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FOOD SECURITY AND THE EU'S COMMON AGRICULTURAL POLICY: Facts Against Fears

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ABSTRACT

Fears about food security in the EU have become a driving force in the debate about the future Common Agricultural Policy (CAP). But the facts do not bear out these fears. This paper brings together the available evidence against EU food security concerns: the size of EU production, the even greater EU production potential and the reliability of imports. It also looks at the argument that a strong CAP is needed to feed the world. While hunger in developing countries is undeniably a most serious problem, paying direct income support to European farmers is a most inefficient response. It would be preferable to invest the money to boost agricultural productivity in developing countries.

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1. INTRODUCTION[1]

As FOOD PRICES surged in 2007/08, the traditional concerns over low farm incomes, the decline of rural communities, and the landscaping benefits of farming looked like dispensable luxuries when compared to this potential threat to survival. In 2010, the spike in wheat prices pushed the issue back into the headlines.

The European Commission, the European Parliament and many member states have proposed food security as a key theme for the post-2013 CAP. In its recent communication 'The CAP towards 2020', DG Agriculture, for instance, highlights the need to preserve the EU's food production potential, 'so as to guarantee long-term food security for European citizens'. All this has turned food security into the most pervasive and powerful argument of those calling for the protection of EU agriculture.

This raises three questions: first, to what extent is food security actually endangered in the EU? Second, what precisely are the dangers to EU food security and which policy instruments are most appropriate to counteract them? Third, how should the EU contribute to global food security?

These questions are of crucial importance as the EU is searching for a new policy model for its agricultural subsidies. The upcoming reform of the Common Agricultural Policy (CAP), negotiated in the context of the EU's next multi-annual budget framework for 2014-2020, will constitute the first major reform since 2003. At stake is a landmark change that will determine how much will be spent on the CAP – which currently absorbs €57 billion per year, that is, more than 40% of the EU budget – and to which objectives and policy instruments the money will be dedicated.

The questions also matter for the tariffs that shield EU production from foreign competition. EU MFN-tariffs on agricultural products average 13.5%, over three times more than charges on other goods. All EU tariffs greater than 100% relate to agricultural products. Lowering these tariffs would decrease consumer prices and remove distortions to the EU economy. It would also encourage trade liberalization abroad – through WTO negotiations and unilateral reform – thus creating new export opportunities for EU businesses.[2]

Finally, a better understanding of food security will have implications for policy areas beyond agricultural subsidies and tariffs. At issue is, for instance, how much the EU should invest in what type of agricultural research; how quickly it should adapt new and potentially risky technologies; how it should manage its water resources; how strictly it should preserve fertile land against other uses, such as housing and infrastructure; and to what extent it can rely on bioenergy.

This paper finds that EU food production per capita has constantly increased in the past and far outstrips dietary energy requirements. The share of income that households spend on food has steadily declined. By now, food prices are so low compared to income that even a 10-fold increase in the farm gate price of staple crops would be far off from provoking food scarcity in the EU. Forecasts predict roughly stable or increasing production quantities for the EU – even in the case of subsidy and tariff cuts. The expected main effect of climate change during the coming decades will be to shift production from southern to northern Europe without significantly curtailing overall production.

If food prices rose dramatically, the EU could increase the agricultural area used for growing cereals; in particular, by cutting back on biofuel and livestock production. Furthermore, agricultural labor and capital input could be multiplied. An additional measure would be to enhance investments into agricultural productivity.

Therefore, the EU does not depend on imports for its food security. In any case, most EU imports are not staple necessities but luxury items, such as coffee, tea and flowers, or feedstuff. Nevertheless, it is worth mentioning that EU food imports are reasonably reliable. World food trade is expanding; the number of countries with strong food exporting capabilities is increasing; export restrictions are rare and limited in scope; and key EU trading partners have stable, liberal trading regimes. Furthermore, food is a homogenous good traded on spot markets – that is, any one supplier can easily be replaced by another.[3]

Farm income and market price support, which are the centerpieces of current EU agricultural policies, are irrelevant for the high level of food security that Europe enjoys in the short- and medium-term. It is open to debate whether they exercise a small beneficial or detrimental effect. However, these instruments deteriorate food security perspectives for the second half of the 21st century. Research and development, as well as protection of genetic and other environmental resources, constitute more appropriate measures to ensure long-term food security in the EU. Food security is thus a weak argument for a 'strong' CAP.

Global food security – or, in more traditional terminology, world hunger – remains a serious concern. However, even at the global level, current food supplies are sufficient to nourish the world population. Food insecurity, therefore, results from uneven distribution. In the coming decades, calorific production is projected to further outpace population growth.

Farm income and price support in the EU is at best an absurdly inefficient approach to contributing to global food security, if its net effects are not outright harmful. Investments into agricultural research, farm advisory systems, improvements in agricultural property rights and markets, and rural infrastructure in developing countries promise much higher returns in the fight against hunger. Moreover, further liberalization of EU agriculture would create a signal for developing countries to abstain from expensive and distorting interventions in their agricultural markets.

Section 2 takes stock of how the food security argument has been employed in the CAP reform debate. Section 3 discusses the concept of food security as it is implied in the scientific debate. Section 4 analyzes the contribution of international trade to EU food security, while section 5 looks at domestic production and consumption. Section 6 examines the implications of EU policies on EU and global food security. Section 7 concludes.

2. THE SPURIOUS POWER OF FOOD SECURITY RHETORIC IN THE CAP DEBATE

EU FOOD SECURITY concerns are widely used to justify the maintenance of agricultural tariffs and a 'strong' CAP with a large budget that is mostly paid directly to farmers and channeled especially into farm modernization and production subsidies. The EU farmer federation Copa-Cogeca (2008) claims: 'There is a clear danger that the further opening of markets could lead to a contraction in EU production in certain key sectors which, once lost, would be difficult to regain. This would threaten the EU's strategic food independence. It is therefore extremely important that the CAP of the future provide a stable framework for the development of EU agriculture's full production potential through measures to encourage increased productivity and competitivity …'

The 'Paris declaration for a Common Agricultural and Food Policy', sponsored by France, the tireless promoter of the food (in)security argument, and agreed by 22 member states in December 2009, affirms this: 'In the face of climate change, global political and food insecurity, the volatility of global market prices and the resurgence of health crises, only an ambitious, continent-wide policy can safeguard Europe's independence.' And the news service AgraFacts reports from the December 2010 meeting of ministers of agriculture that 'broad consensus emerged on the role of the CAP in contributing to food security – recognised as the 1st main objective for the future CAP.'

Even Mariann Fischer Boel, the former Commissioner for Agriculture, says that 'both direct payments and our remaining market instruments give farmers a safety net. This means that, during times of real crisis, they are less likely to be driven out of production. This is positive for our food security.'[4] She also argues that 'if we leave agriculture too exposed, we're gambling with the security of our food supply' because serious crises could 'wipe out large parts of our production base'.[5] Dacian Ciolos, Fischer Boel's successor at the helm of DG Agriculture, has repeatedly justified the CAP budget with food security concerns. It does thus not come as a surprise that the Commission communication 'The CAP towards 2020: Meeting the food, natural resources and territorial challenges of the future' lists food security among the three main challenges to which the CAP has to respond.

The EP Committee on Agriculture has stressed the importance of the CAP as a means 'to secure food production in the EU' in a report on the CAP and food security.[6] Another draft report 'on recognition of agriculture as a strategic sector in the context of food security' is underway.

