An Exploratory Economic Assessment of Climate Change Impacts on Israeli Agriculture

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1. Introduction

The overall objective of this study is to assess – in monetary terms - the potential damage associated with the impacts of climate change due to the greenhouse effect in Israel. The socioeconomic impacts will affect water resources, agricultural production, biodiversity resources, forestry resources, coastal regions (due to sea level rise), tourism, health levels, and population migration due to desertification and related phenomena. Damage are estimated for a future point in the 21^{st} Century when CO_2 levels in the atmosphere will double from pre-industrial levels. This is a common reference benchmark in the literature, given that there is still a great deal of uncertainty regarding which of the global greenhouse gases (GHG) emission scenarios will actually materialize. There is a widespread tendency in the literature, however, to associate this doubling with the period 2030-2050. The study aims to sum-up damage by sectors, employing the "Bottom-up" approach, assuming present or (when possible) forecasted technological know-how. This is in contrast to the "Top-down" approach that is based on econometric and macroeconomic models.

In this paper we assess the impacts of climate change on Israeli agriculture. During the past fifty years, Israel's highly sophisticated agricultural[1] sector has increased yields 16-fold while introducing a variety of new crops. In more recent times, as is the case in other developed economies, the comparative advantage of agriculture has declined, and the sector's output has amounted to only 2.4% of GDP (1995). The percentage of labor employed in agriculture was 3.4%, and agricultural exports were 4% of total exports, valued at $740 million. Agriculture's share of export has declined over the years, as well as its composition. Presently, field crops make up of 10% of the total value output, vegetables, potatoes and melons 15%, citrus 8%, other fruits 15%, flowers 8%, poultry 18%, and cattle 16%. The total cultivated area in 1995 was 367,000 hectares, out of which 199,300 are irrigated.

The damage estimates are derived using a simple production function approach, similar to that employed by a number of similar studies, using rather strong assumptions on adaptability potential or the lack thereof. Despite a number of strong assumptions made in this study, we believe it provides a useful order of magnitude estimate of damage with and without some adaptation, which would be of value in policy making regarding proactive adaptation as well as Israel's contribution to the global mitigation efforts under the Kyoto Protocol. We further believe that it is a useful exercise to focus on irrigation water shortage as the major determinant of agriculture's response to climate change in the semi-arid region where the country is located

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In general, there are three independent categories of costs related to climate change: direct damage (designated as D), adaptation costs (A), and net (of ancillary benefits) mitigation costs (P). Mitigating GHG emissions in turn affects the magnitude of damage, or reduces the need for adaptive measures. Similarly, adaptation reduces exposure to damage. The policy objective is to minimize total costs (T), the sum of the three categories: D+A+P. In this study we focus on the first two cost categories: direct damage and

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[1] The information presented here is taken from Publication No.2 of Israel's CBS, "Jubilee Publications" series.

adaptation costs. Clearly, a region the size of Israel or even the whole eastern Mediterranean basin has a negligible impact upon total global GHG emissions and concentration. Therefore, a benefit-cost framework comparing mitigation costs with damage and adaptation cost would make sense only on a global level, due to the common-property nature of the earth's atmosphere with regard to the impact of GHG on global and regional climate.

We employ commonly used assumptions for the economic calculations:

- According to the average emission scenario ("IS92") of the Inter Governmental Panel on Climate Change (IPCC), doubling CO_2 is expected to occur in 2055-2060. (IPCC, 1996a).
- Average temperatures in the eastern Mediterranean are expected to rise by up to 2°C taking into account the cooling effect of aerosols (polluting particles that "swallow" part of the returned radiation) is considered (IPCC, 1996a).
- Sea level rise by 2060 is expected to range between 10-55 cm, with an average prediction of a rise of 25 cm. (IPCC, 1996a).

