The Hefer Valley as the Green Lung of Central Israel: An Economic Evaluation of Alternative Programs for the year 2015[1] And their interaction with the Economy of Israel

By

Daniel Freeman[2] & Zeev Hagali[3]

Abstract

The objective is to sustain a "Green lung" between the towns of Netanya and Hadera in Central Israel by initiating essential economic prerequisites that will be profitable enough to foment and maintain viable agricultural production.

The agricultural plans for the year 2015 entail the use of 17 million m^3 of fresh water for production of vegetable and flower crops and 34 million m^3 of recycled sewage water from three recycling plants used in the production of fruit plantations and field crops. The foregoing prerequisites will be the simultaneous increases in quality and quantity of yields due to a quantitative diminution of concentrates of all free salinity ions in the irrigation water inclusive of the concentration of chlorides down to around 150mg/l.

A comparative evaluation of the outcomes of four alternate plans of water supply is performed in order to select the most efficient one: in the 1st one both kinds of the irrigation water will be supplied from the current sources without any diminution of salt concentration. This plan will be used as a basis for comparison with the outcomes of the other three alternate plans in which a diminution of chlorides to 150mg/l is proposed to be implemented. The 3rd alternate plan, in which desalinated sea water will be supplied directly to Netanya is the most efficient one, since it avoids the need to desalinate neither the supply of fresh drinking water to the population nor the recycled water later on. The diminution of the desalinized quantities will minimize the operating cost of Afikei Emek Hefer[4] in distributing the recycled water to the farmers simultaneously with a resultant reduction of the subsidy which is the difference between the operating cost and the charge of $^{NIS}0.59/m^3$ to be paid by the farmers. The outcomes of the four alternate plans were spliced sequentially 4 times into an Input–Output model of all the sectors of the

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[1] This is a brief of a research report by our team, financed by a grant of the water authority of Israel.

[2] Computerized Economic Models, 11 Rupin st., Rehovot, Israel

[3] Afikei Emek Hefer, an association of growers that supplys recycled water to its members.

[4] Afikei Emek Hefer is the association of growers that manages the distribution of recycled water to the growers. The words in Hebrew are: afikei=river beds, emek=valley, Hefer=name of the valley.

Hefer valley economy in order to estimate the share of agriculture in the outputs and profits of its economy.

Introduction

The background for this research is the decision of the regional council to activate a plan that will enable the Hefer valley to be the Green Lung of central Israel according to a comprehensive national plan whose objectives are the following:

1. Establishment of a rural environment for the population of the valley.
2. Maintenance of a "green belt" between Hadera and Netanya that will contribute to the quality of the environment.
3. Substitution of most of the fresh water used for irrigation by recycled water.
4. Deceleration of the quality of the coastal aquifer by attending to the pollutants that sift down into it due to agricultural uses of water and chemicals.
5. Maintaining a high enough level of output to ensure the viability of agricultural production whose profitability will ensure the sustenance of the "green lung".

The arguments for the performance of this research

1. Sustaining a "Green lung" between the towns of Netanya and Hadera in Central Israel depends on the profitability that will induce farmers to maintain the agricultural production, despite the limitations of fresh water quantities for agriculture, due to both diminution of rainfall and the rising needs of a growing population.
2. Maintaining the quality of the underground aquifer by diminution of pollutant quantities such as chlorides, and other free salt ions that the tillage, the animal and human effluents and the industrial residuals pour on the land:
   - It is essential to prevent the increase in salinity of soil and water, since the substitution of fresh water by recycled ones enhances the danger of contamination by excesses of chlorides and nitrates and other salts.
   - The cost of supplying water will rise due to desalinization of sea water to the population and recycled water to agriculture.

- The outcome will be **an increase** of the output and the contribution to the GDP due to the rise in both the yields and their quality that will encourage the farmers to maintain the agricultural production.

The research objective

The research objective is to evaluate and compare the contribution of each of the following four alternate plans:

1. Enlarged quantities of both kinds of the irrigation water for larger areas will be supplied from the current sources without any diminution of salt concentration;
2. Three alternate plans in which a diminution of salt content is performed by desalinization of differing fractions of the quantities from the current sources and also of sea water for use by the population. The economic cost-benefit ratios of these alternate plans are compared to the first one as well as among them in order to decide which is the most effective one for the year 2015 including the costs of effluent reduction in comparison to the current costs in 2003.