Such references to food security are powerful in the debate because they draw on past, present, and future concerns. The recollection of the food shortages after the Second World War stirs dreadful memories, still alive among the elderly and deeply engrained in our cultural heritage. The pictures and reports of hungry protesters in developing countries give an emotional, present-day reality to the issue. And threatening megatrends – population growth, water scarcity and climate change – nourish fears that the specter of famine might come to haunt Europe again.

Another source of power for the food security argument rests on analogy. Sometimes, food imports are likened to energy imports. The underlying message is: 'We are already dependent on unreliable and dictatorial regimes in the former Soviet Union and the Arab world – we do not want to also be at the mercy of foreign food producers.' (This comparison is frail. There are much fewer actual and potential suppliers of oil and gas on the world market, and these imports hinge on long-term contracts, pipelines, and suitable refineries. As a result, importers become dependent on their suppliers. Even if suppliers are reliable, oil deliveries can more easily be interrupted by third parties. And since the EU production potential in oil and gas is much further away from autarky, incomparably graver problems would be created should imports stay out.)

More generally, the food security argument benefits from references to the financial and economic crisis. The lesson drawn from this recent experience is that we must not leave food production to markets that are inherently erratic. (Again, this argument does not withstand scrutiny. Financial markets have a long history of volatility that is fundamentally distinct from the 'real' economy and especially from a traditional sector such as agriculture. Moreover, the problem during an economic crisis is excess supply, of inventories, production capacity and labor. It is unreasonable to infer threats of food shortages from occasional excesses of capacity in non-agricultural sectors. This issue is different from the question of whether financial speculation may temporarily lead agricultural prices away from equilibrium prices. If speculation can be shown to lead to excessive volatility, targeted measures against speculation may be undertaken.)

Through all these diffuse channels, the food security argument wields significant influence in the CAP debate, even though none of the arguments stand up to closer scrutiny. There is no study that describes and tests scenarios under which EU food supplies would be insufficient. This is astonishing. An argument used to justify major policy choices – including the €57 billion CAP – should come with scientific evidence corresponding to the highest standards. This absence of evidence is characteristic: in agriculture, the burden of proof rests with those who criticize the CAP but not with those who wish to spend taxpayers' money or impose higher prices on consumers.

The only in-depth study is the 'UK Food Security Assessment: Detailed Analysis' that examines a comprehensive list of food security indicators.[7] This assessment highlights that food security in the UK does not depend upon the CAP, but upon intra-EU and international trade, as well as on the resilience of the food chain and food safety. This exception aside, the research agenda deals with global models or selections of developing countries

3. THE SCIENTIFIC CONCEPT OF FOOD SECURITY

The FAO's definition says that food security 'exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.' Apparently, one would not say that the EU was food insecure if the price of lobster or any other luxury good skyrocketed or if staple goods, such as wheat or rice, became some percentage points more expensive. Food is only considered insecure if basic nutrition demands cannot be fulfilled even at a significant sacrifice.[8] Accordingly, food security is not binary – either the EU is food secure or not – but a matter of degree. It should not be perceived as a cut-off limit, such as a certain amount of calories per person and day, below which food becomes the exclusive concern. Instead, food should be understood as a source of human satisfaction as any other, competing with all others for fulfillment in a world of limited resources. Even the hungry trade in some food for health care and physical security, and those who can afford a sufficient diet wish for a healthier and tastier choice.[9]

In this relative sense, the EU is more food secure, the better the food supplies that can be obtained at a given cost. Another formulation is to say that the EU is more food secure, the lower the costs that are necessary to enable a given level of satisfaction derived from food consumption.

History shows that no society ever manages to distribute food in a rational manner, according to utilitarian principles for instance.[10] People with the same needs will always have different access to food. To attain a certain level of security, more food is therefore needed than what would be necessary if a needs-based distribution was possible at no cost. When analyzing the supply and demand of food at EU level, this paper assumes that a decently effective redistribution mechanism is in place. The fact that a significant number of individuals in the EU do not have sufficient access to food today, according to broadly shared standards, does not call for increased production but enhanced help for the needy. Increasing production lowers prices for all, including those who are not in need of assistance. Targeting support to the needy is therefore considerably less expensive.

With these caveats in mind, a numerical threshold is still useful. The minimum dietary energy requirement established by the FAO is less than 2000 kcal/person/day. The recommended calorie intake for a healthy diet is about 2,000 per day for women and 2,500 per day for men. EU food supply in 2007 was 3,466 kcal/person/day.[11] But even in 1961, around the time the CAP was created and the earliest year of FAO data, EU food supply was well above critical levels.

TABLE 1: FOOD SUPPLY OF THE EU-FOUNDING MEMBERS IN 1961

	calories/capita/day
Belgium-Luxembourg	2942
France	3194
Germany	2888
Italy	2956
Netherlands	3042

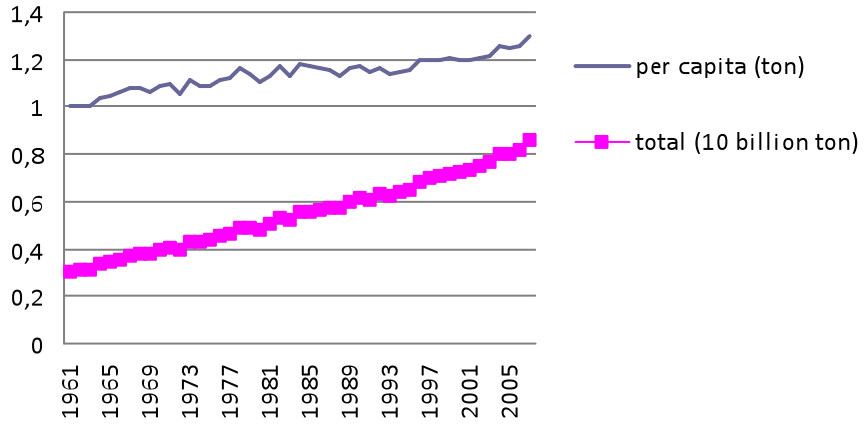
Source: FAOSTAT.

4. INTERNATIONAL TRADE

4.1 THE WORLD FOOD MARKETS

World food production has expanded from 3 billion tons in 1961 to 8.6 billion tons in 2007. This has permitted production per capita to increase from 1 ton in 1961 to 1.3 tons in 2007, despite unprecedented population growth (Figure 1). This is all the more remarkable as livestock products have increased their share in total food supplies. A change in eating habits would raise supplies available for human consumption: if all the cereals that are currently being fed to animals were used for human nutrition, the calories (with the meat calories foregone already subtracted) would suffice for an additional 3.5 billion people.[12]

