Assessment of the Impact of Climate Change on Water Productivity in Rainfed Wheat Systems in the Mediterranean region

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Introduction

According to IPCC report, increased C02, temperature and climate variability will affect the hydrological cycles with changes in precipitation, storm events, evapo-transpiration, runoff and soil moisture. In the face of a changing climate, adaptation responses are urgently needed; however, these responses should be related to the specific risks that threaten the agriculture namely: declining crop productivity, loss of agro-diversity and loss of food security. Based on these, the goals of adaptation could be:

- to enable the transfer and adoption of adapted technology and contribute to human and institutional capacity building
- to Maintain natural resources, ecosystem and agro-diversity
- to provide enough food to sustain population and improve the overall food security situation.

The goal is managing future risks in a changing climate; adaptation measures are expected to reduce the vulnerability to a certain extent but we will not expect it to give a complete adaptation.
In the domain of Agriculture, several types of action can be undertaken:

- Changes from rain-fed to irrigated agriculture,
- Change in how irrigation is carried out so that the benefits derived from it are less sensitive to climate stresses.
- Protect and improve water resources.
- Increase the level of and access to knowledge and skills that can enable better decision making for managing climate related risks and recovery

Current trends in Mediterranean agriculture reveal differences between the Northern and Southern Mediterranean countries as related to population growth, land and water use, and food supply and demand. The changes in temperature and precipitation predicted by general circulation models for the Mediterranean region will affect water availability and resource management, critically shaping the patterns of future crop production. Strategies to improve the assessment of the potential effects of future climate change on agricultural production should be addressed. The Southern Mediterranean region has the world's lowest rates of renewable water resources per capita; and associated environmental and social constraints. In this area, an example of adaptation action for wheat management (Annex 1) is irrigation management or management of water scarcity, in response to drought during the growing season and highly variable and unpredictable rainfall, to reduce the risks of malnutrition of rural poor. The objective of this assessment is to manage future risks in a changing climate through the use a combination of

European-developed climate and crop modeling tools to develop options (germplasm, crop, soil and water management practices) that can increase water productivity of wheat-based cropping systems.

Results

Step 0: getting familiar with DSSAT and the required data for its validation in our environment.

DSSAT is a microcomputer software program combining crop soil and weather data bases and programs to manage them, with crop models and application programs, to simulate multi-year outcomes of crop management strategies. As a software package integrating the effects of soil, crop phenotype, weather and management options, DSSAT allows users to simulate results by conducting, in minutes on a desktop computer, experiments which would consume a significant part of an agronomist's career. DSSAT also provides for validation of crop model outputs; thus allowing users to compare simulated outcomes with observed results. Crop model validation is accomplished by inputting the minimum data set, running the model, and comparing outputs.

Minimum data set

The minimum data set (MDS) refers to a minimum set of data required to run the crop models and validate the outputs. Validation requires:

1. Site weather data for the duration of the growing season,
2. Site soil data, and
3. Management and experimental data for the experiment.

1. MDS Weather Data

The minimum required weather data includes:

- latitude and longitude of the weather station,
- daily values of incoming solar radiation (MJ/m^2-day),
- maximum and minimum air temperature (ºC), and
- rainfall (mm).

The length of weather records for validation must, at minimum, cover the duration of the experiment and preferably should begin a few weeks before planting and continue a few weeks after harvest so that "what-if" type analyses may be performed.

The meteorological inputs require more attention than others because of more potential damage they can produce if they supply the model improperly.

2. **MDS Soil Data**

Desired soil data includes soil classification (SCS), surface slope, color, permeability, and drainage class. Soil profile data by soil horizons include:

- upper and lower horizon depths (cm),
- percentage sand, silt, and clay content,
- 1/3 bar bulk density,
- organic carbon,
- pH in water,
- aluminum saturation, and
- root abundance information.

3. **Management and Experiment Data**

Management data includes information on planting date, dates when soil conditions were measured prior to planting, planting density, row spacing, planting depth, crop variety, irrigation, and fertilizer practices. This data are needed for both model validation and strategy evaluation.

In addition to site soil and weather data, experimental data includes crop growth data, soil water and fertility measurements. This data are needed for model validation.