Specifically, our estimates are based on a recent research study (Dayan et al., 1999) which has produced climatic forecasts for the coastal region of Israel. The study's forecasts are on a global circulation model (GCM) developed in the University of East Anglia (Palutikof et al., 1996). According to this study, the expected changes in temperature for Israel are:

$$2020:(-2)-(-1)\%$$

$$2050:(-4)-(-2)\%$$

$$2100:(-8)-(-4)\%$$

With corresponding changes in precipitation:

$$2020:0.3-0.4°c$$

$$2050:0.7-0.8°c$$

$$2100:1.6-1.8°c$$

The paper first surveys relevant climate change factors and their potential impact on agriculture in Israel. It then reviews a number of relevant studies and the methodologies employed by them. A brief review of the Israeli agricultural sector is then followed by a description of the methodology and specific assumptions used in this study and their application to the Israeli data. As expected, given the highly sophisticated nature of this sector in Israel, there is a wide variation between estimates assuming no adaptation, compared with those based on optimal crop selection and adaptation to the change in climatic variables, specifically precipitation changes.

2. Agriculture and Climate Change

Agriculture (and commercial forestry) are the most vulnerable production sectors which would be influenced by climate change, due to its great dependence on climatic variables. The factors that affect agriculture and which are related to climate change can be classified into several subcategories:

1. Climatic factors: temperature, precipitation and soil moisture.
2. Factors that accompany climate change: the effect of CO_2 levels on plant development (fertilization effect), and the impact of other gases such as tropospheric ozone and SO_2.
3. Factors related to human activity in coping with climate change, such as adaptation measures in various fields.

2.1 Climatic Factors

Temperature. Temperature largely controls the rate of plant growth, flowering and fruiting responses, seed development, the water vapor flux, plant water status, soil drying, and irrigation practices. On the individual plant level, we can observe that different crops reach their optimum at different ranges of temperature (IPCC, 1996b). For crops in temperate climates the optimal range is between 30-35°C (Parry et al., 1988). Changes in temperature can directly influence livestock, as well as indirectly influence pest distribution (weeds and insects). Another change related to temperature is the length of the growing season. Global warming reduces significantly frost danger to all the Mediterranean region climates. It enables to plant crops earlier in the season and lengthens the harvest season. On the other hand, higher temperatures accelerate development, shorten the growing period and decrease yields if the shortened growing period is not compensated by an enhanced development of the plant (Ellis et al.,1990).

Precipitation is likely to become the most critical component in the structure of stresses that agriculture could face in the future. Any amount of global warming will increase water demand of almost all crops. Changes in annual precipitation affect agriculture directly through soil moisture and non-irrigated crops, and indirectly through refilling water reservoirs. In addition to the total annual rainfall, there is a great importance to the distribution of the precipitation over the year. It should be mentioned, however, that most of the Global Circulation Models (e.g., GISS and UKMO (IPCC, 1996a)) do not provide a uniform picture regarding the predicted changes in precipitation, and forecasts differ from one region to another and from one model to the other.

One of the more significant impacts is the rise in drought incidents. Drought is the most common cause of yield loss, especially in arid to semi-arid regions. Drought is an example of broader phenomena, namely, annual fluctuations in precipitation (and temperature), which influence agriculture.

Other factors are the **moisture** and the amount of **solar radiation** to which the plant is exposed. Moisture affects plant growth rate, fruiting period, evaporation rates and water demands. A constant level of moisture is essential in most phases of crop development. Generally, the hydrological cycle is about to increase with climate change, including precipitation and moisture.

Future agriculture will face a serious challenge due to **Soil degradation**. Among its causes are enhanced erosion, loss of organic matter and accumulation of salts. Climate change is expected to enhance such effects, due to changes in intensities and amounts of precipitation, higher radiation levels and extreme weather events.

Pest impacts. The predicted changes in temperature and CO_2 level will influence the distribution and range of different kinds of pests (weeds, insects and disease-borne organisms). This will probably aggravate the damage to crops. Their influence will be most noticeable in shorter crops and in additional prevention and control costs will become necessary (Rosenzweig et al., 1998).