FIGURE 1: WORLD FOOD PRODUCTION, 1961-2007



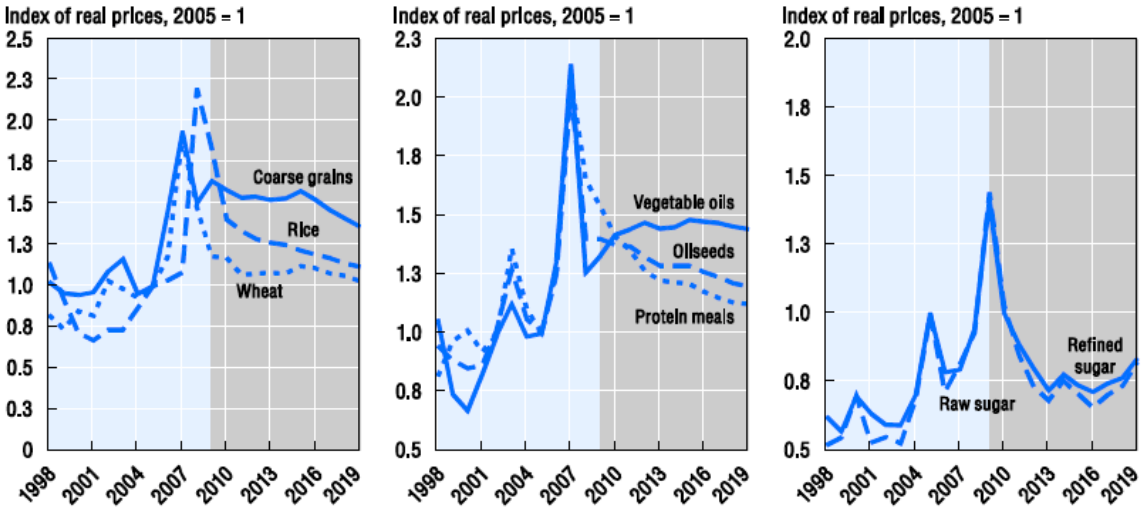
Source: FAOSTAT.

Already in the 19th century, real food prices were on a downward trend as capital and labor moved from Europe to land-abundant countries, especially in the Americas, and a revolution in transport costs created a world market for bulk commodities. After the Second World War, this trend continued: average prices in 1980-2000 were about half of the average price level of 1950-1980. With the new millennium, food prices have started to climb, with a surge in 2007/08.

By 2010, world food prices have declined from their peaks. Sugar and wheat are exceptions, as prices soared in 2009 and 2010, respectively, due to bad harvests. Most observers predict prices will remain well above their averages of the last 25 years but below the 2007/08 highs. The OECD and FAO (2010) expect prices for basic staples that are important for global food security, such as wheat and rice, to soften (Figure 2). Several other studies also expect moderate price develop-

ments, pointing to the potential to enhance yields and the return on investment in agricultural productivity (see Annex 1)

FIGURE 2: GLOBAL CROP PRICE INDICES, 1998-2019.



Source: OECD and FAO (2010).

4.2 THE EU IMPORT POTENTIAL

Against this background, it is safe to say that, as long as world markets function properly, the EU will be able to fill any gap in food supplies through imports. Food prices are so low compared with EU wealth that the EU could afford sufficient imports even if prices rose tenfold (always speaking of basic staples, not caviar and passion fruit).[13] Since the EU has high agricultural tariffs, domestic prices of imported products can furthermore be diminished by simply removing these artificial barriers to trade.

Except for a world war,[14] only export restrictions could impair the EU's import potential. A number of considerations show how unlikely this threat is. First, agricultural markets are becoming thicker: world food trade has increased by 230% between 2000 and 2008.[15] The greater the volumes, the more food can still be bought on the world market if a given amount of supplies is interrupted.

Second, export concentration has been low, or at least decreasing, during recent decades in the most important agricultural markets.[16] The concentration of countries' share in world food exports matters because export restrictions are more lucrative and can be more easily upheld if most of the market is in the hands of one or few suppliers.

Third, a significant share of EU imports comes from highly reliable exporters: the US, Canada, Australia and New Zealand. These countries could greatly expand their exports to the EU if the need arose. The other main source of exports to the EU, South America, is decently stable.

Fourth, food is a homogenous good if the issue is not taste but calories. If exports of wheat were seriously curtailed, they could be replaced by rice, maize and other grains. Export restrictions are therefore less harmful to importers and less attractive to exporters.

Fifth, food is mostly traded on a spot market and can be easily transported. Food thus differs greatly from oil and gas where imports hinge on long-term contracts, pipelines and suitable refineries.

Sixth, food production in major exporting countries can be more easily increased than energy production (beyond currently available capacity) as the latter depends on long-term capital investments. If some suppliers restrict their exports, it is thus easier for their competitors to pick up market shares.

Seventh, no prolonged and encompassing phases of export restrictions have occurred since the Second World War. Export restrictions taken during the 2007/08 price spikes were usually of short duration and limited to one or a few products.[17]

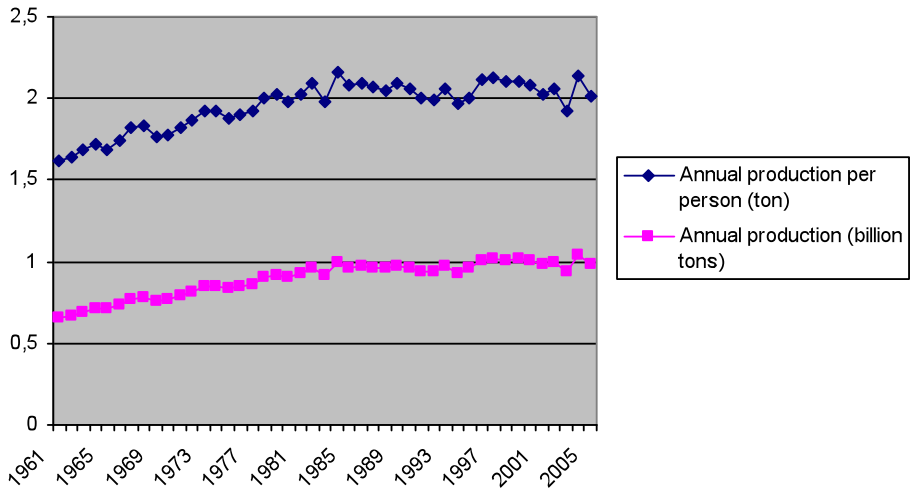
5. DOMESTIC PRODUCTION AND CONSUMPTION

5.1 PAST EU FOOD PRODUCTION AND CONSUMPTION

Between 1960 and 1980, EU food production, net of animal feed, increased from 700 million tons per year to roughly one billion tons (Figure 3).[18] Since then, production quantities have leveled off. One reason for this is that the price markup of the EU compared to the world market has fallen: applied tariffs decreased (through the Uruguay Round of multilateral trade negotiations, free trade areas and preferential market access for developing countries) and guaranteed prices on the EU market were lowered. In addition, the European Union took measures to curb production, such as production quota and schemes to set aside land as fallow. Other factors are stricter environmental legislation and higher labor costs. In short, the stabilization of production quantities was intended, or at least accepted, and does not indicate difficulties with production, such as declining soil fertility or expanding pests, which could lead to a future decline. Indeed, agricultural productivity kept increasing. 25% less labor was needed in 2009 to produce the same overall quantity of farm output as in 2000.[19]

It is also remarkable that production quantities fluctuated little from one year to another. 6.3% is the largest year-to-year decline (which occurred in 2003). Supply declined only once in three consecutive years and twice in two consecutive years, and these combined decreases were minor (the three-year decline amounted to about 4% in total). This shows that farmers have been able to compensate a weak harvest quickly, mostly already in the next year.[20]

