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European and Central Asian Agriculture Towards 2030 and 2050

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European and Central Asian agriculture: towards 2030 and 2050

Contents

Tables

Figures

Boxes

European and Central Asian agriculture: towards 2030 and 2050

Summary and overview

The FAO global outlook study concludes that by and large world agriculture should be capable of producing the necessary food, provided the efforts to invest in infrastructures, agricultural research and human capital continued, and sustainability issues are addressed. The message of the study is, however, far from optimistic since significant local problems will remain. For example, by 2050, some 4 percent of the developing countries' population (or some 320 million persons) could still be chronically undernourished. On the other hand, overnourishment (obesity and associated non-communicable diseases) is rapidly becoming a major problem, not only in developed countries but also in many developing countries alongside problems of undernourishment. Likewise, while at the global level there probably are still sufficient untapped land and water resources, locally an increasing number of countries (and regions within countries) are running out of land and fresh water, in particular in North Africa, the Near East and parts of South Asia. Also there are a considerable number of developing countries still experiencing unabated population growth with a high share of its population dependent on agriculture in an environment of very limited land and water resources, which make their development prospects look very bleak.

As for agriculture in the Europe and Central Asia region, it is probably fair to say that the region's agriculture will be facing demand constraints and that its production potential (at least for temperate products) far exceeds effective market (domestic and foreign) demand. An important qualification to this general statement is in order. The countries of the region span a wide range of developmental and resource-endowment situations, ranging from those with low incomes, relatively high rates of undernourishment and dependence on agriculture for food supplies and employment (Caucasus and Central Asia), to those in the middle-income range (Russia, Turkey and Eastern Europe), to highly developed countries (European Union and Other Europe). However, because of space constraints, the results presented here are mainly at regional level or for selective alternative country groups which masks wide inter-country differences.

The region is characterized by a stagnating population at a level of about 880-900 million people. This is the combined effect of some countries (sub-regions) experiencing a declining population while others would still witness a moderate growth. The region is strongly urbanized with the share of its urban population in total continuing to increase from some 70 percent at present to over 80 percent by 2050. Likewise, provisional projections show that its agricultural labour force could continue its decline from about 50 million persons at present to 'only' 15 million persons in 2050. According to the World Bank, per caput income could grow at an annual rate of 1.36 percent which would imply that by 2050 average per caput incomes would be some 80 percent higher than in 2005/07.

The region has – on average – already attained a high level of daily food energy supply (DES). About two-thirds of its population lives in countries with a DES of over 3400 kcal per person per day which would leave little room for further increases. The projections of food demand would imply an increase from 3340 kcal in 2005/07 to a high 3500 kcal in 2050. The prevalence of chronic undernourishment could decline from some 10 million persons at

present to about 3 million persons by 2050, while even in the worst-off sub-region, the Caucasus and Central Asia, it could decline from almost 6 percent of the population at present to less than 1 percent by 2050. One could call the region one of 'zero hunger' (which is not to say that there are and will be no pockets of undernourishment). On the other hand, the region is facing serious and growing problems of overnourishment with obesity at present affecting some 15 percent of its population. Provisional projections show that this could increase to over 20 percent by 2050.

In spite of the region's relatively high per caput food energy supply, there is still room for further diet diversification which would continue. While per caput (direct) consumption of cereals and sugar would remain constant or decline somewhat, consumption of vegetable oils, meats, milk and dairy products could continue to increase, in particular in Eastern Europe and Russia.

Apart from developments in food and feed demand, the region (essentially the European Union) would face additional demand for agricultural products (in particular wheat, coarse grains and oilseeds) for use as feedstock in biofuel production. This study takes into account such demand up to 2020 as foreseen in the OECD/FAO Outlook study. This would give a mini-boost to demand in the first half of the projection period. Overall total domestic demand (for all uses) would grow at an annual 0.4 percent over the projection period (0.15 percent from 2030 to 2050), down from 0.6 percent over the period 1961 to 2007.

Production would respond and show a similar development in annual growth rates as for total demand, although they could be marginally higher to meet additional export demand from the rest of the world for the region's cereals (mainly wheat from Russia and Ukraine). Overall, annual agricultural production could in 2050 be some 20 percent higher than in 2005/07 (compared with some 60 percent for global agriculture). This would range from a meagre 10 percent for the European Union to some 50 percent for the Caucasus and Central Asia.

