Mitigation and adaptation to Climate Change in Hungary

Márta HUNKÁR ZEMANKOVICS

Department of Economic Methodology, Georgikon Faculty, University of Pannonia, Deák F. 16, H-8360 Keszthely Hungary, e-mail: hunkar@georgikon.hu

Abstract

This review paper is a brief summary of the climate change story, transforming of primary concept from a scientific idea to a threatened world, and the contribution of Hungary in solution of above mentioned problems. According to the National Inventory published in 2010 the time series of GHG emissions together with real GDP changes will be shown. The way of mitigation available for Hungary is illustrated by climate strategies on different levels. Since the most vulnerable sector of the economy is agriculture as Hungarian researchers found, mainly the increasing frequency of drought seems to be dangerous. The impact of climate change was studied on the production level of main crops and the whole agricultural sector as well as on the GDP of the country. Some possible ways for agriculture to adapt to the increasing extremities will be mentioned. Altogether climate change means a challenge to technological development in all sectors of the economy and also in social cohesions and that is a feedback to adaptation.

Keywords: climate change, GDP, drought index, mitigation, adaptation

Összefoglaló

A dolgozatban röviden áttekintjük hogyan vált a klímaváltozás fogalma a tudományos hipotézisből a mindennapjainkat is befolyásoló paradigmává. A klímaváltozás elsődleges okának tekintett üvegházgázok (GHG) kibocsátását mutatja be a “Nemzeti Nyilvántartási Jelentés”. A GHG kibocsájtás idősorát összevetjük a GDP alakulásával. A klímaváltozás mérséklésére vonatkozó intézkedések különböző szinteken jelennek meg. Magyarország lehetőségei ezen a téren a nemzeti klímastratégiából kiindulva, ezt mintegy lebontva a helyi önkormányzatok is megfogalmaznak helyi klímastratégiákat és ilymódon egyre növekszik az úgynevezett klímatudatosság. Az utóbbi évtizedben folytatott kutatások alapján megállapítható, hogy Magyarországon a klímaváltozásra leginkább érzékeny szektor a mezőgazdaság. Főként az aszályos évek előfordulásának megnövekedett valószínűségével számolhatunk. Bemutatjuk egyrészt az aszálynak a főbb mezőgazdasági terményekre gyakorolt hatását. Kapcsolatot kerestünk a PAI aszályindex és a GDP között is, de közvetlen kapcsolat nem volt kimutatható. A szélsőséges időjárási viszonyokhoz történő alkalmazkodás néhány lehetőségét is számba vesszük. Mindazonáltal arra a következtetésre jutottunk, hogy a klímaváltozás paradigmája kihívást jelent a technológiai fejlesztés terén, melynek visszacsatolása jelenti az alkalmazkodást.

Introduction

The new paradigm of climate change has begun from the late seventies in the last century. Before that time climate was considered as a stable system and the year by year variability of climate elements was taken by chance. Studying climate had had a meaning to work with data from the past. The enormous rate of computerization made enable developing of physically based general circulation models (GCM). The first equilibrium models in the eighties showed that the increasing level of atmospheric CO_2 results in higher temperature therefore they predicted the global warming. There were only few people who accepted this result at that time. According to doubters the first generation of climate models were said to be too simple and of course a lot of complicated processes were neglected or even unknown. In spite of the uncertainty of model outputs the impact studies became very popular. A lot of model studies dealt with the impact of climate change on biological systems obviously plants and animals are the most exposed to their natural environment. These studies were extremely usefull especially for understanding of the biological systems working mechanism [1, 6, 7, 8, 9, 10]. Nevertheless, in the end of eighties Reifsnyder [21] summarized the controversy concerning the potential climatic effects of increasing atmospheric CO_2 and reviewed opinions through a sceptical eye. And what happened after that?

The question of climate change proved to be so exciting and the possible consequences were so important that politicians were inclined to organize a committee namely the Intergovernmental Panel on Climate Change. The first assessment report was completed in 1990, [12] and served as the basis of the United Nations Framework Convention on Climate Change (UNFCCC). One of the statements from that first report: “Our judgement is that: global mean surface air temperature has increased by 0.3 to 0.6^{0}C over the last 100 years...”; The size of this warming is broadly consistent with predictions of climate models, but it is also have the same magnitude as natural climate variability. Observed increase could be largely due to natural variability; alternatively, variability and other human factors could have offset a still larger human-induced greenhouse warming. The unequivocal detection of the enhanced greenhouse effect is not likely for a decade or more.

