Climate change research review – 10th anniversary of the VAHAVA report

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2: Gránátalma Alapítvány, 51. Bem rakpart, H-2016. Budapest, Hungary

Abstract: Climate change processes highly affect agriculture. The impacts of climate change may influence almost all fields of agricultural activities; production efficiency, quantitative and qualitative deterioration of crop yields produced for alimentary purposes, and to determine postharvest manifestation of agricultural products inducing hazard in the field of food safety, transport, storage and distribution. There are many factors like soil-climatic conditions, amount and distribution of precipitation, anomalies and extremities of temperature as well as various manifestation of air movement from stand still to storms that may influence agriculture. Climate change may have indirect impacts as well like pollution, which has been considered solely as the presence of unfavourable alien matter in the environment, but in reality pollution is far more than that. Agri-environmental pollution is less anthropogenic since many pollution or degradation processes may begin with no direct relationship to human activities. Soil degradations or irreversible damage to natural ecosystems by climatic factors (drought, flood, water logging and salinity) are to be seen as the most frequent consequences. Biological pollution, like weed infestation, epidemics and gradations, pollen allergy, the poisonous effect of mycotoxins on farm animals and humans, new pests and diseases, the emission of greenhouse gases and biological factors which cause quality deterioration represent an increasing pressure on agri-environment. This paper is intended to give an overview of some research activities and their results in relation with climatic aspects of agri-environment in Hungary on the occasion of the 10th anniversary of the edition of the VAHAVA report, a major national climate change research project. The majority of its postulates are still valid. Novel follow up research results are presented in the review.

Keywords: climate change, agri-environment, VAHAVA project

Introduction

Agriculture in general and crop production in particular are highly affected by climate change impacts. Results of recent climate change researches have highlighted, that climate change impacts may influence almost all fields of agricultural activities; production efficiency, quantitative and qualitative deterioration of crop yields produced for alimentary purposes, and determine postharvest manifestation of agricultural products inducing hazard in the field of food safety, transport, storage and distribution (Czelnai, 2003; Láng et al., 2007; Jolánkai, 2008). Agriculture has a special place in human activities since it is closely linked to nature and wildlife. For many centuries pollution was considered simply as the presence of unfavourable alien matter in the environment altering its qualitative and quantitative characteristics. Actually pollution is far more than that.

A basic characteristic of agri-environmental pollution is that, unlike industrial or urban pollution, it is largely independent of mankind, since a wide range of pollution or degradation processes may begin with no direct relationship to human activities (Láng et al., 2004; Láng et al., 2009; Jolánkai, 2010; Jolánkai et al 2012). Examples of this are soil erosion, or irreversible damage within natural ecosystems by climatic factors (drought, flood, water logging, salinity etc.). Biological pollution, like weed infestation in agricultural fields, epidemics and gradations from abandoned or set-aside areas, which may also be a source of human ailments like pollen allergy, the poisonous effect of mycotoxins on farm animals and humans, new pests and diseases, the emission of greenhouse gases by soils and ruminants, and biological factors which cause quality deterioration represent an increasing pressure on agri-environment.

DOI: 10.18380/SZIE.COLUM.2017.4.2.55

Table 1. Main climatic characteristics of Hungary, Source: KLIMAKKT, 2008

Annual precipitation	580 mm
Annual mean temperature	11 °C
Altitude	78-1014 m
Heat amount in vegetation period	1280-1465 °C
Dry matter production	8.3-17.6 t/ha/year
Photosynthetic active radiation	1518-1612 MJ/m^2
Annual snow coverage	41 days/year

The problems of any of the above are manifold:

- High variability of yield performance in accordance with weather extremities.
- Economic losses in agricultural and food production.
- Quantitative and qualitative deterioration of food and feed products.
- Lack of sustainable long term vertical and horizontal technology structures.
- Limited chances for forecast and prevention, as well as for technological implementation.
- Environmental hazards affecting agro-ecology as a whole.