Europe as a whole is a net importer of agricultural products and is expected to remain so over the projection period although it could show a marginal improvement in its importer status. The overall situation is heavily dominated by the net trade position of the European Union which recently considerably increased its net imports, imports which are expected to rise even further in the future (mainly imports of vegetable oils and oilseeds and sugar). Within Europe and Central Asia these increasing (EU) imports would (in value terms) be offset by projected increases in, among other things, cereal exports from Russia and Eastern Europe.

While direct food use of cereals in the region would remain about constant over the projection period at a level of around 150 million tons (again at the individual country level trends can differ considerably), total cereal production in the region could still increase by some 130 million tons to 600 million tons in 2050. Various factors would account for this. An increase in net exports from the region to the rest of the world would account for over 40 million tons, additional feed use of cereals for a 35 million tons (feed use of cereals alone absorbs some 54 percent of total use), and another 28 million tons would go into feed stocks for the production of biofuels.

Per caput consumption of meat in Europe and Central Asia is expected to increase by 18 percent to 78 kg by 2050, which combined with an almost stationary population would lead to a 20 percent increase in total demand, from 59 million tons in 2005/07 to 71 million tons by 2050. Production would respond (although Europe and Central Asia would remain a small

net importer of meat) but given the faster growth in the rest of the world, the region's share in world meat production would fall from 22 percent in 2005/07 to 15 percent in 2050. Consumption of milk and milk products in Europe is and has been since the early 60s among the highest in the world and stands now at over 200 kg per person per year. There is therefore, on average, only little scope for further increases in per caput consumption, but as for meat consumption there are considerable differences among sub-regions and countries. Although the region is a major player in the world market for both meat and milk (accounting for between 40 and 60 percent of world imports and exports), its net trade position (exports minus imports) is relatively small and expected to remain so (at around 2.4 million tons of net meat imports and around 12 million tons of net milk exports).

The oilcrops sector was and will be one of the most dynamic sectors in agriculture. Total demand for oilcrops nearly tripled in Europe since the early 70s and stand now at some 32 million tons (in oil equivalent), and could still considerably increase to over 50 million tons by 2050. Contrary to the past, this would hardly come anymore on account of additional food use of vegetable oils (+1.5 million tons) but be mainly due to additional use in biofuel production (+ 11 million tons) and additional other non-food uses in the production of paints, detergents, lubricants, oleochemicals, etc., (+ 5 million tons), so that by 2050 non-food use would absorb some 60 percent of total use of oils. While European and Central Asian production of oil (80 percent of which is sunflower and rapeseed) could increase by more than 60 percent, the region would continue to rely on imports for almost 40 percent of its needs (the European Union for almost half of its oil use).

While the region's food use of sugar could decline slightly over the projection period, total demand could still rise somewhat due to additional use in biofuel production. Production is expected to follow quite different development paths within the region. The projections assume policy reforms in the EU to continue with the EU facing a declining production and increasing net imports, while opposite developments are seen in Eastern Europe where both Belarus and Serbia recently increased their production and exports of sugar. Also Russia would continue to increase its production and thus reduce its net imports. The overall result for Europe and Central Asia as a region is a decline by about 2.5 million ton in its production and as a consequence the region's net imports could increase from about 4 million tons in 2005/07 to nearly 10 million tons in 2050.

The region is well-endowed with land and water resources with, of course, local exceptions. A recently completed agro-ecological suitability study estimates that Europe has some 815 million ha of prime and good land of which nearly 40 percent is in agricultural use. If one excludes of the balance land under forest, built-up areas and strictly protected areas, still 210 million ha of suitable unused land are left (most of it in Russia and Central Asia). Much of this net balance however is not readily available as it might be remote and lack infrastructure and therefore its use might not be economically viable.

As in the past, growth in crop yields will be the mainstay of crop production growth and also compensate for the decline in the arable area that has been going on since the late 60s. The arable area is projected to decline by another 8.5 percent over the projection period from 355 million ha in 2005/07 to 325 million ha in 2050. The area equipped for irrigation would hardly increase anymore from 40 million ha in 2005/07 to 42 million ha in 2050. As for total arable area, these are net changes and taking into account replacement of unproductive land and obsolete irrigation schemes, gross land development could be higher. Fresh water withdrawal for irrigation would change only marginally and on average amount to about 4

percent of all renewable water resources. The Caucasus and Central Asia however is experiencing and will continue to face severe water shortages with water withdrawal for irrigation accounting for almost half of all renewable water resources.

