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Climate change, agricultural land use and food safety

INTRODUCTION

Due to the increase of population, there is an increased demand for agricultural products which makes it necessary to expand agricultural areas. However, the current agricultural practice is also responsible for negative environmental impacts, such as climate change, the reduction of biodiversity, water and air pollution and soil erosion. In order to increase production and reduce environmental load at the same time, it is essential to synchronise RDI activities, demand and production.

POPULATION

In 1950, the Earth's population was 2.5 billion people which increased to 6.5 billion by 2005. By 2050, the population is estimated to reach 9 billion (UN, 2006). The peak yearly growth rate was observed in 1963 (2.19%). By 2005, the extent of growth reduced nearly by half (1.1%), approx. 75 million people per year. The yearly growth of the population is expected to further decrease in the years to come. According to current estimation, the growth rate will by less than 1% by 2020 and less than 0.5% by 2050. This means that the population is going to further increase in the 21th century, but at a lower rate than in the previous period. The Earth's population doubled (100% growth) in 40 years (3 billion in 1959 and 6 billion in 1999). According to current estimations, another 50% increase in population takes 42 years; therefore, it could reach 9 billion by 2042. The highest rate of population increase is expected in Asia and Africa, where nearly 86% of the Earth's population is going to live in

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2050, while it is expected to decrease in Europe (UN, 2011).

In 2011, the population of Hungary was 9 982 000 people, which is 2.1% less than the value measured during the 2001 census. The population of the country has been constantly decreasing since 1981. The sharpest decrease was observed in the 1980s which was followed by a more moderate reduction. The population decline became more intense again between 2001 and 2011. According to the current predictions, the population of Hungary is expected to be 9 200 000 by 2050 (HCSO, 1970–2011).

FOOD PRODUCTION, STARVATION

Crop production is carried out on 1400 million hectares all over the world. 8 of the 15 most important culture crops (wheat, rice, maize, barley, millet, sorghum, soybean, cotton, oat, bean, potato, peanut, rye, sweet potato and sugarcane) belong to the group of cereals whose total sowing area is 700-710 million hectares.

During the green revolution (1950–1985), the cereal production of the world was increased to nearly three and a half times as large as it was before. This result was achieved by using high inputs (fertilisation, irrigation, mechanical sowing, crop breeding, and chemicals) (FAOSTAT, 1960–2010). Growth rate significantly decreased during the last decade.

The sowing area of wheat was 1.098 million hectares in Hungary between 2000–2012; however, 2011 (0.978 million hectares) and 2001 (1.206 hectares) were extreme from this aspect. In the same period, the amount of harvested maize was 4.393 million tons on average. The extremely dry year of 2003 (2.941 million tons) and 2004 (6.007 tons) were the two extremes of this period. In 2012, wheat was harvested on 1.070 million hectares, of which 4.011 million tons were stored.

The use of wheat for food and feeding purposes is around 2.6–2.8 million tons per year. No significant change in use can be expected in these two areas in the future. In addition to the domestic use, 1-2 million tons of extra wheat is available each year which is also reflected by export details.

In Hungary, maize has been produced on the largest area for decades. Averaged over 13 years between 2000 and 2012, its stable sowing area was 1.181 million hectares. The two extreme years in this period were the dry year of 2007 (1.079 million hectares) and 2001 (1.258 million hectares). The amount of maize harvested in the same period was 6.873 million tons on average. From the yield aspect, the extreme years of this period were 2005 (9.050 million tons) and 2007 (4.027 million tons). In 2007, nearly 14% of the sown maize perished due to the water shortage at the silking stage. The average yield was only 3.7 t ha^{-1} which is one of the weakest values of the recent years. As a result of favourable weather, the average yield per hectare in 2008 was twice as much as that of the previous year (7.4 t ha^{-1}). In 2012, again, the amount of stored maize yield was only 4.763 million tons which were harvested from the 1.191 million hectares of land sown with maize.

1 billion people are starving in the world and 25 thousand people die of starvation each year, while 1.3 billion tons of food go to waste on a yearly basis. This amount is more than 50% of the cereal production in the world (UN, 2011). In Hungary, around 100 thousand people are starving, of whom 10 thousand children do not get enough food.