2.2 Atmospheric changes

Future changes in CO_2 levels. The most important change, which was studied a great deal recently, is the rise in CO_2 concentrations in the atmosphere. This change is predicted to enhance photosynthesis and plant water-use efficiency. The average response of C3 group crops (most of the crops, excluding sugarcanes, maize and several cereals) to doubling CO_2 levels is an increase of 30% in yields, ranging between -10% and +80%. The factors that affect the response include temperature, soil fertility and precipitation (IPCC, 1996b). A recent study, using the FACE method (Free Air Carbon Dioxide Enrichment), found that CO_2 concentration of 550 ppm would cause a 15-16% increase in yields. Other studies point out the effects of changes of CO_2 concentration on the form, shape and compound of crop yields. For example, rice grown under higher CO_2 concentration will contain higher concentration of Amylose, while Fe levels will be lower (Seneweera & Conroy, 1997).

Other atmospheric changes. Another change expected to influence agriculture is the level of plants exposure to tropospheric ozone. Its concentration has doubled in the last century, and has caused an estimated drop in yields in the range of 1-30% (IPCC, 1996b). The depletion of the ozone layer leads to higher exposure to UV-B radiation that has been proved to affect crops. These radiation damage are manifested mainly in high altitudes.

2.3 Human induced factors

Crop adaptation is becoming an important component in the process of agriculture's adjustment to climate change. However, research that has examined the independent adjustment capability of crops to changes in growth condition has not yielded encouraging results. Human activity in this field can be divided into two major categories: Choosing an optimal crop mix and biotechnological development. In selecting new genotypes, the factors that should be taken into account are high sensitivity to CO_2 concentration, the maintenance of yield levels even when higher temperatures cause enhanced development, and sustainability to heat waves and water shortage in growth and reproduction phases. Biotechnology is open to research and development of more sustainable crops for a changing environment.

3. A short methodological survey

To date, numerous studies have dealt with the impact of climate change on statistical regressions on past data. More recent studies using 'dynamic crop models', attempt to model the principal physiological, morphological, and physical processes involving the transfer of energy and mass within the crop and between the crop and its environment. From such relationships, these models derive predictions of crop performance under various conditions (Rosenzweig, 1998). These studies rely on climate scenarios derived from a variety of GCM. Among them CERES, dynamic crop model applied for several crops such as wheat and maize (Ritchie et al., 1989, Godwin et al.,1990) and SOYGRO for soy crops (Jones et al., 1989). A number of works incorporate market responses and long-range adaptation options. Failing to incorporate market reactions probably leads to an overestimation of the impact of climate change and should be classified in a "worst case scenario" category.

More recently, attempts have been made to combine crop responses and economic models in order to evaluate future changes in production and welfare. These works can be divided into two main groups: research based on structural models and evaluations base on spatial models.

Structural models, such as the study by Adams (Adams et al., 1998) specifies the production processes and incorporates it into an economic optimization. The main advantage in this approach is that it can estimate the impact of climate change on market equilibrium. The main omission to date has been overlooking adaptation potential.

Spatial ("Ricardian") models rely on econometric evaluation and are based on historical data. They estimate the relationship between economic data such as land and other asset values and climatic variants. An example is the work by Mendelsohn (Mendelsohn, 1994), which has examined the impact of the warming in a Ricardian approach, in a partial equilibrium framework (agricultural land markets), on the basis of land prices in over 3000 counties in the U.S. Thus, it implicitly reflects (past and present) adaptations to climate-related variables throughout the US. Application of the model to climate change scenarios reveals lower future impacts due to climate change. While including adaptation options, this approach can not represent production processes specifically, and therefore cannot, for example, take explicit account of phenomena such as CO_2 fertilization.

In an attempt to apply this methodology, we examined official documents of the Ministry of Agriculture which provide normative assessments of profitability by crop groups. In theory, we could have used these values as proxies for land prices, assuming land is the only fixed input, and the calculated net profits (after returns to labor) represents computed (i.e., not observable) land rents. Given that most of the agricultural land in Israel is state-owned, and that effectively there is no fully functioning agricultural land market, these computed values could have been used as proxies. However, these values are national averages, and consequently useless in the present context, since regional climatic variability cannot be factored out from the data.

4. Other Mediterranean Countries Studies

Naturally, studies with the highest relevance to this study are those which examined neighboring countries. However, comparisons not easy to make, since one would expect to find differences in methods used (models, the inclusion of adaptation, etc.), the nature of basic climate change assumptions (climate scenarios, CO_2 fertilization), and the type of crops examined.