As said, crop yield growth will be the main source of crop production growth. In response to the slowdown in demand growth, growth in production and thus crop yields has also been slowing. This process is expected to continue in the future. Annual growth in average crop yields (i.e. over all crops) could more than halve over the projection period (to 0.5 percent p.a.) as compared with growth in the historical period (1.2 percent p.a. over 1961 to 2007). For cereal yields this slowdown would be even more pronounced: 0.5 percent p.a. in the future against 1.8 percent p.a. in the past. Comparison of actual (2005/07) crop yields with what the above-mentioned agro-ecological suitability study estimated to be attainable, shows that current yields in major producer countries are far below what would be agro-ecological feasible yields, while actually harvested areas are far smaller than the areas deemed to be suitable for producing these crops. This suggests that the agro-ecological potential for considerably higher production is there if other factors (economic incentives, infrastructure and institutions, etc.) would be in place.

The developments projected in this study are subject to two major uncertain factors: population growth and developments in energy markets. If new population projections would deviate drastically from the ones used in this study (UN 2008 Assessment), developments might turn out to be quite different. The other unknown is the development in the average energy price (say US$ per barrel of oil). At current oil prices, the production of biofuel (except for ethanol from sugar cane) seems not to be economically viable and justifiable (i.e. in the absence of mandates and border measures this production could in most cases not survive in OECD countries). Naturally, if energy prices would be and remain much higher for a sustained period, demand for biomass to be used in biofuel production could be limitless (with all consequences).

Barring unknown developments in these two factors, European agriculture seems to be demand-constrained, and its (policy) problems seem more related to such issues as ensuring continuing agricultural research, ensuring environmental sustainability, how to ascertain an orderly transition to a more commercial industrialized agriculture, increasing its competitiveness in international markets and establishing the right institutional frameworks.

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1 Introduction

This paper is meant to be a background paper for general use at the FAO Regional Office for Europe and Central Asia and at the same time to provide material for a paper on "Challenges of European and Central Asian Food and Agriculture to 2050" to be submitted to the 2012 FAO Regional Conference for Europe (ERC).

The paper deals with major expected developments in food and nutrition as well as in agricultural production, trade and resource use in Europe and Central Asia over the period to 2030 and 2050. One of the main objectives of the paper is also to place European and Central Asian agriculture in a global context, i.e. against the background of expected developments in global food and agriculture.

This paper is based on existing material available at FAO/ESA from the work carried out during 2010-11 for a new report on "World Agriculture in the 21st Century" (hereafter WA21, expected to be published during 2012)[1].

This study uses a "positive" approach rather than a "normative" approach. This means that its assumptions and projections reflect the most likely future but not necessarily the most desirable one. Therefore, the prospective developments presented here are not strategic goals. Rather, they can provide a basis for action when coping with both existing problems that are likely to persist and new ones that may emerge. It should also be stressed that the projections are not trend extrapolations. Instead, they incorporate expected future developments that can significantly deviate from past trends.

The WA21 study presents a base line scenario ('most likely outcome') based on the Medium Variant population projections from the UN2008 Assessment (UN, 2009) and (2010) GDP projections to 2050 and 2080 from the World Bank. The main data base used was the FAOSTAT Food Balance Sheets 1961 – 2007 (converted to the WA21 commodity classification – see Annex I) and related FAOSTAT data on land use, crop yields and livestock production, all as known in June 2010. Additional data came from the recently completed update of the Global Agro-ecological Zone study (GAEZ – Fischer *et al.,* 2011) and updated parameters used in the estimate of the prevalence of undernourishment (FAO, 2010).

It would be more correct to describe the WA21 baseline scenario as one accounting for 'limited use of biofuels and ignorant on climate change'. The scenario takes into account the use of agricultural commodities (cereals, vegetable oils, sugar) as foreseen in the 2010 OECD/FAO *Agricultural Outlook* (OECD/FAO, 2010) which in turn mainly reflects the use of biofuels as mandated in the USA and the European Union with no further increase in their use after the final implementation dates (i.e. for 2030 and 2050). The WA21 also does not explicitly take into account the (largely unknown) impacts of climate change by 2030 and 2050[2] (see for a further discussion of these issues Annex 3.1 in FAO, 2012).

[1] At the time of writing, drafts for three chapters were completed: Chapter 2 (Prospects for food and nutrition) and Chapter 3 (Prospects for agriculture and major commodity groups) by N. Alexandratos, and Chapter 4 (Agricultural production towards 2050 and 2080) by J. Bruinsma.