In case of Hungary, two facts can be observed in the Carpathian basin (Harnos and Csete, 2008; Várallyay, 2011). In first place, the ascending levels of temperature rise, with a magnitude of 1° C during the past century. The other is the decreasing trend-line of annual precipitation according to what during one century 83 mm rainfall has disappeared. Hungary is a country in the centre of Europe in the Carpathian basin with a most peculiar geographic location regarding the possible impacts of any sort of climatic changes due to the physical environment and the high ratio of agri-ecosystems of the country (*Fig* 2; WWF, 2010). The climate of the region has always been highly variable (*Table* 1; UN, 2011, *Fig* 3).

Expert teams of various fields of agriculture have been working within the framework of three major projects between 2003 and 2010: the national VAHAVA and the KLIMAKKT projects, and the European ADAM project. From 2012 a new national climate research network has been established; AGRÁRKLÍMA and its succession the AGRÁRKLÍMA-2. The main task of these research projects was to study climate change impacts and possible responses in the respective fields. The working hypotheses of the projects were based on international surveys as follows:

- The warming of the climate will be stronger in the Carpathian Basin;

- We may expect the decreasing of annual average precipitation;

- The number and intensity of extreme weather events will be increasing.

- Adaptation strategies need to be supported by decision making based on reliable nationwide scientific research results.

The hypotheses of the VAHAVA project have been approved by recent results with one exception concerning the precipitation scenarios (EEA 2017).

Climate change research results

The VAHAVA report was edited in 2007 and 2010 with auxiliary follow up research results.

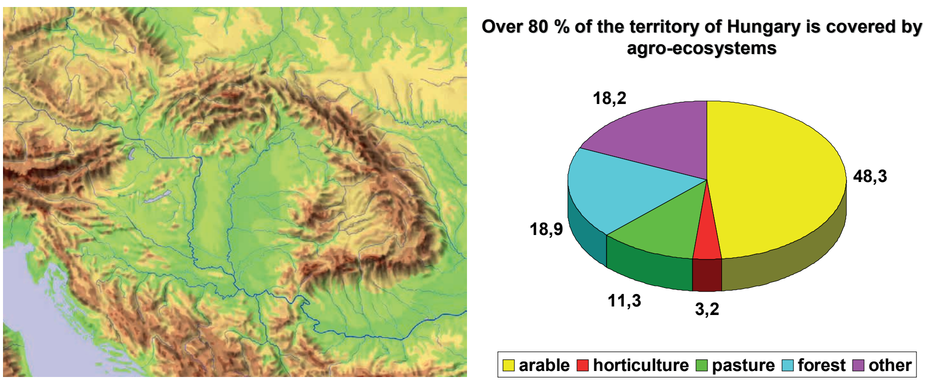

Figure 2. Geographic location and land use distribution of Hungary, Source Jolánkai, 2008

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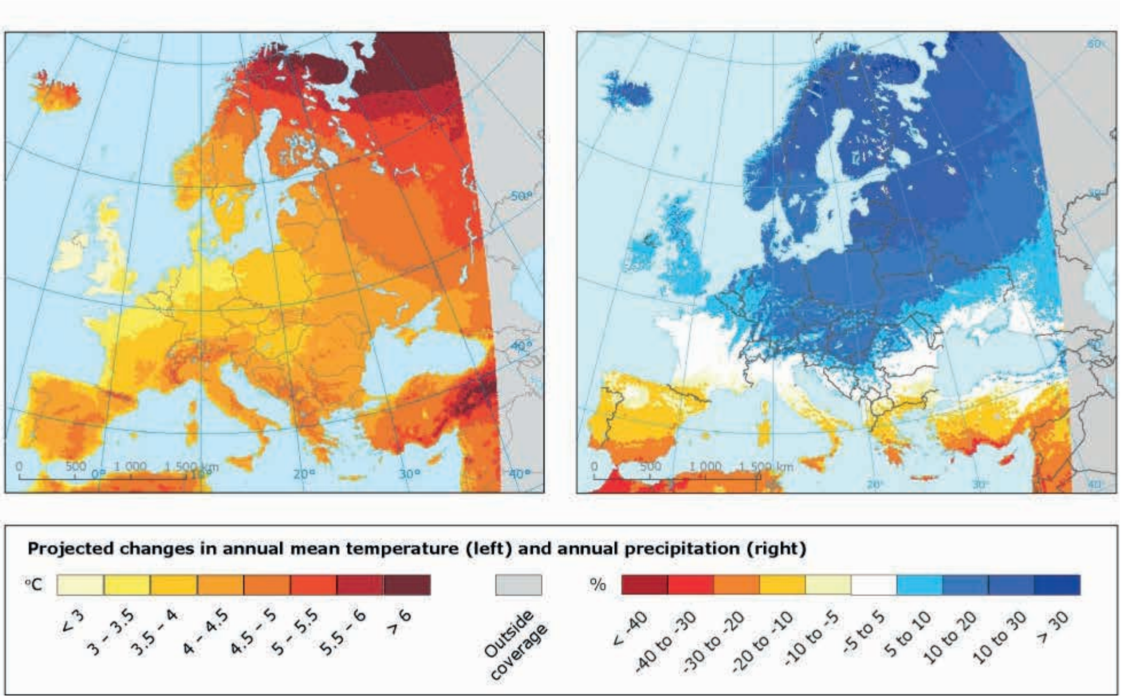

