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# ***Natural Resource Management in the West Bank: Potentiality of Water and Land Allocation for Irrigation***

## INTRODUCTION

The agricultural sector plays an important role in the Palestinian economy. It contributes 15% to 20% of the gross domestic product, comprising 25% of the total Palestinian export. Palestinian agricultural activities are divided into rain-fed agriculture and irrigated agriculture. The total cultivated are in the West Bank is 1,682,062.5 dunums with total Production of 514,451.7 tons. Irrigated agriculture represents only 6% of the total cultivated area in the West Bank.

In spite of the small area of irrigated agriculture due to limited water resources, it represents 52% of the total agricultural production. Thus this sector represents a major source of income for Palestinians and it plays an important role in the development of their economy.

The development of irrigated agriculture is very important as it has a significant impact on the Palestinians' life. The expansion and the development of this sector depend mostly on land and water availability. However, the total current available water for irrigation in the Palestinian agricultural sector is 150 mcm per year, which is used to irrigate 10% of the cultivated land, (93 mcm in the West Bank and 57 mcm in Gaza). This quantity is very small compared to the available water amounts used by the neighboring countries such as Israel and Jordan. In Israel for example about 1275 mcm is used for agriculture, and 625 mcm is used in Jordan.

To be able to generate the maximum profit from the development of this sector, especially in the long run when changes in economic situation and total population take place, an optimal quantity of water and optimal allocation of land must be defined. This definition will assist the policy makers and responsible authority to make the proper decisions about agricultural policies, which depends mostly on land and water availability.

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The potentiality of increasing and developing the area under irrigation can take place only when the Palestinians get their water rights from the West Bank aquifer and the Jordan River.

A technical parameter can help in providing an optimal solution for water and land that must be allocated for irrigated cultivation. The solution can be provided by the utilization of "modelization", which will be realized by the model "PSERM". The optimal solutions that will be obtained from the model define the optimal water needed in the irrigated sector with the optimal land that could be irrigated.

## The Model (Palestinian System for Environmental Ressource Management (PSERM))

The model PSERM tends to find the optimum use of water and land for a better production in the irrigated agricultural sector. In order that the model "PSERM' becomes able to serve as an integrated model for such optimization, a wide spectrum of relevant data must be collected and defined in the model. This data combines factors such as crop types, crop production and distribution, consumption, cropping patterns, agricultural markets, prices of produce, cost of production, exports and imports, water availability, population growth and distribution, availability of land, soil types and others.

The ability of this model to integrate and analyze these multidisciplinary sets of data makes Palestinians capable of drawing policies and projections regarding critical issues in the field of agriculture and related natural resources. It is also capable of simulating scenarios to predict the consequences of certain agricultural and development policies on the natural resources revenues, land and water.

Four major constraints are used in this model. The first constraint is related to the availability of land for agricultural use. The second constraint defines the lower bound of water to ensure that Palestinians get enough water for agriculture. The third constraint defines the upper bond on water to ensure that Palestinians do not use more water than what is accessible to them. The last constraint is a market constraint to ensure that irrigated agricultural production does not result in a big surplus.

The model can be used to run different population and economic scenarios. These scenarios give the user a combination of 143 scenario options to choose from. A combination of different economic population scenarios will be used in this paper to describe the possible optimum water and land allocation for a better irrigated cultivation in the West Bank. Certain cases for water and land allocation in the West Bank are going

to be examined in this paper. These cases are based on two assumptions, which are going to be entered into the model to conclude the optimum water and land allocation.

In the first case the model will assume that the Palestinians will not get back their water and land rights (no accessibility to their natural available water and land)and there will be no Palestinian returnees re-settling in Palestine. This case is defined as the status of no peace process achievement. The model will simulate the current economic and population scenario to describe the optimal land and water allocated to irrigated agriculture in the West Bank. On the other hand, the model will be used to predict the optimal values of land and water that must be used in the year 2010 under different population scenario.

