# Simulating the Impact of Global Warming on Surface Water Budget and Biomass Production

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## 1. Introduction

We comply with the general scientific consensus that due to emission of greenhouse gases global climate is gradually changed. In this study we demonstrated how the changes may affect surface water budget and biomass production. The Overall goal was to model the link between the climate scenarios the regional hydrological processes water budget and agroproductivity.

Specific Objective was the modeling of crop responses and crop yields, under climate scenarios and respective changes in the water balance.

## 2. Model description

The simulations of the impact of global warming on agroproductivity was carried out with a model describing the Soil Water Atmosphere Plant (SWAP) processes. The model is based on a study conducted in Holland during the last three decades ( van Dam et al). Data input and outputs of the model are summarized in table 1 and schematization of hydrological processes incorporated in SWAP is given in Fig1. Reduction coefficient for root water uptake, as function of soil water pressure head *h* and potential transpiration rate is given in Fig.2

## 3. Crop production in arid and semi-arid regions

An example of agroproductivity of several crops during the early seventies in Israel is given in table 2. The table expose the production function of several important crops in the arid and the semi arid regions of Israel. It can be seen from table 2 that on the average each reduction of 1 mm rain was associated with productivity reduction of about 52 kg/ha.. During the ICCAP project this table will be used as one of our base lines to identify the impact of global warming on agroproductivity.

## 4. Presentation of global climate change

Warmer climate will modify rainfall , evapotranspiration runoff and soil moisture storage. How any one of them will be affected and what will happen to the agro-ecosystems when any one them is changed as a result of possible global warming? We propose to evaluate these changes in the main climate regions to provide useful predictions and empirical results that may be relevantto the general public interest. It is hypothesized that during the years the amount of rain is reduced, evaporation from the soil increased and accelerated transpiration in the plants themselves will cause moisture stress and regional desertification. .In this paper we For simplicity we unified, for simplicity, all the above factors under single term which is known as aridity index. The aridity index presented in fig. 3. is the ratio between rain and potential evapotranspiration. The last is dependent not only on global radiation but also on relative humidity and ambient temperature. Thus, when simulating the impact of global climate change on biomass production, the term aridity index can provide a single independent variable which unifies some of the most important climatic factors affected by global climate change.

## 5 Impact of global climate change on agroproductivity

As demonstrated in table 1 (adapted from Hadas 1997 ), in arid regions, productivity is not sufficient to support a basic farming unit during the many years of low annual rain. In table 1 the minimum economical wheat yield ( about 1500 kg/ha.) can be obtained 95 out of 100 years in the semi-arid region while the economical yield in an arid region can be obtained only about 60 out of 100 years. Thus, a desertification process which convert semi arid to arid regions may lead to reduction of productivity under rain-fed agriculture. Preliminary simulation results with SWAP in fig 4, indicated that as the aridity index moves toward the more arid conditions (due to desertification) , relative yield of corn may reduce from its maximum around 80% in the sub humid regions, to its minimum around 60% in the arid regions for sandy soils and 40 % for clay soil, probably due to lower soil water potential in clay soils.

Surprising effect of slow changes in relative yield between aridity index of 0.6 and 0.1 should be further studied. Thus, Factors affecting relative yield: are: Aridity Index = rain/potential ET, Soil texture ( hydraulic properties) ,and Crops' draught tolerance.

## 6. Current modifications in SWAP for ICCAP project

1. Stochastic ( Rather than deterministic ) climate input
2. Layered physical and biological data input
3. Pixel by pixel runs of SWAP to form quasi 3D model
4. Use the minimum energy concept and modify the root uptake model
5. Use remote sensing data to specify soil water and crop conditions.