FIGURE 3: EU FOOD PRODUCTION 1961-2005



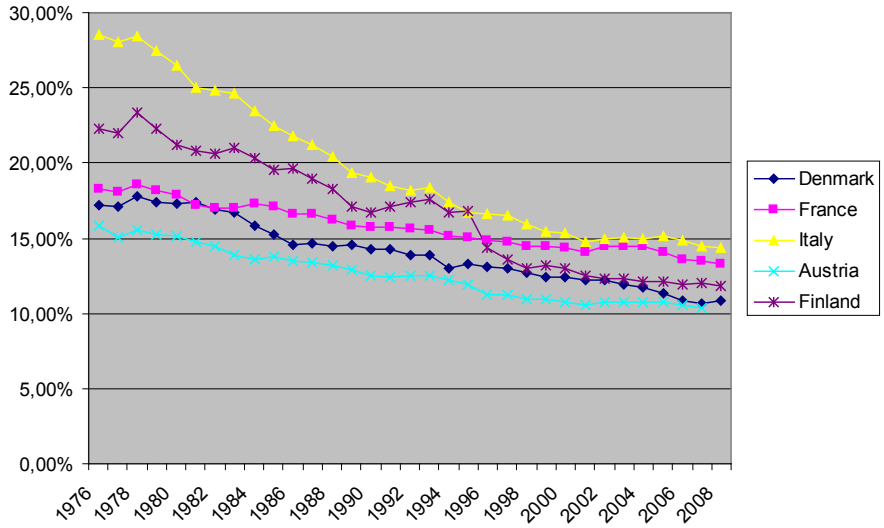
Source: FAOSTAT.

As the EU population increased by only 20% since 1961, food production per person grew from 1.6 tons in 1961 to over 2 tons in 2005. Future EU population growth is predicted to be very modest. Eurostat estimates that the EU population will increase from 495 million in 2008 to 521 million in 2035, and thereafter gradually decline to 506 million in 2060.

Are 2 tons per person enough?[21] There are no reliable calculations of EU calorific production, but a look at cereals that deliver the brunt of a European's calorie intake is sufficient.[22] During the period of 1991-2009, cereal production in the 27 EU member states moved between 245 million and 325 million tons. At its lowest point in 1992, more than 500 kg of cereals were produced per citizen (before subtracting feed, seeds, processing and other waste). A kg of cereals consumed in the EU contains on average 2,800 kcal, ranging from 3,670 kcal for rice to 2,070 kcal for oats.[23] Approximately 4000 kcal/person/day – or twice the recommended intake – were thus available from cereal production alone, even during the weakest production year. Apparently, all member states integrated into the EU-27 at the present moment could have nourished their combined population without any food imports in every single year since 1991 (and the same holds true when going further back to 1961).

Household expenditures for food and non-alcoholic beverages, excluding restaurants, have been falling for decades (shown in Figure 4 for those member states for which data is available). In the EU 27, these expenditures accounted for 14.5% in 1995 and for 12.8% in 2008.

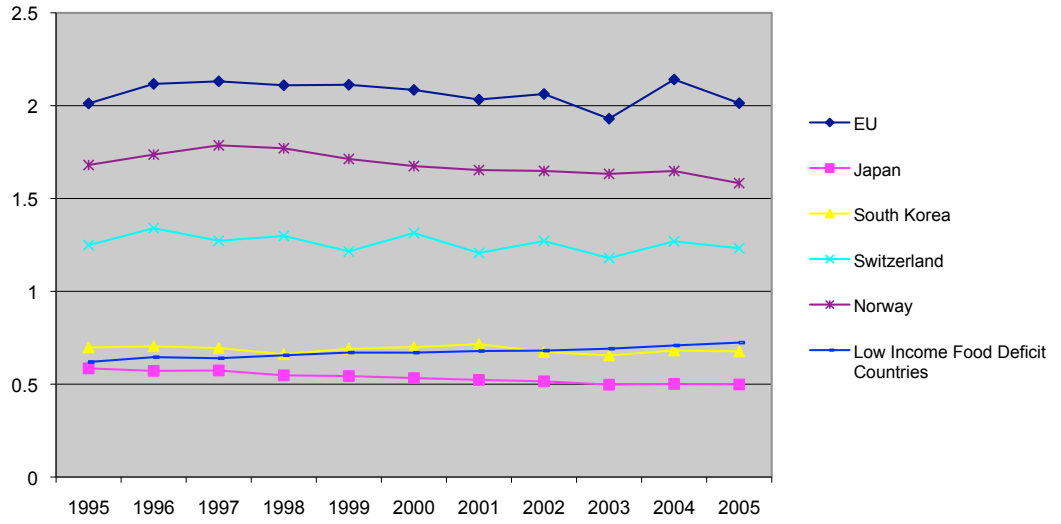
FIGURE 4: SHARE OF HOUSEHOLD EXPENDITURES FOR FOOD AND NON-ALCOHOLIC BEVERAGES, 1976-2008.



Source: Eurostat.

A complementary way to get a feeling for the level of EU food security is to establish a comparison with other countries (Figure 5). The EU is faring far better than Norway and Switzerland. It produces three times more food per person than South Korea and the group of 'low income food deficit countries', and even four times more than Japan. South Korea, Japan, Switzerland, and Norway are all trying to enhance their self-sufficiency. However, these programs are curiously focused on one commodity per country (rice, potatoes, milk).[24] They look more like politically motivated support for farmers dressed in the food security disguise than a serious worst-case strategy.

FIGURE 5: ANNUAL FOOD PRODUCTION PER PERSON IN DIFFERENT COUNTRIES, 1995-2005, IN TONS



Source: FAOSTAT.

5.2 PRODUCTION FORECASTS

The most recent and in-depth forecast of EU production is the updated Scenar-2020 study.[25] It analyzes future production under three different scenarios. The reference case assumes a 20% (nominal) CAP budget reduction, reduced intervention stocks, full decoupling, a 30% direct payment reduction, a 105% increase for the second pillar, and a moderate Doha agreement (based on the so-called Falconer paper, including the elimination of export subsidies). The conservative scenario presumes that the status- quo is largely maintained, direct payments reduced by only 15% and second pillar payments raised by 45%. The liberal scenario is very liberal indeed, with a 55% CAP budget reduction, no intervention stocks to stabilize prices, no direct payments, a 100% increase for the second pillar and no tariffs.

The study predicts an aggregated change for 2007-2020 for livestock of about +2% in the reference and conservative scenarios and -4% in the liberal case. Meat production declines by 10% in the reference and by more than 30% in the liberalization scenario. By contrast, crop production expands in all scenarios. In the reference case, cereal production is expected to rise by 10% in the EU-15 and by almost 20% in the EU-12 between 2005 and 2020 (with slightly lesser growth in the liberalization scenario). Agricultural land use remains roughly unchanged in the reference and conservative scenarios and declines by 6% in the liberal scenario. In sum, overall changes are small and the greatest losses occur in the meat sector, which is not crucial for food security, whereas the calorifically more efficient cereals production expands.

Other models deliver equally reassuring results.[26] The European Commission (2009) predicts usable cereal production to remain relatively unchanged between 2008 and 2015. The Food and Agricultural Policy Research Institute (FAPRI) expects EU wheat production to climb from 138 million to 157 million tons between 2009 and 2019, with the yields increasing from 5.44 to 5.82 tons per hectare.[27] The International Food Policy Research Institute (IFPRI) similarly forecasts per capita cereal production to increase in Europe.[28] These production levels will allow the EU to stay a major exporter of basic staples.[29]

5.3 THREAT ANALYSIS

The forecasts clearly show that under normal conditions EU production will be more than sufficient to meet demands. But what if something extreme occurs that is not accounted for in the forecasting assumptions? To be on the safe side, it is wise to think about what such a catastrophe could be and whether there is any way to assess its likelihood.