In the research report are presented the outcomes of the following projections:

1. The size of the areas of each of the vegetal crops,
2. water uses in 2015,
3. The operating costs of the supply systems to agriculture,
4. The subsidy to the growers,
5. The market value (i.e. output) of the crops,
6. The contribution to GDP of the valley,
7. The share of agricultural outcome in a model that presents all the sectors of the economy of the valley.

1.The research method

Estimation of the share of the output and GDP of agriculture in the valley in an economic Input-Output model of all the sectors of the regional economy. An economic and environmental analysis tests the benefit–cost ratios of the investments and costs of the foregoing activities, as well as the conditions that will ensure the stimulation and continuation of production by growers. The target year of the model is 2015.

2. The stages in the research procedure

- Projection of the water consumption for the cropping program for 2015.
- Allotment of 17 million m^3 of fresh water for each settlement according to type (i.e. moshav or kibbutz or private growers) out of a total 31 million m^3 of "water rights of 1989"; the residual quantity of 14.1 million m^3 will be substituted by recycled water.
- The current supply of recycled water is 19.9 million m^3 to which an additional supply of 16.9 million m^3 will be added in exchange for the foregoing 14.1 million m^3 of fresh water at the ratio of 1.2 m^3 of recycled water for 1 m^3 of fresh water; thus, the "new rights" of recycled water will be 36.8.
- The supply of recycled water for the year 2015 is the outcome of the fresh water for non agricultural uses and for the population in 2015 whose size is projected by the average rate of growth of the last ten years. The estimates are from the following recycling plants (in millions $m^{3)}$: Netanya19.2, Merez 4.6, Yad Hana 6.5 (an extra 2.5 to Nahal Alexander[5]) plus 4 from winter floods to a total of 34.3 - less than the foregoing "new rights" of 36.8.
- The plan for 2015 is of 14,025 dunam of vegetables and flowers using 17 million m^3 and of 54,025 dunam of fruit orchards and field crops using 34 million m^3.
- The real operating cost of fresh water of Mekorot Company is ^{NIS}1.50/m^3, but the supply price to the farmers is ^{NIS}1.425 according to a circular by Yoram Tamari.[6] The subsidy is the difference between the operating cost and the supply price.
- Afikei Emek Hefer, receives the recycled water for the price of 0 at the recycling plants, and its operating cost for all the activities to supply the recycled water to the growers is ^{NIS}1.50/ m^3, excluding the costs of desalination and removal of salt concentrates. The growers pay only ^{NIS} 0.59 / m^3 according to Tamari, and the difference is the subsidy. Of course, the acts of desalination will increase the operating cost.
- A positive economic benefit due to the diminution of chlorides to 150 mg/l, as well as all the other ions, is proven in the outcome from both kinds of water for irrigation, of both a greater yield and a better market quality, simultaneously with

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[5] Nahal is in Hebrew a stream of water or a dry river bed, which in Arabic is called wadi.

[6] Yoram Tamari in charge of the water quota and the supply price in the Association of Agricultural Producers in Israel.

a diminution of water quantities per dunam. The outcome is a larger output value of some of the fruit orchards (especially citrus and avocado) and some of the vegetables (especially cucumbers, tomatoes and pepper) which were pointed out by experienced instructors and growers.

- The output, its local and export sales and the GDP are spliced into an Input-Output linear model that comprises all the sectors of the economy of the valley. The model is run four times since it is run for each alternate plan separately .

3. The salinity impact of all free ions

The foregoing discussion has been so far in terms of the concentration of chlorides , but it is essential to include in the discussion the total impact in terms of EC (i.e. electrical conductivity) of all the free salt ions. Research conclusions in some professional publications state that there is no reduction of yield levels of crops irrigated with water whose total salinity impact is between EC= 0 to 1.5; according to the following research results it seems that the foregoing statement is erroneous because the researchers did neither measure nor report the amounts of irrigation water that were used to attain the maximum yields.