Step 1: Data collection for crop model (DSSAT, CROPSYST and SWAP)

- **Historical weather data**
  Most available sets of weather data in Morocco do not account for incoming solar radiation, the only measured variables are min and max temperature and rainfall. An incomplete or bad representation of the climatic set constitutes both a limitation and a potential bias factor for the simulation after several tentative and contacts, a set of 30 years weather data for the experiment location with min, max temperature, rainfall and duration of sunshine was rendered available from the National Direction of Meteorology. Incoming solar radiation can be calculated from hours of sunshine.
- **Soil analysis measurement**: Main required variables at least for 0-30cm, some times up to 60cm are available for all experiment locations. Variables such as 1/3 bar bulk density; aluminum saturation and root abundance information were not measured but can be estimated.
- **Management and Experiment Data** are available, a chosen set of 3 locations experiment (different previous crops) over 3 years (2003-04, 2004-05, and 2005-06) with crop phenology, yield components, dry matter production and N uptake survey at different growth stages of wheat crop.
- **Wheat genotype** coefficients are still to be corrected and adapted to our local variety 'Amal'

Step 2: DSSAT model Adapting and validation to predict growth and yield of Wheat

DSSAT was run several times with the available data and results are still to be confirmed once data sets are completed, especially, with respect to wheat genotype coefficients which should be, correctly, adapted.

Data sets of wheat production from several experiments have been assembled for testing DSSAT. The model test of performances revealed some satisfactory results for the simulation of whet phenology (growth stages dates of realization). Validation tests show that the estimated grain yields and yield components were overestimated, though within reasonable agreement of reported grain yield in one area. Wheat growth, dry matter production is somewhat overestimated by the model, this is probably due to the hypothesis that eliminates all kind of limiting factors that can hinder the progress of crop cycle as well as the absence of attacks of parasites and weeds. DSSAT performances in our environment are questionable? It seems that use of more sophisticated calculations, for example for evapo transpiration must be provided? Furthermore, Wheat genotype coefficients have still to be corrected and adapted to our local variety 'Amal'

Constraints

Although somewhat accurate in its output for few variables, one difficulty is the level of expertise which must be employed to set the initial input parameters. Overall, use of standard data formats for documenting experiments and modeling crop growth and development can greatly facilitate exchange of information and software, allowing researchers to focus on science rather than on re-formatting data. The standards used in DSSAT software package contain ambiguities that make them unsuitable for certain uses. They should provide more complete documentation of experiments, allow use of the standards in a wide range of decision support situations and place the standards in a more general framework, necessary as software systems evolve and researchers move towards more generic mechanisms for data interchange. Efficient interchange of data among researchers, especially for use in simulation models and other decision support tools requires use of a common vocabulary and strategy for organizing data. The agricultural research community increasingly encounters research problems that require interdisciplinary collaboration. Agronomists, soil scientists and irrigation specialists combine efforts in order to increase the efficiency of crop water use. In such collaborations, ready data interchange is essential. The goal is to provide a reliable, portable, and flexible structure both for documenting experiments and for specifying realistic conditions for running dynamic simulation models. For documentation, it is desirable to have sufficient detail on weather (with possibilities of calculation of frequently unavailable variables such as solar radiation), soil, crop cultivars, weeds, diseases, pests, and crop management to permit a full reproduction of the experiment and to conserve any information measured or noted during or at the end of the experiment. Because of the diversity of experiments, the list of variables documented should be extended to accommodate new variables, and the implementation files contracted by omitting variables. A "flexible dataset" would be more convenient and practical.

Annex 1. AGRIDEMA Pilot Assessment

1	Title	Assessment of the Impact of Climate Change on Water Productivity in Rainfed Wheat Systems in the Mediterranean region
2	Researchers	F. Mosseddaq, M. Medany, A. Larbi
3	Location	Egypt, Morocco, Syria
4	Justification	The West Asia and North Africa (WANA) region has the world's lowest rates of renewable water resources per capita, and suffers from associated environmental and social problems. The majority of poor farmers operate under rainfed conditions or ground water withdrawals to provide food security and have varying dependencies on agriculture for income and livelihoods. According to IPCC there is high probability of increased C02, temperature and climate variability which will affect the hydrological cycles -changes in precipitation, storm events, snow fall and snowmelt, evapo-transpiration, runoff and soil moisture. There is need to apply for options for diversified production systems that can cope with climate variability, more extreme events and increasing water scarcity.
5	Objective	Use a combination of European-developed climate and crop modeling tools to develop options (germplasm, crop, soil and water management practices) that can increase water productivity of wheat-based cropping systems – i.e. make them more robust and able to withstand increased climate variability and extreme events.
6	Methodology	6.1 *Data collection*: crop and weather data will be collected for one location in Egypt, Morocco and Syria
		6.2 *Model validation*: Some models e.g DSSAT4.0, CROPSYST, SWAP.
		6.3 Climate Change Data: Scenarios (A1, B1, A2, B2) of the SRES of the Inter-Governmental Panel for Climate Change (IPCC) will be collected from Treista, Italy for the selected sites for the following time series - 2040, 2060, 2080, 2100
		6.4 Model Simulation: Climate Change data will be used to run the validated models to predict water productivity under different management strategies.
7	Outputs	Make the resulted recommendations available for policy makers in the highest level possible.