European
Commission

Climate change and agriculture

PESETA IV conducted an integrated quantitative assessment, involving climate, biophysical and economic models, to understand how climate change will affect EU agriculture. In the absence of adaptation, climate change is expected to substantially lower grain maize and wheat yields in southern Europe, and to a lesser extent grain maize in northern Europe. However, EU production could still slightly increase due to the interplay of different market forces. This is because the negative effects in Europe are projected to be lower compared to other world regions. This provides the EU a comparative advantage in terms of climate change impacts on agricultural productivity, which could positively affect its competitiveness.

Climate change driven biophysical impacts in Europe

Grain maize is an irrigated crop in most of Europe. When assuming the irrigation infrastructure of nowadays remains in place and that sufficient water is available for irrigation (i.e. projecting future “potential yields”), climate change will substantially lower yields in most producing EU countries – see Figure 1 (top panels). The most severe impacts on irrigated grain maize are projected for southern Europe, where potential yields could decline by more than 10% in a 2°C warming scenario. The losses are slightly lower with 1.5°C warming.

Climate change could further restrict the water available for irrigation and result in yields that are lower than the potential achievable under full irrigation. Under an extreme assumption of no irrigation in the future, severe declines in grain maize yield are projected with global warming (Figure 1, bottom panels). Under such “rain-fed” conditions, declines in yield of over 20% are projected for all EU countries, with crop losses up to 80% for some countries in southern Europe (Portugal, Bulgaria, Greece and Spain). This implies that without market adjustments, grain maize production may no longer be viable in areas where there is water scarcity and significant decreases in precipitation.

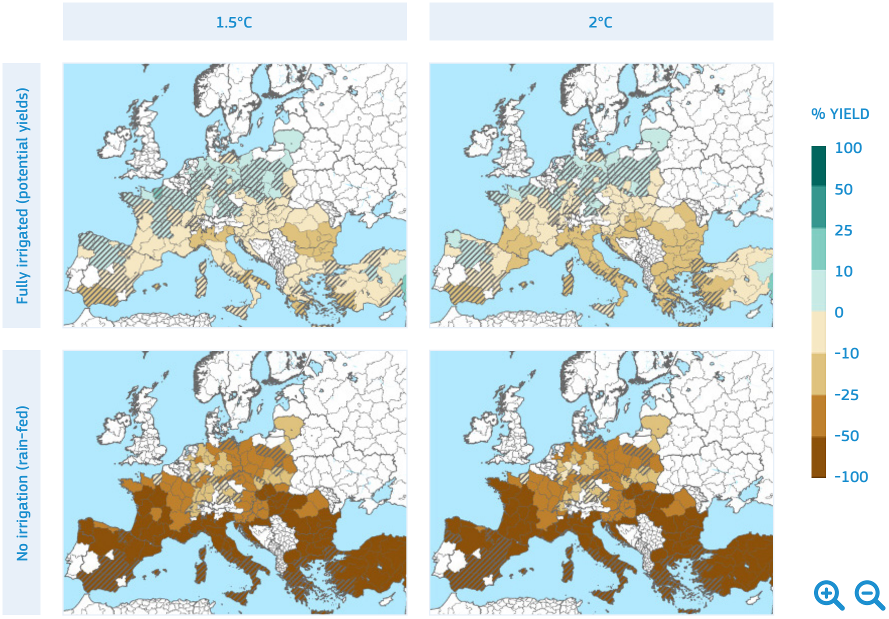

Figure 1. Results of the biophysical assessment, showing ensemble mean changes of grain maize yield relative to present (%) for 1.5°C (left panels) and 2°C (right panels) warming scenarios, assuming fully irrigated conditions (“potential yields”; top panels) and no irrigation in the future (“rain-fed yields”; bottom panels). Hatching denotes areas with low model agreement.

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KEY MESSAGES

Pure biophysical effects of climate change

Without adaptation and market adjustments, climate change will substantially lower grain maize and wheat yields in southern Europe, and to a lesser extent grain maize in northern Europe.

Market adjusted effects of climate change

Global market demand may steer adaptation in Europe, with advantages for the European farming sector.

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About PESETA IV

The JRC PESETA IV project aims to better understand the biophysical and economic consequences of climate change. It does this by using projections of climate change for Europe from several climate models along with a set of climate change impact models. The project covers several sectors that are relevant to society and the natural environment, such as freshwater, agriculture, and coasts.

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In contrast to grain maize, wheat is mostly a non-irrigated, rain-fed crop in Europe. Increases in yields by around 5% on average are projected for northern Europe, due to changes in precipitation regime combined with enhanced growth from increasing atmospheric CO_2 concentrations. Yield reductions are projected for southern Europe, by around 12% on average, corroborating empirical evidence of a limited CO_2 effect on wheat under limited water conditions. Limiting global warming to 1.5°C could reduce these losses by 5%.