And the science went further on its way.

From the nineties transition GCMs which have already dynamic approaches have been predicted the process of the climate change, consequently climatology became a science relating to the future. The possible level of greenhouse gas emissions was taken into consideration as different scenarios with strong relationship to the expected economical development, a higher rate of development supposed to a higher amounts of emission of GHG. Number of studies increased worldwide and thanks to some enthusiastic and responsible persons the concept of climate change became the prevailing paradigm. It happened in spite of the lack of enough observed data. Even the observed meteorological data derived from the Global Climate Observing System (GCOS) of World Meteorological Organization (WMO) did not prove unambiguously the increasing global temperature because of the natural variability of data.

Huge work of The Climate Research Unit at University of East Anglia [13, 17, 18] after 2000 and participation of other scientific centres compiled a database on global scale suitable to prove the warming tendency of the global temperature, like mentioned in NOAA/National Climatic Data centre, Hadley Centre and Max Planck Institute. Now we accept the idea of global warming proved on statistical basis used observed data. It has to be noticed that the other elements of the climate like precipitation or frequencies of extreme events have more uncertainty and may show different pattern for different regions. GCMs are used like basis to predict the climate, but regional climate models (RCM) were developed recently. Global climate statistics data, such as the global mean temperature, became good indicators of global climate vary. However, most people are not directly affected by global climate changes. They take care about the climate factors on the local level: the temperature, rainfall and wind. When you are observing influences of a climate change or specific adaptations on them, you often need to know how a global warming will affect the local climate [22].

Abrupt climate change

Abrupt climate change has a specific definition and should not be confused with climate changes that occur slowly or individual extreme events that affect relatively small areas. Abrupt climate change refers to sudden (on the order of decades); large changes in some major component of the climate system, with rapid, widespread effects. The potential for abrupt climate changes cannot be predicted with confidence; however, abrupt climate changes are an important consideration because, if triggered, they could occur so quickly and unexpectedly that human or natural systems would have difficulty adapting to them. Abrupt climate changes occur when a threshold in the climate system is crossed - a trigger that causes the climate rapidly shifts from one state to a new, different one. Crossing thresholds in the climate system may lead to large and widespread consequences [23]. Frequent reports of record-breaking events suggest that climate extremes are becoming more common [2]. There is only limited scientific evidence, however, that this may be the case at the global level. The most recent Intergovernmental Panel on Climate Change scientific assessment concluded that it was likely that higher maximum and minimum temperature, more hot days and fewer cold days. More intense precipitation events have been observed in the latter half of the 20th century [11]. Scientists can't state with confidence that today's extreme events are the first signs of climate change. They simply do not understand the climate system and the effects of greenhouse gas emissions well enough to conclude that particular events are linked to the problem. Nevertheless, monitoring and studying extreme events, and learning how to predict and cope with them, must be a priority. Of all aspects of climate variability, extreme events are likely to have greatest effect on human well-being in the decades to come. What is most certain, however, is that it is likely to be the poorest and most vulnerable societies in the developing world which will be least able to adapt to any increase in the frequency and magnitude of extreme weather phenomena [5].

Recurrent natural disasters such as droughts, floods, and tropical storms have devastating impacts on the agriculture, livestock and fisheries, threatening the livelihoods of hundred thousands of rural people.

The question of adaptation and mitigation is even more serious considering an abrupt climate change. It means an increasing risk in natural conditions of the economy and the society.

Mitigation

Mitigation is motive for numerous debates on the reasons of climate change. Climate change may result from both natural and human causes. Factors that affect the climate over time-scales from hundreds to millions years include: energy output from the sun, variation in the earth's orbit and the orientation of its axis, the greenhouse effect of water vapour and other trace gases, volcanic and meteorite activity and plate tectonics.

Most scientists agree that global warming caused by anthropogenic greenhouse gas emissions is one of the most serious environmental problems facing the world today, with far-reaching consequences for all sectors of society. The importance of human causes has been increasing during the past few decades. To avert catastrophic impact it is generally agreed that atmospheric CO_2 concentration should be constrained to 550 ppm, which is believed will limit the temperature increase to 2^0C. Reaching that goal needs huge efforts on different levels of human activity:, on global, regional, national, local and personal level.