The change of agricultural land use

The productive land of the world is a constantly changing resource. The productive area changes as a result of climate changes, natural disasters and human interventions. In 2002, 38% of the world's land (150 million km^2) was suitable for agricultural activities, but this area has been constantly decreasing. Less than 30% of agricultural area is plough land (1.38 billion ha). The plough land per capita is significantly decreasing (CEU-ENS, 2007) due to the following reasons: erosion deteriorates potential agricultural lands, salinization due to over-irrigation, expanding cities, building roads shopping centres and parking lots on agricultural areas. According to estimates, 7.8 hectares of fertile land are lost each minute.

In Hungary, plough land decreased to 52% and the grassland to 13% by the time of the political restructuring in comparison with the 1950s. However, the proportion of forests greatly increased (18%) and the amount of areas withdrawn from agricultural production also doubled. The latter phenomenon can be explained partly by the development of infrastructure and the increase of areas occupied by settlements. For today, these proportions further changed. The most important process is the reduction of plough land. Its proportion was decreased to 46% in 2012. Similarly, grasslands decreased to 8%, but forested areas further increased. The largest change was observed in the proportion of areas withdrawn from agricultural use which increased to 21%. This phenomenon can still be explained by the wide range of infrastructural development (Figure 1).

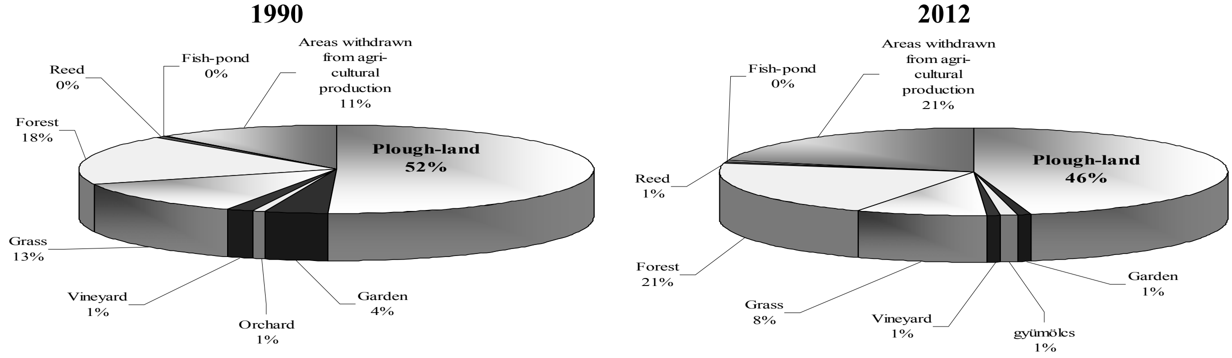

Figure 1. Land use in Hungary (1990, 2012)

Source: own construction based on HCSO data from 1990 and 2012

CLIMATE CHANGE

Climate is a fundamental factor in food production. The impact of climate has to be examined at all times in order to make food supply safer (Varga-Haszonits, 2005). Changes in climate factors (e.g. temperature, precipitation) and the higher frequency of extreme weather events (drought, flood, storms) greatly affect yield. At the same time, climate change can alter the types of vegetable and animal pests, as well as the frequency of their occurrence, the amount of available irrigation water and the severity of soil erosion (Adams et al., 1998).

The near surface mean air temperature increased by 0.74 ± 0.18°C since it was first recorded (1890). The warmest decade on a global scale was observed between 2000 and 2009. However, the increase in temperature did not stop, it is expected to be between 0.1^0–0.2^0C in the next decade.

The amount of carbon dioxide in the atmosphere was estimated to be around 280 ppm at the time of the industrial revolution and it increased to 379 ppm for today. If CO_2 emission increases at this rate, its atmospheric concentration will reach the critical 400 ppm by 2015. Based on certain models, this could result in as much as 4°C increase in the atmospheric temperature in comparison with the current value (Bánsági-Domokos, 2009). However, according to the analysis of Haworth (2008), it is not probable that this warming up will not exceed 4°C – this is double the value that is still considered safe from the aspect of avoiding a climate disaster.

Compared to the last 100 years, temperature increased by 1°C in Hungary. According to forecasts, it is expected to further increase by 2.6°C until 2050. Also, the yearly amount of precipitation decreased significantly from 640 mm to 560 mm and the temporal distribution of precipitation is also uneven. The change in temperature will affect the Great Hungarian Plain the most negatively and the greatest increase in temperature is expected in the autumn months (Láng et al., 2007).

