, a fee related to water use could be invented. The techniques would be very similar to those described for taxes. But unlike tax revenues that go to the general fund, the fee revenues could be used to finance groundwater related services, for example the installation of water meters, education about the current groundwater situation or conservation techniques. Fee revenues could also be used to finance a set of positive incentives as described in chapter 3. Groundwater users would finance groundwater policy by paying fees into a fund in case of high water use, but receiving money out of the fund in case of adoption of water conservation measures.

2.3. Evaluation of User Charges on Groundwater

It was argued in the beginning of chapter 2 that the concept of user charges can lead to an efficient reallocation of groundwater, namely a reallocation towards the socially optimal resource use. As mentioned earlier, an important argument in favor of the charge concept was that the final decision about water use is left to the individual entrepreneur instead of being transferred to an institution that sets limits for individuals' water use, thereby reducing greatly the flexibility in dealing with the water scarcity problem.[28]

Evaluation of a policy measure must consider in what way it changes the situation of the affected members of society. The question is whether the resource users suffer a loss by being forced to pay a price on water, or whether they will experience welfare gains in the long run because of lower pumping costs and a longer availability of groundwater for irrigation.

Different answers to that question can be found in the literature. Jaquette/Moore[29] argue that resource users will suffer welfare losses under a constant tax per unit solution, because the tax revenues would be significantly larger than the benefits that accrued to the groundwater user in form of lower future pumping costs. Feinermann/Knapp say that variable pump taxes (tax as a function of water pumped) allow resource users to capture the benefits of groundwater management completely or to a large extent.[30]

The impact of a graduated per unit pump tax on the income flow of groundwater users is calculated by Mapp and Eidman.[31] Their study area is the Central Ogallala Formation, including a portion of two counties in southeastern Colorado, eight counties in southwestern Kansas, the three Panhandle counties of Oklahoma, and eight counties in the northern part of the Texas High Plains. Mapp/Eidman calculate net income streams for a representative farm in two resource situations. In situation 1 the farmer faces "poor" water conditions, and in situation 2 "adequate" water conditions. Saturated thickness of the underlying aquifer and well yield are the criteria: in the "adequate" situation saturated thickness is such that declining well yields and rising pumping costs are not experienced in the next 40 or more years.

In the "poor" water conditions the decline of saturated thickness leads to higher irrigation costs: new wells have to be drilled and energy costs of pumping rise. Eventually, irrigation has to be given up.

The net farm income in the Mapp/Eidman model for the "poor" water situation under a graduated tax ($.50 per acre inch, when water use exceeds the limit of 1.5 acre feet per crop year) over a 20-year period is predicted to exceed the income under unrestricted pumping in every year except in the fifth year.[32] More conscious and therefore more efficient and more timely irrigation practices are responsible for this result, in combination with a slower rise in pumping costs due to reduced water extraction. Water use is reduced considerably, mainly in the years three to eight, compared to the unrestricted water-use solution.

For the "adequate" water conditions, future net farm income is projected to be only slightly smaller than income under unrestricted water-use, but water-use drops by around 1000 acre inches per year. The life of the groundwater reservoir is extended significantly at the cost of a slight loss of net income for irrigators.

The graduated tax solution appears to be a rather attractive way to induce groundwater users to conserve the natural resource, so that it can be used for a longer time in the future. As mentioned earlier, the optimal tax rate has to be determined in a political decision process, in which some future values of variables can only be guessed.

2.4. The Groundwater Depletion Allowance

The Internal Revenue Code of 1954, Sec. 611, provides:

"(a) General Rule. In the cases of mines, oil and gas wells, other natural deposits, and timber, there shall be allowed as a deduction in computing taxable income a reasonable allowance for depletion ..."

In December 1954, an irrigation farmer in the Southern High Plains, Texas, requested a ruling from the Internal Revenue Service, allowing a cost depletion allowance under Sec. 611 of the 1954 code on groundwater pumped for irrigation (Shurbet case). In the year 1965, the Internal Revenue Service issued the following ruling:

"Cost depletion will be allowed to taxpayers in the Southern High Plains under facts similar to those in the Shurbet case." (Rev. Ruling CB 1965-2,181; Rev. Ruling Sec. 13, Dec. 1965, 65-296). The ruling was limited to groundwater withdrawal from the Ogallala Aquifer in the Southern High Plains of Texas and New Mexico.[33]

In the year 1978, a lawsuit was filed in the Kansas Federal District Court (Gigot case), claiming the tax depletion allowance for declines in the water table of the Ogallala Aquifer in southwestern Kansas. The suit was settled in 1980: the Justice Department agreed that the Gigots were entitled to the depletion allowance.[34]

The depletion allowance as a federal tax write off had been introduced into the federal income tax in recognition of the fact that capital investments in mineral deposits are gradually exhausted by the extraction of the mineral. The taxpayer can use the depletion allowance under three conditions: The mineral must be exhaustible, the taxpayer must derive income from the extraction of the mineral as a return of his capital, and he must demonstrate a capital investment in the mineral in place.[35] The formula for the depletion deduction in the Shurbet case for the year 1959 was: decline in static water level during 1959 (in feet), divided by the saturated thickness of the Ogallala at time of purchase of the land, multiplied by the price paid for the water at purchase, equals the allowable depletion deduction.[36]

2.4.1. Effects of the Depletion Allowance

In general, a depletion allowance can be characterized as a negative severance tax; in other words, a subsidy on mineral extraction.[37] Exploration and development of natural resources are encouraged,[38] and the extraction of the natural resource tends to be reallocated over time: resource use in the present is encouraged rather than conserving and leaving the resource in stock for future use.[39]

In the case of groundwater, the depletion privilege in income taxation provides a tax incentive for groundwater extraction and use. Sweazy/Asce[40] claim that the depletion allowance and the calculation of income derived from the use of groundwater for irrigation have led to increased recognition of the value of the remaining water resource and have therefore helped to reduce wasteful practices. But the financial incentive still encourages use, not conservation.

In the case of the Kansas portion of the Ogallala Aquifer, the depletion allowance can only be used by irrigators who bought their land in the 1960s and 1970s because prior to that time the land costs were not tied to groundwater value (see formula for depletion allowance at p. 20).[41] Among that group, farmers with a high income benefit the most from the depletion allowance: a tax write off in a progressive income tax system always saves more tax payments for taxpayers with high incomes in a high tax bracket than for those with low incomes in a low tax bracket.

The depletion allowance has the same effect on water use as mentioned above for other natural resources: resource extraction, in this case pumping of groundwater from the Ogallala, is encouraged, the depletion allowance is a positive incentive for water use. Why then does it belong in this paper and in this chapter about negative incentives for water use?