## 7. References

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Shalhevet J. A.Mantel.H.Bielory and D.Shimshi 1976 Irrigation of field and orchard crops under semi arid conditions IIIC Publication no.1 Volcani Center Bet Dgan Israel and Ottawa Canada

Van Dam J.C. ,J. Huygen , J.G.Wesselimg , R.A. Feddes , P.Kabat, P.E.V.van Walsum, P.Groenendijk and C.A. van Diepen Theory of SWAP version 2.0 Simulation of water flow, solute transport , and plant growth in the Soil Water Atmosphere Plant environment. Report 71 Dept. of Water resources Wageningen Agricultural university The Netherlands pp 167

Table 1 . Data input and output used in the simulation study with SWAP

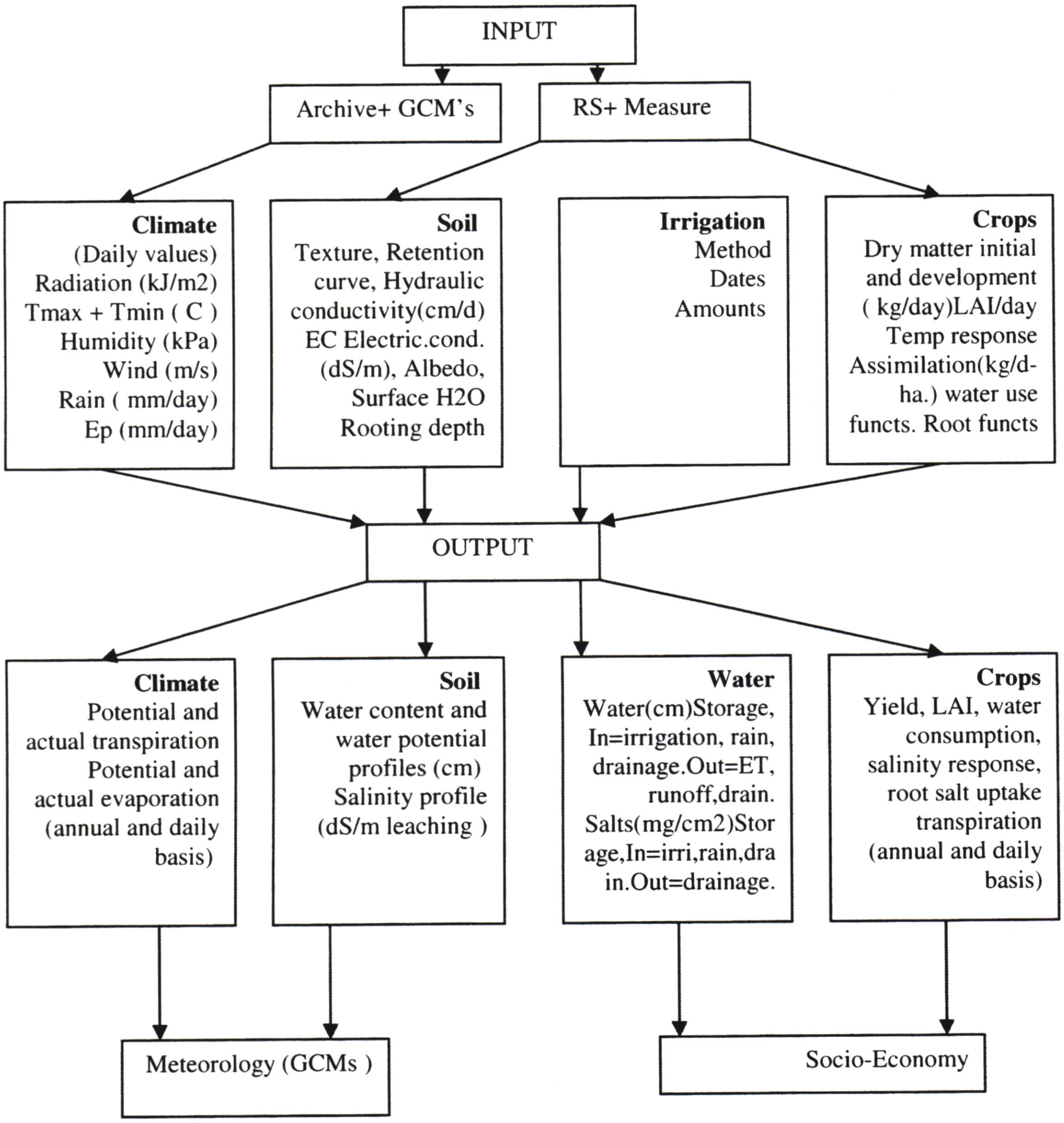


Fig.1 Schematization of hydrological processes incorporated in SWAP

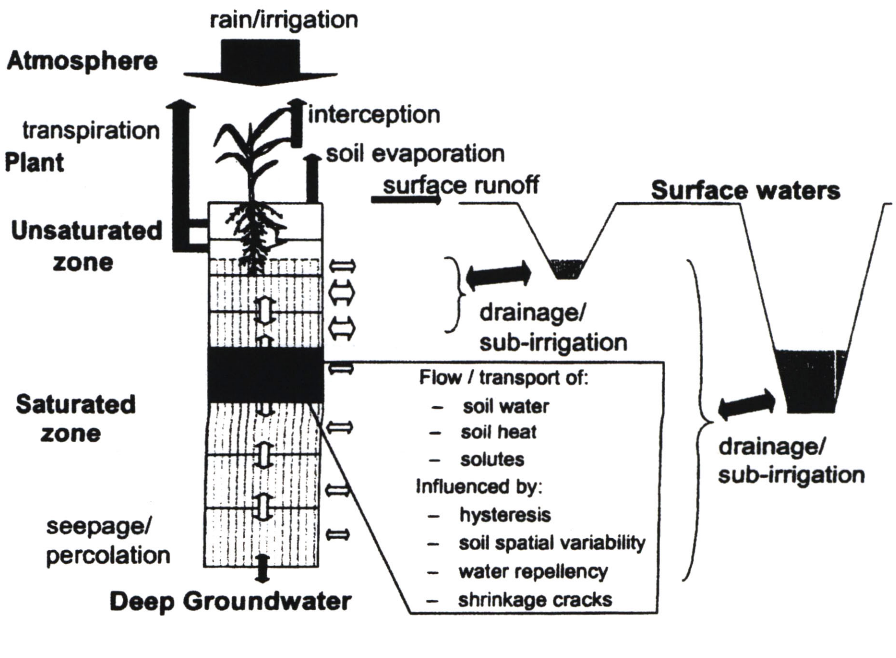


Fig. 2 Reduction coefficient for root water uptake, as function of soil water pressure head ***h*** and potential transpiration

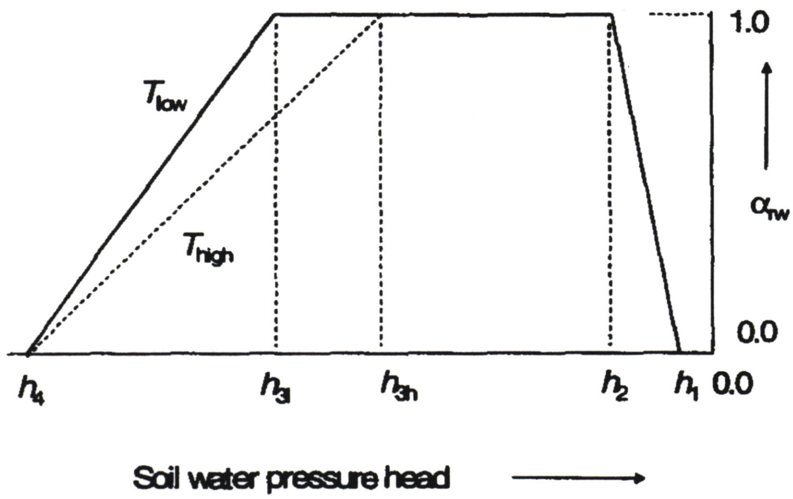



Table 2. Crop production function Collected and interprated from Shalhevet et al 1976

