The case for a water pricing scheme in Ternata, in the Drâa Valley

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ELD MOOC Land Valuation Course - Final Assignment

Contents

Foreword:

This report presents the results of a cost benefit analysis of managing water resources in the Ternata oasis in the Middle Drâa Valley through the establishment of surface water pricing scheme and the introduction of drip irrigation.

The intended audience of this report are the various stakeholders of the valley, such as the local farmers and inhabitants, as well as the local and national government and various politicians that operate in the area.

The report is targeted at such a large audience because so far the study relies purely on data from the literature. This was done by design, as the study was completed as part of coursework for the Land Degradation MOOC organized by UNU-INWEH, GIZ and other ELD partner organizations. Within the time frame allocated and with the given resources we were unable to obtain stakeholder feedback.

Care was given when choosing the papers to use to select those that had interacted with a subset of the aforementioned stakeholders, in order to mitigate our inability to do this. Using this data, our study showed that the intervention designed could be viable and have a significant positive impact on the water resources present in the Drâa valley.

However, in order to properly implement this intervention is it crucial to have some buy in from the various stakeholders. This is necessary to make sure the stakeholders are genuinely interested in the intervention, and believe in it, as well as to make sure the intervention is properly designed and addresses a problem.

Overview:

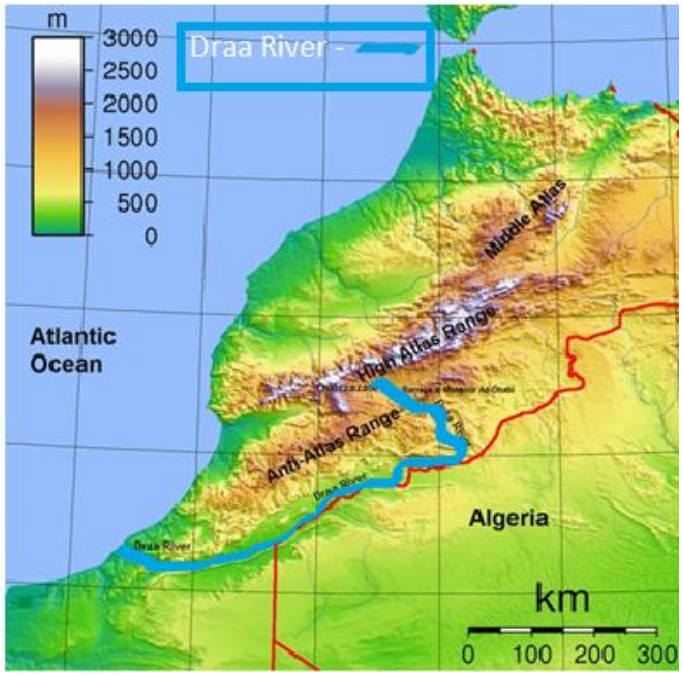

Figure 1- Map of Morocco showing the Drâa River adapted from The Encyclopedia of Earth

The Drâa valley is an arid region situated in southern Morocco and takes its name from the eponymous river. About 225,000 people live in the valley (Wikipedia), which is also Morocco's poorest region (M'barek, Schmidt and Koll).

A part of it, known as the Middle Drâa valley is supplied by the Drâa River which begins at the intersection of the River Dades and the River Ouarzazate and runs along a 200 kilometers belt of six aligned palm tree oases and drains into Atlantic Ocean. The oases are named from north to south: Mezguita, Tinzouline, Ternata, Fezouata, Ktaoua and Mhamid (Klose).

The Ternata oasis, in the Zagora province, is the biggest of the six oases of the Middle Drâa valley and covers an area of 8 hectares (ha). The oasis is mainly composed of a valley, and, like the other oases around it, its revenue is dependent on irrigation based agriculture. According to ORMVAO (Organisation pour la Mise en Valeur Agricole de Ouarzazate) 6 ha of the Ternata area is considered arable farmland and is cultivated by 4 farming families (Kuhn et al.).

Agriculture is characterized mainly by subsistence farming. Palm trees are intercropped with cereals and small bush trees such as grenadines or figs. Date palms are the only cash crop cultivated in the Drâa oases and therefore the most important source of income from agricultural activities. Altogether, cereals make up 90 % of the crops cultivated in total, alfalfa 5 %, the rest is for a mixture of vegetables and henna (Kuhn et al.).