The answer is this: if the depletion allowance is a positive tax incentive for water use, abolishing the depletion allowance could reduce water use. If the depletion allowance would be abolished, not only irrigators pumping groundwater from the Ogallala Aquifer in Kansas would be affected but other natural resource users as well.

To abolish the depletion allowance for all natural resources would require a political decision at the national level. But it would help to conserve exhaustible resources, and among them the groundwater reservoir in Kansas.

Chapter 3

Financial Incentives for Groundwater Conservation

Negative financial incentives or financial disincentives promote conservation of a natural resource by increasing the cost of using it and thereby reducing the financial attractiveness of resource use. Positive financial incentives directly increase attractiveness of resource conservation by providing a reward for the adoption of conservation measures or the reduction of resource use. Positive financial incentives may be categorized as tax privileges and as direct payments (subsidies) to individuals.

If the positive incentives do not fully cover the costs of resource conservation, they cannot, by themselves, induce the adoption of resource conservation because resource use will still be more profitable than conservation.[42] In this case, additional political measures are necessary, for example regulations or negative incentives for resource use.

3.1. Tax Privileges

A tax incentive for natural resource conservation has to be a reduction in tax burden for the individual who conserves. A reduction in tax burden for individuals can be achieved by so-called tax expenditures: tax exclusions, exemptions, deductions, preferential tax rates, tax credits or tax deferrals may be introduced into the existing tax structure.[43] A choice has to be made concerning which of the different options, applied to what tax, would be appropriate to establish an incentive for regional groundwater conservation as required in western Kansas.

It might be a difficult task to establish a financial incentive by integrating a tax privilege rule into the structure of a federal tax in a way that adequately deals with groundwater conservation in Kansas. Probably, groundwater users in other regions would benefit, even if the rule was not designed to include them. To avoid undesired distortions in other regions, the tax policy measure should be aimed as exactly as possible at the region in consideration: The incentive should not be built into a federal tax.

Different options for tax expenditures as financial incentives are presented in the following paragraphs.

3.1.1. Tax Exclusions, Exemptions and Deductions

Exclusion, exemptions and deductions reduce the tax burden by reducing the tax base. (For example: for the Kansas income tax, taxable income is left as a residual after exclusions, exemptions and deductions have been subtracted.[44] Special sources of income can be excluded, a certain part of the income can be exempt from taxation or expenditures can be deducted to reduce the taxable income). The tax rate schedule is applied to this reduced tax base and therefore the tax liability is lower than without the tax base reduction.

To establish a positive financial incentive for groundwater conservation, exclusions, exemptions or deductions have to be tied to conditions related to water use. For example: If the water use of a taxpayer in the Ogallala region is below a certain limit, he is entitled to deduct x $ from his tax base. As mentioned in chapter 2.4. about the groundwater depletion allowance, taxpayers with a high income in a high tax bracket benefit more from this type of tax reduction, than do individuals with low income in a low tax bracket.

3.1.2. Preferential Tax Rates

Preferential tax rates can be applied to the taxable income of a special group of taxpayers. Integrating an incentive for groundwater conservation into the existing tax structure is a rather complicated way to encourage water conservation. Therefore, preferential tax rates are not considered to be a practical solution in the Kansas groundwater case.

3.1.3. Tax Deferrals

The postponement of the tax payment due date for certain taxpayers and a certain time period is called a tax deferral. The gain for the taxpayer is the interest he can earn or save by the availability of the tax money for an extended time period (opportunity costs). The effect of this type of tax expenditure is hard to trace, and as a positive incentive, a tax privilege with more transparent effects is desirable.

3.1.4. Tax Credits

A tax credit is deducted from the tax liability after the tax rate schedule has been applied. Income distribution is not affected because the same amount is subtracted from the tax liability of every eligible taxpayer, independent of the tax bracket.[45] Compared to deductions, preferential tax rates and tax deferrals described above, tax credits seem to be a less complicated instrument. To create a positive incentive for the conservation of Ogallala groundwater in Kansas, a tax credit could be integrated into a regional tax.

The size of the tax credit has to be related to water use or water conservation. For example, if water use does not exceed a certain limit, a tax credit of x $ can be subtracted from the tax liability. In this form, the tax credit has almost the same effect as a cash payment to the groundwater user: a subsidy of x $ is given to the water users whose water use is below the limit. Both ways, the water user ends up with x $ more disposable income (Exception: The marginally profitable firm might not benefit from an income tax credit, because it does not pay income tax.[46])

Into what tax should the tax credit be integrated?

This question is relevant only for the revenue side. (Of course, it has to be a tax that is paid by all the individuals the incentive is aimed at. A tax credit on wheat tax would leave out all water users who grow corn or alfalfa.) The revenue of the particular tax is reduced by the amount of the tax credit times the number of recipients of the tax credit.

3.2. Subsidies as Positive Incentives

There is no "true" definition for the term subsidy. A wide interpretation includes support of any kind, even research and information services, to a group of individuals who meet certain criteria. A narrow definition would only include direct cash payments given to a certain group of individuals under special conditions.[47] This narrow definition causes some ambiguities: can price supports be classified as subsidies? They imply no direct cash payments, but they can improve the income of recipients of the supported price. Furthermore, supports in form of low interest loans are an ambiguous case: the loans have to be paid back; however, the low interest is a benefit for the recipient, but no cash payment.

In this paper, a wider interpretation of the term subsidy is used: any kind of financial support is considered a subsidy, including cash payments, low-interest loans and price supports. These options for financial support can be used to establish a positive incentive for a reduction in groundwater use.

To be used as a an incentive for individuals to act in a certain way, the subsidy has to be related to the desired action. This relationship can be more or less direct, and yet can leave a degree of freedom of decision to the recipient, dependent on the type of condition the subsidy is tied to. The subsidy can also be related to criteria other than strictly water conservation, for example the income class or the type of business of the recipient. Several suggestions for subsidies, conditions, and their effects are described in the following paragraphs. Different options are discussed and applied to the issue of groundwater conservation in Western Kansas.

3.2.1. Cash Payments (Tax Credits)

A direct cash payment (or a tax credit according to paragraph 3.1.) is a very clear and straightforward instrument: a certain amount of money is given to individuals who fulfill the conditions set up for the reception of the subsidy. The quality of these conditions and the size of the subsidy are crucial for the success and the effectiveness of the instrument in providing an incentive strong enough to induce irrigators to change their water consumption in the way that is decided to be socially desirable. Ideas for subsidies in the western Kansas case are presented in the following sections 3.2.1.1. through 3.2.1.3..