As a result of global warming, the arable land of developing countries would decrease by 11% until 2015 and they would lose about 280 million tons of potential cereal yield which equals to 56 billion USD loss of value. In addition, extreme weather would reduce supply also by means of decreasing yields. For example, floods make it impossible for people to access foods still available by damaging infrastructure and reducing income. At the same time, developed countries in North America, Northern Europe, Russia and Eastern Asia would win with climate change, as they could start using their northern areas for agricultural purposes. Altogether, climate change would not result in any serious increase in cereal prices. However, developing countries – more specifically the poorest ones – will not be able to counterbalance the decline in supply caused by production lag with food import. For this reason, the extent of malnourishment and starvation is going to increase (CEU-ENS, 2007).

WATER MANAGEMENT, IRRIGATION

Global warming causes drought and drought causes evaporation which reduces the water stock of the Earth by a great proportion. The total water stock of the Earth is 2 billion cubic kilometres. 97.5% of this water stock is saltwater and 2.5% is sweet water. The only usable form of water is precipitation, but the global yearly average amount of precipitation is only 6000 m^3 per person and only a certain part of it (2000 m^3 per person) can be used. This is twice the amount needed by a person in a year (Somlyódi, 2011). Water need increases as a result of population growth, climate change and economic development. For example, the water need of China and India may increase 2-3 times, as it is currently 700 m^3 per person in a year.

According to WHO (2010), 1.2 billion people do not have access to proper drinking water. The drinking water stock per person is expected to reduce to its one third in the next two decades. According to UNESCO (2010), if the current tendencies (drastic climatic and ecological changes, population growth, high extent of urbanisation) continue, more than two billion people in at least 48 countries will have to face serious water restrictions in 2050.

In Hungary, the average yearly amount of incoming water is 114 km^3 and the yearly amount of precipitation is 58 km^3. Therefore, the average amount of precipitation in a year is 600 mm. 52 km^3 of this precipitation evaporates and infiltrates into the soil; therefore, 120 km^3 of water leaves the country in a year. The distribution of precipitation is uneven, there is usually less precipitation in the eastern part of the country, especially in the southern part of the Great Hungarian Plain, where the number of sunny hours per year is higher than the country average and the quotient of evaporation and precipitation reaches 1.5. For this reason, there is a high probability of drought which strikes Hungary usually every 3-5 years.

The water stock per inhabitant is 598 (600) m^3 and the yearly sweet water use is 612 m^3 per person in Hungary. This amount is more than the yearly renewable stock (598 m^3). The country makes up for the difference from subsurface waters.

Agricultural water use is nearly three quarters of world's water use. The amount of water used for agricultural purposes was nearly 7200 km^3 on a global scale in 2000.

The growing population of the world needs increasing amount of food. In order to produce this food, the extent of irrigation also has to be increased; therefore, it might be that the extent of agricultural water use reaches 13 000 km^3 per year by 2050. In order to avoid such increase, agricultural technologies need to be reshaped (water preserving cultivation, growing drought-resistant species/hybrids, using precision irrigation methods, etc.).

The irrigated area of the world was 94 million hectares in 1950 which increased constantly. By 2009, it reached 310 million hectares (*Figure 2*) of which only 17% was used for cereal production purposes, but it provides 32% of cereals produced in the world. The size of irrigated lands in Asia reached 73% of all irrigated lands in the world in 2009. The share of irrigated lands in North America was 10% and that of Europe was 7.2% (*Table 1*).