Agriculture is by far the largest user of water in the region. Farmers depend on water to irrigate their fields as rain-fed agriculture is not possible and hardly practiced (Heidecke and Heckelei). The water requirements per crop throughout the year vary depending on the type of crop and the period of the year though it is certain cereals consume the highest share of water(Chichagov). The water consumed by date palms can only be regarded as an approximation as they are cultivated in between other crops and can therefore make use of infiltrated water from other crops (Askri et al.).

The majority of the agricultural production is consumed by the farmers or sold on local markets. The notable exceptions are dates, which are sold nationally(De Haas). Some livestock and other crops are also sold, but there is little data on this as the sales are at a smaller and more local scale. In recent years, there has been an increase in the tourism sector, and it now brings in approximately 7% of the valley's revenue (Werner).

In addition to being essential for income generating activities, the oasis provides numerous Eco services. Its tree and plant biomass helps with carbon sequestration (Chelleri et al.). The palm trees serve as wind breakers, which protects houses and the lands. The trees shield crops from high temperatures by decreasing the rate of evapo-transpiration (Chelleri et al.). The trees also decrease the risk of soil erosion, and help to conserve a healthy soil ecosystem. The latter two services benefit the majority of the inhabitants.

The problem:

Historically, at least part of the Drâa River flows all year round. Born from melting snow packs and the high levels of rainfall in the High Atlas Mountains, the river's flow has decreased over the past 15 years as a result of the declining precipitation levels (Heidecke and Heckelei).

Like in other arid regions, the agricultural production is dependent on irrigation, which is used to supplement rain fall in the Middle Drâa Valley. In this area, irrigation is extremely important as it mitigates the impact of variable rainfalls, helping decrease extreme fluctuations in production and prices (Fox and Rockström).

In the Middle Drâa Valley water for irrigation is obtained from the river's flow, which is near continuous year round(Heidecke and Heckelei). Alternatively, groundwater in the shallow aquifers is pumped up to the surface using diesel pumps. Due to the high cost of the fuel, groundwater pumping is only done in extreme situations, and normally only accounts for nine tenth of the total water used (Heidecke and Heckelei). However for the past few years, which have been very dry,

people have increasingly relied on groundwater. This has caused a fall in the water table as the rate of pumping exceeds the natural recharge rate, further decreased by the low rainfalls (Heidecke and Heckelei).

A consequence of the overuse of groundwater resources is the resulting salinization of the land, combined with an increase in soil erosion. Both these factors are linked to an increase in poverty levels, and reduce the productivity of the land. This is very damaging for a community that relies on agricultural production for survival. Furthermore, according to FAOSTAT, while Morocco is among the 13th in the world (FAOSTAT) in terms of gross production volume of dates (70 000 Tonnes) (CEAFE), it has a low productivity per hectare (16kg/tree) (CEAFE). We can assume that this situation is only worsened by the decrease in soil quality.

The cause of the problem (and the possible solution)

When analysing the situation in Ternata, it becomes apparent that numerous production inputs are not marketed. For example, rangelands and water are common resources and free for all to use. This brings to mind the situation economist's often refer to as "the tragedy of the commons", where a free resource that everyone can consume is overused.

This results in a high number of negative externalities. These are defined as a transaction that impacts third parties. For example, cattle damage the ecosystem as the livestock trample the fragile flora and overeat it (Werner). This has an impact not only the owner of the cattle, but as this can increase erosion, it can impact a farmer downhill. The destruction of the ecosystem also decreases the Eco services it delivers, thus affecting all the people who benefitted from them.

Another example is that of farmers using groundwater which depletes the aquifer, which impacts someone living nearby in case of soil erosion. Another example relevant to Ternata is the pollution of water sources due to the indiscriminate use of chemical pesticides in crop protection.

One way to mitigate externalities is to set the price of the good that is responsible for the negative externality high enough that it covers it. A higher price results in less demand for the good and better allocation of the resource. Thus, we hypothesize that one way to counter the overuse of water resources in Ternata is to introduce a water pricing scheme for farmers. Since farmers are dependent on water for irrigation, the scheme also includes incentives for farmers to adopt drip irrigation, which is more water efficient than the current technique.

Study Objective

The objective of this cost benefit analysis is to evaluate the feasibility and impact of developing an integrated water management program that consists of implementing a water pricing structure alongside a scheme promoting drip irrigation in Ternata.