In the following section are presented graphs and tables derived by a model which is capable of reliably predicting plant–environmental inter-relationships for variable species, climates, soils and management options. It is a necessary tool for creating sustainable agriculture and environmental preservation. This mechanism-based analytical model, the first of its kind, is based on multiple environmental variables and their combined effects on plant response. It was developed and found to predict successfully water use and yield of crops with variable soils, climate conditions, input water levels and water salinity[7]. Water uptake by plants, water and salt leakage below the roots and the yield are calculated by solving for transpiration in a single mathematical expression where response to combined water and salt stress is determined according to effective root zone salinity and water status. Input variables include the quantity and salinity of applied water, a term for plant sensitivity to salinity, a term for plant sensitivity to water stress, potential evapotranspiration, and soil hydraulic parameters. Application of the

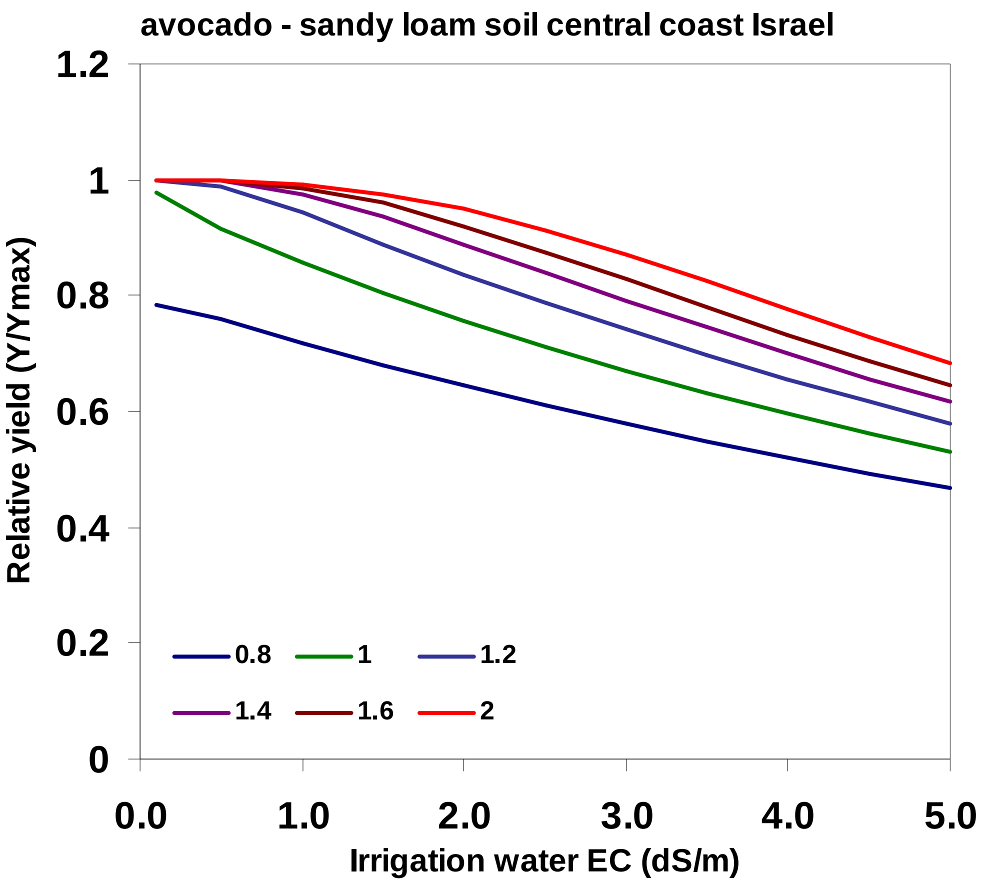
[7] A Model by Shani U. Ben Gal A., Dudely L.M, see bibliography.

model for agricultural output analysis due to reduction of salinity is presented in the following graph and table.

Graph no.1 presents the impact of total salinity in sandy–loam soils on the ratio of water supply to yields of avocado due to the rising total salinity which is measured in terms of EC[8]. The vertical axis presents the ratio of yields where the digit 1 stands for maximum yield when EC=0 on the horizontal axis, and the colored lines present the ratio between the quantity of water (I) to the water needs of the plants measured by evapotranspiration (ETp) from a pan of water and inserted in the equation as(I/ETp). For example, the **green line** presents the diminution of yield due to the rising salinity in terms of EC. The line begins on the vertical axis with EC=0 with an optimal quantity of water according to the foregoing measurement, and its descent indicates the maximum yield at each level of the rising salinity which is measured on the horizontal axis. When EC=5 the yield is about 60% (0.6 on the vertical axis). In contrast to this the **red line** which is marked by the digit **2** presents the scenario of maximum yields at each level of salinity with a **double quantity** of water. The extra water is needed to wash away the excess salt in the root zone.