| crop | region | Min H2O app | Maximum H2O app | Slope** | intercept | r2 | yield change |
|---|---|---|---|---|---|---|---|
| Units | | mm | mm | kg/mm | kg | --- | kg/(mm-ha.) |
| Wheat | BS + JV# | 250 | 600 | 0.268 | -58.3 | 0.933 | 13.4 |
| Sorghum* | N N | 100 | 500 | 2.47 | 1248 | 0.965 | 7 |
| Grain Corn | N C P# | 100 | 800 | 0.288 | -1.2 | 0.961 | 25.6 |
| Peanuts | N N | 200 | 500 | 1.866 | -147.23 | 0.676 | 7.6 |
| Tomatoes | CP | 230 | 600 | 9.6 | 2589 | 0.888 | 130 |
| | Lachish | 230 | 600 | 11.3 | 2056 | 0.697 | 107 |
| Shamuti | general | 300 | 750 | 7.89 | 4130 | | 78.9 |
| Grapefruit | general | 400 | 900 | 10 | 2600 | | 100 |
| Avocado | | 400 | 1000 | 0.1 | 0 | | 1.0 |
| Appels | NG | 200 | 900 | 8.87 | 3000 | | 90 |
| Loan grass | general | 300 | 800 | 0.31 | -2.0 | | 3.1 |
| Average | general | 246.36 | 722.73 | 4.815 | 1401.3 | 0.853 | 51.2 |

*Actually second order equation $Y=1248+2.47W-0.00217W^2$
# CP =Coastal Plalain, NCP=North Coastal Plain, CCP=Central Coastal plain, WG,NG = Western and Northern Galil , NN=Northern Negev, JV= Jordan Valley, BS = Bet Shean Valley, JezV=Jezereel Vally **Kg dry matter/dunam