Looking at the history of famines, one can see that throughout the last century – and including developing countries with low production potential and purchasing power – production shortfalls that provoked hunger have mostly been man-made. Natural causes, such as bad weather, have frequently played a role in these famines. But the main culprits have been war, civil unrest and dictatorial regimes that experiment with policies or punish parts of the population.[30] This is an important lesson: if natural causes have been largely insufficient to cause famines in the 20th century, it is unlikely that they will do so in the 21st-century EU with its much advanced technology.

One potential source of disruption stems from the reliance of EU agriculture (and processing and distribution) on fossil fuels, which are largely imported from rather unreliable sources. The more energy that is required to produce a sufficient supply of food, the higher the adaptation costs will be of a drastic reduction of fossil fuel imports incurred in other sectors of the economy. Another incentive (in addition to the competition for energy) to let food prices increase in the case of energy shortages would arise from the temptation to draw agricultural production towards biofuels and away from food. However, whatever the food prices that turn out as market-driven solutions of these trade-offs, or are deemed optimal by a governmental regulator, they will not lead to food insecurity given that only 2.2% of the EU's energy is consumed by agriculture.[31]

Anthropogenic deterioration of natural resources – such as soil erosion, water depletion and biodiversity loss – is another potential source of disruption that might undermine future EU production in ways that are not appropriately captured in the production forecasts. While these environmental problems deserve greater policy action, current stocks and trends do not indicate that they will provoke food shortages in the coming decades.[32]

A study commissioned by DG Agriculture sheds light on the likely effects of climate change on EU agriculture.[33] A greater frequency of extreme weather events and an intensified hydrological cycle are expected to decrease yields. Hydrological changes include increased winter precipitation falling as rain, rather than snow, thus decreasing snow pack and spring runoff and potentially exacerbating spring and summer droughts. Rising sea levels will destroy agricultural area, and the transfer of housing and industrial sites to locations further inland will also come at the cost of agriculture. Furthermore, higher atmospheric ozone concentration threatens production because ozone enters plant leaves, reducing the efficiency of photosynthesis.

Higher temperatures and changing temperature patterns (with winter and nocturnal temperatures projected to rise disproportionately) have mixed effects on agriculture, varying across regions. Higher atmospheric CO_2 concentration is even helping agriculture, leading to a so-called fertilizer effect. Experiments where other factors such as moisture supply, nutrients and pest and disease incidence where limited have shown that increased concentrations of CO_2 significantly increase crop yields. In practice, increased weed competition – among other factors – may diminish these gains.

The forecasted changes in yield vary greatly across the EU, depending on local climate, water availability and soils etc. Relatively northern zones (Boreal, Atlantic Central and Continental North) fare better than southern zones. Yield increases up to 40% in Scandinavia's boreal areas and decreases up to 40% in the Mediterranean region under current management conditions.

Shifting patterns of food production without drastic changes in overall supplies are also found in several models that take a global rather than an EU perspective.[34]

5.4 CRISIS SCENARIOS

The preceding analysis has shown that the EU has an extremely comfortable buffer of food supply over needs, that this buffer is expected to expand further in the coming decades, and that there are no discernible threats that may not be grasped by forecasting models but that may have the potential to provoke food shortages.

But what if some unforeseeable catastrophe hit the EU? At what point would food price increases become critical for EU food security? As mentioned above, EU households spend an average 12.8% of their income on food and non-alcoholic beverages. Does this mean that – unless they ate less – households would have to spend half of their income on food if drastically deteriorated growing conditions led to a fourfold increase in farm gate prices? No. First, current expenditures are based on current consumption patterns. If food prices rose significantly, consumers would change eating habits and prefer cheap cereals. Second, it should be noted that the markup for processing, transportation and retail selling in current EU food expenditures is higher than the farm gate price. In the UK, for instance, the farm gate share fluctuated between 24% and 31% during the last decade.[35] This means that an increase of farm gate prices by 10% will translate – with a constant mark-up – into a retail price increase of only 3%.[36] Third, the farm gate share in retail prices for cereals is much lower than for vegetables, dairy and, in particular, meat. In the UK in 2009 the farm gate share in a loaf of bread amounted to only 7%. With very high food prices, processing, transportation and retail costs would therefore become marginal. Therefore, any increase in farm gate prices triggers a much more moderate increase in retail prices. The more dramatic the increase in farm gate prices, the weaker the relative impact on retail prices and households' food expenditure.

Let us focus on cereals as one of the cheapest provider of calories and put largely fixed mark-ups aside. The farm gate price for 1 kg of soft wheat fluctuated generally between €0.08 and €0.14 in the EU member states during 2000-2006, between €0.14 and €0.23 in 2007-2008 and between €0.10 and €0.14 in 2009. Let us assume as the baseline case that EU citizens consume 1 kg of cereals (more than enough) for which they pay €0.15. In other words, EU citizens would have easily been able to fulfill their calorific needs at about €0.15 per day, or €55 per year, at farm gate prices during the recent decade, with the exception of the 2007-2008 price hike when a slightly more money would have been needed.

The €55 per year that is necessary for the average EU citizen to fulfill his calorific needs is just 0.23% of the EU GDP per capita in 2009 (which was 23.600 Euros). With a tenfold increase in cereals prices, EU citizens could still pay for their calorific needs with 2.3% of their income on average. But a tenfold increase in cereals prices is already a most unlikely scenario. Real prices for cereals on the EU market rose by only 61% from 2000 to their 2008 peak.[37]

How would EU production react to significant price increases? How large is the potential to boost production by expanding land, labor and capital inputs and by improving technology? Let us assume that the catastrophe primarily affects agriculture (take climate change or pests) and is not generalized (as in the case of civil war or interstate war within the EU), so that a reasonable response by markets and governments remains possible.

40% of the EU surface is used for agriculture. While some expansion is possible (though on less productive soils and at environmental costs), the main issue is the use of the land already in pro-

duction. One reaction to rising food prices could be to shift from biofuels and other industrial crops to food production. In 2007, the EU used 8.2% of its agricultural area to grow industrial crops. Even more important would be a shift from meat and dairy to crop production. In 2007, 31.4% of agricultural areas were permanent pastures, and a further 11.3% were dedicated to fodder crops. Only 34.4% of the agricultural land was actually used to grow cereals.[38]

Reductions in the area for meat and milk production would not yield one-to-one gains in cereal production. Grazing area is generally of lesser quality than arable land, manure can be used as fertilizer and food waste can serve as animal feedstuff. Furthermore, some meat and milk production may be advisable to provide proteins. Nonetheless, food production could be tremendously increased by a reduction of the livestock sector and a concentration on animals with an advantageous fodder-to-yield ratio, such as pigs and poultry.

If combined, all farm work in the EU corresponds to 11.2 million full-time job equivalents in 2009.[39] It would thus be easily possible to double or triple the amount of agricultural labor, drawing on other sectors or the unemployed. Generally, these workers would not be trained farmers, but they could nevertheless work productively under professional guidance.

The value of intermediate inputs in the crop sector in 2008 was €77 billion – or about 0.6% of EU GDP. In the case of emergency, a five- or tenfold increase in inputs is thus financially viable.[40]

A further possibility for enhancing agricultural productivity per ha – besides increases in labor and intermediate inputs – is to improve production methods. The simplest way to do so is to ramp up training and extension services. In OECD countries, yields in best-practice experimental stations are generally 25% to 50% higher than average yields.[41] Another quickly available production booster would be to resort to production methods that are technically but not legally available in the EU, such as GMOs.