3.2.1.1. Subsidy for the Installation of Water Conserving Equipment

A cash payment from public funds to irrigators can be tied to the condition that the recipient of this subsidy installs equipment that is thought to promote the conservation of water. The condition could require the use of more efficient irrigation technology in order to reduce water use. Efficiency of irrigation could be increased by using equipment that reduces the loss of water on the way from the well to the crops, equipment that achieves more exact water application, so that irrigation water does not percolate below the root zone of the plants, or equipment that catches runoff from irrigation and makes it available for reuse.[48]

To induce farmers to apply for the subsidy and install water saving equipment, the subsidy has to provide a net gain for farmers (if it is used as the only water policy measure and not in combination with regulations or additional financial disincentives). For the calculation of the size of the subsidy necessary to provide this net gain, two aspects have to be considered:

- The costs of the equipment in consideration
- The cost reduction for the farmer due to reduced water use achieved by the new equipment.

Both aspects vary with the size of the irrigation operation on the individual farm. If a small amount of irrigated acres is equipped with water conserving technology, less equipment and less labor for installation are needed than in the case of a large irrigated acreage. The costs per acre might be higher for the small irrigation operation (no economies of scale), but the absolute costs are higher the more acres have to be treated. At the same time, the absolute amount of water saved on a farm with a large irrigated acreage is higher than for a farm with a small number of irrigated acres. This is important for the second aspect mentioned above. For a large irrigation operation these cost reductions sum up to a higher amount of money saved than for a small irrigated acreage.

The net costs of the installation of water conservation equipment can be calculated by subtracting the reduction in pumping costs from the costs of installing the equipment. The outcome of these calculations is subject to changes in prices of energy and equipment. A higher reduction in pumping costs is realized by water saving equipment when energy prices are high.

So the net costs of installing the water saving equipment are lower with high energy prices than in case of low energy prices. Rising (falling) equipment prices will raise (lower) the net costs for the installment of the equipment.

These considerations are important for the decision about the size of the subsidy for conservation equipment. Several cases can be considered.

Case 1: if the subsidy is the same fixed amount of money for every recipient, it has to be higher than the net costs of equipment installation in the most expensive case in order to provide a net gain to all recipients. (The case with the highest net costs would be a large irrigation operation, high equipment prices and low energy prices). Since all recipients get the same amount of money, recipients with low net costs are privileged compared to those with higher costs, because they get a higher net gain out of the subsidy.

Case 2: per acre subsidies could be used, for example a certain cash payment (tax credit), paid per acre of irrigated land equipped with conservation technology. In this solution, the per acre net gains are equal for all recipients, but these per acre net gains lead to a financial advantage of large acreage operations over small acreage operations.

Case 3: to achieve equal absolute net gains among all recipients, a formula has to be constructed that yields higher per acre net gains for a smaller irrigated acreage than for a large acreage. In this case the incentive would be equally distributed among irrigators, it would not imply size privileges.

Obviously, a decision has to be made about the desirability of size privileges: Since the absolute amount of water saved on a large irrigated acreage can be considerably higher than on a small acreage, the question has to be addressed, whether irrigators with a large acreage "deserve" a higher absolute net gain (whereas the fact that large operations often are in a better financial situation than small businesses[49] could lead to the normative question if large operators "need" this privilege.)

Another problem with this type of conservation equipment subsidy is that the equipment installation might in fact lead to conservation of water on the acres with the new equipment, but by providing long-run savings in irrigation costs, they may also provide an incentive to expand irrigated acreage. Less water is wasted, but more water is actually used. An additional condition for the subsidy ("no expansion of irrigated acreage") would have to be tied to the subsidy to prevent this effect.[50]

A special case of equipment subsidy would be a subsidy for the installation of water meters. Water meters do not directly lead to a reduction in water use, but they indirectly help to save water because they measure the success of any kind of water conservation policy. Irrigators are not necessarily interested in having water meters on their wells, so they will probably not install them on their own initiative. Public action is required to induce the installation of water meters and a subsidy, covering the cost of purchase and installation of the instruments. Such a subsidy would provoke less resistance from irrigators than regulations forcing every water user to install a water meter at his own expense. Water meters installed under the control of an authorized institution would guarantee that the same kind of instrument is used all over the region and that the meters are properly installed. Another advantage is the neutrality with respect to income distribution of this type of subsidy that directly "donates" equipment to farmers.

In sum, the "donation" of equipment, might be the only way to handle a subsidy without getting involved with income distribution among farmers. If the cash payment type subsidy is used, one must choose in advance what kind of income distribution effect is desirable: privileges for small irrigation operations or for farms with a large irrigated acreage. Furthermore, due to the reduction in irrigation cost, the equipment subsidy on water use might lead to an expansion of irrigated acreage and therefore the net effect on water conservation could turn out to be less than expected.

3.2.1.2. Subsidy for Changes in Farm Practice

Water consumption can be reduced by changes in farm policy that involve more than the installation of additional equipment. A subsidy could be paid to induce such farm policy changes.

a) Subsidizing the Switch from Irrigated to Dryland Farming

The most dramatic change would be the switch from irrigated production to dryland farming, which would at the same time lead to the highest possible reduction in water consumption. A subsidy inducing this change has to make dryland production of crops financially more attractive than irrigated production. If a farmer is producing irrigated corn with a net return of $ 86.99 per acre (table 1), whereas dryland grain sorghum yields a net return of $ 77.46 per acre, then the switch to dryland production becomes profitable if the subsidy for dryland grain sorghum production exceeds $ 11.53 per acre (ceteris paribus).

Several problems have to be mentioned.

A subsidy of $ 12 per acre for the switch from corn production to dryland grain sorghum would require a very powerful source of money in case of a high ratio of participation in the subsidization program.

The subsidy has to be adjusted to movements in crop prices and production costs, because these movements affect the net return situation. These adjustments might cause considerable instability, because they have to be made frequently due to price fluctuations. If the adjustments are not carried out timely, the subsidy does not at all times guarantee a profit advantage of the subsidized crop over the irrigated crop and in that case does not create an incentive for a change in farm practice. The adjustment process would probably require substantial administration effort which would further increase the public expenses necessary for this type of subsidy.