Recognizing the importance of those actions, the European Union strengthened its apparatus. The Directorate-General for Climate Action ("DG CLIMA") was established in February 2010, climate change being previously included in the remit of DG Environment of the European Commission. It leads international negotiations on climate, helps the EU to deal with the consequences of climate change and to meet its targets to 2020, as well as develops and implements the EU Emissions Trading System. Given the necessity to keep global average temperature increase below 2 degrees Celsius compared to pre-industrial levels, DG CLIMA develops and implements cost effective international and domestic climate change policies and strategies, especially with regard to reducing its greenhouse gas emissions. The Directorate-General for Climate Action is at the forefront of international efforts to combat climate change. It leads the respective Commission task forces on the international negotiations in the areas of climate change and ozone depleting substances and coordinates bi-lateral and multi-lateral partnerships on climate change and energy with third countries.

On national level, the Hungarian National Assembly adopted a National Climate Change Strategy (NCCS), in March 2008. Above mentioned strategy have like one of the goals 18 % reduction in greenhouse gas emissions up to 2020 and increase renewable energy sources. Scientists believe that the rise in average temperatures of 1-2^{0}C is expected, which may lead to the extinction of species and vegetation can lead to transformation, as well as the pathogens proliferate. There will be a serious problem of water scarcity, and the ensuing migrations. In Hungary, many rivers are exposed to more floods and flash floods, and then cause trouble.

NCCS determines the following three main action scopes:

I. Measures in accordance with the European Union and international requirements in order to reduce greenhouse gas emissions and to prevent the increase thereof. Mitigation of greenhouse gas emissions should be implemented together with the reduction of the total energy consumption in a way that the structure of production and consumption should shift into a less material and energy-intensive direction.

II. It contains the most important elements of the protection against the adverse ecological and socio-economic impacts of already inevitable climate change as well as of the improvement of the capacity to adapt to the consequences of climate change; and

III. Strengthen the social climate awareness.

According to the National Inventory Report [14] the greenhouse gas emission has a decreasing tendency. For better understanding the Hungarian emission trends (Fig.1), the time interval of the inventory should be split into three periods with different emission relevant economic processes in the background. The first period (1985-95) would be the years of the regime change in Hungary, whereas in the second period (1995-2006) the rules of the market economy became decisive. The second period can also be characterized by the decoupling of GDP growth from the

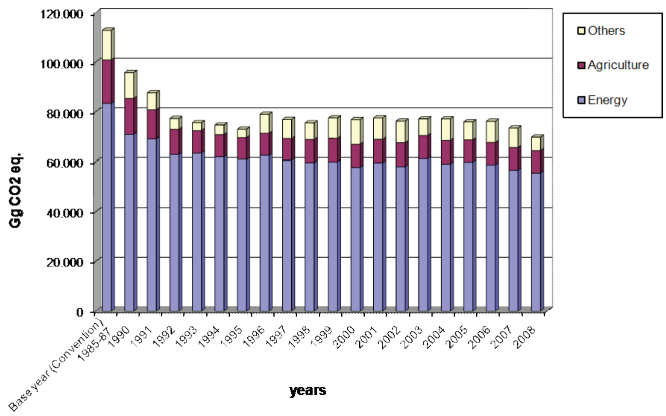

Figure 1 Sectorial distribution of the greenhouse gas emissions (Gg CO2 eq.) of Hungary. Colours: blue – energy, dark red- agriculture, light yellow –others. Source: [14]

Magyarország üvegházgáz kibocsájtása (Gg CO2 eq.) szektorok szerint Színek: kék-energia, bordó-mezőgazdaság, halvány sárga –egyéb. Forrás: [14]

GHG emission trend which is undoubtedly an important development. By 1999, the GDP reached the pre-1990 level (Fig.2); however, emission levels remained significantly below the levels of the preceding years. Thus, the emissions per GDP are decreasing. In the third period, basically in the last 2-3 years, Hungary experienced on emission reduction of about 8% basically due to mild winters, higher energy prices, and modernization in the chemical industry.