Investment into research and development generally takes some years to bear fruit – but priority technology initiatives can lead to breakthroughs surprisingly quickly. International conflict and competition have historically been the drivers for governments to give massive endowments to single technology initiatives. The Manhattan Project to build the atomic bomb started in 1939, most work was done after 1942, and the bomb was ready by 1945. The US president, John F. Kennedy, gave his famous speech to announce the manned mission to the moon in 1961, and Neil Armstrong set foot on the moon in 1969.

More generally, military conflict shows the potential of modern economies to allocate enormous resources to wartime purposes at short notice. At their respective entry into the First World War, Germany, France, Russia and the United States all increased their military expenditures by a factor of 10 or more within a year or two and turned arms production into the main sector of their economies. This tremendous productive capacity has been further magnified over the last century. Any serious threat of food insecurity in the EU would mobilize resources at a scale unseen in human history.[42]

But such efficiency leaps driven by capital investment and technology are not even necessary. Fairlie (2007) calculates whether Britain could feed itself, looking not only at calories but also dietary needs of proteins, fruits and vegetables. He examines different consumption menus (vegan and with livestock) and production systems (conventional and organic). He also factors in technologically simple changes to production techniques that would be suitable to achieve self-sufficiency: the use of lower yielding cows that can be used for milk and meat production and thus lowering the feedstuff demand currently incurred for running a beef suckler herd; more

liberal feeding regulation for pigs; and increased recycling of sewage as fertilizer. The result is that Britain – one of the EU member states with the lowest agricultural potential per person – could feed its population even with organic agriculture, albeit with reduced meat consumption, and that conventional agriculture leaves a very comfortable margin between production potential and food requirements. Similarly, Halberg et al. (2006) argue that EU food security can be achieved with an exclusive reliance on organic farming.

The least demanding option is not to produce more but to waste less. Wastage occurs during harvesting, at the various intermediate steps of storage, transportation and processing, at the retail stage and at the consumer level. Regrettably, no comprehensive EU-wide data is available. But one study estimates that in the UK, 6.8 million tons of food waste – that is about 20% of food purchases – could have possibly been avoided by consumers alone.[43]

6. EU POLICIES AND FOOD SECURITY

6.1 POLICIES TO ENHANCE EU FOOD SECURITY

The two main instruments of the current CAP are farm income support (through the Single Farm Payment and the Single Area Payment) and market price support (through tariffs, export refunds and other subsidies). However, it is unclear whether these instruments have a positive or a negative impact on short-term food security. They are generally credited for keeping land and labor in agricultural production. But the Scenar-II study, commissioned by DG Agriculture, estimates that even in the case of radical liberalization, agricultural area would decline by only 6%.[44] Furthermore, land that lays fallow regenerates its fertility. Keeping land uncultivated and taking it back into production if the need arises may thus increase the production potential compared to the scenario where as much land as possible is constantly farmed. A last point that speaks against any short-term food security benefits from income and price support is that these instruments slow down productivity enhancing structural change.

In any case, short-term food security is not endangered in the EU. If food security should be of concern to policymakers, the focus should be on 2050 and beyond. In this long-term perspective, many instruments of the current CAP are actually detrimental: they stimulate more intensive production that weakens the ecological sustainability of farming.

In the pursuit of long-term food security, two key themes emerge. One is investment into research and development.[45] The other is protection of genetic and other environmental resources. This challenge reaches beyond agriculture: for instance, when it comes to protecting water and limiting urban sprawl. A third theme, which is perhaps of lesser importance, concerns energy. Food security can be increased by reducing the energy intensity of agriculture (especially by scaling back fertilizer usage) and by avoiding excessive reliance on biofuel production that competes with food production.[46]

A surprising argument in the CAP debate is that the old system of guaranteed prices and intervention buying leading to large stocks had a food security rationale. In reality, the system was driven by special interest politics: those products were accumulated that had the strongest lobby rather than those most important for food security. Furthermore, stocks increased when prices were low; that is, when food insecurity appeared to be even more remote. Instead of intervention buying in a system of guaranteed prices, stocks should be managed by a food security calculus.[47]

6.2 GLOBAL FOOD SECURITY

Even if EU food security is not threatened, it is still possible to argue that the EU has a moral responsibility to help feed the world. A vocal supporter of this thesis is Michel Barnier, French Minister for Agriculture from 2007 to 2009, and afterwards, EU Commissioner for the Internal Market and Services. He warns that 'if Europe were to cut back on its agricultural production then the increase in its own food imports would contribute significantly to a worldwide increase in food prices. This makes it imperative that EU food production levels should be held steady – both for the sake of Europeans themselves and also for the sake of people in the world's poorest countries. In other words, maintaining Europe's farm outputs at present levels also contributes to the stabilization of global food markets.'[48]

Though world food production is likely to exceed population growth, and real food prices are unlikely to rise dramatically in the long term, several hundred million people must be expected to remain food insecure in the coming decades.[49] What efficient policy responses could the EU adopt?

The Single Farm Payment (SFP) can be excluded from the start, as it increases EU farm incomes with minor effects on production. Measures, such as farm modernization subsidies and tariff protection that stimulate EU food production and reduce EU imports, thus putting downward pressure on global food prices, are not recommendable either. First, lower global food prices benefit all consumers and not only those who are most food insecure. A part of the effect is thus 'eaten up' by the wealthy. Second, lower food prices are a mixed blessing in the fight against hunger and poverty.[50] Since the very poor tend to consume more food than they produce, lower prices probably reduce hunger in the short term. But in the long run, lower food prices depress agricultural production in developing countries. This diminishes wages for low-skilled labor, which is frequently employed in agriculture. It also reduces economic growth in the developing countries and shrinks their tax revenues that can be spent on the poor.

While it is not reasonable for the EU to invest in food production to drive world market prices down, the EU should be careful with policies that raise food prices. Biofuel production that competes with food production is estimated by some studies to contribute significantly to global food insecurity.[51] This problem cannot be satisfactorily addressed by subjecting first-generation biofuels to sustainability criteria.

The EU should invest more in agricultural research, farm advisory systems, improvements in agricultural property rights and markets and rural infrastructure in developing countries.[52] Foreign aid from national and international donors for agricultural development in (least) developing countries has dropped over the last three decades. Following the 2007/08 price spikes, the G8 and other international organizations promised to reverse this trend. These promises must be followed by action.

The example the EU is giving to developing countries also matters. Many developing countries have protectionist policies in agriculture and they often intervene excessively in agricultural markets. Some even pay harmful subsidies – for instance to promote exports (thus wasting public money and raising food prices for domestic consumers) or to lower the costs of energy (thus encouraging wasteful energy usage and the overexploitation of water resources through pumping). The EU could facilitate policy reform in these countries if it shows that market-oriented agriculture combined with targeted, sustainable subsidies works best. As a result, developing countries could increase their agricultural production, benefit from enhanced (South-South) trade and invest their public budget more effectively.[53]

By the example it gives with its own policies – but also through trade agreements and development aid – the EU should promote an open trading system in agriculture. Population growth tends to be highest in countries that are already food insecure and who will be the most affected by climate change. Removing export and import barriers will therefore be crucial to fulfill the needs especially of Middle East and Northern African, Sub-Saharan African and South Asian countries. Trade can respond to these structural differences in supply and demand, and it can help the world cope with increasing supply variability due to climate change. World market prices tend to be less volatile than domestic prices because the many national supply and demand shocks are only partly correlated: a drought in Australia can be off-set by a good harvest in Europe, and vice versa. The world market can thus act as a buffer.[54]

7. CONCLUSIONS

The claim that the EU should massively invest in food security – and current subsidy and tariff levels result in massive costs – builds on attitudes like 'better safe than sorry' and 'you never know'. There are a number of threats out there about which we cannot have absolute certainty: attacks by Martians, killer mummies from the Pyramids and dinosaurs escaping from Jurassic Parks. Serious policy makers have to analyze and weigh these risks. Food security does not pass the test; there is no reasonably discernible threat during the coming decades.