In the second case the model will deal with another Palestinian status where the peace process agreement is going to be achieved. Thus assuming that the Palestinians will practice their land and water rights and 200 000 returnees will re-settle in Palestine.

The two cases will deal with the water and land allocation based on the current economic and population scenario and predict the same allocations for the year 2010 based on different economic and population scenarios.

## Optimization Principles

The optimal solutions that the model defines depend on profit maximization and cost minimization. In the optimization process and the definition of the optimal values of water and land, the model depends on the cost/performance theory. It takes into consideration the prices and the cost of production defined in the model.

The optimal quantity defined by the model, as the quantity that can be produced at a minimum cost. Any attempt to increase the quantity of production more than the quantity defined by the model, cause an increase in the cost of production. This increase in the cost will be higher than the revenue (the difference between the selling price and the cost of production), leading to a negative effect of the generated profit, and thus mis- implementing the goal of the optimization especially the profit maximization.

The other thing that the model takes into consideration in the optimization process is the net import/export in the West Bank. This is to assure that there will be no surplus

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in the agricultural product. Excess in the agricultural product means high supply and low demand. This situation has negative impact on the selling prices, which can cause a decrease in the generated profit.

## Current Status of Irrigated Agriculture

At present, the total cultivated land in the West Bank is 1,682,064 dunum, where only about 6% of the total cultivated lands are under irrigation. Despite that the Palestinians have 92.69 mcm of available water, it has been estimated that the Palestinians use 89.16 mcm of water for irrigation. This amount of water is used to irrigate some major plants in the West Bank. The major plants under irrigation in the West Bank are vegetable crops; fruit trees; field and forage crops. Vegetable crops, in particular, are cultivated under different systems, mainly, open field; plastic houses; high plastic tunnels and low plastic tunnel.

A description of irrigated agriculture sector in the West Bank is summarized in table (1). The table shows the area of the actual irrigated land, the actual production for different crops cultivated under different agricultural patterns, and the estimated quantities of water used for irrigation.

**Table 1** Description of actual situation of irrigated agriculture in the West Bank

| Type | Areas (Dunums) | Actwater use (MCM) | Production (Ton) |
|---|---|---|---|
| Open Fields | 52409 | 28.94 | 110915 |
| Low plastic tunnel | 7219 | 3.82 | 21229 |
| High plastic tunnel | 5.801 | .70 | 2765.3 |
| Plastic houses | 5163 | 4.60 | 36143 |
| **Sub-Total** | **65593** | **38.06** | **171052** |
| Fruit Trees | 28504 | 45.40 | 93894 |
| Field Crop & Forage | 7520 | 5.70 | 4934.3 |
| **Total** | **101617** | **89.16** | **269881** |

Source: ARIJ, 1998.

The table indicates the available amounts of water allocated for different agricultural patterns. For example, it is recognized that a total quantity of 38.06 mcm of water is used to irrigate vegetable crops under the different systems of cultivation. A total quantity of 45.40 mcm of water is used to irrigate 28504 dunums of fruit trees and a total quantity of 5.7 mcm of water is used to irrigate 7520 dunums of Field and forage crops.

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# The Potential for Land and Water Allocation in the Irrigated Agricultural Sector

As it is explained previously the model "PSERM' will be used to describe how water and land can be allocated for optimum use in the irrigated agriculture in the West Bank, but under different constraints defined in the two cases.

## CASE ONE

In this case, as it was explained previously, we assume that the peace process agreement will not be achieved, Palestinians will not get back their water and land rights, and no returnees will come back home. The model will allocate water and land according to the current economic situation and current population.

It will also be used to predict the allocation of water and land in the year 2010 under the same situation described in this case, but under different population scenarios as described below.

### Assumed constraints:

Three constraints in this case were entered into the model to optimize the current (economic and population situation)and predicted (year 2010) situations of irrigated agriculture as follow:

The first constraint:
The available cultivated land in the West Bank is by 1682064 dunums, which is the current available land for cultivation in the West Bank.