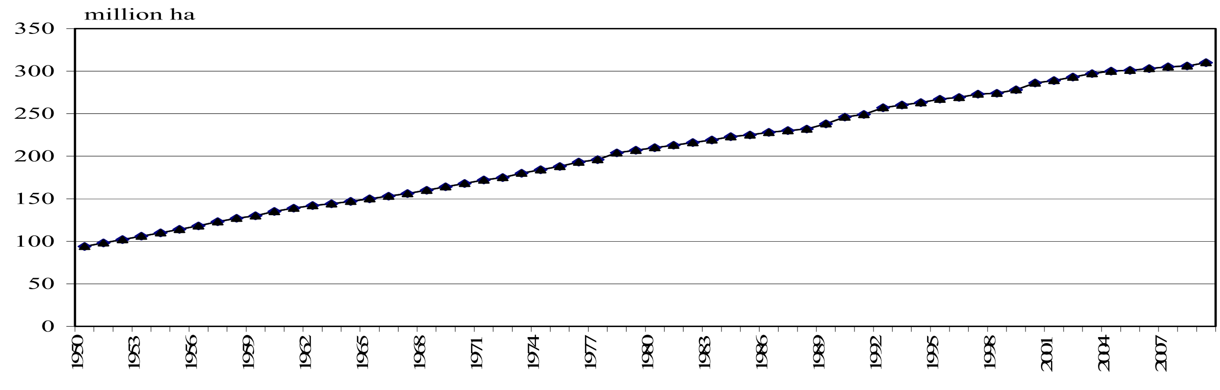

Figure 2. Change of the amount of irrigated lands in the world, 1950–2009

Source: FAOSTAT, own construction based on 1950–2010 data

Table 1 Change of the amount of irrigated lands in the world, million ha (2009)

Continent	Irrigated lands, million ha			
	1980	1990	2003	2009
World	193.0	224.2	277.1	3044
Africa	9.5	11.2	13.4	13.4
Asia	132.4	155.0	193.9	222.2
Latin America	12.7	15.5	17.3	10.4
Caribbean	1.1	1.3	1.3	1.7
North America	21.1	21.6	23.2	31.8
Oceania	1.7	2.1	2.8	2.8
Europe	14.5	17.4	25.2	21.8

Source: FAOSTAT, own construction based on 2009 data

The intensity of irrigation depends on climate, the produced crops and the used farming systems in various countries of the world. Irrigation has totally different practices in the Southern European countries, where it is indispensable in agricultural production, as opposed to Central and Western Europe. The majority of all irrigated lands in the EU can be found in Greece (83%), Spain (68%), Cyprus (69%), Italy (57%), France (54%) and Portugal (52%) (Berbel et al., 2007).

In Hungary, only 2.1% of the agricultural area is irrigated (*Figure 3*). In the whole agricultural area, the majority of vegetable biomass is produced with precipitation management. Irrigation is a supplementary water replenishment resource in Hungary both statistically and ecologically. In Hungary, ecological supplementary water replenishment irrigation (where the purpose is to cover the need of ecological soil moisture need) is an economical solution.

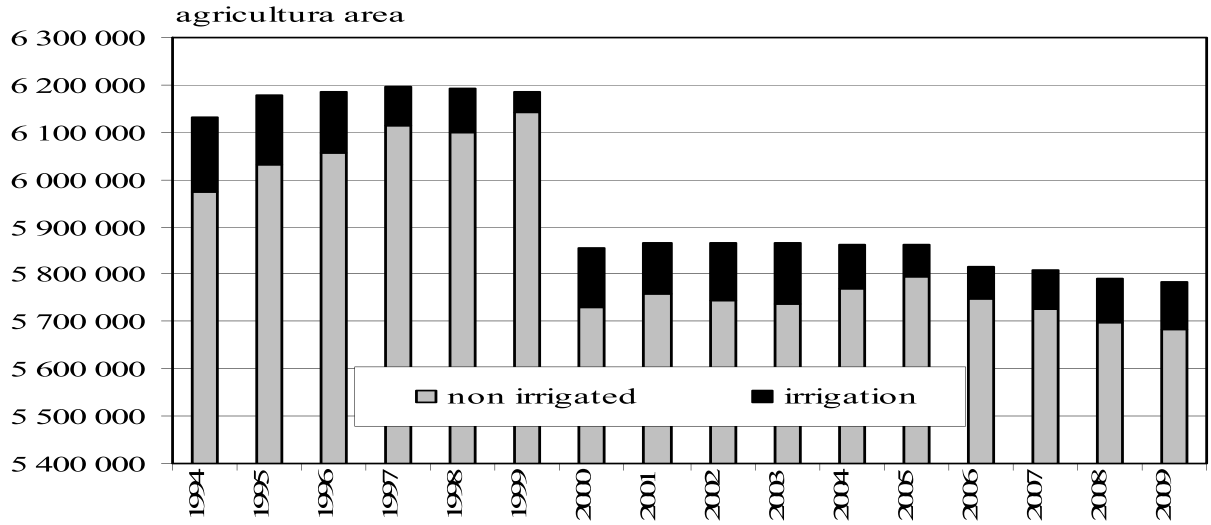

Figure 3. Irrigated agricultural areas in Hungary, 1994–2009

Source: HCSO, own construction based on 1994–2009 data

IMPACTS OF CLIMATE CHANGE

The following aspects can be considered in the relationship of climate change and agriculture: a) the impact of agriculture on climate change, b) the impact of climate change on agriculture and the food supply of the Earth and c) the impact of climate change on food safety.