Figure 1. Changes in temperature and precipitation by RCP model scenarios. Source: EEA, 2017

The ADAM report and the KLIMAKKT report were both published in 2008. The result of expert teams' work was summarized in these volumes. The following passages present a digest of the respective reports' agri-environmental postulates (Láng et al., 2007; ADAM, 2008; KLIMAKKT, 2008; Harnos and Csete, 2008; VAHAVA, 2010; Jolánkai et al 2013; Bidló et al 2014; Mátyás 2016).

The VAHAVA results' postulates (Láng et al 2007, Láng et al 2009, VAHAVA 2010)

Climate change impacts in crop production can be prevented or reduced by the following measures. Water preserving soil tillage that may contribute to storage of higher amounts of annual precipitation. Increment of irrigation. Novel crop production technologies, breeding and use of drought tolerant crop varieties. Establishment of appropriate cropping structures and crop rotations.

Water supply of crop production involves three major sources; annual precipitation in rainfed cropping depending on the amount and distribution as well as the preservation and storage of that; irrigated cropping where rainfall is considered as additional or modifying means of water supply only; and flood irrigation systems that are mainly independent from precipitation impacts. In favour of preventing harmful climate change impacts the two latter cropping systems should be given priority in the future.

Climate change impacts may have an influence on the trends of temperature as well as on the vegetation period of various field crops. Ascending levels of temperature induce alterations in the physiological requirements of heat amount. This may result in a change of duration of crop variety vegetation periods, and also, there is a chance for alterations in yielding ability, winter hardiness, phenological phases etc.

Warming and drying may have an effect on plant nutrition. In general there is scientific evidence that high levels of mineral fertilization may counteract the harmful effects of drought. In particular there are several crop species that may respond with yield declines in case of permanent drought. Abundant nutrient supply may result in higher concentrations that may be less beneficial to crop performance. Optimal soil conditions are required for better crop plant development.

Abiotic stress resistance of wheat varieties is a major issue in Hungary. The major task of plant breeding is to provide high yielding wheat varieties of marketable quality that are

