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Use of CROPWAT 8.0 Program for the Assessment of Water Demand of some Agricultural Crops in Albania

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Abstract: Climate change in Albania is an extremely important issue since the majority of population depends directly or indirectly on activities which are impacted by this change. Agriculture is one of the most important economic activities in Albania. Albanian First and Second National Communication to UNFCCC state that the rise in temperature may cause the productivity decrease of certain agricultural crops, water stress and slowdown of crop growth. Agriculture is one of the most significant sectors of Albanian economy, representing approximately 20.6% of GDP (2011) and about afro 58% of employed people in the country. Since the irrigation system in the region is not operational for years, farmers built their agricultural activity mainly on rainfall/precipitation and irrigation carried out on small scale by household wells opened in the vicinity of arable lands. As everywhere else in the country and all over the world, climatic change is increasingly becoming more evident. In many cases crops in the region are failing totally out of the lack of water. Even in particular cases when the failure of agricultural crops is not total, financial losses are substantial for the poor budget of households. Very frequently the expenses of agricultural crops cannot be covered by the sale of products obtained from them. As climate change is becoming increasingly more aggressive for agriculture impeding obviously its development, it is necessary that farmers should be instructed properly on how to cope with these situations, how mitigating and adaptive measures should be taken, how crops should be planted, how the accurate date of planting should be defined, etc.

Keywords: Climate Change, Agriculture, Sustainable Development, Rural Development

INTRODUCTION

Myzeqe field which is part of Lushnja region is the biggest and most important area in our country. It is situated in the agro-ecological lowland zone alongside the Adriatic Sea. About 80% of annual rainfall/precipitation (about 900-1200 mm/year) is concentrated during the October – March period. Climate and terrestrial conditions make Lushnja region and more specifically Myzeqe field one of the most important agricultural areas in Albania. The biggest areas of greenhouses are located there. Also it represents the area with the highest productivity of agricultural crops in Albania. The area's products supply the major domestic and foreign countries. Situated in the western lowland of Albania, Myzeqe field extends from 0 to 20 meters above sea level, but there are also places like the former marshes of Tërbufi in Divjaka, Hoxhara etc. that are also below the sea level. It has been noticed that recently Myzeqe relief tends to decrease. Divjakë – Karavasta is one of the biggest lagoons in the Mediterranean region. The area is located between two big rivers; Shkumbini and Semani. The most problematic issues are caused by floods from Shkumbini River and Semani River. Divjakë-Karavasta is a protected area (National park, second category of IUCN). That national park is an important part of natural potential of Europe and a complex of international importance. Some other important aspects of that area are described below:

- It contains about 20% of agriculture land in Albania;
- It contains 50% of the greenhouses' area in the country;
- It contains 15% of the area of fruit trees;
- It yields 44% of the production of citrus;
- It yields 31% of the production of olives;
- It yields 15% of the production of the fruit trees.

Given that the area represents the most important part of the Albanian agriculture, the expected impact of climate change will play a significant role in this

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respect. This means that the living of area's farmers will become substantially more difficult. Also domestic and foreign markets will be impacted by the expected reduction of the agricultural production in the area. This not only makes agricultural unsustainable and unstable but above all affects the area's sustainable rural development.

METHODOLOGY

CROPWAT 8.0 for Windows is a computer program for the calculation of crop water demand/requirements and irrigation demand/requirements based on soil, climate and crop data. In addition, the program allows the development of irrigation schedules for different management conditions and the calculation of scheme water supply for varying crop patterns. CROPWAT 8.0 can also be used to evaluate farmers' irrigation practices and to estimate crop performance under both rainfed and irrigated conditions. The development of irrigation schedules in CROPWAT 8.0 is based on a daily soil-water balance using various user-defined options for water supply and irrigation management conditions. In this study, the "no irrigation/rainfed" option of the program has been used.

The climate of Lushnja region was analyzed, and this region is simultaneously the major reference for Albanian agriculture.

First, the projection of climate elements was conducted, using the relevant program MAGICC/ SCENGEN (version 4.1).

Climate data used by the program are based on monthly data of:
Temperature, rainfall/precipitation, wind speed, solar radiation, air humidity/moisture.

Year 1990 was taken as baseline year for the data projection. For the purposes of this study, only data generated by average scenario have been taken into account/analyzed.