The study serves as a pilot for a future transformation of the agricultural sector in the Middle Drâa river basin. We will take into account select environmental goods and benefits the oasis ecosystems provides to the local population.

Given time constraints, we decided to focus on only one of the six oasis of the Drâa Valley, with the intention for our results to be replicable in the other ones, as well as different arid regions. The chosen oasis, Ternata, is the largest oasis and located in the centre of the valley. This placement

ensures that it is in the middle range with regards to water availability and water and soil salinization as a result of groundwater pumping.

Without-Scenario: Date palm production with traditional channel surface irrigation:

In the without scenario, we assume that the situation in Ternata is the same as in the present. Therefore, cultivations are irrigated using flood irrigation. Furrow and basins are built to direct the flow of water from the bed of the river through narrow channels dug between the rows of plants. Thus, water is not evenly distributed throughout the field and instead irrigates key areas. This traditional irrigation method is not very water efficient due to high losses because of evaporation.

The costs of using groundwater consist in the costs of pumping it, thus the price of fuel and the cost and maintenance of the motor pumps, which is equal to 0.07 USD/m^3 (Storm, Heckelei and Heidecke).

The total amount of irrigation water used for agricultural purposes in the Ternata oasis is estimated to be 58.28 million m^3 per year. Irrigation water requirement for date palm production in Ternata is approximated to be 6.25 million m^3 per year.

Using 1995 ORMVAO figures, we estimate that there are currently 330.000 palm trees in the Ternata oasis, which is equivalent to a tree density of 56.3 trees/ha. Date palms are intercropped with other plants, and irrigated indirectly alongside the other crops in normal years. Dates generate an annual revenue of approximately 12 656 250 Dirham/Year (1 549 416 US$).

When water levels run low, farmers will prioritize the irrigation of the Date palms over their other crops. This is partly due to the fact that trees are perennial crops so they have a long term value for farmers, but also because the trees are the major income source and the main cash crop of the oases. On average palm trees yield 18 kg of dates per tree (ORMVAO)however, in times of water scarcity the yield decreases to 12 kilogram per tree (ORMVAO).

With-Project-Scenario:

In the following section we will present components of the intervention we designed. A pilot program will be carried out in the Ternata oasis, and this is what we base our cost benefit analysis on.

The two co-interventions are detailed below. The first intervention consists in the introduction of a water payment scheme in the Ternata oasis to diminish the unsustainable use of the water from the Drâa River. The second intervention is the introduction of a sub-surface dripping irrigation system to enhance the water efficiency in date palm production and decrease overall volume of water used.

The expected time span of the project is 5 years.

Co –Intervention A - Water pricing scheme:

In addition to the current costs of pumping groundwater, farmers who use it will also face a fine to discourage them and allow the aquifers to recharge.

The big difference will be in the pricing of the surface water obtained from the Drâa River. Using previous studies and the benefit transfer method, we calculated we should charge approximately 2,025 Dirham/m^3 (0.25 USD$/ m^3)of surface water used (Heidecke and Heckelei). This figure was obtained by averaging the values obtained by a study that calculating farmer's willingness to pay in the region.

The fees will be levied by a special branch of ORMVAO and will be put in a trust fund whose revenues will be used to stimulate the economic development of Ternata. Furthermore, the trust fund will be used to pay for the salary of the enforcers of the water scheme, as well as any material they need. A mechanism will be designed so that the local population has oversight of the fund, to discourage mismanagement of the money. In general, revenues generated from this fee can only be spent on projects that directly benefit the payers.

According to the irrigation water requirements listed in the above section, this equals to 118.017.000 Dirham/year (14 000 US$) charged for the total amount of irrigation water (assuming there is no change in the amount used). We will also initially assume that there is no change in the amount of the date production as a result of the water pricing scheme.

Using benefit transfer, we calculated that in total, Ternata will use 8.13 million m^3 of water, which will generate 16 463 250 Dirham/Year in revenue (2 000 000 US$).

Water revenues will be managed in a community trust fund which will be used to finance economic development projects in the oasis, such as a campaign to promote Drâa valley dates in national and international markets. This measure will be accompanied by the introduction of a seal for "oasis products from the Drâa valley" to enhance competitiveness of the agricultural production (e.g. dates).