Adaptation in Europe

Adaptation strategies, such as changing sowing dates and the crop variety sown, would not suffice to offset the projected strong reduction in grain maize yields. Changing varieties could have a much larger beneficial effect on rain-fed wheat production. Plant-breeding, guided by modelling, can identify ‘faster’ wheat varieties, which reach the flowering stage earlier. These may lessen the projected yield reduction from climate change and in some cases even give rise to an increase in yields. Furthermore, if irrigation infrastructure is built in wheat growing areas and assuming there is sufficient water availability, wheat losses could turn into yield gains across all of Europe. As climate change progresses, farmers may also decide to grow different crops, which are better suited to the new agro-climatic conditions.

Crop production impacts with market adjustments

The negative effects of climate change on crop yields in the EU as projected by the biophysical models may be reduced considerably as a result of market adjustments due to more severe climate change impacts on agriculture outside Europe (Figure 2). Varied projected biophysical yield changes across world regions will result in global production changes, reflected in increases in crop prices. Due to market adjustment effects, the price increases will induce changes in EU farmers' management practices (e.g. input use per unit of land) which in the end causes European yields to readjust.

For example, with market adjustments, in southern Europe there is a 3% increase in grain maize and a 2% increase in wheat production (Figure 2), which is different from the projected declines for both crops in the biophysical assessment (Figure 1). In northern Europe, however, the substantial increase in wheat yield projected by the biophysical assessment is downsized due to market adjustment.

Besides the market adjustment effect, methodological limitations explain the differences in the biophysical and market adjusted projections. These include: the use of different climate and crop models; slightly varying magnitudes of global warming; different modelling assumptions around irrigated and rain-fed yields; and the effects of elevated atmospheric CO_2 concentrations. Changes in crop varieties and sowing dates are also responsible for the differences.

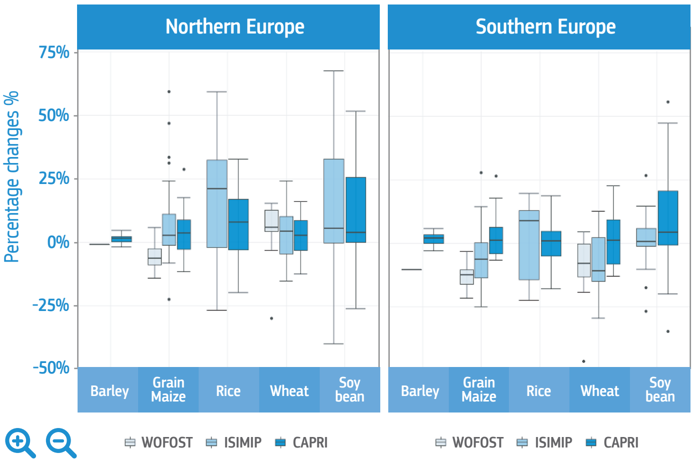

Figure 2. Crop yield changes (%) for northern and southern Europe in 2050 relative to the baseline based on biophysical modelling (WOFOST, ISIMIP) and economic modelling (CAPRI) when accounting for market adjustments. Horizontal lines show the ensemble median and boxes show the 25th and 75th percentiles. The warming in this scenario in 2050 corresponds to approximately 2°C.

Approach

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The WOFOST model was used in the biophysical assessment to simulate crop yields across Europe under 1.5°C and 2°C warming scenarios derived from 10 regional climate models run for two emission pathways (RCP8.5 and RCP4.5). Crop growth was affected by elevated CO_2 concentrations. Two types of yields were estimated: 1) “potential yields”, where it was assumed that current irrigation infrastructure remains in place in the future and there is sufficient water available for irrigation; and 2) “rain-fed yields”, where there is no irrigation and therefore crops can be affected by water availability constraints. The effects of respectively including and excluding adaptation options such as changing sowing dates and crop varieties were explored. The effects of nutrient limitations, heat stress at flowering, and pests and diseases were not considered.

The CAPRI model (www.capri-model.org) was used to explore the effects of global climate change on European crop production, land use, consumption, income, prices and trade. Yields for year 2050 from 7 global crops models, run with five global climate models under the RCP8.5 emissions scenario (sourced from the ISIMIP Fast Track database), were used as input to CAPRI. WOFOST could not provide climate change yield changes for the rest of world and was therefore not added to the model ensembles. For Europe, there is a partial overlap between the ISIMIP and WOFOST crop yield projections. The range in global warming across the climate models in 2050 is 1.6-2.7°C. CAPRI did not consider water availability constraints, the effect of elevated atmospheric CO_2 concentrations, nor changes in crop varieties and sowing dates.

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