Change of production methods

15-30% of the GHG emission is caused by food production, processing, transport, storage, preparation, acquisition and consumption (Garnett, 2008).

Agriculture is responsible for 9.3% of GHG emission measured in the area of the European Union. Of this emission, dinitrogen oxide of agricultural origin (5%) is discharged from organic and mineral nitrogen fertilisers, while methane (4%) mostly originates from the digestive processes of animals and the storage and application of liquid manure. Carbon dioxide is released during the disturbance of soil and whenever peat bogs rich in CO_2 are involved in agricultural production (BruxInfo, 2010; EEA, 2010).

The emission of agricultural GHGs can be reduced to the highest extent in the case of dinitrogen oxides whose amount can be greatly decreased by using less nitrogen fertilisers and using them more efficiently (precision farming), by using biofertilisers produced from waste (local biomass and other organic wastes originating from intermediate cultures), by developing transitional cultures such as pasturage and researching new varieties which have high carbon and nitrogen binding ability. Methane emission is in connection with animal husbandry; therefore, a reduction in emission can be achieved by developing foraging and breeding techniques (modifying the diet of ruminants) (EEA, 2010; DEFRA /Department for Environment, Food and Rural Affairs/, 2011; ADAS, 2009).

Climate change contributes to the proliferation of the pests of agricultural produces, as well as their diseases which may result in a greater extent of pesticide use, including herbicides and fungicides (Boxall et al., 2009). According to the estimations of Chen and McCarl (2001), the use of pesticides increases in the USA, but their impact depends on the given crop culture and the site of production.

Climate change may have an impact on the proliferation of the existing pathogens and the development of new pathogens (Tirado et al., 2010). Permanent heat is the primary factors which increases the number of Salmonella bacteria which mainly cause intestinal infection. There is a linear correlation between the frequency of Salmonella diseases and temperature changes (Kovats et al., 2004ab).

The level of mycotoxin infestation of animal fodder is still a global problem. Since temperature and moisture are the two major factors in the proliferation of fungi and the subsequent mycotoxin production, climate plays a key role in the occurrence of mycotoxins (Vass et al., 2008; Russel et al. 2010; FSA, 2012).

Irrigation for agricultural purposes is a key issue worldwide. According to the estimation of Döll (2002), water use for irrigation purposes caused by climate change may increase by 5-8% globally. Although irrigation with wastewater can reduce water extraction, it may also increase the risk of pathogens affecting consumers (WHO, 2006). For this reason, agricultural water use has to become more efficient in order to provide enough water not only for irrigation, but also to serve the needs of the local population, healthy environment and other economic sectors.

In the case of extreme weather conditions, a diverse range of stable performance plant and animal species need to be bred, maintained and improved, thereby greatly contributing to biodiversity, while it is also an investment in the field of food safety.

Food prices

Several studies were dealing with the expected impact of climate change on the world's food prices, especially cereal prices. As a result of the increasing global temperature, incalculable damages may occur in agriculture, leading to decreasing production and increasing prices (Esterling et al., 2007). The increasing use of biofuels which can be achieved at the expense of food crop production on agricultural areas may result in increasing food prices, such as the global food price increase in 2007 (Lock et al. 2009). Also, the production of biofuels could mitigate the overproduction and restructuring problems which arise in the agricultural sector of developed countries. A wide range of political instruments are used to drive and support biofuel production (FAO, 2008; Rajagopal and Zilberman, 2007; Sorda et al. 2010), including tax exemption, investment subsidies, etc. (Banse et al. 2008).

As a result of increasing food prices, consumers may prefer cheaper food products which have lower quality that could eventually result in adverse health consequences. Healthy foods are often more expensive than less healthy foods (e.g. lean meat, fatty meat); therefore, increasing prices often lead customers to buy less healthy foods (Cummins and Macintyre, 2006). Energy-rich foods raise special concern, as they are often cheaper than their less energy-rich counterparts. Increasing prices also increase the risk of obesity mostly among children, young adults, smokers, people at lower income levels and elderly people with poor health (Lock et al. 2009).