Graph no.1

[8] See footnote 3. The graph was prepared by Dr. Alon Ben Gal, which he derived by the foregoing model;. He asserts that the parameters which he used to activate the model, and especially the sensitivity of the crops, were taken from the literature and he did not measure them personally.



In Table no.1 the columns represent the data in the graph up to a salinity level of EC=2. Each column is colored with an identical color to the one in the graph. In the **green column** when EC=**1**, the yield is 85% which is presented by the figure **0.85** which indicates that a yield of 85% is a loss of 15%, on the other hand while in the **red column** when EC=1 the yield is represented by the digit 1 which represents a 100 % yield. If a grower gets the saline water at EC=1 and wants to increase the yield he will have to add the following quantities of water: 20% (indicated in the header of the **blue column** by1.2) to get a 95 % yield, and 40% for a 98% yield (in the **violet column),**etc.

A significant comment here is that the foregoing data indicate that the claim that there is no yield reduction up to a salinity of EC=1.6 is erroneous, since the reports did not include data of the extra irrigation quantity that was applied in order to maintain the maximum yield. [9]

Table no.1

[9] Other tables and graphs in Research Report no. 4 of our team show that the rate of yield diminution is faster in heavier soils.

Yield levels of avocado, given increases of both quantity and salinity of water

EC In the irrigation water	An opimal water quantity	A water quantity of +20%	A water quantity of +40%	A water quantity of +60%	A water quantity of +100%
	1	1.2	1.4	1.6	2
0	1	1	1	1	1
0.5	0.92	0.99	1	1	1
1	0.85	0.95	0.98	0.99	1
1.5	0.81	0.89	0.95	0.98	0.98
2	0.76	0.85	0.92	0.93	0.96

4. The four plans and the findings

4.1 The four alternate plans are

1. A plan of the "current resources", where the assumptions are: a. A greater quantity of drinking water will be supplied from the same sources of both Mekorot[10] and private wells; b. Desalinization will not be applied:
   - The fresh water will be supplied by Mekorot from the Kakun wells and from private wells of settlements and growers all over the valley.
   - Recycled water will be supplied from three recycling plants: Netanya, Merez, Yad Hana and their quantity will be augmented from floods in dry rivers of the area.

   This alternate plan is presented as a basis of comparison of the increases of outcome and benefits of the other three alternate plans in which desalinization is to be implemented.
2. A "Base Plan" in which the saline fresh water from wells in Netanya and the quantity from Mekorot will be desalinized.
3. A "West Coast Conduit" plan which is based on the idea that desalinized sea water will be supplied directly to Netanya by a direct conduit along the coast from the plant "Orot Rabin" in Hadera.
4. A "Desalinization of Recycled Water" plan which is based on the idea that the supply of fresh drinking water to Netanya will be from the national conduit, which will blend

[10] Mekorot is the national water supply company.

300 million m^3 from lake Galilee and a100 million m^3 of desalinized sea water from the plant in "Orot Rabin".

All phases of the following analysis were performed for 90 different types of crops that were later aggregated into 30 industries in the input output framework.

4.2 The results of the analysis

Table 2 presents data of water supply, totals of the operating costs, price to the growers and the subsidy (millions NIS). The comparison of operating costs shows that:

- In alternate plans no. 2,3,4 it is higher than in the 1st one though the water quantities are identical;
- In the 3rd alternate plan it is lower than in the 2nd and the 4th.

Table 2 Totals of operating cost, subsidy, and cost to growers (millions NIS)

the alterna-tive	description of the alternative	crop area dunam	operating cost	subsidy	cost to the growers
1	Current resources	68,100	77.4	32.6	44.8
2	Base, before adding crops	68,100	113.8	74.3	39.5
	Base, after added crops	77,600	131.6	86.9	44.8
3	Western Conduit	77,600	93.6	48.8	44.8
4	Desalinized Recycled Water	77,600	112.2	67.4	44.8

Table 3 presents the needed quantities of nitrogen in both the irrigation water and the fertilizers, and the quantities that are re-bought due to the removal of some of the foregoing ones due to desalination. The alternate plans 2, 3, 4 include the outcome of additional irrigated areas with the saved water quantities due to the reduction of the salinity.

Table 4 shows that in the 3rd alternate plan the desalinized quantities are the lowest, which explains the lower operating cost in table 1.

The findings of the impact of decreased salinity for a part of the crops were supported by both instructors and leading growers of vegetables and fruits.