The second constraint:
The lower limit of water (to ensure that the Palestinians get enough water for irrigation) is 92.94 mcm.

The Third constraint:
The upper limit of water (to ensure that Palestinians are using the full accessible amount of water) is 92.94 mcm.

### Results of current optimization

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? The total optimal water that can be used by Palestinians does not exceed 92.90 mcm.

? The total optimal land that can be irrigated by this quantity is 95096 dunums.

? The optimal production from such allocation is 192915 tons.

By comparing these results with the actual situation of irrigated agriculture, it appears that the optimal irrigated area and the optimal production obtained by the model is less than the actual use of land and the actual production. The reason of this result as it was explained previously, in the optimization principle, is that the model takes into consideration the cost/performance theory and the net import/export when defining the optimal solutions.

A summary of optimal quantities of water and land that must be allocated for the irrigated crops used in the West Bank, and the optimal product that could be produced according to the assumed constraints appear in table (2).

**Table 2** Optimal water in mcm, optimal areas in dunums and optimal production in tons that the model defines

| Type | Optimal Area (Dunums) | Optimal water use (MCM) | Optimal Production (Ton) |
|---|---|---|---|
| Open Fields | 43092 | 29.30 | 68230 |
| Low plastic tunnel | 5566 | 2.80 | 12172 |
| High plastic tunnel | 1527 | 0.26 | 3249 |
| Plastic houses | 4811 | 5.92 | 45225 |
| Sub-Total | 54996 | 38.28 | 128876 |
| Fruit Trees | 36287 | 53.80 | 61751 |
| Field Crop & Forage | 3813 | 0.86 | 2288 |
| **Total** | **95096** | **92.90** | **192915** |

**Results of the predicted optimization**

Different population scenarios have been simulated to predict changes in water and land allocation. The optimal land and water values that the model predicted by running different population scenarios, (but assuming that the economic situation will stay as it is currently), are as follow:

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In the first scenario the population growth rate is assumed to increase by 3.5%. According to this increase the model predicts that the total optimal water quantity that can be used in the year 2010 by the Palestinians (92.69 mcm) can only irrigate 14% of the total current cultivated land available in the West Bank. As a consequence the optimal production will not exceed 179067 tons.

In the second scenario the population growth rate is assumed to increase by 4%. According to this increase the model predicts that the total optimal water quantity that can be used in the year 2010 by the Palestinians (92.93 mcm) can only irrigate 15% of the total current cultivated land available in the West Bank. Consequently, the optimal production will not exceed 178073.3 tons.

In the third scenario the population growth rate is assumed to increase by 4.5%. According to this increase the model predicts that the total optimal water quantity that can be used in the year 2010 by Palestinians (92.94 mcm) can only irrigate 15% of the total current cultivated land available in the West Bank. Consequently, the optimal production will not exceed 177311.379 tons.

A description of how water and land are allocated for the irrigated crops under different population scenarios is shown in table (3,4,5)

**Table 3** Predicted quantity of optimal water in mcm, optimal land in dunums, and the optimal production in tons by simulating 3.5% population growth rate in the year 2010.

| Type | Optimal Area (Dunums) | Optimal water use (MCM) | Optimal Production (Ton) |
|---|---|---|---|
| Open Fields | 13474 | 6.1 | 22341 |
| Low plastic tunnel | 2460 | 1.6 | 5554 |
| High plastic tunnel | 3283 | 4.0 | 12941 |
| Plastic houses | 492 | 0.66 | 7027 |
| **Sub-Total** | **47863** | **12.36** | **47863** |
| Fruit Trees | 55488 | 50.4 | 35468 |
| Field Crop & Forage | 170998 | 29.93 | 95736 |
| **Total** | **274349** | **92.69** | **179067** |