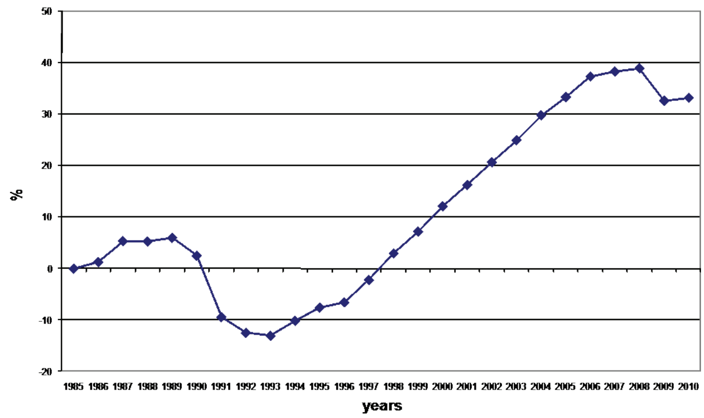

Figure 2 Real growth of GDP (adjusted for inflation) in Hungary (1985=100%) Data source: [4]
Magyarország valódi (az inflációval korrigált) GDP növekedése (1985=100%) Adatforrás: [4]

Strengthening the social awareness

If you type the words “climate change” in Hungarian language into Google it gives 157 000 hits. This facts means that not only scientists and politicians are involved in this question, but also the public is interested in it. That is a result of a long process. According to an international survey done by Gallup Institute in 1992, Hungary was the only country where none of the respondents mentioned environmental problems as the most important problem and 33 % of the respondents considered climate change a serious problem. The Research Institute of Sociology launched a project about climate change, recently. The public awareness was surveyed among other things and the results show an increasing awareness about climate change mainly in larger cities [28] (Fig.3).

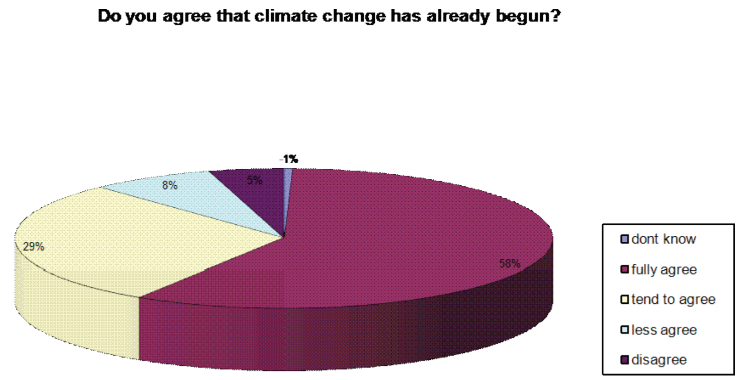

Figure 3 Public survey related with climate change. Source of data: [28]
A klímaváltozásra vonatkozó közvéleménykutatás eredménye. Adatforrás: [28]

Local initiatives for climate strategy

In March, 2007 the Municipality of Tatabánya signed a partnership agreement with the Sociological Research Institute of the Hungarian Academy of Sciences to elaborate the first local climate change strategy of Hungary. The climate group has members from the local environmental NGOs, economic stakeholders, the main public utility companies, public institutions, but there are also teachers, nurses, students and pensioners present, who represent the citizens of the city as a whole. The climate manager is the first such Hungarian position to be filled in on local level. The local climate change strategy was elaborated by the climate group and the researchers of the academy. It was accepted by the General Assembly of Tatabánya in December, 2007. The strategy includes priorities, short-term and long-term plans and concrete steps to be taken by the city management in the future. The members of the local climate group and the representatives of the main health care institutions of the city have also prepared a Heat and UV-alert plan for the city, which is also the first such plan of the country. In November, 2007 the Alliance of Climate Friendly Settlements was formed in Hungary, with up to 18 cities joined the initiative today. The local climate group of climate friendly settlements makes a work plan for a given year. The objective of the planned time schedule is to transform the climate program into effect, to raise the environmental awareness of the civil citizens, and to motivate their active participation. By the implementation of the climate change pilot project, the city can prepare for the threats of global climate change, while on the other hand the local emission of greenhouse gasses can be decreased, the absorption of local greenhouse gases can be increased, and the citizens will become more sensitive and adaptive to the problems of climate change. However, not only on local, but also on regional and national level, this program will serve as an example for other settlements to prepare and implement their climate change strategy.