The subsidy, promoting the change from an irrigated crop to a dryland crop, seems to be a fairly complicated instrument to achieve groundwater conservation if it is used without additional policy measures like regulations or negative incentives. Changing the relative net return of two crops by paying the difference as a positive incentive appears to be expensive and requires difficult and costly adjustment procedures.

b) Subsidizing the Use of Less Water Intensive Crops

Less dramatic changes in farm policy provide less groundwater conservation, but are easier to subsidize without disturbing the market process as much as with a direct crop subsidy. Without changing the production structure to a different product mix water can be saved by using less water intensive varieties of the crops. The subsidy would have to overcompensate the reduction in net return due to lower yields, minus the reduction in water pumping costs.

c) Subsidizing a Change in Tillage Practices

Water could also be saved by changing tillage practices. Conservation tillage practices leave crop residues on the surface and the surface is left rough, so that infiltration of water is promoted and runoff reduced. Reduced runoff implies more available water for crop production.[51] A subsidy to promote the use of conservation tillage practices can thereby contribute to groundwater conservation.

d) Subsidizing Irrigation Scheduling

As a last possibility of a change in farm policy in order to conserve groundwater, the implementation of irrigation scheduling is presented. The plant's water needs change during the growing season. Stone and Lee/Bieri/Kanemasu[52] indicate that by adapting irrigation applications to these needs instead of applying maximal amounts of water during the whole season, water can be saved without a reduction in crop yield. The implementation of irrigation scheduling methods could be induced by paying a subsidy to irrigators to make the transition financially more attractive.

3.2.1.3. Cash Payments Per Gallon of Conserved Water

As opposed to subsidies that require an exactly defined action by the recipient, a cash payment per gallon of conserved water would leave the decision to the farmer, by what kind of change in farm policy or with what kind of equipment he wants to achieve water conservation. The eligibility for the subsidy is established by the result (conserved gallons of water) of an action and not by the particular action itself.

The subsidy could be given as a cash payment related to the amount of water conserved: x $ per gallon of conserved water. Water meters and exact information about recent water use on the particular farm are necessary for the calculation of the size of the cash payment to each individual recipient. As in section 3.2.1.1., size privileges have to be considered, when this type of subsidy is used. Large irrigation operations can save a higher absolute amount of water and therefore receive a higher subsidy. The problem can be solved, if desired, by constructing a formula for the subsidy that yields decreasing payments per gallon of conserved water the higher the amount of irrigated acres is on the particular farm.

With a subsidy per gallon of conserved water each irrigator will practice water conservation until the marginal costs of conservation per gallon are equal to the subsidy per gallon plus reduced pumping costs per gallon due to reduction of water consumption. This is illustrated by figure 4. MC represents the marginal costs of conserving water (per gallon) under the assumption of increasing marginal costs (due to rising technical problems the more gallons of water are conserved). A constant per gallon subsidy for conserved water is shown by the line S, whereas the MB curve represents marginal benefits (lower pumping costs) of reduced water use. These benefits are the reduced pumping costs, which are assumed to fall with rising amounts of conserved water.

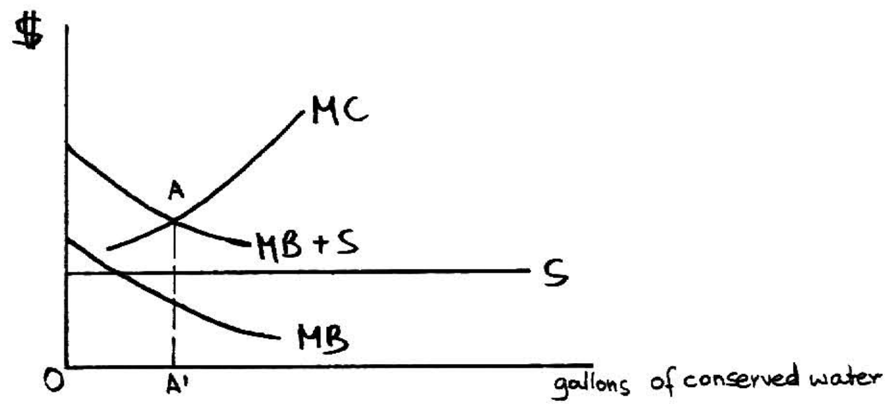

Figure 4. Effect of a Per Gallon Subsidy on Water Conservation

OA' in figure 4 marks the amount of gallons of conserved water due to a per gallon subsidy on conservced water.

Irrigators might use very different techniques to reduce their water consumption, adapted to their individual production structure; some producers might even take land out of production (in this case federal land retirement programs might lead to a twofold subsidization). Allowing individual solutions for recipients the subsidy per gallon of conserved water will probably promote more efficient water conservation practices than a subsidy that prescribes certain techniques for all recipients.

3.2.2. Other Types of Financial Support For Water Conservation

Financial support other than direct cash payments can be used to induce basically the same changes of farm policy. For instance, low interest loans could be offered to irrigators to support investments in water conservation equipment.

Price supports for less water intensive crops could be offered to make the production of these crops more profitable compared to irrigated crops. Thus, the price of grain sorghum could be raised by government purchases. The increased supply of grain sorghum would require additional programs stimulating grain sorghum consumption. For example, a subsidy given to the regional feedlot industry for feeding grain sorghum instead of corn can induce the necessary shift in demand for sorghum, but it seems that a subsidy system like this is fairly complicated. Therefore, price supports are not considered a practical financial incentive for water conservation.

3.2.3. Evaluation of Positive Financial Incentives

The list of examples given above for the application of positive financial incentives to achieve groundwater conservation is not claimed to be complete. Among the different options, cash payments for the amount of conserved water seems to be the most practical and efficient solution.

The problem with all the presented options is that their application as a single incentive without additional policy instruments is expensive and rather complicated, because a net gain to the farmer has to be provided to induce the desired farm policy change. Therefore, positive incentives are more likely to be used in combination solutions with other instruments for water conservation policy. These are discussed in chapter 4 of this paper.

3.2.4. Non-Financial Instruments to Promote Groundwater Conservation

Information is an important issue, because it can be used by irrigators to achieve a more adequate farm policy planning for the future. Descriptions of the current water situation in different parts of Western Kansas and projections of groundwater depletion rates could be a valuable planning tool.

A consulting service would be a way of non-financial support, providing the mentioned kind of information, planning help and eventually technological assistance for the application of new equipment.

A research service could develop new varieties of less water consuming, high yield crops. Research can also help find new irrigation methods that reduce water consumption without affecting yields.

In combination with financial incentives, non-financial support in form of information and research services would lead to more widespread and profitable participation in the existing programs.

Chapter 4

Building an Incentive System for Western Kansas

An incentive system using a combination of negative and positive types of incentives, developed respectively in chapters 2 and 3, might be a more practical and effective way to reduce groundwater consumption than the application of either one alone.

One important argument for a combination solution is that revenue from a water tax or fee can be redistributed to irrigators and thereby the initial income and wealth position of the irrigating farmers as a group can be maintained.[53] A groundwater tax without redistribution of revenues would probably cause strong resistance of irrigators against the water conservation program and might therefore be politically infeasible.