Fig 3 The aridity index of the main climatic regions

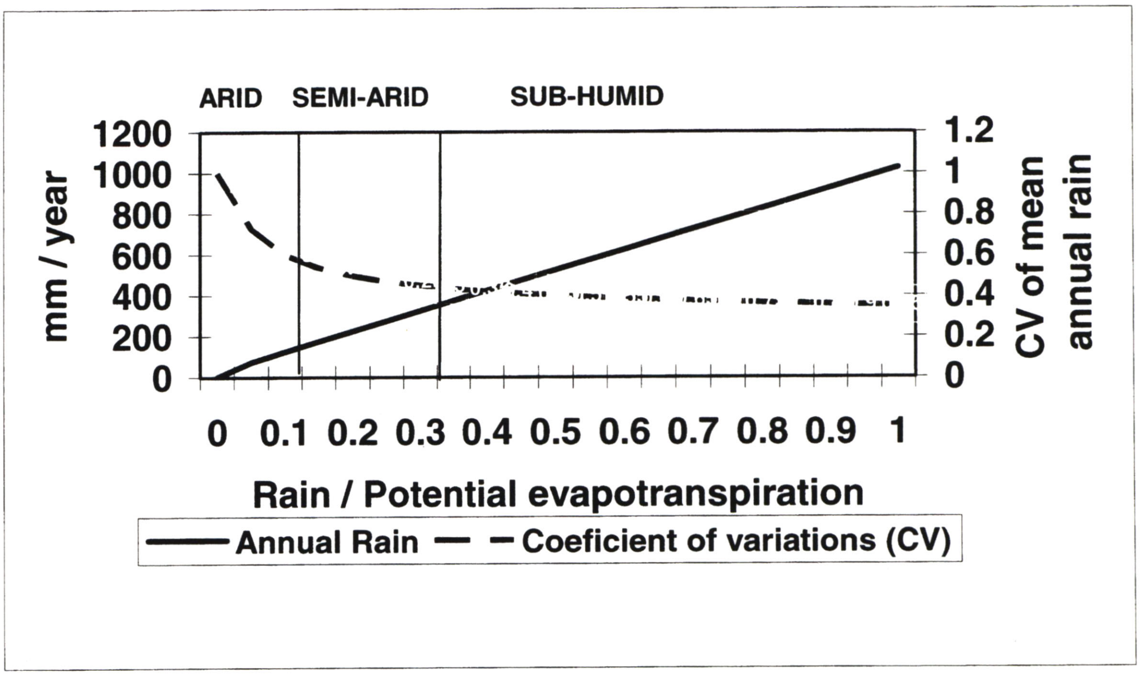
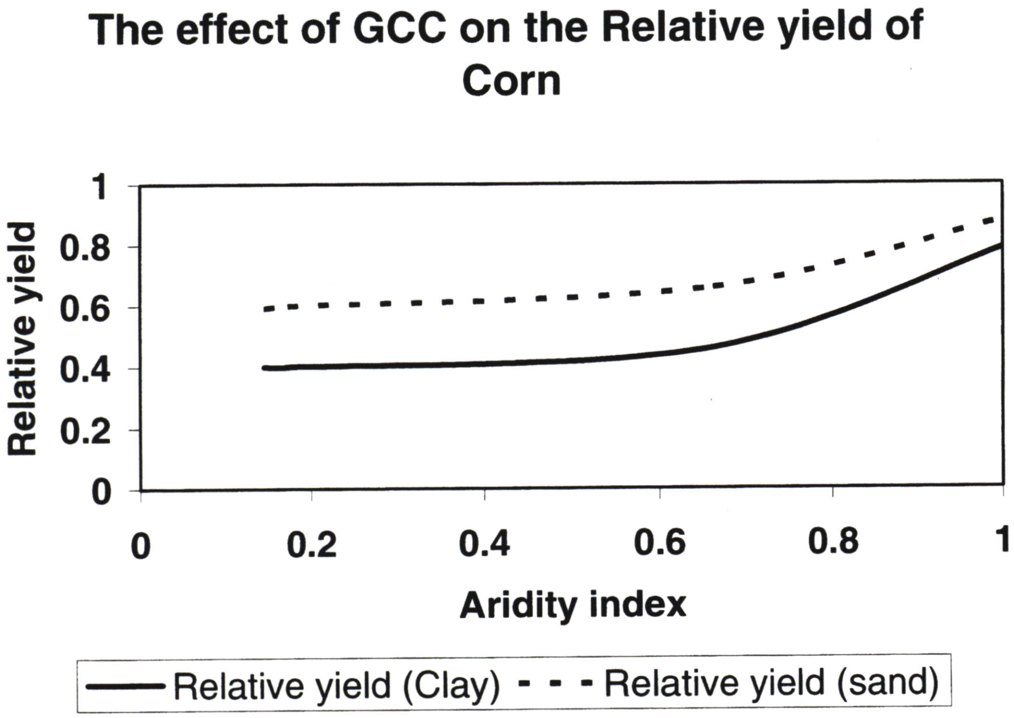



Table 3. Probability of wheat yield with respect to probability of rain in arid and semi arid regions of Israel

| return period | rain greater than | yield higher than | rain greater than | yield higher than |
|---|---|---|---|---|
| No. of years out of 100 | mm in semi arid region | kg/ha. in semi arid region | mm in arid region | kg/ha. in arid region |
| 95 | 209 | 1450 | 50 | 0 |
| 80 | 277 | 2240 | 150 | 200 |
| 60 | 340 | 2900 | 235 | 1700 |
| 50 | 371 | 3340 | 250 | 2000 |
| 40 | 404 | 3520 | 270 | 2200 |
| 20 | 498 | 4120 | 350 | 3000 |
| 5 | 659 | 4750 | 465 | 4000 |


The effect of GCC on the Relative yield of Corn
Relative yield
1
0.8
0.6
0.4
0.2
0
0
0.2
0.4
0.6
0.8
1
Aridity index
Relative yield (Clay)
Relative yield (sand)