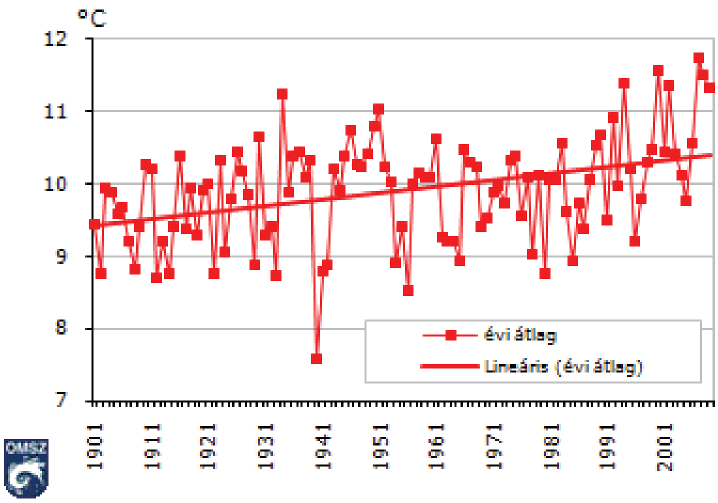

Figure 4 Annual mean temperatures on a country wide scale (average of 15 meteorological stations) Source: Hungarian Meteorological Service
Az évi középhőmérséklet országos átlaga (15 meteorológiai állomás alapján) Forrás: Országos Meteorológiai Szolgálat http://www.met.hu/eghajlat/magyarorszag_eghajlata/eghajlati_visszatekinto/elmult_evek_idojarasa/

Adaptation to climate change in Hungary

Hungary is located in the Carpathian Basin in the heart of Europe. Surface of her territory is 93030 km^2, and represent typical low-lying country: 73 per cent of its territory is flatland, which is less than 200 meters above the sea level. The country belongs to the catchment area of Danube and Tisza and their affluent. Hungary is located at the shifting frontier between the temperate continental (hot summer and relatively cold winter) and the Mediterranean (hot, dry summer and rainy winter) climate zones, with complementary effects of the temperate oceanic climate. Southeast part of Hungary belongs entirely to the semi-arid and dry sub-humid climatic belts. The annual mean temperatures show increase with 0.7^0C/100 years [24]. The slope of the trend is somewhat higher in the last 25 years (Fig.4). The yearly amounts of precipitation show decreasing tendency, nevertheless in 2010 the yearly amount was higher than ever (Fig. 5).

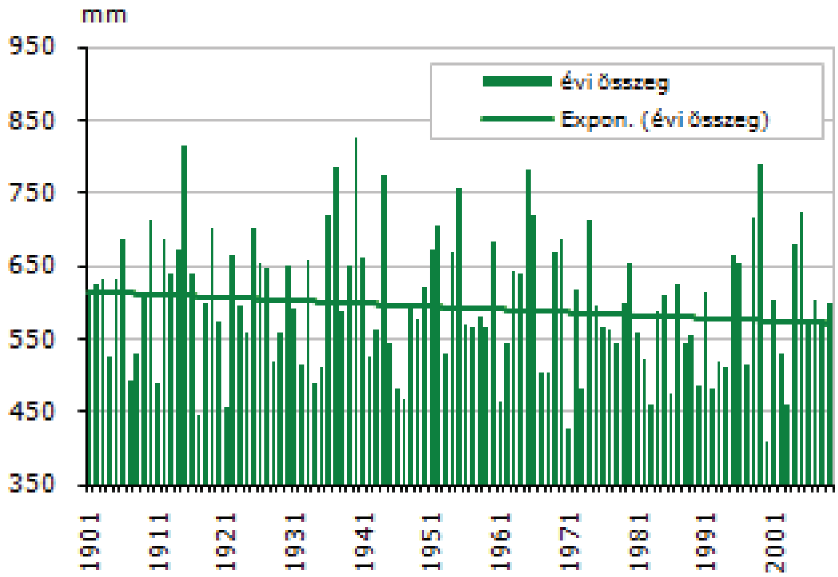

Figure 5 Annual amounts of precipitation (average of 60 meteorological stations) Source: Hungarian Meteorological Service
Az évi csapadékösszeg országos átlaga (60 meteorológiai állomás alapján). Forrás: Országos Meteorológiai Szolgálat http://www.met.hu/eghajlat/magyarorszag_eghajlata/eghajlati_visszatekinto/elmult_evek_idojarasa/

Concerning regional climate prediction research has been done at the Department of Meteorology at Eötvös Loránd University [3] and at the Hungarian Meteorological Service [24, 25]. The first results can be seen on the website of HMS (Fig. 6 and Fig.7). Increasing temperature is expected in summer time, especially. The pattern of precipitation change is more complicated. In summertime, 20-40% decrease is predicted, but in the other seasons, two applied models give different results, comparing to each other and comparing the sub regions of Hungary.