On the other hand, using positive incentives alone as instruments to change the allocation of groundwater would require considerable funds, which could probably not be drawn from the state's general funds.

Redistributing the revenues of the groundwater tax by giving subsidies for groundwater conservation practices could solve both problems. The tax revenues would be redistributed to farmers, so that their wealth position as a group is not worsened by the tax. At the same time, distribution of subsidies for water conserving practices provides incentives to reduce water usage. The combination of negative incentives with positive incentives therefore seems to be a solution that could make the water conservation program effective and politically feasible. Applied together in a system, incentives to conserve water and disincentives to use it would tend to strengthen each others effect and acceptability. The same administrative facilities could be used for both, but more flexibility is achieved compared to the implementation of only positive or only negative incentives.

Suggestions for systems including positive and negative incentives as elements are presented in the following section 4.1.. In section 4.2., the issue of regional differentiation and in section 4.3., a "water banking" or "tradable quota" system as a special way to change the financial attractiveness of groundwater use will be described.

4.1. Systems With Positive and Negative Incentives as Elements

In chapter 2, an independent tax on groundwater use was described as the easiest and most efficient way to establish a negative incentive for water consumption. To combine the tax with positive financial incentives in a system, the tax revenues have to be collected in a special fund that is available for other water policy measures. This fund could be used to finance different positive incentives for groundwater conservation, like cash payments, other types of financial support, or non-financial support for different farm policy changes. These subsidies would help irrigators to manage the transition to less water consuming practices.

Positive incentives alone might be given for a transition period, the tax being announced as a future negative incentive that will be imposed in a later time period, for example two or three years later. The initial expenditures for the positive incentives could be credit financed, the credits being paid back when tax revenues start to flow in. The announcement of a future tax on groundwater use gives irrigators the opportunity to plan and slowly adapt their farm management (with the help of the positive incentives) to the new water policy. If the tax would be phased in with slowly rising tax rates over the first few years, a smooth adaptation to the water policy change could be achieved. The effects of the financial incentives could be measured during this time, and one could calculate how high the combined financial incentives would have to be to reach a certain degree of water conservation desired by policy makers.

By giving the subsidy first and later imposing the tax, the acceptability of the program would probably be higher than without the subsidy. The only problem in this case is that money has to be spent which has not been collected yet. However, this should not be an prohibitive obstacle for the program, because the prospect of future tax revenues could help raise the necessary funds by making credits available.

If a tax per unit of groundwater consumption is applied as a negative incentive, several different options exist to establish the positive incentive, because basically all forms of subsidies presented in chapter 3 can be used to support the adoption of groundwater conservation. The system could be constructed such that total tax revenues approximately equal total expenditures for subsidies, including interest on the initial two or three years of subsidies without taxes.

The financial situation of the farmer or the size of his business could be introduced as an additional criterion for the eligibility to receive a water conservation subsidy, because smaller irrigators often are less able to afford water conservation practices than large irrigators.[54] An income or size limit could be set up as "sufficient" condition for the reception of subsidization out of the water policy fund: farmers with an income or size of business exceeding the limit are not eligible for the subsidy (The "necessary" condition would be the use of the money for water conservation practices). A different option would be that all irrigators are eligible for certain subsidies, but those with an income below the limit are eligible for additional financial assistance.

This kind of policy could prevent farmers from being forced out of business by solely negative incentives, for example a groundwater tax in the water conservation program. Marginal producers of irrigated crops might have to go out of business if irrigation costs and thereby production costs were increased. By receiving financial assistance to implement water conservation techniques, these producers would be able to reduce their water consumption. This would lessen the tax burden and might save these producers from bankruptcy.

The application of combined positive and negative incentives in a system of water conservation policy measures seems to offer significantly more flexibility than the implementation of positive or negative incentives alone. Therefore, the option of this type of combination solutions could be considered when a water policy framework is designed.

4.2. Solutions With Regional Differentiation

The water supply in the Western Kansas is not equally distributed: There are areas that expect severe water scarcity problems in the near future. But there are also regions with a supply of groundwater that will provide water for irrigation at current levels for many more years.[55] Therefore, stronger policy measures are necessary to "stretch" the groundwater supply in certain regions, whereas in other areas conservation policy could be phased in more slowly.

Would a regional differentiation of water conservation policy measures be feasible?

Actually, regional differentiation is already applied in Kansas water policy: Groundwater Management Districts (GMD's) and Intensive Groundwater Use Control Areas (IGUCA's) have been established in the past to protect the groundwater supply. GMD's have the power to levy water charges in the area they cover,[56] so this instrument would not be new to the Kansas water policy framework.

A regionally differentiated tax on groundwater use, with a higher tax rate in areas with severe depletion problems, would leave those farmers better off whose land lies in an area with abundant water supply and lower tax rates. On the other hand, regional differentiation could be implemented by giving higher subsidies for water conservation practices in areas with severe water depletion. Policy makers have to decide to what extent financial incentives should vary among regions.

4.3. Water Banking or Transferable Quota Systems

A water banking system or a water distribution system with transferable quotas can establish a market for water use rights.

In a water banking system, water use rights or quotas are allocated to the users by an agency called a water bank. The allocation could be based on user's historic use. In order to achieve efficiency in water use, the rights have to be easily transferable,[57] with the water bank arranging the transactions among users and directing the flows of money and water. Water right holders who do not wish to use their entire quota can "deposit" any portion of their water into the bank and receive a price for it. The water then is available for other users, who are willing to pay a fee for "withdrawals" of water from the bank.[58]

A market price for water will develop from these transactions. Less efficient water users in the region will tend to use less water and "deposit" it in the water bank for higher monetary return. More efficient water users will buy the water from the bank and use it - the water is allocated to its most efficient uses.

Scarcity increases the price of water and stimulates conservation efforts. Therefore, water banking can be considered as a system to establish financial incentives for water conservation. The water bank can influence the price of water by buying and keeping water use rights from the public. The incentive to conserve water can thereby be strengthened and water use reduced.

The water bank could be a national, state, local or a regional agency. The more centralized the water bank would be, the more different issues have to be considered in its policy. A federal water bank would have to allocate groundwater and surface water to agricultural, industrial, municipal, and recreational uses and to nature and wildlife protection.