The Lebanese Ministry of Environment (Ministry of Environment; Republic of Lebanon, 1999), For UNDP and the Global Environmental Facility (GEF) prepared a major study. It examined the vulnerability of Lebanese agriculture to climate change. The study divides Lebanese agriculture into four main crop groups: apple orchards, citrus, olives and sugarcane. Three approaches have been employed by the researchers: (1) "Analogue" – assuming that following climate change, agricultural regions would assume characteristics similar to those of presently lower altitudes; (2) Field studies relying on past data; (3) "Expert judgment". The study's results have been expressed largely in qualitative terms. They predict a drop in yields and a rise in production costs for apples and citrus; inconclusive results for olives, and a negligible impact on sugarcane production. It should be pointed out that the study assumes more severe climate scenarios than ours (a rise of 1.6-4.1°C by 2080).

The Egyptian Environmental Affairs Agency (1999) conducted a similar study, which also examined the influence of climate change on the major crops in Egypt for standard GCM predictions, as well as arbitrary climate change assumptions (+2°, +4°, and 10-20% in precipitation). The study reports a decrease of 18-19% in wheat and maize yields, and an increase of 17% for cotton. Adaptation options were examined using three models: COTTAM, TEAM, DSSAT3. The most important adaptation measures presented by the models are: (1) Improvement of wheat and maize cultivars; (2) Switching from maize to cotton, and replacing wheat with winter crops; (3) Changing agricultural techniques, such as planting dates, water and nitrogen applications and plant density; (4) Removing crops with high water consumption.

Yet another study, reported in the second IPCC report, examined Egyptian agriculture in 2060 (with 2*CO_2) (Yates & Strzepeck, 1998). The study is based on GCM scenarios GFDL, UKMO, and GISS A1. It investigated crop response to climate change with and without adaptation, and included the CO_2 fertilization effect. The forecast (prepared for wheat, rice, other cereals and fruits) indicated a decrease in yields of -5 to –51% for wheat, -5 to –27% for rice and –2 to –21% for other cereals and fruits. The study states that yield damage could decrease by up to 50% if proper adaptation measures are taken, such as changes in crops, fertilizers, and seeding and watering patterns. An earlier study (Eid, 1994) also investigated climate change impact, using the same scenarios. It predicted a more noticeable decrease in yields; for wheat: -18 to –75% and for maize: +6 to –65%.

5. Assessing the Damage to Israeli Agriculture

5.1 Assumptions

A number of simplifying assumptions were made in this rather preliminary study. A major one limits the impact to one climatic factor, namely – precipitation. That is, climate change would affect the agricultural sector only through the availability of water (including soil moisture) to crop production. The assessment is therefore based on the impact on water supplies, and further assuming that all such shortage, if and when they occur (around 2060) will have to be absorbed by agriculture. However, given the elastic nature of the demand for irrigation water (compared with household demand), this is not a too heroic assumption. The branches included in the calculations are: field crops, vegetables and plants alone[2].

A couple of additional strong assumptions underlie the estimated damage to agriculture, namely, no structural changes will take place due to adaptation, and there relative (real) price levels for agricultural output will remain constant.

A number of important reasons underlie the approach and assumptions adopted for the present analysis.

1. The available climate change data for Israel is scant, at best. Israel's small land area requires climatic forecasts of a very high resolution, which are still lacking. This leads to high uncertainty regarding predicted warming. Recall that according to the forecast used here, only a rise of less than 1°C (Dayan et al., 1999) is predicted for the coastal region of Israel. This makes it hard to estimate impacts using standard models, such as Dynamic Crop Models.
2. The most limiting factor of Israel's agriculture is water. This will be aggravated in the future given the expected rise in domestic and industrial water demand.
3. Because of the nature of land ownership in the Israeli agricultural sector (most of the land is owned by the state), there is no developed market for agricultural land, and therefore there is no possibility to apply the spatial model approach.
4. Only partial consideration is given to adaptation. Adaptation options that have not been analyzed are: (1) crop mix changes (including cultivars development); (2) development of new agro-technologies in agriculture and water management; (3) changes in crop location.
5. The study does not incorporate the CO_2 fertilization effect and other atmospheric

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[2] Flowers and livestock were not included in the calculation due to lack of relevant data. In any case, we assume that these branches will not incur any water cutbacks.

changes that might alter crop yields significantly.