Table 3 the quantities of needed nitrogen (alternatives 2,3,4 include added areas)

the alternative	needed nitrogen (tons)	nitrogen in the water (tons)	nitrogen in the fertilizer (tons)	nitrogen cost in fertilizer (million NIS)	quantity of nitrogen losses (tons)	cost of replaced nitrogen (million NIS)
1	1406.6	969.1	437.4	2.0		
2	1648.6	969.1	679.5	3.06	328.6	1.48
3	1648.6	969.1	679.5	3.06	296.2	1.33
4	1648.6	969.1	679.5	3.06	888.5	4.00

Table 4 quantities of chlorides before and after desalinization

the alternative	desalinized quantity (‘000 m^3)	total chlorides before desalinization (tons)	the remaining chlorides after desalinization (tons)	The quantity of removed chlorides (tons)
1	0	11,900	no desalinization	none
2	33,087	12,783	5,899	6,884
3	10,023	12,050	6,425	5,625
4	32,813	14,219	7,446	6,773

Only those crops are included in the increase of the yields. But crops such as flowers and some of the fruit plantations, such as olives, pomegranates, and some of the field crops were not included in the yield increases.

Table 5 presents the increase in output values on the basis of the foregoing expert opinions. The increase is from 838 millions NIS to 959 millions NIS before the addition of 9,500 dunam which are irrigated by 6,463,000 $m^{3.}$ The additional areas will be 7,800 dunam of avocado and citrus fruits grown on recycled water, and 1;750 dunam of vegetables in green houses grown on fresh water. The addition of output value will be 1,088 millions NIS, which is an increase of 30% while the addition to GDP will be 42%. This greater proportional growth of GDP is explained by the fact that the additional yield does not increase the tillage and caring cost for the crops, and the cost increases are only due to picking and packaging costs; thus, the net addition to GDP is relatively larger.

Table 5 The output and GDP of the vegetal crops

the alternative	cropping area (dunam)	output (millions NIS)	GDP (millions NIS)

1	66,100	838	430
2,3,4	77,800	1,086	611
difference	14%	30%	42%

5. The construction of the input output model

The I-O model is designed to create a framework for a comparative analysis of the outcome of the four foregoing alternate plans and the share of agriculture in the region's output and GDP.

5.1 The Model structure

The model size is 86*86 industries:

agriculture		30
manufacturing		28
water supply:	fresh	2
	recycled	10
Chlorides and Nitrogen		2
electricity, construction &services		14
	Total	86

The primary resource components are:

- Import: 2 rows, 1. from the rest of Israel, 2. from the rest of the world;
- Labor costs;
- Taxes +capital returns.

The Final demand components are:

- Private consumption;
- Public consumption;
- Investments;
- Export .

The phases in the construction are:

- Formation of a symmetric table for the year 1995 (the last table that had been constructed in Israel) by a multiplication of the direct coefficients of the **Use** by the **Supply** table and the outcome is $X_{ij,1995}$.

- An $X_{ij,2006}$ table is the outcome of the pre-multiplication of a diagonal table of outputs $\hat{X}_{j,2006}$ of Israel for the base year by the matrix of coefficients of the symmetric table $A_{ij,2006}$.
- The final uses of Israel for 2006 were placed to the right of of the $X_{ij,2006}$ and deducted from a transpose of the $X^{t}_{j,2006}$ that was placed to their right. The outcome is the expected column of intermediate uses of each row $\sum_{j=1}^{n} X_{ij}$ whose column sum $\sum_{i=1}^{n}\sum_{j=1}^{n} X_{ij}$ is equated with the row sum of the intermediate uses $\sum_{j=1}^{n}\sum_{i=1}^{n} X_{ij}$
- A bi-proportional RAS method[11] is applied to the industry to industry quadrant.
- A second bi-proportional RAS is applied to the primary resource quadrant, in which the right end totals are for the base year 2006 .
- The outcome is an input output table of Israel for the base year of 2006.
- A table of direct coefficients A_{ij} is derived.
- The construction of the I-O table of Emek Hefer is performed in a similar procedure: the foregoing one: the coefficient table of Israel pre-multiplies the output of Emek Hefer and is followed by an identical procedure .

5.2 Crop areas and water uses

The foregoing crop areas, the water uses, their costs and subsidies were aggregated into 30 industries that were spliced into the I-O table . The water uses were aggregated into 12 industries.