In this report, only Western Kansas groundwater is considered, therefore, the "Western Kansas Regional Groundwater Bank" would be the practical application of the water bank concept in the given case. For groundwater, the water banking system works perfectly only if the groundwater reservoir is a totally common pool resource with the water moving underground to where it is being pumped. The Ogallala Aquifer does not fulfill this condition, it is only partly "mobile." Therefore, different sub-regions would need their own water market and the water price would vary among different parts of Western Kansas, due to different degrees of groundwater depletion: The transfer of water use rights from one irrigator to his neighbor in a region with severe water depletion problems but fairly high demand for water would require a higher payment due to higher scarcity than it would in a region with an abundant water supply, so regional differentiation of the price for water use rights would emerge. The water bank would have to establish regional sub-markets, keep track and register the different prices for water rights in the different areas. The transferability could eventually be increased by water pipelines for water imports and exports among regions (a very costly solution).

Policy makers can increase the price of "bank water" (in selected areas) to a level higher than the current price by buying water rights from the bank. The increased price of the water use rights would be an incentive for water conservation. The responsible political authority might need considerable funds to buy enough water rights to rise their price.

A water bank seems to be a rather efficient tool to allocate water in a region and promote water conservation: a high price for water use rights could induce irrigators to switch to dryland production and sell their water rights. However, it might also cause farmers with relatively small, less efficient, operations to go out of business and sell their water rights, thereby producing concentration tendencies in the region. From an efficiency point of view this might be desirable, but policy makers have to decide if it also desirable from a social and political point of view.

Chapter 5

Summary and Conclusions

The purpose of this paper was to present economic policy instruments that can help to promote groundwater conservation and achieve a slower rate of depletion for the Ogallala Aquifer in Western Kansas.

Two categories of financial policy instruments are discussed:

Negative financial incentives are presented in chapter 2. This type of water policy instruments decreases the profitability of irrigated crop production by an increase of water use costs. The different options for negative incentives presented in this report are:

1) linear tax (fee) per unit of groundwater use
2) progressive tax (fee) per unit of groundwater use
3) tax (fee) on irrigated acreage
4) tax (fee) on new groundwater pumps
5) tax (fee) on highly water consuming crops (per bushel).

In the second category of financial policy instruments are positive financial incentives that increase the attractiveness of groundwater conservation practices by offering subsidization from public funds. Like negative incentives, the subsidization can be given in various forms:

1) tax exclusions, exemptions, deductions
2) preferential tax rates

3) tax deferrals

4) tax credits

5) cash payment for the installation of water conserving equipment

6) donation of equipment

7) subsidy for changes in farm practices (for example the switch from irrigated to dryland farming, the use of less water intensive crops, change in tillage practices or irrigation scheduling)

8) cash payment per gallon of conserved water

9) low interest loans

10) price support for less water intensive crops.

Both categories of incentives can be used as elements of an incentive system, that at the same time increases costs of groundwater use and provides financial assistance to farmers who change their farm practices. For example the groundwater tax (fee) could be combined with one of the ten different positive incentives. Combinations are theoretically possible between all 5 negative and all 10 positive incentives. The idea of regional differentiation of financial incentives can be integrated in such systems.

Water banking as a special form of incentive system is described as a last suggestion in chapter 4.

When policy makers decide to use financial instruments to reduce groundwater use for irrigation in Western Kansas, they have to choose which instrument or combination of instruments they want to apply in the given political, social and economical situation. The reduction of groundwater use is the main or primary objective of groundwater policy, but there are also several "secondary objectives" that political authorities may consider when they set up a water conservation program. A catalogue of 14 "secondary objectives" is presented here:

1) The income and wealth position of irrigating farmers as a group should not be affected
2) Production efficiency should be promoted (no waste of resources)
3) Economic efficiency should be increased (reduction of externalities)
4) The program should be as fair as possible (horizontal and vertical equity)
5) The program should not imply size privileges for large farms
6) The program should take into account the financial strenth of individuals (farmers should not be forced out of business by the water conservation policy)
7) The program should not include instruments with implicit side effects on income distribution (like the side effect of tax deductions that provide higher tax savings for individuals in higher tax brackets)
8) The effects of the program should be clear and easy to trace
9) The costs of the program for the state should be as low as possible
10) The elements of the program should leave enough freedom of decision to the individual farmer so that solutions can be found that are adapted to special situations (flexibilty)
11) The program should include a transition period to minimize

adjustment pains

12) The interference with the market mechanism should be as small as possible

13) The water conservation program must be politically acceptable

14) The program should be flexible enough to deal with special regional situations.

To become operable as guidelines in policy, the objectives have to be clearly defined and explained. The objectives listed here might also not all be equally important to the political authority, so they have to be put into a hierarchical order according to their importance.

To set up a water conservation program with financial instruments, the policy makers have to find the optimal instrument or combination of instruments with regard to primary and secondary objectives. Because of the multitude of instruments and objectives, a systematic approach could help to facilitate the decision process: instruments, combinations of instruments and objectives could be put together in a matrix. Table 1 on the following page contains an example for such a matrix with four instruments and four objectives. Four financial policy tools are listed horizontally and four objectives are listed vertically. A minus in the matrix means that the instrument in the column of the minus has a negative effect with regard to the objective listed in the row of the minus (the minus signs in table 1 represent the author's opinion).

Instead of minus signs, a grading scale can be used to rank the instruments with respect to their effectiveness in achieving

Table 1. Example for a matrix with policy objectives and financial incentives

Instrument \ objective	negative incentives: tax on ground-water use (per gal.)	negative incentives: tax per irrigated acre	positive incentive: subsidy for water saving equipment	combination of positive and negative incentive: tax per gal. of ground-water use and subsidy for water saving equipment
keeps income and wealth position of farmers constant (1)*	—	—		
take into account financial strength of farmers (6)*	—	—		
low costs for the state (9)*			—	
political acceptability (13)*	—	—		

* The numbers in brackets are the numbers of the objectives in the text.

an objective. More exact information would then be yielded by the matrix.

According to table 1, the combination of a positive and a negative incentive in an incentive system can be more effective in reaching the objectives than the positive and negative incentives alone. The reason for this is that side effects of one instrument, considered undesirable by farmers or decision makers can be partly or fully compensated by the side effects of another instrument. For instance, the costliness of subsidies (conflicting with objective 9) can be compensated by groundwater tax revenues: the tax may worsen the income and wealth position of irrigating farmers as a group, force some farmers out of business and be politically unacceptible (conflicting with objectives 1,6 and 13)... but the addition of a subsidy could reduce or eliminate these effects. Thus, groundwater use may be reduced, while the positive and negative side effects of the incentives offset one another so that secondary objectives are not violated. Only a system including both positive and negative financial incentives can have this advantage. This is not only true for the narrow framework of table 1 but also when more instruments and objectives are added to the matrix.