Main results of expected climate elements are shown in Table no. 1 below:

Table 1. Climate change scenarios for Lushnja Region, 2030-2100.

Years	Temperature, in ^{0}C (average)	Rainfall/Precipitation, in mm/year	Wind speed, in m/s	Radiation, hr/day	Humidity/moisture, in %
1990	16.1	917.9	2.5	7.1	66.9
2030	17.2	885.5	2.7	7.2	64.9
2050	17.8	844.3	2.9	7.3	62.9
2080	19.1	781.5	3.1	7.4	60.9
2100	19.7	746.3	3.3	7.5	58.9

As it can be seen from Table No. 1 above, drastic changes are expected to take place in some of the major climate elements and more specifically:

- Annual average temperature is expected to rise by 3.6 ^{0}C in 2100 as compared to 1990.
- The quantity/amount of annual rainfall/precipitation will fall by 19% in 2100 as compared to 1990.
- Average wind speed is expected to increase to 3.3 m/s in 2100, as compared to 2.5 m/s in 1990.
- Solar radiation is expected to increase to 7.5 hr/day in 2100 as compared to 7.1 hr/day in 1990.
- Average air humidity/moisture is expected to be 58.9% in 2100 as compared to 66.9% in 1990.

It is obvious that each of these factors plays a very important role in agriculture:

- Temperature is one of the most highly influential factors in agriculture, since it affects the increase in evapotranspiration (ETo), and is the major factor that causes water stress in plants.
- Rainfall/precipitation, being the primary source of soil humidity/moisture, is probably the most important factor determining the productivity of crops[1].
- Wind affects the movement of air currents. It also impacts the composition of air humidity/moisture, plant transpiration and soil humidity/moisture.

[1] P. Parvatha Reddy. 2015. Climate resilient Argiculture for ensuring food security. P.62. http://klimat.czn.uj.edu.pl/enid/1__Past_and_present/-_crops_11i.html

- Solar radiation is also a significant factor in agriculture. It impacts the air and soil temperature, humidity/moisture, wind, etc. Another important impact of solar radiation is that at specific moments of the day it burns (scorches) agricultural crops such as tomatoes, peppers, eggplants, etc.
- Humidity/moisture is also an important factor, which is influenced by temperature, soil cover, wind, etc.

As a conclusion, based on expected climate changes up until 2100, it turns out that agriculture in Albania is exposed to these changes and consequently is very vulnerable to them and this is why taking mitigating and adaptive measures in this sector is urgent.

The following data concerning analyzed agricultural crops such as: Crop characteristic (Stage length in days, Depletion Coefficient P, Root Depth in m, Crop Coefficient Kc, Yield Response Factor Ky), Stages of Development (initial, crop development, mid-season, late, total), and plant date based on region are provided by FAO – Crop and Water Information.

The change assessment in crop water demand due to climate change was conducted for four periods: 2030, 2050, 2080 and 2100.

In this case, the program CROPWAT 8.0 is used to analyze the water demand of agricultural crops in terms of expected increased temperatures, radiation, wind speed and reduced rainfall/ precipitation and humidity/moisture. Analyses were conducted for 12 agriculture crops which are commonly cultivated in Lushnja region: maize, winter wheat, tomatoes, alfalfa, cabbages, potatoes, peppers, watermelons, beans, citruses, grapes, vegetables. The water demand under different climate conditions was calculated for each of them.

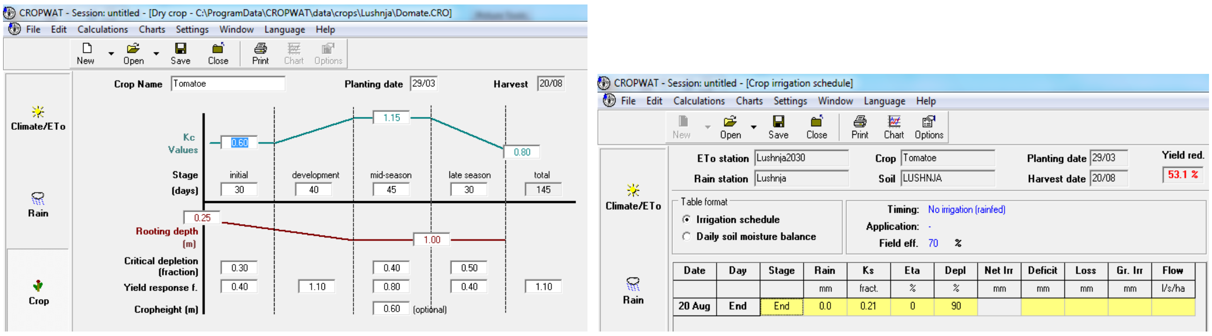


Figure 1. Using CROPWAT 8.0 program

RESULTS AND DISCUSSIONS

In figure no.2 agricultural crops and change in their water demand is given, due to increase in water stress, as a consequence of climate change:

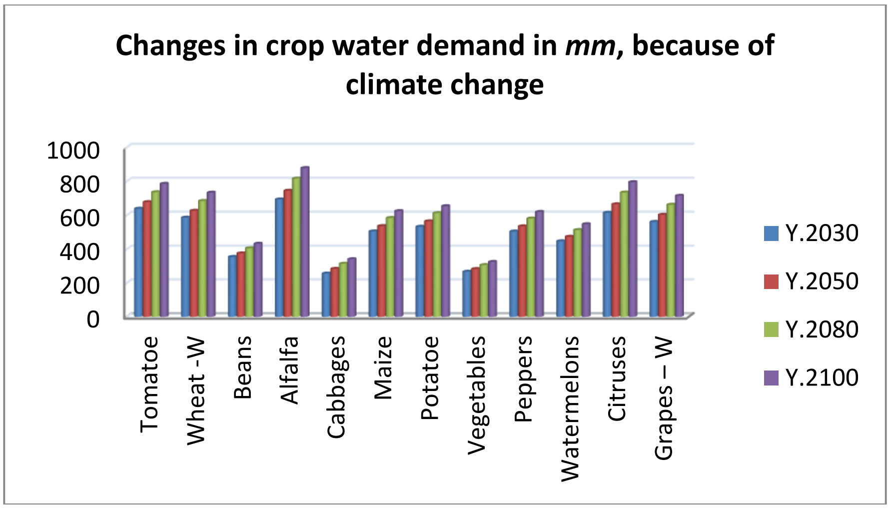


Figure 2. Estimation of crop water demand over different time series for Lushnja region

In all crops, an increase in their demand for water during the period 2030-2100 is noticed. Also, it can be deduced that the bigger the effect of climate change is, the bigger the demand of crops for water will be. This is because the expected temperature rise and reduction of rainfall/precipitation increase water stress of crops.

In order that crops cope better with water stress, the accurate definition of their planting time should be made. There are two main reasons for this: (i) effective use of rainfall/precipitation water, and (ii) optimization of crop vegetative period as opposed to the climate change, avoiding the impact of high temperatures and water stress during the critical stages of crop growth and development. In the context of agriculture completely depending on rainfall/precipitation, the amount of effective rainfall/precipitation is rather important to its progress.

Figure no. 3 shows the amount of effective rainfall/precipitation for Lushnja region for the period 2030-2100:

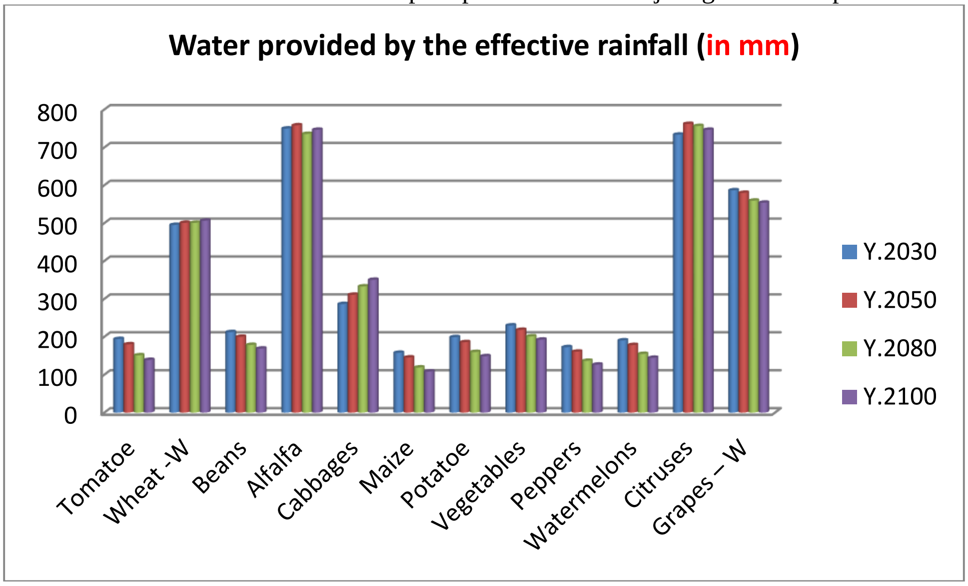


Figure 3. Water provided by the effective rainfall in mm for Lushnja region

As seen from the figure above, some crops with perennial growth period such as alfalfa, citruses and grapes meet a large part of the needs for water from the effective rainfall/precipitation. Even other crops- winter wheat and cabbages meet an important part of the water needs from the rainfall/precipitation, as a part of their growing season coincides with abundant rainfall/precipitation- winter and spring.

Since for most agricultural crops the annual amount of effective rainfall/precipitation is insufficient to meet their water needs, that difference (between water demand and effective rainfall) presents "Unmet water demand" which is shown in the Figure no.4:

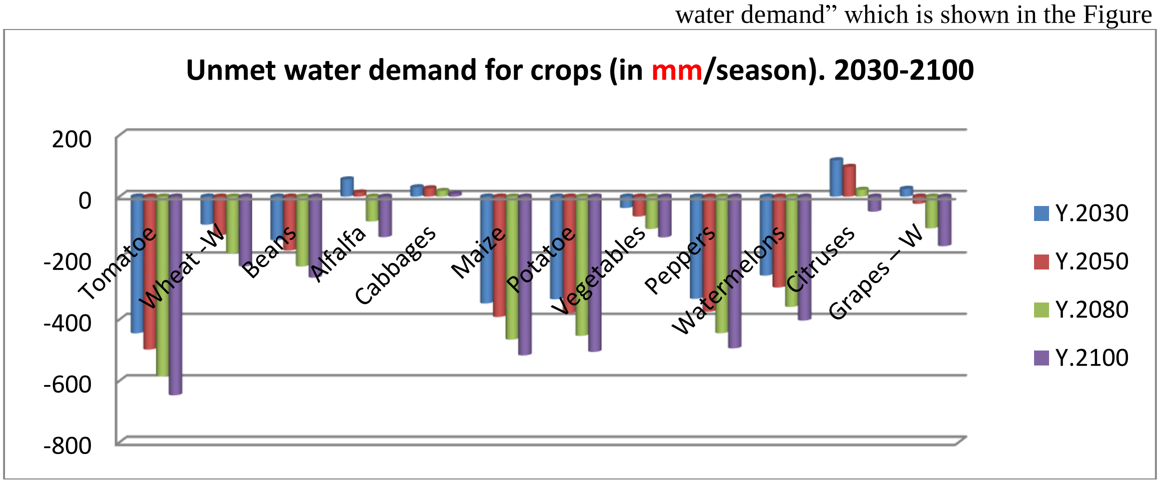


Figure 4. Unmet water demand for crops for Lushnja region

As it can seen from the Figure above, a large number of crops will require increasingly high amounts of water from irrigation due to increased temperatures and reduced rainfall/precipitation. This happens because the period of cultivation/harvesting of agricultural crops (spring-summer) coincides with that of reduced rainfall/precipitation and increased temperatures (high water stress).

This is better illustrated in Figure no. 5 below about tomatoes:

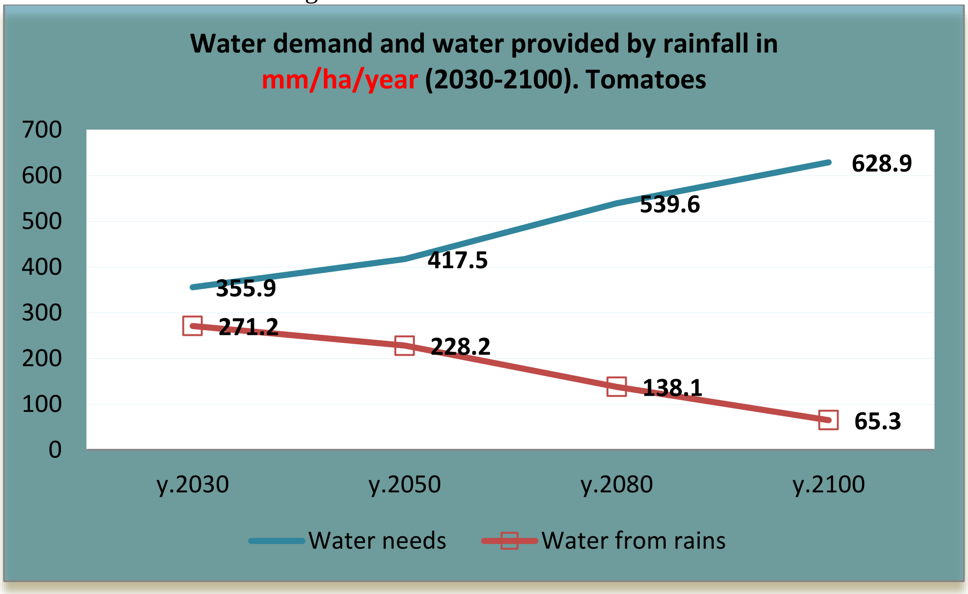


Figure 5. Water demand and water provided by rainfall for tomatoes, in mm.

As it can be seen from Figure 5, the amount of water generated by rainfall/precipitation is absolutely insufficient to meet the crop needs as a rainfall/precipitation reduction and temperature rise are expected to happen during the period 2030-2100. Meanwhile, for the same reasons, the demand for water will be continuously increasing over that period of time.

Figure No.4 shows that maize, tomatoes, potatoes, peppers and watermelons will need greater quantities of water for irrigation. This makes these crops with higher demand for water than others, be more exposed to climate change effect. Therefore, these crops present simultaneously the highest risk in their harvesting in the context of an agriculture based only on rainfall/precipitation.

Some crops like cabbages, alfalfa, citruses and grapes present different situations when compared with the other group of crops. It seems that these crops constitute the main agricultural crops that are less vulnerable to the impacts of climate changes.

Also through the application of CROPWAT 8.0 program, it was made possible to calculate agricultural yield for crops over different time series (2030-2100), using "**no irrigation - rainfed**" option. Almost in all cases and crops, it is noticed that in the case of "no irrigation/rainfed" scenario, all crops are expected to dramatically reduce their production.