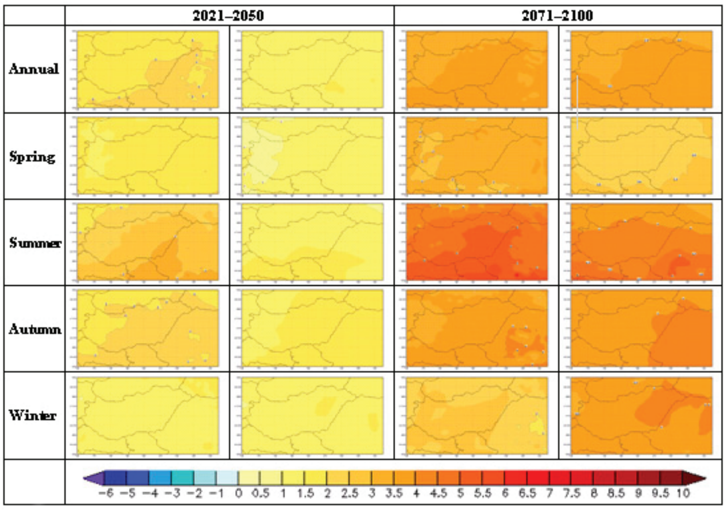

Figure 6 Annual and seasonal mean temperature changes (°C) based on the two applied regional climate models for the periods of 2021-2050 and 2071-2100 with respect to the mean values of 1961-1990. Source: Hungarian Meteorological service
Az éves és szezonális hőmérsékleti átlagok változása (oC) a két regionális klima modell alapján a a 2021-2050 valamint a 2071-2100 időszakra az 1961-1990 időszakhoz képest. Forrás: Országos Meteorológiai Szolgálat http://owww.met.hu/omsz.php?almenu_id=homepages&pid=numprog&mpx=0&kps=1&pri=9#head3

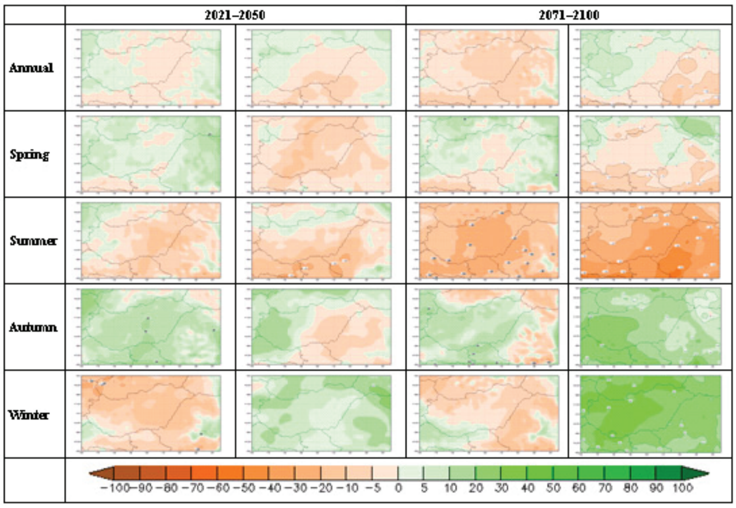

Figure 7 Annual and seasonal relative precipitation changes (%) based on the two applied regional climate models for the periods of 2021-2050 and 2071-2100 with respect to the mean values of 1961-1990. Source: Hungarian Meteorological Service
Az éves és szezonális csapadékösszegek relatív változása (%) a két vizsgált regionális klímamodell alapján a 2021-2050 és a 2071-2100 időszakra az 1961-1990 időszakhoz képest. Forrás: Országos Meteorológiai Szolgálat http://owww.met.hu/omsz.php?almenu_id=homepages&pid=numprog&mpx=0&kps=1&pri=9#head3

Impacts of climate change in Hungary

In the last decade many studies have made on the possible impacts of climate change [16]. The most vulnerable sector seems to be agriculture. The frequency of drought and floods expected to increase [27]. Present study focuses on the effect of drought expressed by drought index developed by Pálfai [19, 20]. The Pálfai drought index (PAI) is a kind of hydro-thermic index adjusted to the climate of Hungary. The yearly value of this index is calculated from the mean temperature of the April-August period, the amounts of precipitation weighted by monthly factors from October till September. The country average of PAI is used to be calculated by the hydrological authorities (Fig.8). According to the experiences, when the PAI is below 5 there is no drought, between 5 and 6 means a moderate drought, between 6 and 7 is medium drought, between 7 and 8 a severe drought and when the PAI index is exceeds 8 that means extreme drought.