Additional combinations of financial incentives with laws or regulations that limit groundwater use are possible and could increase the effectiveness of a political strategy. They could be added as further instruments to the matrix.

ENDNOTES

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Appendix

Table A-1

BUDGETED ACTIVITY FOR IRRIGATED CORN
PRE-PLANT 4 INCH + TASSEL + BEGINNING OF EAR GROWTH IRRIGATIONS

	Costs	
VARIABLE COSTS PER ACRE:	PRODUCTION	IRRIGATION
1. Labor (1.85 hrs.x$ 6.00/hr)	$ 11.10	$ 9.37
2. Seed	27.11	
3. Herbicide ($25) and Insecticide ($25)	50.00	
4. Fertilizer - 110# N + 40# P_2O_5	23.55	
5. Fuel & Oil - Crop	17.50	
6. Fuel & Oil - Pumping		32.58
7. Crop Machinery Repairs	12.00	
8. Irr. Equipment Repairs		6.75
9. Drying ($.10/bu)	10.80	
10. Total Irrigation	48.70	48.70
11. Interest on 1/2 Variable Cost @ 14%	14.05	
A. TOTAL VARIABLE COSTS	$ 214.81	
FIXED COSTS PER ACRE :		
12. Real Estate Taxes	$ 5.00	
13. Depreciation on Crop Machinery	17.14	
14. Interest, Taxes, Ins. on Crop Mach @ 8%	9.60	
15. Depreciation on Irr. Equipment	22.50	
16. Interest, Taxes, Ins. on Irr Equip. @ 10%	18.00	
B. TOTAL FIXED COSTS	$ 72.24	
C. TOTAL COSTS	$ 287.05	
D. YIELD PER ACRE	112.2 bushels	
E. PRICE PER BUSHEL	$ 3.25	
F. RETURNS PER ACRE	$ 364.65	
G. RETURNS OVER VARIABLE COSTS (F-A)	$ 149.84	
H. RETURNS OVER TOTAL COSTS (F-C)	$ 77.60	

Table A-2

BUDGETED ACTIVITY FOR IRRIGATED CORN
PRE-PLANT 4 INCH + TASSEL + HALF WAY BETWEEN TASSEL
AND BEGINNING OF EAR GROWTH + BEGINNING OF EAR GROWTH IRRIGATIONS

	Costs	
VARIABLE COSTS PER ACRE:	PRODUCTION	IRRIGATION
1. Labor (1.85 hrs.x$ 6.00/hr)	$ 11.10	$ 11.30
2. Seed	27.11	
3. Herbicide ($25) and Insecticide ($25)	50.00	
4. Fertilizer - 120# N + 40 # P_2O_5	24.93	
5. Fuel & Oil - Crop	17.50	
6. Fuel & Oil - Pumping		43.45
7. Crop Machinery Repairs	12.00	
8. Irr. Equipment Repairs		9.00
9. Drying ($.10/bu)	11.41	
10. Total Irrigation	63.75	63.75
11. Interest on 1/2 Variable Cost @ 14%	15.25	
A. TOTAL VARIABLE COSTS	$ 233.05	
FIXED COSTS PER ACRE :		
12. Real Estate Taxes	$ 5.00	
13. Depreciation on Crop Machinery	17.14	
14. Interest, Taxes, Ins. on Crop Mach @ 8%	9.60	
15. Depreciation on Irr. Equipment	22.50	
16. Interest, Taxes, Ins. on Irr Equip. @ 10%	18.00	
B. TOTAL FIXED COSTS	$ 72.24	
C. TOTAL COSTS	$ 305.29	
D. YIELD PER ACRE	120.7 bushels	
E. PRICE PER BUSHEL	$ 3.25	
F. RETURNS PER ACRE	$ 392.28	
G. RETURNS OVER VARIABLE COSTS (F-A)	$ 159.23	
H. RETURNS OVER TOTAL COSTS (F-C)	$ 86.99	

Table A-3

BUDGETED ACTIVITY FOR DRYLAND SORGHUM
SORGHUM-FALLOW ROTATION

	Costs
VARIABLE COSTS PER ACRE:	PRODUCTION
1. Labor (1.55 hrs.x$ 6.00/hr)	$ 9.30
2. Seed	2.92
3. Herbicide ($28) and Insecticide ($15)	43.50
4. Fertilizer - 60# N + 30# P_2O_5	14.58
5. Fuel & Oil - Crop	13.50
6. Crop Machinery Repairs	12.00
7. Drying ($.10/bu)	8.34
8. Miscellaneous	6.00
9. Interest on 1/2 Variable Cost @ 14%	7.71
A. TOTAL VARIABLE COSTS	$ 117.85
FIXED COSTS PER ACRE :	
12. Real Estate Taxes	$ 5.00
13. Depreciation on Crop Machinery	19.65
14. Interest, Taxes, Ins. on Crop Mach @ 8%	11.00
B. TOTAL FIXED COSTS	$ 35.65
C. TOTAL COSTS	$ 153.50
D. YIELD PER ACRE	83.4 bushels
E. PRICE PER BUSHEL	$ 2.77
F. RETURNS PER ACRE	$ 230.96
G. RETURNS OVER VARIABLE COSTS (F-A)	$ 113.11
H. RETURNS OVER TOTAL COSTS (F-C)	$ 77.46

Table A-4

BUDGETED ACTIVITY FOR IRRIGATED SORGHUM
MID-JULY 4 INCH IRRIGATION

	Costs	
VARIABLE COSTS PER ACRE:	PRODUCTION	IRRIGATION
1. Labor (1.55 hrs.x$ 6.00/hr)	$ 9.30	$ 5.54
2. Seed	4.37	
3. Herbicide ($15) and Insecticide ($10)	25.00	
4. Fertilizer - 80# N + 40# P_2O_5	20.51	
5. Fuel & Oil - Crop	15.00	
6. Fuel & Oil - Pumping		10.87
7. Crop Machinery Repairs	12.00	
8. Irr. Equipment Repairs		4.50
9. Miscellaneous	3.00	
10. Drying ($.10/bu)	9.56	
11. Total Irrigation	20.91	20.91
12. Interest on 1/2 Variable Cost @ 14%	8.38	
A. TOTAL VARIABLE COSTS	$ 128.03	
FIXED COSTS PER ACRE :		
14. Real Estate Taxes	$ 5.00	
15. Depreciation on Crop Machinery	17.14	
16. Interest, Taxes, Ins. on Crop Mach @ 8%	9.60	
17. Depreciation on Irr. Equipment	22.50	
18. Interest, Taxes, Ins. on Irr Equip. @ 10%	18.00	
B. TOTAL FIXED COSTS	$ 72.24	
C. TOTAL COSTS	$ 200.27	
D. YIELD PER ACRE	95.6 bushels	
E. PRICE PER BUSHEL	$ 2.77	
F. RETURNS PER ACRE	$ 264.81	
G. RETURNS OVER VARIABLE COSTS (F-A)	$ 136.78	
H. RETURNS OVER TOTAL COSTS (F-C)	$ 64.55	