Serious policy makers also have to think about adequate responses to existing risks. Stimulating current production undermines the EU's long-term food supply, while farm income support is irrelevant for food security. The precautionary principle, however, suggests better protection of productive resources, such as soils, water, biodiversity and the genetic variety of farming plants and animals. The final and most difficult challenge is to prevent the most pessimistic climate change scenarios for the post-2050 period materializing.

The real food security challenge affects the poor in developing countries. The EU should respond to this challenge by promoting an open and stable trade regime for agricultural products, so that world markets can handle geographically dispersed fluctuations in production and structural imbalances across world regions. A major step would be the removal of its own agricultural tariffs and all subsidies that are not efficiently targeted at clearly defined public goods. This should be accompanied by additional support for enhancing agricultural productivity in developing countries.

ANNEX 1

The Food and Agricultural Policy Research Institute (FAPRI) expects moderate price developments for the main staples. The price of wheat is anticipated to rise by 0.34% per year between 2009 and 2019, and the price of corn to grow slightly more, by 0.9% per year, whereas the world reference price for rice is forecast to decrease by 2.5% per year.[55] The IIASA world food system simulation predicts world market prices in 2020 to be 2% lower and in 2050 to be 15% higher than at the low levels of 1990.[56] The World Bank is similarly optimistic, expecting agricultural prices to fall, relative to manufacturing prices, by 0.7% a year between 2008 and 2030. Even the pessimistic scenario of a productivity slowdown sees prices rise only by 0.3% on average.

As a result of continuing productivity gains and slower population growth, FAO researchers estimate world kcal production per day and person to gradually increase from 2,771 in 2003/05 to 3,047 in 2050.[57] The Agrimonde study undertaken by a French research consortium concludes

that it is possible to comfortably produce 3,000 kcal/day/person in 2050 even under low-productivity-growth assumptions.[58] Rosegrant et al. (2009) also predict that calorie availability will improve until 2050 in all world regions and rise above 2,500 kcal/capita/day in all world regions.

The greatest source of uncertainty in these predictions stems from climate change.[59] The IIASA model compares agricultural production with climate change to production under the average 1960-1990 climate conditions.[60] The consequences of climate change until 2050 are moderate. Negative effects dominate for wheat (-10% production potential without CO2 fertilization, -5% with CO2 fertilization), while positive effects dominate for maize (the production potential increases by 5%/9% without/with CO2 fertilization). Overall, the cereals production potential remains roughly stable (-2%/+3% without/with CO2 fertilization), as do agricultural prices (+5%/-2% without/with CO2 fertilization). Climate change becomes more detrimental for agriculture in the second half of the century.

The IFPRI (2009) calculations are more disquieting. Without CO2 fertilization, climate change could cause wheat prices to more than double compared to 2050 prices without climate change. Climate-change induced price increases for maize could be up to 55% and up to 37% for rice. These losses would, in particular, hit the least food-secure countries in Sub-Saharan Africa and South Asia.

Yield increases per hectare are forecast to continue. Rosegrant et al. (2009) expects 1% productivity increases for cereals. Bruinsma (2009) assumes that yields will increase by 1.1% per year, with 77% of this change attributable to productivity gains. INRA and CIRAD (2009) assume productivity growth to be between 0.14% and 0.96% per year. Fischer, Byerlee, and Edmeades (2009) review projections for individual crops (wheat, rice and maize) and reports growth of at least 50% during the coming decades. It has often been observed that yield growth has been slowing down, and most experts agree that yield growth during the next decades will be even slower. However, Fuglie (2008) shows that total factor productivity growth (the efficiency of transforming inputs into outputs) has not declined – lower production growth rates are thus best explained by decreasing input growth (e.g. labor and fertilizer).

The level of this productivity growth will strongly depend on investment. von Braun et al. (2008) find that increasing investment in public agricultural research in a large subset of developing countries, from about US$4.6 billion to US$9.3 billion during 2008-13, could increase output growth coming from research and development (R&D) from 0.53 to 1.55 percentage points. The high-investment scenario could reduce the price of maize by 67% in 2025, wheat by 56%, and rice by 45% compared to the baseline scenario.[61]

In another study, Rosegrant et al. (2009) forecast cereal price increases between 2000 and 2050 by 60%-97%. However, these results are reversed if more is invested in agricultural productivity. With US$579 billion additional investments into agricultural research, irrigation, rural roads, education and clean water – leading to 40% higher productivity increases than in the baseline – 2050 prices would be about half of 2000 prices.

A good indicator of yield growth potential – without any innovation at the knowledge frontier – is the gap between average farm yields and the yields attained on experimental stations with representative natural resource endowments where the best available agricultural techniques are applied. Fischer, Byerlee, and Edmeades (2009) report that 14 out of 17 studies find gaps of more than 30%. In sub-Saharan Africa, gaps can reach 100% or even 200%.

Bruinsma (2009) compares average 2003-07 wheat yields with attainable yields under local agro-

ecological conditions. The results in tons/ha: Ukraine 7.1 vs. 2.5, Poland 7.0 vs. 3.8, Kazakhstan 3.3 vs. 1.1, Russia 3.8 vs. 1.9, and the U.S. 6.3 vs. 2.8. It should be noted that attainable yields are calculated rather conservatively – countries such as Denmark, the UK and Germany exceed their attainable yields.

Bruinsma (2009) provides a second pointer for yield growth potential. The yield of the top decile of developing country wheat producers is 9.02 tons/ha compared to 1.50 tons/ha for the bottom decile. Similarly, Bravo-Ureta et al. (2007) note in a meta-analysis of 167 studies that average farmers are only 70% to 80% as efficient as the best farmers in their region.

Third, Bruinsma (2009) highlights that irrigated agriculture, which makes up only 19% of all arable land in developing countries, is responsible for 47% of total crop production and 59% of cereal production. With additional investments in water-efficient irrigation, this share could be increased (Bruinsma projects a 17% increase in harvested irrigated area between 2005/07 and 2050).