5.2 Damage Calculations

A number of factors will affect water supplies in connection with climate change: a decrease in precipitation, enhanced evaporation from water reservoirs (as a result of the rise in temperature), aquifer salinization due to over pumping and sea water intrusion. Since it is not easy to evaluate the impact of the two last factors in quantitative terms, we use only the predicted precipitation shortfall (Dayan et al., 1999), employing the upper limit of 4% as a "worst-case" scenario. Given that the average annual supply is 2000 million cm, the supply shortfall assumed in the calculations is 80 millions cm.

As mentioned earlier, the approach used in this assessment is the production function approach. i.e., using an estimated production function for water (other inputs held fixed) for a number of key crops, we estimated the drop in yields due to cuts in irrigated water and natural precipitation. We used recently estimated production functions by Vered (Vered, 2000), which examined crop yield responses to water of different quality (fresh, recycled, and brackish).

The production function with water as single variant, and all other inputs constant (evaluated at their means and added to the intercept):

$$Y_i = a + b(W_i) + c(W_i)^2$$

where

Y_i = yield per dunam (0.1 hectare) for crop i

W_i= irrigation water input per dunam of crop i.

a = constant (incorporates yield with only natural rainfall)

b, c = coefficients

The estimated functions in Vered (2000) incorporate additional variables, which influence output beside water quantity and quality. These are: the geographical region (there are significant differences in climatic and soil characteristics between regions) and the type of irrigation system (dripping, etc.). However, for our purpose (crop yields as a function of water input) we assumed them to remain constant, and incorporated them into the constant term. agriculture (IPCC, 1996b). The earlier ones forecasted future responses on the basis of

The crops were divided into several groups, and a representing crop was selected in each group as given in Table 1.

Table 1: Crop Groups

Group	Selected crop
Citrus	Oranges
Fruits (non citrus)	Avocado, apples
Cereals and oils	Wheat
Fibers	Cotton
Vegetables	Tomato, Watermelon, Potato[3]

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[3] Because of the large size of the vegetables group, three representing crops, equally weighted, were taken for it.

5.2.1. Scenario I (the "Naive" scenario)

The underlying assumption in this scenario is that production cutbacks will be undertaken in an arbitrary fashion due to the water shortfall. There will be a proportionate cutback in water use by each crop group, relative to its present water consumption. Total damage is given therefore by summing the value of yield cutbacks for all groups, namely,

$$(1) TD = \sum_{i=1}^{n} \Delta Yi \times Pi$$

Where:

TD= annual damage in monetary terms
i = crop group
Pi = Average price per ton for crop group i[4].
$\Delta Yi =$ Change in yield for crop group i.

Yield change is a function of a change in water allocation to the respective crop group and the change in the value of the constant coefficient (due to decline in rainfall), given by (2):

$$(2) \Delta Yi = f(\Delta Wi) + \Delta a$$

where
Wi= Amount of water consumed by crop group i
Δ Wi = The change in the amount of water consumed by crop group i.

The change in the water allocated to each crop group is proportionate to its present consumption,

$$(3) \Delta Wi = \Delta W \times \frac{Wi}{TW}$$

where

TW= total amount of water consumed by all groups
Δ W= total change in water consumption.

$$\sum \Delta Wi = \Delta W$$

Out of the assumption that production will be affected not only by irrigation cutbacks but also due to decline in rainfall, one must incorporate this impact as well. The intercept in the response function is supposed to capture this effect, as well as other factors not explicitly represented in the model specification. We estimated its weight, roughly to be around 66% of the value of the intercept.[5]. This part of the intercept would therefore need to be re-calculated along with the change in the irrigation water input[6], as given in equation (4)

$$(4) \Delta a = 0.66 \times 0.04 \times a$$

Table 2 summarizes the loss in production value in the naïve scenario. The total annual loss is about $208 million, in present prices.