Analysing the time series of PAI the probability of drought (PAI>6) for the 90 years period is 0.25, but for the last 25 years period is 0.36. That is an increase, but statistically not significant. The probability of extreme drought (PAI>8) is 0.09 from the 90 year period and 0.24 from the last 25 year period. Comparing proportions by using a z-test the increase in that case is statistically significant (α=0,05).

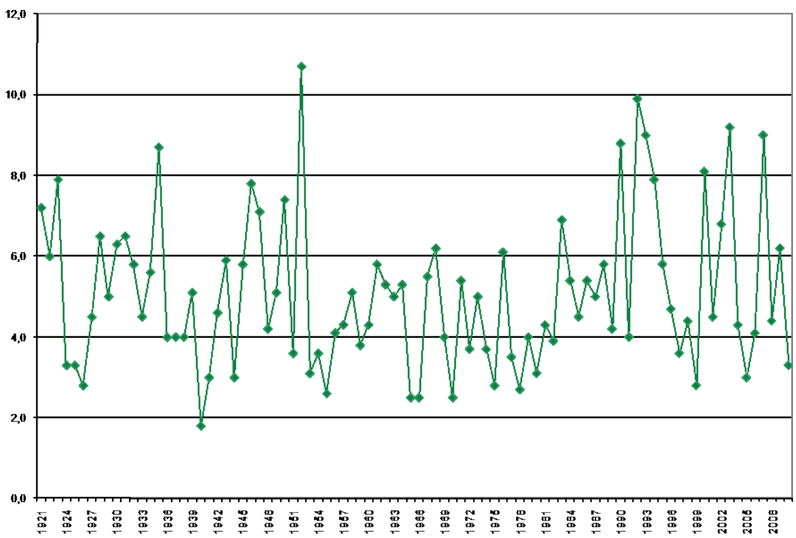

Figure 8 Country average of PAI for the period of 1921-2010. Data source: [20]
A PAI index országos átlaga az 1921-2010 időszakban. Adatforrás: [20]

Relationship between drought index and the main agricultural crop yields

The main agricultural crops in Hungary are wheat and maize. The long time series on country level of the average yields are presented in Figure 9 [15].

The 90 year period can be divided into three parts. The first part is from 1921 up to 1960 that is characterized by the traditional producing system. From 1960 up to 1985 that is the extensive growth period thanks to the reorganization of the agricultural sector and introducing new hybrid seeds together with technological developments. From 1985 up to now the potential production had reached a higher level but fluctuations occurred in a higher range. Focusing our investigation on the last 25 year period the relationship between PAI and maize yield is quite strong (Fig. 10) while the relationship between PAI and wheat yield is much weaker, without significant effect (Fig. 11). Obviously the vegetation period of wheat does not match with the drought periods in general. Beside that there are strong efforts to breed and introduce new drought resistant wheat varieties; it is can be taken like a kind of adaptation.

In the Hungarian economy, agricultural sector income is only 2.8 % of the total GDP [4], nevertheless it was examined the effect of drought on a more aggregated characteristic of the economy on the yearly change of GDP on fixed prices. No relationship was found. That means that the other sectors of the economy are less sensitive to drought. Obviously there might be other climatic characteristics with negative impact on the economy. We expect that climate change and strong intention to mitigation and adaptation strengthen a technological development which may lead to positive effects on the whole economy.

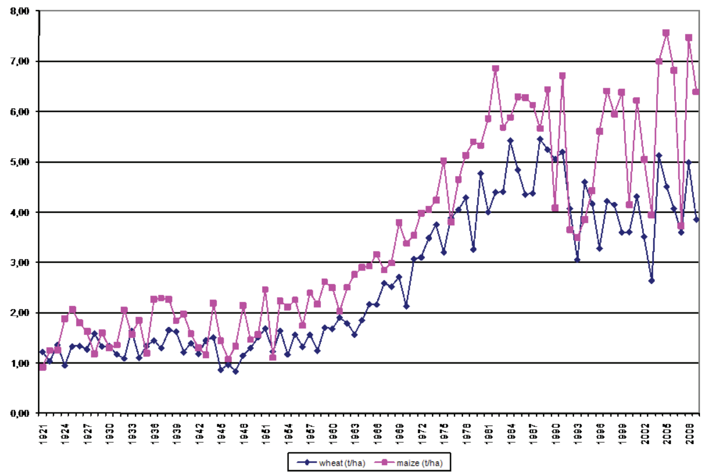

Figure 9 Average yields (in country level) in Hungary of wheat and maize 1921-2009
Data source: [15]
A búza és a kukorica országos átlagtermései Magyarországon 1921-2009 között.
Adatforrás [15]

