

Climate change impacts on European crop production

A literature review

Sophia Lüttringhaus, Steffen Noleppa,
Christoph Gornott, Hermann Lotze-Campen



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Sophia Lüttringhaus, Steffen Noleppa
(HFFA Research)

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Christoph Gornott, Hermann Lotze-Campen
(Potsdam Institute for Climate Impact Research)



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List of abbreviations

CMIP	– Coupled Model Intercomparison Project
EEA	– European Environment Agency
FAO	– Food and Agriculture Organization
GCM	– General Circulation Models
GISS	– Goddard Institute for Space Studies
IPCC	– Intergovernmental Panel on Climate Change
NASA	– National Aeronautics and Space Administration
PIK	– Potsdam Institute for Climate Impact Research
PPP	– Plant Protection Product
RCP	– Representative Concentration Pathways
UK	– United Kingdom
UN	– United Nations
WMO	– World Meteorological Organization

Executive summary

The global and European agriculture faces multiple challenges. A growing world population in combination with a significant rise in per capita consumption of agricultural goods force farmers to produce ever more with less inputs. Consequently, agricultural supply will have to increase substantially. Increasing agricultural production through yield enhancements, however, is a challenging effort, especially because of adverse climate change impacts.

Recent extreme weather events such as extreme heat, dry spells or massive rains during summer months have made climate change and its impacts to be among the top headlines in the news. This has increased peoples' consciousness regarding the topic, but people working with and within the agricultural sector have already established it for a long time, as they have been facing climate impacts for decades. The above-mentioned extremes are in line with the latest report of the Intergovernmental Panel on Climate Change (IPCC) projecting that extreme weather events such as high temperature extremes, meteorological droughts and heavy precipitation will increase substantially in frequency and intensity in the future. Thus, it will be crucial for the agricultural sector to adapt to these fast changes and also to mitigate its own effects on the climate.

As climate change is a very fast changing and complex phenomenon, it is vital for farmers and all stakeholders along the food value chain to have up to date knowledge on how climate change is affecting their production systems and management strategies. Therefore, this study provides a broad overview of current and future climate change conditions as well as their impacts on European crop production. We describe the spatially and temporarily heterogeneous effects on this region and highlight areas which are particularly vulnerable to climate change. As weed management is of special interest in plant production, we analyse in detail how the crop-weed interaction changed and will continue to change in the future. For this purpose, we analysed current literature to condense the most important patterns of climate change impacts.

Climate change manifests itself in rising temperatures as well as structural changes in precipitation patterns and overall water availability. The climate has already changed in Europe and worldwide and the consequences are diverse impacts over time and space. Global annual near-surface temperature has increased by nearly 1 °C during the recent decades as compared to preindustrial levels. The latest decade has been the warmest on record. An approach to describe these climate shifts is the concept of climate analogues, which compares the projected future climate of a city to the current climate of another city. For example, with unabated climate change in 2071-2100 Berlin is likely to have the present climate of Saragossa. And as a general rule one can say that precipitation levels will increase in Northern Europe and decrease

in the South. Another effect of climate change is that the probability of occurrence and intensity of extreme weather events increases. Thus, such extreme summers as the one in 2018 will be more likely and longer in the future.

Climate change also considerably impacts water availability and irrigation demand. Despite the temporal and spatial shifts of rain fall patterns and a higher likelihood of extreme rainfall or drought events, another straightforward condition is important to note. As global and local temperatures rise, plants' evapotranspiration also increases which means that plants lose more water which will have to be compensated for by rainfall. And if precipitation decreases plants' will sooner face water stress.

These current and future effects make it clear that agricultural systems have to change. Climate change has led and will further lead to systematic problems such as irreversible environmental degradation. The impacts vary regionally and are very complex as many climate systems are interlinked and feed back into one another. Thus, the overall climate system has to be taken into account when projecting climate change impacts on agricultural production. Depending on the climate model, yield decreases are projected to be very high in the far West of the continent, on the Iberian Peninsula, in Italy and in the Balkans, whereas yield increases are forecasted mainly for Scandinavia and some parts of Central and Eastern Europe. Furthermore, climate change will affect the growing season length and crop life cycle. Since 1992 the thermal growing season has already expanded by 10 days and this trend continues. Also, crops' phenology has changed, visible by e.g. earlier flowering dates. Additionally, a habitat shift or habitat expansion occurs as thermophile crops move northwards. One example is the expansion of the ecological niche of maize due to increasing average temperatures.

Not only crops, but also weed plants shift their habitat and expand their seasonal activity. Consequently, the damage to specific cropping systems by weeds will change over time and across space. The shift of weeds' geographic niche, the overall area suitable for the specific weed species, and the damage niche, where the weed can grow and also possibly damage a crop, is also affected by climate change. Climate change effects can cause morpho-physiological and anatomical changes in plants (e.g. waxy leaf surface), which can alter nutrient and plant protection uptake. Hence, herbicide application is difficult under arid conditions as moisture is needed for product uptake by weed plants and soil incorporation. Moreover, dry conditions decrease microbial processes and often reduce plant health of the weed and also main crop, which increases the risk for crop injury.

Another aspect of climate change is the increasing level of CO₂ which can have positive yield effects due to CO₂ fertilization. Nevertheless, it is difficult to quantify the exact net effect taking into account other climate change effects on yields.

Following an increased occurrence and intensity of extremes, climate change impacts will increase soil erosion and reduce soil fertility, too. In particular rainfall induced soil erosion will occur more often and wind erosion will enhance around the Baltic sea and in arid regions such as the Mediterranean and Central-East Europe.

Based on this meta-analysis of climate change impacts, the report comes to the following recommendations for action. It is crucial to adapt to and mitigate climate change to uphold agricultural activity and thus farmers' livelihoods, but also to sustain consumer welfare. Concrete measures should be site-specific, cost-efficient and scalable. To help farmers cope with the risks posed by climate change, the information and knowledge loop between farmers, input suppliers (incl. breeders, plant protection), consulting and extension services as well as science has to be constantly updated to ensure timely, efficient and optimal knowledge transfer and thus practical implementation of suitable climate-resilient measures. In addition, more public funding should be provided for analysing climate change impacts on agriculture and creating innovations in climate-resilient agriculture (e.g. plant breeding, resilient cropping systems) as well as mitigating the negative effects for farmers. Farmers should be able to choose from a pool of measures and pick those that are most effective for their farm.

Our synthesis shows that climate change has already affected agricultural production systems and that overall negative effects will aggravate in the future, if climate change continues unabated. Thus, all agricultural stakeholders need to be prepared so that future supply of agricultural goods is ensured.



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HFFA Research GmbH
Bülowstraße 66/D2
10783 Berlin, Germany

E-Mail: office@hffa-research.com

Web: www.hffa-research.com



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HFFA Research GmbH
Bülowstraße 66
10783 Berlin, Germany
Phone / Telefon: +49 (0)30 21 96 16 61
E-Mail: office@hffa-research.com