5.3 All other industries

The number of the employed per industry was surveyed and then multiplied by the Israeli national average of Output/employed.

5.4 The final uses and Imports

- The Private Consumption (C) is derived per person from that of Israel (Data from CBS[12]) multiplied by the number of residents (data: the regional couuncil) in Emek Hefer.

- [11] Department of Applied Economics, Cambridge U., *Input-Output tables Relationships 1954-1966* vol.3, in A Program for Growth, Chapman and Hall 1963, (see ch.3) ;

[12] CBS-Central Bureau of Statistics, Prime Minister’s Office, Jerusalem

- The Public Consumption(G) and Investment (I) : data from the regional council.
- The Export (E) was calculated by deduction from the transpose of X_J , in each row, the sum intermediate uses $\sum_{j=1}^{n} X_{ij}$ and the sum of [C+G+I]:

  Of $X_j^t - \sum_{j=1}^{n} X_{ij} - [C_i + G_i + I_i]$, i.e: the deduction from the transpose of each column the sums of the intermediate uses and final uses exclusive of the export. If the outcome is positive the value is entered in the export column in the row of the industry i , but if it is negative the value is multiplied by (-1) and entered as a value in the the import row from the Rest of Israel in the column of industry i.
- Thus, The table is adjusted to an Identity of each column sum to to the sum total of the corresponding row.

5.5 A summary of results

Table 6 presents the output of all the sectors of the economy of the Hefer Valley in alternate plans 1 and 3. The output of alternate plan 1, before the reduction of salinity, inclusive of the chlorides will be 7,775 millions NIS, of which the outputs of the sectors are(in millions NIS): agriculture 1,118 (including livestock), manufacturing 4,300 and sum of the other sectors 2,357 , which are consecutively in percentages: 14, 55, 31.

The output of alternate plan 3 in millions NIS will be 7,972 , and the shares of the sectors in it are: agriculture 1,306, manufacturing (no change) 4,300, the rest of the sectors 2,386, which are consecutively in percentages 16, 54, 30.
An increase of export from 3,946 millions NIS to 4,118 is due to the increase of agricultural output.

Table 6. The output of the Hefer valley in the year 2015

the alternative	agricultural output	manufacturing output	other sectors output	total output	from it: the export
1	1,118	4,300	2,357	7,775	3,946
	14%	55%	31%	100%	
3	1,306	4,300	2,386	7,972	4,118
	16%	54%	30%	100%	

The significant projected increase of agriculture is + 2% due to the additional crop area. But, it is also important to note that this share is relatively larger than the share of 2% that agriculture has in the national economy.

5. Conclusion

The objective of this research is to evaluate the viability of sustaining the Hefer valley as the Green Lung of central Israel. The conclusion of this research is that the precondition to achieving the sustainability of a profitable agriculture is the one that will enable the growers to improve and increase the quantity and quality of the yields. It can be achieved through a reduction of salinity of the fresh and recycled irrigation water in which the chloride concentration will not exceed 150mg/l.

The 3rd alternate plan, in which desalinized sea water with 20mg/l of chlorides is to be supplied as drinking water directly to the population is the most efficient one, since it avoids the need to desalinize greater quantities of recycled water . Thus, the need to desalinize irrigation water is minimized and the operating cost and the subsidy (the difference between the operating cost and the payment by the farmers) will be minimized relatively to the other alternate plans.

6. Recommendations

1. It is essential to evaluate and quantify the impact of reduction of salinity on all the crops and find out the benefit cost ratio of each of them.
2. Three findings of this research are:
   a. That the decreased water uses per dunam for only a part of the crops will be 13% down from 51 millions m^3 to 45 millions m^3;
   b. There will be an extra increase of 14% of output without using the saved water.
   c. If the saved water will be used the output value will increase by an additional 16%, and it would be a total of 30%.
3. The ministry of agriculture and rural development will have to evaluate whether the diminution of salinity will be sufficient to sustain a viable agriculture, or whether it will be necessary to invest in increasing the cropping area with the saved water quantities.

4. The proposal is to supply desalinized sea water to the population in the Hefer valley, and by that avoid the need to desalinize the recycled water of the Merez recycling plant.

5, It is necessary to form an apparatus that will mobilize water quota of both fresh and recycled water between growers depending on the types of crops that each will grow. Some will need only fresh water for vegetables and others only recycled water for fruit plantations and field crops.

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