**Table 4** Predicted quantity of optimal water in mcm, optimal land in dunums, and the optimal production in tons by simulating 4% population growth rate in the year 2010

| Type | Optimal Area | Optimal water use (MCM) | Optimal Production |
|---|---|---|---|

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| | (Dunums) | | (Ton) |
|---|---|---|---|
| Open Fields | 12807.15 | 6.09 | 21128.52 |
| Low plastic tunnel | 2218.338 | 1.40 | 4999.671 |
| High plastic tunnel | 2973.752 | 3.65 | 11709.796 |
| Plastic houses | 459.537 | 0.61 | 6564.815 |
| **Sub-Total** | **18458.777** | **11.75** | **44402.802** |
| Fruit Trees | 56150.66 | 50.12 | 34299.202 |
| Field Crop & Forage | 177503.5 | 31.06 | 99371.343 |
| Total | **252112.94** | **92.93** | **178073.3** |

**Table 5** Predicted quantity of optimal water in mcm, optimal land in dunums, and the optimal production in tons by simulating 4.5% population growth rate in the year 2010

| Type | Optimal Area (Dunums) | Optimal water use (MCM) | Optimal Production (Ton) |
|---|---|---|---|
| Open Fields | 12293.569 | 5.87 | 20198.587 |
| Low plastic tunnel | 2033.204 | 1.28 | 4574.276 |
| High plastic tunnel | 2736.572 | 3.36 | 10765.598 |
| Plastic houses | 434.738 | 0.58 | 6210.547 |
| **Sub-Total** | **17498.083** | **11.09** | **41749.01** |
| Fruit Trees | 56659.035 | 49.93 | 33402.292 |
| Field Crop & Forage | 182493.29 | 31.93 | 102160.079 |
| **Total** | **256650.408** | **92.94** | **177311.379** |

**Case Two**

In this case, it is assumed that the peace process agreement will be achieved. This means that the Palestinians will get back their rights in land and water and there will be more quantities of water available for agricultural sector in the West Bank. According to this assumption and the following constraints, the model will allocate water and land for an optimum irrigation in the agricultural sector in the West Bank.

**Assumed Constraints:**

Three constraints in this case were entered into the model to optimize the current (economic and population situation)and predicted (year 2010) situations of irrigated agriculture as follow:

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The first constraint:

The available land for cultivation in the West Bank is 1682064 dunums. This area is the total current available area for cultivation in the West Bank.

The second constraint:

The lower limit of water (to ensure that Palestinians get enough water for agriculture) is 92.94 mcm.

The Third constraint:

The Upper limit of water (to ensure that Palestinians can use their accessible water amounts)is 459 mcm.

The upper limit of water represents the total water that must be available for irrigation in the West Bank, once the peace process is achieved and the Palestinians get back their water right form West Bank aquiferand Jordan River. It has been estimated that the total quantity of water that exists in the West Bank is approximately 850 mcm. According to the agricultural requirements it has been approved that 54% of the available water amounts, is to be allocated for agriculture.

**Result of the current optimization:**

The optimal values obtained by the model for current allocation of water and land is shown in table (6)

**Table 6** Optimal allocation of water, land and production in the irrigated sector in the West Bank

| Type | Optimal Area (Dunums) | Optimal water use (MCM) | Optimal Production (Ton) |
|---|---|---|---|
| Open Fields | 57931 | 39.36 | 91725 |
| Low plastic tunnel | 7482.454 | 3.82 | 16363.73 |
| High plastic tunnel | 2053.124 | 0.35 | 4368.35 |
| Plastic houses | 6467.504 | 7.95 | 60797.71 |
| **Sub-Total** | **73934** | **51.48** | **173255** |
| Fruit Trees | 48883.619 | 72.31 | 83014.48 |
| Field Crop & Forage | 5125 | 1.15 | 3076 |
| **Total** | **127943** | **124.94** | **259345** |

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It is recognized that the total optimal quantity of water that must be used currently is 124.94 mcm out of the 459.9 mcm that is estimated as the available water for irrigation in the West Bank. Consequently, it is predicted that this quantity will be able to irrigate an optimal area of 127,943 dunums and generate an optimal production of 259,345 tons.