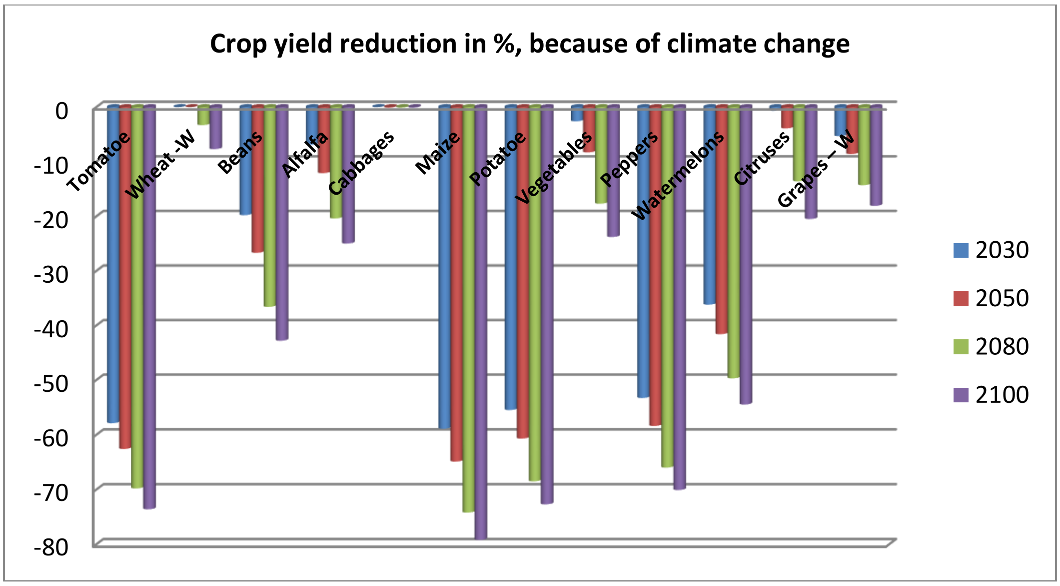
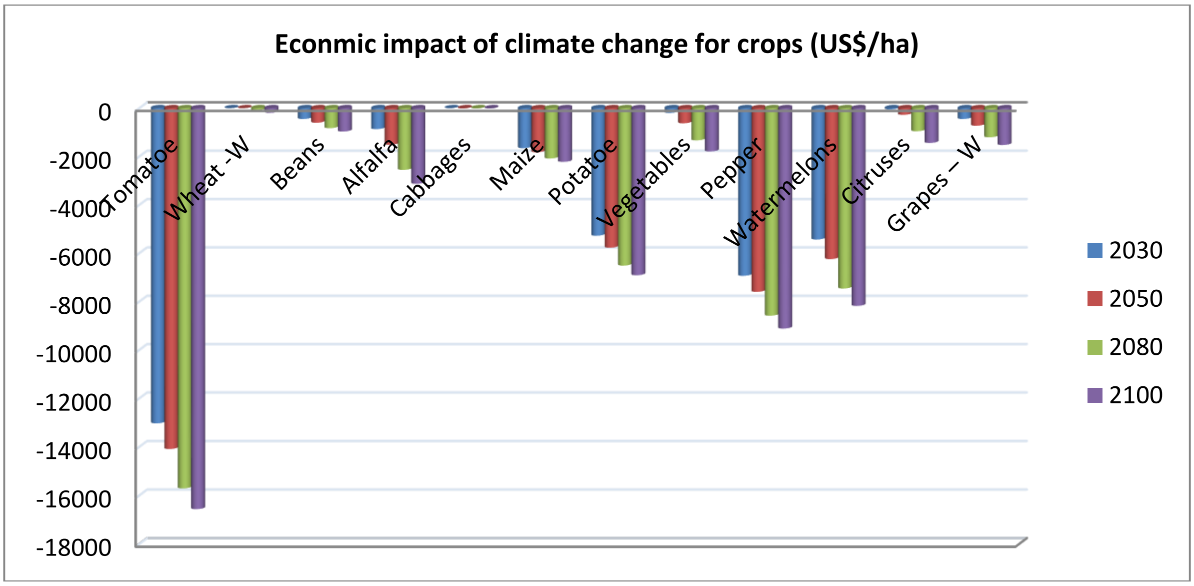


Figure 6. Crop yield reduction for the mean time under scenario "no irrigation"

As it can be seen from Figure no. 6, all crops analyzed are expected to have a reduction in their yield. Agriculture crops with greater decline in their yield are; tomatoes, maize, peppers, watermelons, potatoes. While in some others like winter wheat, alfalfa, cabbages, citruses and grapes, the yield reduction is much more moderate.

In the figure no. 7 is given also an evaluation of the financial losses of different crops (US $/ha) due to the reduction in their yields caused by climate change.



As seen, different plants represent different values of financial loss. Plants such as; tomatoes, potatoes, peppers, watermelons represent plants where financial loss is bigger than in some other plants. This is a good orientation for farmers to assess the level of risk in their farms based in the crops they cultivate.

RECOMMENDATIONS:

- The impact of climate change and financial losses in agriculture are increasing until reaching their maximum in 2100. Therefore, it is necessary to start with mitigation and adaptation measures to climate change.
- In order to use CROPWAT 8.0 program as effectively as possible, it is necessary to conduct detailed studies on crop varieties harvested by farmers in this region, to define the variables program uses (e.g. crop characteristic, stages of development, planting date, etc).

- The programme helps farmers to assess the level of risk in their farm, based on crops they cultivate.
- Agricultural Advisory Service should be trained in using CROPWAT 8.0 program, since they will be considerably helpful to farmers in this way.
- Accurate definition of planting time is a very important element in agriculture, because it enables the optimization of us of water from rainfall/precipitation.
- Priority should be given to local varieties, which are more easily adapted to local climate conditions and are also more resistant to diseases, damagers, and water stress.
- Use of planted saplings in greenhouses limits the crop growth period in the open. This makes crops more resistant and capable of maximizing the use of rainfall/precipitation water.
- Agricultural advisory service should be as close as possible to farmers to advise them about the water demand of various crops and the impact of water stress on relevant crop productivity.
- Use of insurance schemes should begin to be applied in agriculture too, as a way to reduce the danger incurred to agriculture by climate change.

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