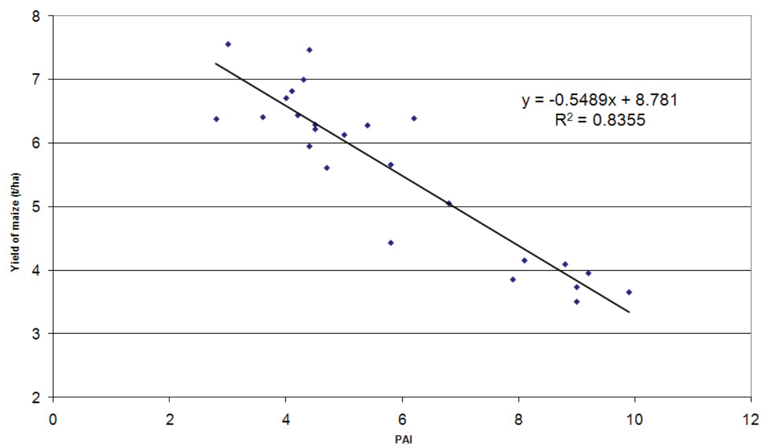

Figure 10 Relationship between PAI drought index and the yield of maize in Hungary (1985-2009)
Kapcsolat a PAI aszályindex és a kukoricatermés között Magyarországon (1985-2009).

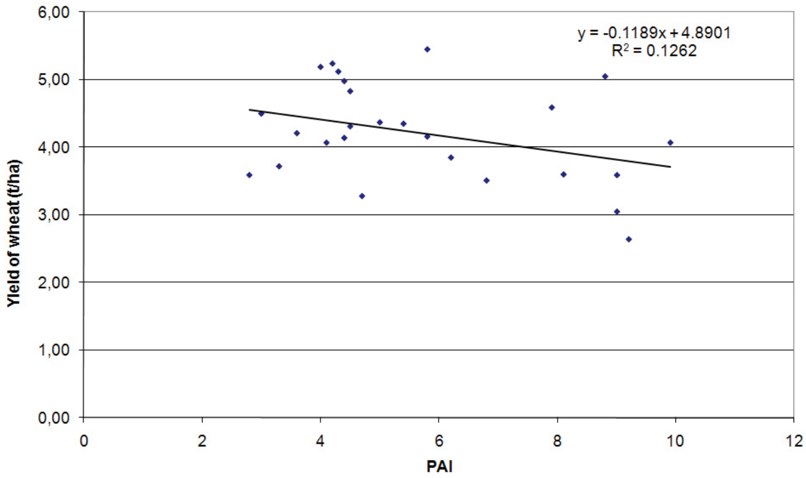

Figure 11 Relationship between PAI drought index and wheat yield in Hungary (1985-2010)
Kapcsolat a PAI aszályindex és a búzatermés között Magyarországon (1985-2009).

Ways of adaptation in agriculture

One of the most obvious possibilities is introducing drought resistant varieties into the agricultural production system. Enormous efforts have been done on this area by the several agricultural research institutes which have been worked on this problem for years, applying traditional breeding technologies. The other possibility to get drought resistant varieties is cultivation of GMO, denied in Hungary.

The other possibility is more investments in irrigation systems. Unfortunately, the area of irrigated crops was decreased in the last decade, because the cost of water increased a lot. Presently, not more than 2% of the agricultural land is irrigated.

The third possibility is a new insurance system. It is seems to be necessary. There is no market based insurance for drought. Producers can apply for governmental support in case of severe drought in the frame of the National Agricultural Loss Mitigation System.

Conclusion

Climate change is not a scientific hypothesis any more. It became the prevailing paradigm of our world. That means an overall challenge to each sector of the economy and even to everyday life of people. Anyway we need that kind of challenges to force developing new technologies in energy saving, more effective industrial processes, less vulnerable technologies in agriculture. Those kind of need generate social cohesion and that is the key for survival.

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