Table 2: Total annual damage by crop groups, Scenario 1.

Sub group	Total damage (mil. $)
Cereals and oils	5.5
Fibers	51.7
Citrus	86.5
Vegetables, Potatoes and Melons	
Vegetables (representing crop-tomato)	21
Melons (representing crop- water melon)	16
Potatoes	11
Total vegetables sub group	48
Fruits (no citrus)	16.5
Total	208

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[4] This price is calculated according to data from the "agriculture Statistics quarterly (CBS, 1997) containing total products (tones) and total monetary return in average prices for 1995.

[5] Based on discussions with Vered.

[6] Greenhouse crops (e.g., tomatoes) were excluded because there is no significance to precipitation in their growth.

5.2.2. Scenario II: Partial Adaptation

It is most likely, even certain, that in reality costs will be significantly lower, given the agricultural sector's ability to carry out adaptive measures over time. Here we assume that (partial) adaptation will be in the form of economic adjustment, by which we mean adjusting crop areas according to the water-use efficiency of the different crops. The naive scenario ignores adaptation altogether, and therefore overlooks significant savings in production costs due to a response in the form of crop adjustment (among many other, of course). In Scenario II we consider two components of damage {given in equation 5}:

1. Decrease in precipitation as an element having an impact on all crop groups. {Equation 6}
2. Cutbacks in water allocated to crops whose water use efficiency is relatively low, based on the **marginal value product** (MVP) of water (= the partial derivative of the response function of the representative crops with respect to the water input, evaluated at the average water input per irrigated dunam of the given crop, multiplied by the average price per ton).

$$(5) TD = \sum_{i=1}^{n} (\Delta Yi \times Pi) + \Delta Yj \times Pj$$

$$(6) \Delta Yi = f(\Delta a)$$

where

j = the crop group for which MVP is the lowest.

$$\frac{\partial Yj}{\partial W} \times Pj \leq \frac{\partial Yi}{\partial W} \times Pi$$

for all i.

However, we should also consider the possibility that whenever a cutback in irrigation reduces a given crop acreage (and not just yield per dunam), there will be a corresponding reduction in production costs. Consequently, *net* damage costs will be correspondingly lower. Production costs for the different crops were taken from the annual agricultural survey (CBS, 1998).

The calculation of net damage for the second scenario is given by:

$$(7) Dj = f(\Delta Wj) - \lambda TC(\Delta Yj)$$

$$(8) \lambda = \frac{\Delta Yj(w)}{Yj(w)} \qquad 0 \leq \lambda \leq 1$$

$$(9) \Delta Wj = \Delta W$$

where:

Dj = total damage value to group j.

ΔYj = yield change, group j.

TC= total production costs for group j.

ΔWj = change in water consumption of group j.

Table 3 gives the MVP for the different crop groups.

Table 3: Marginal Revenue by Crop Groups

Sub group	**Marginal revenue($ / cm)**
Cereals & oils	0.195
Vegetables	2.3
Citrus	2
Fruits	17.75
Fibers	0.4

The crop group with the lowest MVP is Cereals and Oil. It turns out that if it absorbed the entire needed cutback to meet the projected drop in precipitation, production will drop by about 66%, with a corresponding annual decline in output valued at $105 million. However, net damage, after taking into account the corresponding decrease in production inputs (Equation 5} is $40 million.