Table A-5

BUDGETED ACTIVITY FOR IRRIGATED SORGHUM
PRE-PLANT 4 INCH + 9 LEAF + BOOT IRRIGATIONS

		Costs	
VARIABLE COSTS PER ACRE:		PRODUCTION	IRRIGATION
1.	Labor (1.55 hrs.x$ 6.00/hr)	$ 9.30	$ 9.37
2.	Seed	4.37	
3.	Herbicide ($15) and Insecticide ($10)	25.00	
4.	Fertilizer - 120# N + 40# P_2O_5	24.93	
5.	Fuel & Oil - Crop	15.00	
6.	Fuel & Oil - Pumping		32.58
7.	Crop Machinery Repairs	12.00	
8.	Irr. Equipment Repairs		6.75
9.	Miscellaneous	3.00	
10.	Drying ($.10/bu)	11.94	
11.	Total Irrigation	48.70	48.70
12.	Interest on 1/2 Variable Cost @ 14%	10.80	
A.	TOTAL VARIABLE COSTS	$ 165.04	
FIXED COSTS PER ACRE :			
14.	Real Estate Taxes	$ 5.00	
15.	Depreciation on Crop Machinery	17.14	
16.	Interest, Taxes, Ins. on Crop Mach @ 8%	9.60	
17.	Depreciation on Irr. Equipment	22.50	
18.	Interest, Taxes, Ins. on Irr Equip. @ 10%	18.00	
B.	TOTAL FIXED COSTS	$ 72.24	
C.	TOTAL COSTS	$ 237.28	
D.	YIELD PER ACRE	119.4 bushels	
E.	PRICE PER BUSHEL	$ 2.77	
F.	RETURNS PER ACRE	$ 330.74	
G.	RETURNS OVER VARIABLE COSTS (F-A)	$ 165.70	
H.	RETURNS OVER TOTAL COSTS (F-C)	$ 93.46	

Table A-6 Net Returns Per Acre of Corn and Grain Sorghum With Different Irrigation Strategies and Different Water Use Taxes

	Irrigation Strategy (inches/ acre)	tax/ inch ($)	total costs/ acre ($)	tax/ acre ($)	return/ acre ($)	net return/ acre ($)
Corn	16	--	305.29	--	392.28	86.99
"	16	1.--	305.29	16.--	392.28	70.99
"	16	2.--	305.29	32.--	392.28	54.99
"	16	2.50	305.29	40.--	392.28	46.99
Corn	12	--	287.05	--	364.65	77.60
"	12	1.--	287.05	12.--	364.65	65.60
"	12	2.--	287.05	24.--	364.65	53.60
"	12	2.50	287.05	30.--	364.65	47.60
Grain Sorgh.	dryland	--	153.50	--	230.96	77.46
"	4	--	200.27	--	264.81	64.55
"	4	1.--	200.27	4.--	264.81	60.55
"	4	2.--	200.27	8.--	264.81	56.55
"	4	2.50	200.27	10.--	264.81	54.55
Grain Sorgh.	12	--	237.28	--	330.74	93.46
"	12	1.--	237.28	12.--	330.74	81.46
"	12	2.--	237.28	24.--	330.74	69.46
"	12	2.50	237.28	30.--	330.74	63.46

Source of tables A-1 through A-5 and of costs and returns in table A-6: F.D. Worman: Utilizing Agronomic Crop Growth Models in Economic Analysis: The Case of Cropping Adjustments to Decreasing Irrigation Water Availability in Western Kansas. Ph.D. Dissertation, Kansas State University, 1985, tables C-6, C-8, C-21, C-26, C-29

THE EFFECTS OF FINANCIAL INCENTIVES ON GROUNDWATER USE FOR IRRIGATION IN WESTERN KANSAS

by

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An Abstract of a Master's Report

submitted in partial fulfillment of the

requirements for the degree

MASTER OF ARTS

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The economy of Western Kansas is based on agriculture, mainly on grain production, feeding and processing beef and the industries related to agriculture, such as farm equipment, seed and fertilizer businesses and farm service industries.

Irrigation started playing a major role in the Western Kansas agriculture in the 1950s, when several technical discoveries made it possible to tap the Ogallala Aquifer, the abundant groundwater reservoir underlying large parts of Western Kansas. Irrigated acreage, mainly for grain production, expanded significantly.

The growth in irrigated production came to an end in the late 1970s when it became more and more apparent that both the water and energy supply for irrigation were not unlimited and were available only at increasing costs. Since the natural recharge of the Ogallala Aquifer is almost negligible, the water pumped to the surface directly reduces the amount of water left in storage. The aquifer is essentially being "mined".

This report presents economic policy instruments that promote a reduction of groundwater use by giving financial incentives and disincentives to irrigators in Western Kansas.

Financial disincentives increase the costs of water consumption and thereby decrease the profitability of water use for irrigation. Linear and progressive groundwater taxes or fees could be different forms of financial disincentives.

Financial incentives can be given in various forms of subsidization: cash payments and tax credits, donations of equipment, low interest loans or technical assistance to irrigators. The subsidies from public funds could increase the attractiveness of groundwater conservation practices. Different conditions could be tied to the reception of the subsidies, for example the adoption of more efficient irrigation methods, the switch to different crops or the reduction of water usage.

Negative and positive incentives can be used simultaneously as elements of an incentive system that increases costs of groundwater use while it provides financial assistance to farmers who change their irrigation practices. The idea of regional differentiation could be integrated in such systems.

A special way to allocate water would be to establish a market for water use rights in form of a "water bank" that organizes the transactions between buyers and sellers of water. A high price for water established in that market could be an incentive to reduce water consumption.

Under the assumption that political authorities decide to apply economic policy in order to reduce groundwater use in Western Kansas, an incentive system which uses both positive and negative financial incentives seems to have significant advantages compared to the use of positive or negative incentives alone. In a combination of positive and negative incentives, side effects of one type of incentive, considered undesirable by decision makers, can be partly or fully compensated by the side effects of the other type of incentive. At the same time, such a policy could incorporate the desirable effects of both types of incentives.

Combinations of financial incentives with laws or regulations could increase the effectiveness of a political strategy. Subsidies could be used to reduce adjustment costs for farmers and political opposition against the water conservation laws.