Co-intervention B – Introduction of sub-surface dripping irrigation system:

The implementation of water pricing will create a financial incentive for the adoption of water efficient technology. This is critical for more efficient water usage (more crops per drop) in the oasis. As the start-up costs of implementing drip irrigation on one's land are quite high, this project will be achieved through tax rebates. There will be a particular focus on the date palm groves. Drip irrigation will reduce the amount of water used for irrigation significantly in addition to evaporation losses.

Extrapolating data from almond groves in a nearby area, we calculated that the installation of a drip irrigation system would cost US$3254/ha ($2492 for the 4 line rows per hectare, plus $262 for in-between lines for intercrops and $500 for the water tank). Using an alternative drip irrigation cost benefit analysis, we calculated that the cost may be upwards of US$4489/ha or 36.367 Dirham. We will use both values in the cost benefit analysis, as well as those provided by Driptech a startup which provides low cost irrigation systems. The Driptech values yield costs of $108 per hectare,

however the technology has not been tried in Morocco, so there is some uncertainty as to its success rate which we will model by increasing the installation price in the cost benefit analysis.

Discount Rate:

We performed the cost benefit analysis from the perspective of the local farmers. As already mentioned, the majority of the population depends on agriculture for survival. As such, the priority is to survive, and future payoffs have little value in the present. We thus set an extremely high discount rate to reflect this. The results of our calculations can be seen in Table 1, below. The benefit calculations are detailed in Appendix A.

Table 1- Calculation of Present Value

Year ->	1	2	3	4	5
Benefit (USD)	1,549,416	2,014,241	2,618,513	3,404,067	4,425,287
Discount rate %	95%	95%	95%	95%	95%
Discount Factor	1	1.95	3.8025	7.414875	14.459006
Present value	1,549,416	3,927,770	9,956,896	25,240,731	63,985,253

Sensitivity Analysis Factors:

There are numerous factors that could impact the feasibility of the interventions, and these should be examined in the sensitivity analysis.

For the present benefit calculation we used conservative estimates of the increase in crop production with drip irrigation, and assumed a decrease in crop production in the absence of any water management due to an increase in soil erosion and salinity. These values should be both zeroed and brought to extremes to determine their impact on the feasibility of the intervention. Due to how we structured our calculations these are factors are likely to be key.

The percentage of groundwater used, as well as the amount of overall water use should also be varied, as well as the price of surface water. We assumed that the costs of other agricultural inputs remained constant within the scenarios and between the two (and excluded them from our calculations for simplicity), but this may not be the case in real life. One way to account for this without having to rebuild our

Our pick:

Table 2 - Calculation of Net Present Value

	1	2	3	4	5

Incremental Net Benefit	-1,406,250	-92,821	1,148,466	2,432,257	3,873,617
Present value of Incremental Net Benefit	-1,406,250	-181,002	4,367,044	18,034,881	56,008,653
Economic Net Present Value			*76,823,326*		

According to our calculations, the intervention is worth doing, and we would thus pick this scenario. There are however other reasons to support this choice.

Date palm trees (*phoenix dactylifera*) can be short-lived to about 100 years and more. Usually they start fruiting after 3-4 years after planting, up to the top of palm production in the second decade of life after (10-15) years of cultivation, depending on the variety and service operations and environmental conditions surrounding the contribution and continuing at the same rate to the age of 50 years. The palm tree has radical depth, and a root length of up to 10 meters, which helps to bear the drought, salinity and contributes to the maintenance of the soil from erosion. Because of the features mentioned the palm tree plays a very important historic role in Morocco. It is one of the most important economic trees in the hot and dry climate.

Date palm is considered the first and most important cash crop in the Draa valley. It is integrated and well adapted to the existing agricultural ecosystem with great importance in the life of the Draa people, directly and indirectly. Great efforts are made, especially by the Ministry of Agriculture, to maximize economic returns and foster the social and environmental impacts of palm trees.

The Draa valley is famous as the date basket of Morocco. It grows more than 18 varieties. The most important characteristics of these varieties are the considerable variation in quality and time of maturity (early, intermediate, late), the difference in productivity and the rate of annual growth as well as resistance to pests and diseases.