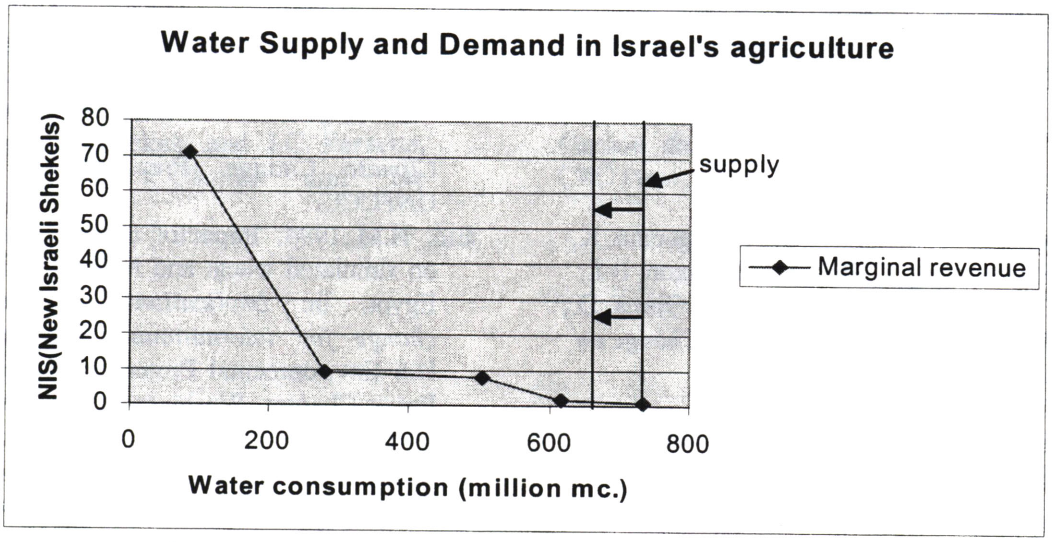
In addition to the cutback achieved through the reduction in crop acreage of crop group j, we should take into account the impact of precipitation decrease on all crops, i = 1,...n, represented by ΔY_i in equations 5 and 6 above. Table 4 gives the monetary value of this impact on crops. Thus, the total annual damage due to a projected decrease in mean precipitation levels amounts to $62 mil. Combining the two components of the forecasted impact (62 + 40), total annual damage under this scenario, adds up to $ 102 mil.

Table 4: Damage resulting precipitation decrease:

Sub group	Damage (mil. $)
Vegetables	
Potatoes	4
Melons	3
Cereals and oils	1.5
Fibers	43
Fruits	2
Citrus	9
Total	61

The outcome is described in Figure 1, which depicts the demand (= MVP) for and supply of irrigation water in agriculture. The expected impact of climate change through the decline in precipitation is depicted by the leftward shift in the supply schedule. The decline in economic welfare (i.e., social damage costs) is given by the triangle formed by the intersection of the demand and the two supply curves.

Figure 1



5.2.3 Scenario III

The third scenario considered in this study examined the possibility of augmenting domestic freshwater water supplies by desalinized water at current production costs. In this case damage is represented by the replacement costs of supply shortage due to climate change will be the sum of the damage resulting from precipitation decrease (Table 4) and the costs of desalinizing 80 million cm. (the assumed water shortage). This is described by equation 10:

$$(10) TD = \sum_{i=1}^{n} (\Delta Yi \times Pi) + TCs(\Delta W)$$

where:
TCs = total desalination costs

The current cost of desalination stands at about 80 cents per cm. This yields an annual bill for this scenario of about $ 126 million.

6. Summary

Our aim in this exploratory study has been to provide a range of rough preliminary estimates of expected future damage to agriculture in Israel resulting from climate change. In addition to the inherent uncertainty in forecasting climate change impacts, there is the uncertainty regarding what adaptation options will be available to farmers several decades from now, the nature of demand for water, and the role of agriculture in the national economy. There are also several additional climatic factors which we were not able to incorporate in the analysis due to a lack of usable data for Israel: change in temperature, climatic fluctuations (temperature and precipitation), the role of CO_2 fertilization, and more.

However, even this modest exercise, tells us a great deal about the importance of adaptation and correct proactive planning in counteracting the adverse effects of climate change. In addition to providing a range of quantitative economic estimates of costs, this is probably the major lesson of the study.

The authors are planning to carry out similar exercises to assess the economic impact on other sectors, believed to be affected by climate change. We hope these studies will serve to stimulate further, more rigorous and detailed studies, in order to provide a better understanding of climate change, through estimates that are of direct relevance for informed policy decisions in this important, emerging area of environmental decision making.

Table 5: Total damage by scenario (mil. US $)

Scenario	**I**	**II**	**III**
Total Damage	208	101.5	125.5

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