A comparison between the current actual situation of irrigated agriculture where 92.94 mcm is accessible for Palestinians for irrigation and the optimal situation of irrigated agriculture where 459.9 mcm is available for irrigation, shows that the productivity of the actual situation is higher than the productivity of the optimal situation. As shown in Figure (1).

Figure (1) Comparison between the current use of irrigated areas and the use of optimal areas defined by the model

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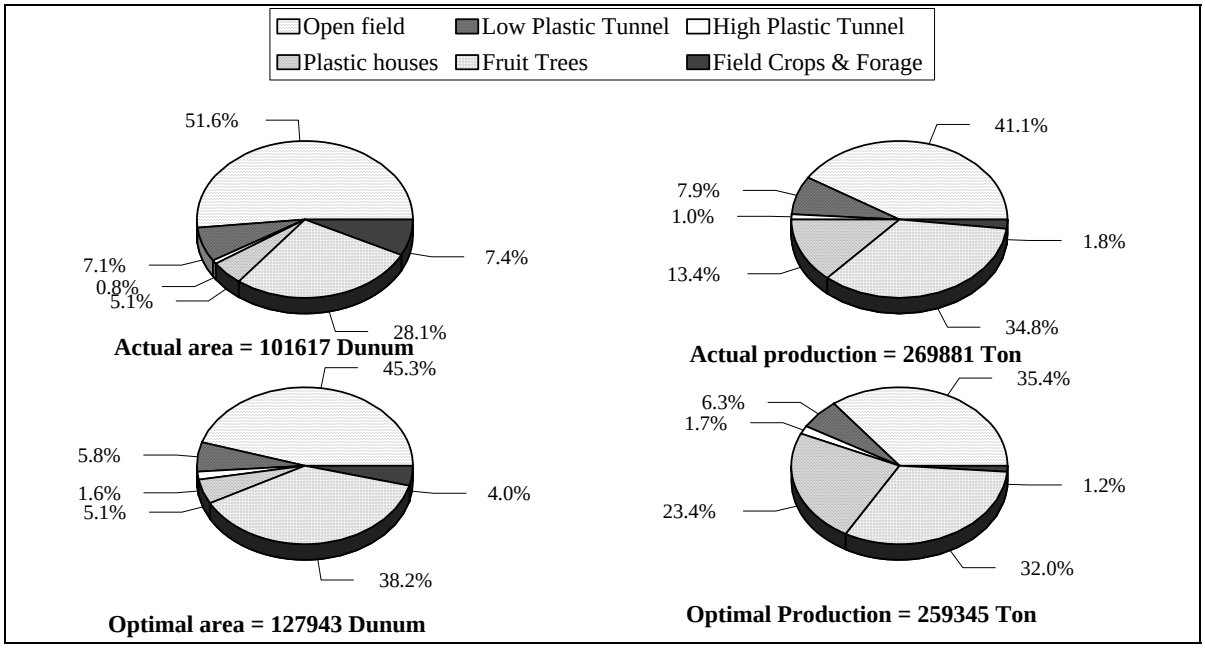


The reason that the productivity of the actual situation is higher than the optimal productivity is that the model takes into consideration the process of optimization, as defined previously in the section of principles of optimization, and the cost/performance theory.

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This means that when the model defines the optimal production, it takes into account the agricultural yield must be produced at a minimum cost so as to generate the maximum profit which the optimization process build on.

Also, the net import/export theory is taken into consideration when the model defines the optimal production so as to ensure that there will be no surplus in the quantity produced. It is known that the surplus means that the supply will be higher than the demand, which will lead to a decrease in the selling price. Thus, the optimization process (profit maximization) will not be achieved.