In conclusion, date palm production is of the great economic and historic importance in the Draa valley. The preservation of suitable conditions for date palm cultivation in the region is critical for economic and social reasons. Thus, considering the local and historical circumstances the conservation of the oasis ecosystem is major priority. Depletion of the water resources in the region due to unsustainable water use has to be inverted as water is the basis of all agricultural activities. The “With-Project-Scenario” is considered as the prioritized one.

The two direct interventions in the Ternata Oasis mentioned will be embedded in a general development strategy for the Draa valley to overcome overall poverty of its population. Therefore a regional strategy to promote date palm and a consistent action plan has to be developed to give date palm producers better market access. The strategy consists in four complementary development programs. Water revenues will be managed in a community trust fund which will be used to finance economic development projects in the oasis.

The scope of this strategy is to maximize the economic returns as well as water, social and environmental benefits for cultivation of date palm in the Draa valley on the individual and regional level. The most important objectives of this strategy are:

- Maximizing the yield potential of palm tree and reducing the surface water use. Both objectives will be achieved by the implementation of the main interventions of the project. The Moroccan Government runs a subsidize program and covers up to 100% of total costs

related to irrigation system if the farmer wants to use drip irrigation. In this context, the ORMVAO provide farmers of the Draa Valley with technical and financial assistance to install drip irrigation. Small scale farmers with up to 5 ha of agricultural land are subsidized by government up to 100% if they want to switch to drip irrigation. If farmers possess more than 5 ha of land, government still pays 80% of total purchasing and installation costs.

- A marketing concept of dates on national and international markets will be developed. An international promotion campaign has to be undertaken by advertising agricultural oasis production (e.g. dates) on international fairs. Therefore a seal will be invented for "Oasis Products from the Draa valley" to enhance competitiveness of the date palm production in international markets.

- Extension program for development of the date palm sector in the Draa region will be implemented. General knowledge of date palm production has to be delivered to the farmers to produce high quality dates which comply with consumer demands. In addition postharvest losses have to be minimized by training the farmers how to treat and store the date harvest properly to avoid cross contamination and pest or fungi infestation.

- A strategic plan to develop tourism sector in the Draa valley will be elaborated to promote the oasis ecosystem as a unique cultural landscape farmed in a sustainable manner to attract international tourists from Ouarzazate city with its international airport. These measures will be developed with help from the same government agency organizing the training sessions, namely ORMVAO (Organisation pour la Mise en Valeur Agricol de Ouarzazate).

In addition to the above mentioned, a contract will be signed with the administration of the El-Mansour Eddahbi dam. The company running the dam for the generation of hydro power has to invest a percentage of their revenues in infrastructure and development programs in the Draa valley. The aim is to establish a close relation between the dam authorities and the Draa valley population to foster development of the region while preserving the water resources which is a mutual interest of the stakeholder groups. Alternatively, payments from the dam could be made directly to the trust fund. A mechanism will be in place to insure the trust fund is not mismanaged.

The advantages of drip irrigation are water application efficiency and reducing the water losses. The unique feature of drip irrigation is the ability to apply small and frequent amount of fertilizer and the potential for applying it uniformly to minimize the loss of soluble nutrients. These advantages can increase yield and revenue, and decrease overall cultivation costs when compared to the other irrigation methods. Drip irrigation can save up to 50-75 % of the irrigation water when compared to canal irrigation. Easily control of the water application in drip irrigation, along with reduced weeds growth, easy fertilizer application has led to increases the yield from 30-100 % while fertilizers use decreases by up to 25- 30 % and which also reduces the growth of weed.

Drip irrigation is also reducing the incidence of crop diseases, by creating unsuitable habitat for insects to regenerate, through low humidity. The life span of the drip irrigation system is usually 5 years. A back of the envelope calculation estimates that, with a 35% decrease in water amount used this would result in a saving of 2.19 million m^3 water per year, or at the established price a saving of 4.429.688 Dirham or 544.852 US$.

On average palm trees can yield 18 kg per tree in the southern regions of Morocco (ORMVAO). If at least 30% of yield increase could be achieved, this would equal to 6 kg of dates per tree. With a tree density of 56.3 trees/ha yield increase per hectare would reach approximately 338 kg.

The highest gross margins are obtained by date palm production. This is due to the high market price of date palms which varies according to the quality but has been set at an average price of 10 Dirham per kilogram for this calculation. In addition, production costs are low for date palms as date palm production does not require fertilizer, seeds or machinery input. Hence, the only variable production costs are water and labor for harvest. For the set price of 10 Dirham/kg, income increase from date production would reach 3380 Dirham/ha (US$ 416) per production cycle.