The impact of food purchase and consumption

As a result of global climate change, the consumed foods will originate from various parts of the world in the future. The micronutrient and macroelement composition of foods are greatly affected by the production zone because of the differences in the produced varieties, soil, environmental conditions, as well as the various agrotechnical solutions, processing and storage methods (World Cancer Research Fund/American Institute for Research 2007; Easterling et al., 2007).

Climate change also has an impact on human behaviour, it can change nutrition and food safety. For example, Mintel (2003ab) pointed out that salad and alcohol consumption was higher during warm summer than during colder ones.

Climate change can also alter nutrient composition; therefore, the population has to change its nourishment habits. For example, in some countries, the governments motivate producers to change the compositions of their food industry products, to reduce salt content which can eventually mitigate health problems (myocardial infarction, cardiovascular diseases) (FSA, 2009ab). In the United Kingdom, food administration authorities have been working with industry representatives since 2004 to develop clearly understandable labelling in order to reduce salt consumption. As a result, the daily salt intake of an average British citizen decreased from 9.5g to 8.6g (FSA, 2010). In Japan, Finland and Portugal, salt intake was reduced by 5 g per day as a result of regulations, information shown on the packaging, public health campaigns and cooperation with the food industry. However, there is often great resistance to such initiatives on behalf of the industry, since the salt industry is a multibillion dollar business (Pendrous, 2009).

Food safety

FAO and WHO put together the Codex Alimentarius in the 1960s. This document contains all general and special food safety standards which serve the protection of consumer health and the provision of the fair practice of the food industry. The majority of the world's population lives in the 166 countries which are members of the Codex Alimentarius; therefore, they participate in formulating its standards and use them at the national and regional levels (FAO/WHO, 2006).

The EU's general law on food contains regulations on the traceability of the food chain from the foraging of animals to the moment when food is put on the table (Szajkowska, 2009). The European Commission supervises whether the regulations are enacted into the national law and whether they are properly implemented. Also, the Commission performs local inspection inside and outside the EU. This duty is performed by the Food and Veterinary Office (FVO) which has the authority to supervise food industry plants, but its main task is to monitor governments inside and outside the EU whether they have the necessary local administrational regulations to supervise whether their own food producers comply with the high standard food safety regulations of the EU (European Commission, 2011).

Climate change can alter the prevailing circumstances; therefore, the current regulation and supervision of the food chain may become obsolete. In addition, climate change points out the necessity of systems which facilitate the timely recognition of risks. These systems help in filtering out food safety problems as soon as possible. The best example for such systems is the prediction of mycotoxin in maize. These systems use computerised models to predict mycotoxin risk based on current weather circumstances (Marvin et al. 2009).

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The evolution of the European Union's agricultural policy

1 Preface

The focus of the European Union's Common Agricultural Policy (CAP) (EU) has changed considerably in the last two decades. However, the reform steps taken over this period are often misunderstood or under-appreciated by the general public. The image of artificial 'mountains' and 'lakes' of grain and milk generated by CAP subsidies in the 1970s and 1980s is still widespread. However this image is outdated. The objective of this article is to summarise the recent evolution of the CAP, with special attention to the results of the most recent CAP reform of 2013.

2 The EU subsidising system

Until the first radical CAP reform in 1992, policy-makers in the European Union (EU) mainly employed price support to subsidise agriculture[1]. They established fixed, guaranteed prices (so-called intervention prices) for most important agricultural products. These prices exceeded the prices on the world market, often by as much as a factor of two or more. Figure 1 illustrates this for the case of wheat in the 1970s and 1980s. These high domestic producer prices were supposed to ensure a decent standard of living for farmers, and to reduce the need for structural change. Policy makers were concerned that many of the small farms in the EU would not be able to survive international competition and would be forced to cease production if they did not receive supported prices.

This policy of supported intervention prices led to increased production and surpluses which could only be exported (in other words, dumped) outside the EU with the help of export subsidies. As shown in Figure 2, market support measures and export subsidies caused the budget cost of the CAP to grow rapidly. Between 1980 and 1991 alone, CAP expenditure almost tripled. Many other major agricultural exporters such as Australia, Canada and the US were angered by the fact that the EU was competing unfairly by dumping agricultural products on the world market. Developing countries complained that subsidised exports from the EU were undermining their efforts to develop

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[1] For a detailed account of the history and development of the Common Agricultural Policy, see TANGERMANN and VON CRAMON-TAUBADEL (2013).