**Results of the predicted optimization:**
Different population scenarios have been simulated to predict changes in water and land allocation. In this case, the optimal values that the model predicted by running different population scenarios, (but assuming that the economic situation will stay as it is currently), are as follow:

The model has used the upper water limit (459.9 mcm)as the optimal water value allocated for irrigation in the West Bank. This value has been used as the optimal water value for each population scenario for the year 2010.

On the other hand, the total optimal area that can be irrigated by this quantity in each scenario are as follow:

In the first scenario the population growth rate is assumed to increase by 3.5%. This increase showed that the 459.9 mcm optimal water value can irrigate 75% of the total current cultivated land available in the West Bank. As a consequence the optimal production be ----------.

In the second scenario the population growth rate is assumed to increase by 4%. This increase showed that the 459.9 mcm optimal water value can irrigate 76% of the total cultivated area available in the West Bank. As a consequence the optimal production will be ----------.

In the third scenario the population growth rate is assumed to increase by 4.5%. This increase showed that the 459.9 mcm optimal water value can irrigate 77% of the total cultivated area available in the West Bank. As a consequence the optimal production will be--------.

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Further Analysis

If the upper water limit (459.9 mcm) is available for the Palestinians for irrigation in the West Bank, 77% of the total cultivated area can be irrigated in the year 2010. This value is the maximum for water and land allocation in the West Bank where the assumed population growth rate is 4.5% and 200000 returnees re-settle in Palestine.

However, if the Palestinians have the lower water limit (92.9 mcm) as the available water amounts for irrigation, only 15% of the total cultivated area can be irrigated in the year 2010. This value is the maximum for water and land allocation in the West Bank with the same criteria as above.

Today the Palestinians have only 92.9 mcm as available water for irrigation in the West Bank. Thus, if this limited amount of water does not increase in the coming 10 years, then the total irrigated area would not exceed the 15%. Consequently the production will not exceed the 177311.38 tons.

However, the current population consumption for cultivated crops reaches 553333.3 tons in the West Bank. Thus, in the year 2010, the estimated total population (assuming that the growth rate is 4.5% and there will be 200000 returnees, will consume 1091409.5 tons.

This means that 177311.38 tons will only cover 16% of the total estimated consumption in the year 2010 in the West Bank.

However, if the Palestinian will get their water and land rights, the 459.9mcm will be allocated for irrigation in the West Bank generating a maximum production of 873145.6 tons. This quantity covers 80% of the total estimated consumption for the Palestinians in the year 2010 in the West Bank.

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# CONCLUSION

We can conclude from the previous demonstration that the availability of the necessary quantities of water for irrigation affects in the first place the development and the expansion of the irrigated agriculture in the West Bank. This development has also a positive effect on the improvement of the economic level and benefiting directly the Palestinians.

Increasing the water quantity allocated for irrigation will maintain sustainability to irrigated agriculture by providing the necessary food in the long run, as there will be increases in the total population. In the long run population expansion means more food will be demanded, and as irrigated agriculture is more productive than non-irrigated, it represent a major source for providing the needed quantity of food.

Also, providing the suitable water in the irrigated agriculture is important from an economical point of view. The irrigated agriculture sector is more profitable than non-irrigated, and water availability will help in increasing the profit generated from this sector. The model defines a maximum profit of 394.70 million Dinars in the year 2010 if a total quantity of 459.9 mcm is available for irrigation. While the actual quantity of water available for Palestinians (92.94 mcm) can generate a maximum profit of 79.97 million Dinars in the same year.

To achieve the maximum benefit from the irrigated agriculture sector in the West Bank, a total quantity of 460 mcm of water must be allocated for agricultural activity. This quantity represents the total quantity of water that must be allocated for irrigated agriculture in the West Bank if Palestinians get their water right from the West Bank aquifer and the Jordan River.