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ENDNOTES

1. I am grateful to Michal Krol for his excellent research assisstance, to Gladys C. Moreno for providing FAO data, to Stephan Cramon-Taubadel for his helpful comments and to Laura James for reliable proofreading.
2. See Daugbjerg and Swinbank (2009) and www.reformthecap.eu/issues/policy-instruments/tariffs.
3. The EU's limitations on GMOs diminish this substitutability.
4. 2009 speech 'The countdown to Copenhagen: climate change, agriculture and global food security'.
5. 2009 speech on 'The global economic crisis, food security and environmental security'.
6. See European Parliament (2008).
7. See Defra (2009b). In a global ranking (see http://www.maplecroft.com/about/news/food-security.html), EU member states are among the most food secure countries with 'low risk' estimates. If one does not take the EU member states individually – as done in this assessment – but considers the EU with its internal market as one entity, the combined risk to food security falls significantly.
8. Time is an important factor in this assessment. A given decline in food consumption becomes the less acceptable the longer it lasts.
9. The FAO's household livelihood security concept observes that, 'it has been realized that food is only one of many competing interests which poor households must finely balance in order to subsist in the short and longer term. It is misleading to treat food security as a fundamental need independent of wider livelihood considerations. The concept of household livelihood security allows for a more comprehensive understanding of poverty, malnutrition and the dynamic and complex strategies that the poor use for survival. Household livelihood security is defined as adequate and sustainable access to income and resources to meet basic needs, which include adequate access to food, potable water, health facilities, educational opportunities, housing, time for community participation and social integration.' See http://www.fao.org/DOCREP/X0051T/X0051T05.HTM.
10. See Devereux (2006), Ó Gráda (2009) and Sen (1982).
11. See FAOSTAT.
12. See UNEP (2009).
13. Section 6 gives reasons for why it is more responsible to help the global poor directly and import food from abroad than to invest public money into expanding EU food production.
14. If important sea routes, such as the Suez Canal, were disrupted, this would only increase transport costs. If all sea routes to the EU were entirely blocked, imports from the republics of the former USSR could take up the lead.
15. See FAOSTAT.

16. See UK Government (2010).
17. See Mitra and Josling (2009).
18. The statistic includes all EU-27 member states for the entire period. The food production data includes fish. Fishing is not considered in greater detail in this study. Future fishery yields are uncertain: while ocean acidification and overfishing reduce the potential yield, advances in aquaculture and stock protection measures may increase it. The net balance of these changes in not decisive for EU and global food security, which depends mostly on agriculture.
19. Agricultural Work Units declined from 15 million in 2000 to 11.2 million in 2009, according to Eurostat.
20. If domestic consumption data is considered where fluctuations in production are smoothed by trade and stock changes, the largest one year decline is only 4% and the longest consecutive decline decreases to two years with a total decline of about 1.5%.
21. It appears that the limiting constraint for EU food security is calories and not macro- and micro-nutrients. The analysis therefore focuses on calories.
22. One should keep in mind that current calorific production is only a rough food security indicator and not decisive in itself. More important is the production potential (see Section 5.4). In particular, a fertile country can prefer to produce goods that deliver few calories, e.g. the Netherlands specializes in livestock, vegetables and flowers.
23. See www.fao.org. The 2, 800 kcal are obtained by dividing the kcal supply derived from the consumption of cereals in the EU in 2007 by the consumption in tons. The number is a close proxy for the calorific content of EU production.
24. See Mann (2008).
25. See Nowicki, K. Jansson, and Verhoog (2009).
26. Another interesting scenario study is done by Vrolijk et al. (2010). They estimate that more than 80% of EU farms are financially viable without income support.
27. See FAPRI (2010).
28. Rosegrant and Msangi (2009). They also expect cereal production in the Eastern Europe/Central Asia region to more than double, making it the most productive region with almost one ton/capita/year.
29. According to USDA (2010), the EU will be a major exporter of staples - such as wheat, coarse grains, corn and barley - in 2019/20. FAPRI (2010) predicts EU net wheat exports to remain almost stable at 12.5 million tons in 2019. By contrast, Witzke, Noleppa, and Schwarz (2008) anticipate the EU to become a net importer of several staples by 2013/15 although they, too, predict two-digit production increases from 2003/05-2013/15.
30. See Ó Gráda (2009) and Sen (1982). This study does not consider such security-related threats, which today includes (bio-)terrorism. Nor does it consider short-term, logistical problems, such as an epidemic that prevents food distribution or natural catastrophes that destroy transportation infrastructure. These threats require specific policy responses that are largely unrelated to agricultural policies. See Hättenschwiler and Flury (2008) for Swiss scenarios where production potential is suddenly and drastically affected, while imports are cut off – as might arise in the case of war. See Suffert, Latxague, and Sache (2009) on bioterrorism.
31. See Eurostat. Proposals of increased food production driven by higher prices or production subsidies paradoxically imply more energy intensity, and thus more dependence on relatively unreliable energy imports.
32. See DG Joint Research Centre, Institute for Environment and Sustainability, and Institute for Prospective Technological Studies (2009), European Environmental Agency (2009), OECD (2008) and the SEBI 2010 biodiversity indicators.
33. See AEA Energy & Environment (2007).
34. See section 5.
35. See Defra (2009a).
36. The movement of food chain margins in a food insecurity scenario is uncertain. On the one hand, food price increases were part of a general commodity price boom in the two recent episodes of 1973/74 and

2007/08. Since energy prices are a major component of the food price margin, this would drive up the food price margin in absolute terms. On the other hand, processing, transportation and retail capacities are largely stable, so that smaller food quantities would trigger greater competition in the food chain in the short run. In any case, absolute changes in the food chain margins must be calculated separately and cannot be extrapolated from current percentage markups on farm gate prices.

37. Based on yearly price averages from Eurostat. Real prices for animal output actually fell by 2% during this time span. As argued in Section 3, hardship for poor households from food price increases should be addressed by redistribution policies.

38. See Eurostat (2009).

39. See Eurostat.

40. Greater use of precision farming for fertilizer and water use, as well as for disease and pest control, would be environmentally beneficial. Nevertheless, the increased use of capital inputs in agriculture with the aim of boosting production would have adverse environmental net effects. This option should thus generally be regarded as a lender of last resort.

41. See Fischer, Byerlee, and Edmeades (2009).

42. Such a move would not necessarily imply a GMO-based revolution but could, for instance, be built around the world wide expansion of IT-and-satellite-based precision farming, irrigation and best-practice extension.

43. See WRAP (2009).

44. See Nowicki, K. Jansson, and Verhoog (2009).

45. See also Matthews (2008).

46. See Fischer (2009) on future food price effects of biofuel production.

47. See Hättenschwiler and Flury (2008) on the Swiss model.

48. Barnier (2008).

49. See Alexandratos (2009) and USDA (2009).

50. See Aksoy and Isik-Dikmelik (2008), Hertel et al. (2007), Ivanic and Martin (2008) and Wodon et al. (2008). It must not be forgotten that 800 million were underfed even when world prices were very low and global production was in surplus earlier in this decade. Lower food prices evidently do not do the trick.

51. See Rosegrant and Msangi (2009) and Searchinger (2009).

52. See World Bank (2007) on agricultural investment and policy reform needs in developing countries. An additional US$4.7 billion for agricultural research and development in 2008-2013 could lift about 282 million people out of poverty by 2020, according to von Braun et al. (2008).

53. Cervantes-Godoy and Dewbre (2010) find that countries that liberalized agriculture (lower export taxes, reduction of overvalued exchange rates, less state intervention in agricultural markets) and invested in agricultural research saw outstandingly strong agricultural growth and poverty reduction.

54. See INRA and CIRAD (2009) and International Centre for Trade and Sustainable Development (2009).

55. See FAPRI (2010).

56. See Fischer (2009).

57. See Alexandratos (2009) based on FAO (2006).

58. See INRA and CIRAD (2009).

59. See Millenium Ecosystem Assessment (2005) and UNEP (2009) for a comprehensive stocktake of environmental threats.

60. See Fischer (2009). While Funk and Brown (2009) anticipate more serious repercussions, these are aggravating regional imbalances than provoking a global food shortage.

61. See also Alene (2010) on positive yield response to increasing R&D investment.