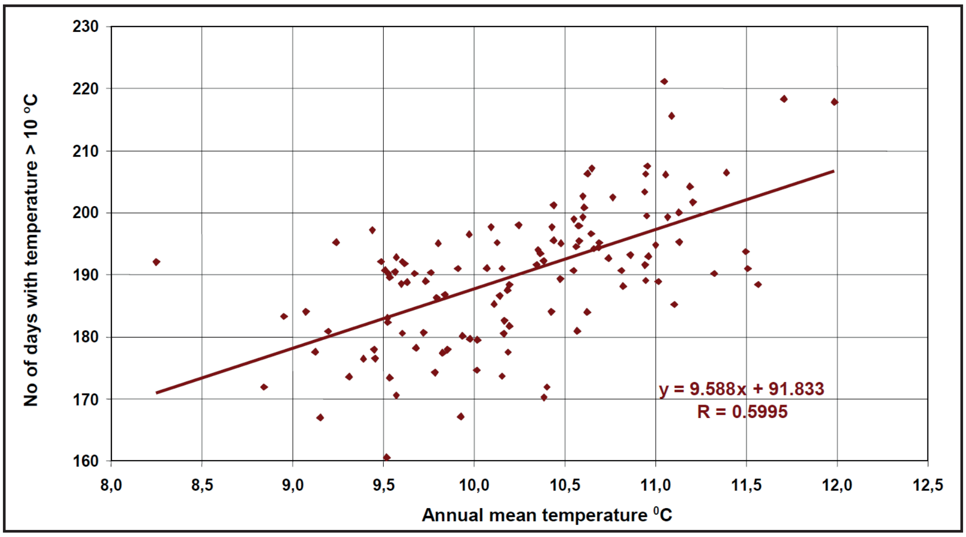

Figure 3. Correlation between the annual mean temperature and the duration of warm periods (>10°C), Source VAHAVA, 2010

less susceptible to climate change impacts. Any variety has to meet a threefold demand: grain quality, quantity and yield stability.

Seed production is a field where climate change impacts may have both positive and negative effects. Arid conditions and weather extremities may risk the results of seed production and processing. On the other hand climate change may contribute to favourable conditions that may be essential for producing seed of new species and varieties.

Agricultural mechanization is also facing new challenges induced by climate change. Such are: Technology improvements (water preserving tillage technologies); combined or reduced number of field operations (to prevent or lessen unfavourable soil conditions); more quick, flexible and efficient machinery; security equipment (installation of special machinery for emergency uses only); propagation of tram line production systems; use of adapted machinery.

Agricultural mechanization may have a major role in mitigation processes, like CO_2 emission control and carbon sequestration. Specific tillage technologies, mulching and appropriate stubble operations may contribute to a better soil water budget.

Plant protection is highly affected by climate change. There is an invasion of new plant diseases, insect pests and weed species. To counteract the harmful effects improved methods of prevention, defence and remediation are needed. The major fields of that are as follows: comprehensive and efficient forecasting systems, extension services, integrated pest management, application of high tech implements, site specific precision methods. Genetic resistance and/or tolerance of crop plants has to be improved by breeding. Means of biological control has to be studied and applied.

A most specific field of agriculture is the grassland and pasture management. In Hungary over 1.1 million hectares of grasslands are exposed to climate change impacts, but on the other hand provide new adaptation chances for agriculture and for the country as a whole.

Specific climate change research statements

In relation with the climate change research results of indirect processes statements have been formulated during the work of the VAHAVA project and its follow up research activities.

Water scarcity and drought represent physiological water stress causing irreversible changes in live structures (Láng et al, 2007; Láng et al 2009). The genetic type of soils provides less information in comparison with water management categories. From among water management categories infiltration rate and water retention are the most

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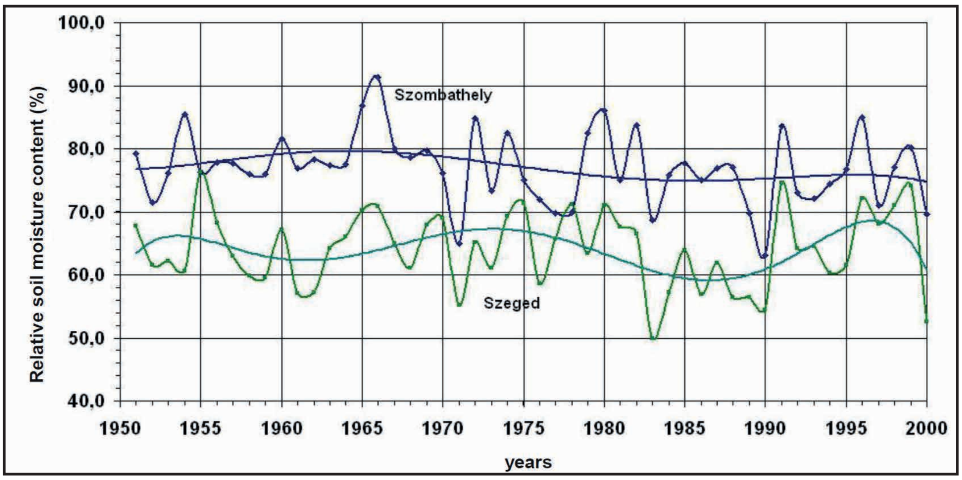

Figure 4. Annual changes in soil moisture content at two locations, Source VAHAVA, 2007

influential properties, however their impact may be modified by permeability, hydraulic conductivity and field capacity properties of the given soil (*Fig* 4). The depth of groundwater is a most influential factor in drought assessment of an agricultural region however its relation with drought indices is highly affected by the water management properties of the very soil. Various drought indices are applied to identify these processes regarding aridity and water scarcity conditions of an agro-ecological site (Pálfai, 2010, Jolánkai et al 2016).