The major crops cultivated on arable land associated with date palm are cereals. Fertilizer and labor input for wheat production are high compared to other cereals cultivated in the Drâa valley. Together with date palms wheat is of priority to the farmers as wheat is used for flour and homemade bread, an important part of the Moroccan diet. A scientific study points out that farmers of the region basically use two types of fertilizer. Both fertilizers are bought on the local markets in bags of 50 kilograms whereas each bag costs 100 Dirham. The same study estimates fertilizer application of 365 kg/ha for wheat production. With a more efficient irrigation system fertilizers use decreases by up to 25-30% which equals to approx. 100 kg/ha of less fertilizer applied, which lowers production cost by approx. 200 Dirham/ha (≈US$ 25).

However, under traditional farming systems, drip irrigation alone may not be very cost effective. This may be because of the lack of technical competence and better inputs availability to achieve higher crop yields. It was observed that farmer's financial return was higher when the drip irrigation system was practiced in combination with improved soil fertility, high-value crops, and trained horticultural work force. The majority of farmers are convinced that labor, time, and capital can be saved through the drip irrigation system. Growers may get higher financial benefits through improved water productivity (WP) and its role in enhancing farmer's participation in commercial horticultural farming is significant.

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Appendix A:

Background Data:	
Population in the Draa Valley	255000
Average annual income per capita (USD)	300
Number of farming families in Ternata	4
Interest rate	3.70%

Productivity per hectare:	
National Date Production (Mega Tonnes)	127000
Cultivated hectares	39300
Productivity Megatonnes/ha	*3.23*

Total production in Ternata (using figures for the Draa valley)	
Number of Trees in Ternata	330000
Output per tree (kg)	15
Total output (kg)	*4,950,000*

Revenue from dates	
Total output (kg)	4,950,000
Total revenue in Ternata (USD)	1,549,416
Revenue/kg	0.31

Production Input	
Amoun of water for dates (m^3)	6250000
% Surface water	0.9
% Groundwater (normal)	0.1
increase groundwater used annually with dry years	1.6
Cost of surface water/ m^3	0.25
Fine for using groundwater	1
Percent time caught using groundwater	0.1
Costs of using groundwater per m^3	0.07
Decrease in productivity due to erosion and salinization	25%

Drip Irrigation	
Price per hectare (conventional)	3254
Price per hectare (driptech)	108

Benefit of irrigation	
Increase in crop production	30%
Decrease in amount of water used	50%

WITHOUT SCENARIO	Year 1	Year 2	Year 3	Year 4	Year 5
Date production (kg)	4,950,000	3,712,500	2,784,375	2,088,281	1,566,211
Revenue (USD)	*1,549,416*	*1,162,062*	*871,547*	*653,660*	*490,245*
Total amount of water used	6,250,000	6,250,000	6,250,000	6,250,000	6,250,000
Groundwater m^3	625,000	1,000,000	1,600,000	2,560,000	4,096,000
Costs of using groundwater	43,750	70,000	112,000	179,200	286,720
Amount of surfacewater used	5,625,000	5,250,000	4,650,000	3,690,000	2,154,000
Costs of using surface water	0	0	0	0	0
Total costs	*43,750*	*70,000*	*112,000*	*179,200*	*286,720*
Net profit:	***1,505,666***	***1,092,062***	***759,547***	***474,460***	***203,525***

WITH SCENARIO	Year 1	Year 2	Year 3	Year 4	Year 5
Date production (kg)	4,950,000	6,435,000	8,365,500	10,875,150	14,137,695
Revenue (USD)	1,549,416	2,014,241	2,618,513	3,404,067	4,425,287
Total amount of water used	6,250,000	4,375,000	3,062,500	2,143,750	1,500,625
Groundwater m^3	625,000	437,500	306,250	214,375	150,063
Costs of using groundwater	43,750	30,625	21,438	15,006	10,504
Amount of surfacewater used	5,625,000	3,937,500	2,756,250	1,929,375	1,350,563
Costs of using surface water	1,406,250	984,375	689,063	482,344	337,641
Total costs	1,450,000	1,015,000	710,500	497,350	348,145
Net profit:	**99,416**	**999,241**	**1,908,013**	**2,906,717**	**4,077,142**