Excesswater in ecosystems according to the amount and/or uneven distribution of atmospheric precipitation may result in floods, water logging and various sorts of physiological stresses (Jolánkai, 2008; UN, 2011). The consequences of temporary, long term and permanent presence of excess water in an agri-environmental ecosystem are physical and chemical deterioration of soils as well as direct and indirect degradation processes like water and wind erosion (Várallyay, 2009; Várallyay, 2011).

Soil degradation is usually a complex process in which several features can be recognized that contribute to unfavourable changes in soil processes and soil properties; loss or decrease in soil fertility and productive capacity; limitations in normal soil functions; and/or serious environmental deterioration (WWF, 2010; UN, 2011). Soil degradation may be the result of natural factors and/or human activities. Climate change may lead to increasing temperature with heterogeneous spatial and temporal distribution. These changes are reflected in changes of vegetation and land use patterns with considerable impacts on soil formation processes, the moisture regime and soil degradation processes (Lal et al., 1994; Lawlor, 2002; Várallyay, 2011).

Land use and soil tillage manifest in a basic agronomic technological process which has a direct influence on the efficiency of crop production. The methods and tools used for soil tillage induce various agro-ecological and soil degradation problems (Birkás et al., 2006). Soil compaction, water and wind erosion and alterations in physical and textural characteristics can be considered as special manifestations of pollution processes. Soil properties depend greatly on land use practices. Alleviation and remediation are complex tasks involved in soil tillage (Birkás et al., 2008). The basic attribute of modern food technologies during processing, storage and transport is of *food safety*. The foods must be protected from microbiological, physical chemical pollution and oxidative deterioration until they are consumed. Some constituents of food are exposed to environmental contaminants. Certain environmental conditions, during improper processing, storage and transport, could facilitate the formation (fermentation) of a wide range of mycotoxins (Láng et al., 2004, Eser et al 2017).

Pests and diseases. Weeds increase the yield loss in the dry periods caused by the global

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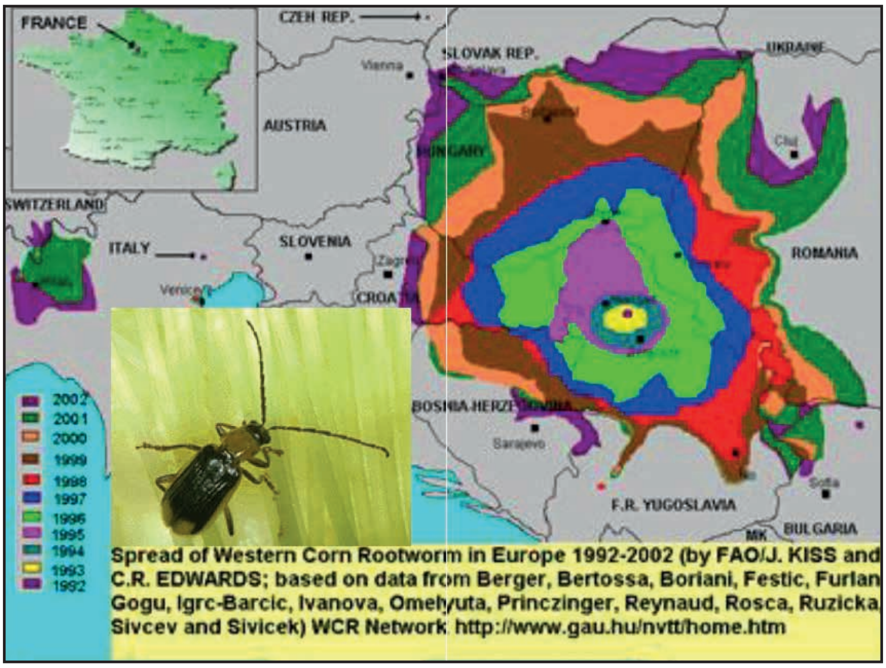

Figure 5. Spread of *Diabrotica virgifera* in Europe, Source Kiss and Edwards, 2002

climate change (Solymosi, 2005). Eight of the ten most important weeds in the Carpathian basin have C_4-type photosynthesis. These species (*Amaranthus* spp., *Sorghum halepense*, *Echinochloa crus-galli*, *Panicum* spp., *Cynodon dactylon*, *Portulaca oleracea*, etc.) are capable of effective photosynthesis and water utilisation even in high temperature and dryness, when the stomata are closed (Czimber, 2004). The spread of western corn rootworm (*Diabrotica virgifera virgifera*) is much influenced by climatic conditions. This insect was brought to Europe during the Yugoslav war in 1992 to the Belgrade airport from where huge tracts of Eastern Europe were then occupied (*Fig* 5). The very unusual year of 1999 when spring drought was followed by moist summer allowed a 150 km distance migration (Kiss and Edwards, 2002; Jolánkai et al. 2015).

Alterations in climate are likely to have considerable impacts on most or all *ecosystems*. The distribution patterns of many species and communities are determined to a large part by climatic parameters; however, the responses to changes in these parameters are rarely simple (Tuba et al., 2004). Ecotones are transition areas between adjacent but different environments: habitats, ecosystems, landscapes, biomes or eco-climatic regions. Climate change due to excessive environmental pollution is expected to exacerbate desertification. Reduced precipitation and increased evapotranspiration will change the spatial features of ecotones (e.g. the coalescence of patches, on the one hand, and increased fragmentation on the other. Furthermore, the overexploitation of the vegetation, which is typical in semi-arid drylands (WWF, 2010; UN, 2011) combined with climate change, will further increase habitat loss and hence the loss of biodiversity, ecosystem services and the potential for adaptation. The overall contribution of agriculture to CO_2 emissions is very low. However, grasslands and especially low input grassland, is believed to act as a sink for carbon dioxide and nitrous oxide (Tilman, 1999), but this cannot be considered as generalised figure. The vegetation of the Carpathian basin suffers from precipitation anomalies, rather than temperature changes (Czimber, 2004). Finally, since there is no chance to give any summary or plausible forecast regarding the direct and indirect problems emerging from climate change phenomena, there is only one hint we may accept: „avoiding the unmanageable, managing the unavoidable" as it has been stated by John Schellnhuber, a spiritual father of European climate change research (ADAM, 2008).

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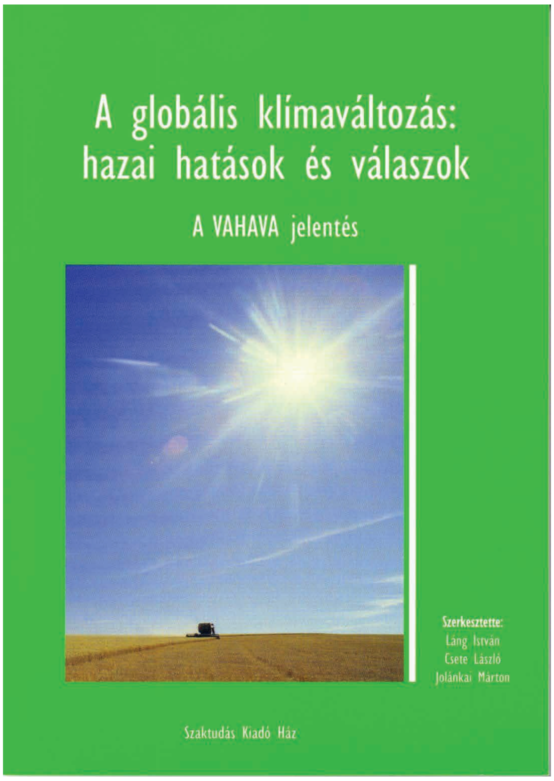

Figure 6. The VAHAVA Report (first Hungarian edition), Source Szaktudás Kiadó Ház 2007

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