[2] In part this was done in Fischer (2009) and an extension of the WA21 report is planned to more explicitly deal with climate change impacts.

This paper presents selected results for 2030 and 2050 (base year being the three-year average 2005/07) for Europe and Central Asia by re-assembling data and results of the WA21 study for the Europe and Central Asia region and re-interpreting these results also against expected developments in the 'rest of the world'. Unfortunately, although the WA21 study covers 50 out of the 54 ERC countries, 48 of them were grouped into four country groups[3]. Results therefore will be presented mainly for Europe and Central Asia as a total, for the four country groups (sub-regions) and for two individual countries (see Box 1).

Box 1. Sub-regions defined for the Europe and Central Asia Region

As explained in the text above, the following sub-regions were defined for the projection exercise in this report. The number of countries in each country aggregate is shown in parentheses.

EU (27). Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and United Kingdom.
Eastern Europe (9). Albania, Belarus, Bosnia-Herzegovina, Croatia, FYR Macedonia, Moldova, Montenegro, Serbia and Ukraine.
Caucasus and Central Asia (8). Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan.
Other Europe (4) Iceland, Israel, Norway and Switzerland.
Russian Federation (1). Russian Federation.
Turkey (1). Turkey.

Note: There are four countries that participate in the FAO Regional Conference for Europe (ERC), namely Andorra, Monaco, San Marino and the Faroe Islands, that are not covered in this study since there exists no FAOSTAT data for these countries.

The reader should bear in mind that most of the quantitative projections presented in this paper should be interpreted as being meant to indicate orders of magnitude and direction of developments only without a claim on great accuracy (in particular at the country level).

2. The global agriculture outlook to 2050

The FAO study "World Agriculture in the 21st Century" examines the world prospects for food and agriculture to the year 2050 and 2080. The study provides the broad framework within which prospects for particular countries or regional groups may be assessed taking into account possible evolutions in the rest of the world.

This time horizon to 2050 (and 2080) offered an opportunity to explore prospects of world food and agriculture up to the time when the end of world population growth would be within sight. Demographic projections suggest that world population may peak by around 2075 at some 9.5 billion, with the bulk of the increase from the present (2005/07) 6.6 billion occurring by 2050. In that year, world population was projected to reach 9.2 billion and the annual growth rate to have fallen to 0.34 percent p.a.

The study concluded that by and large world agriculture should be capable of producing the necessary food, provided the efforts to invest in infrastructures, agricultural research and

[3] Traditionally, the focus of the FAO AT20XX reports has been on the developing countries (which are dealt with in great detail) and the world as a whole.

human capital continued, and sustainability issues were addressed. The message of the study was, however, far from optimistic for a number of reasons.

In the first place, the exogenous overall economic outlook used by the study indicated persistence of low incomes and significant poverty in several countries. Inevitably, this translates into persistence of insufficient access to food and food insecurity for significant parts of world population well into the future. By 2050, 4 percent of the developing countries' population (or some 320 million persons) would still be chronically undernourished.

Secondly, near zero population growth at the global level does not mean that all countries will be on that demographic path. Nearly all the further population increases will be occurring in developing countries several of which even in 2050 may still have inadequate food consumption levels, hence significant scope for further increases in demand. The pressures for further increases of food supplies in these countries will continue. Much of it will have to be met by growing local production or, as it happened in the past and is still happening currently, it may not be fully met – a typical case of production-constrained food insecurity. The creation of slack in some countries with declining populations (e.g. in several European countries, when growth of aggregate demand will have been reduced to a trickle – 0.15 percent p.a. in the final two decades 2030-50) will not necessarily be made available to meet the still growing demand in countries with rising population, e.g. demand growth at 2.1 percent p.a. in sub-Saharan Africa.

In conclusion, zero population growth at the global level will not automatically translate into zero growth in demand and cessation of the building-up of pressures on resources and the wider environment. The need for food will still be growing in several countries with still low food consumption levels and growing population. In those among them that have limited agricultural potential, the problem of production-constrained food insecurity and significant incidence of undernourishment may persist, even in a world with stationary population and plentiful food supplies (or potential to increase production) at the global level. Nothing new here: this situation prevails at present and it will not go away simply because population stops growing at the global level. Projections to 2050 provide a basis for thinking about this possible outcome.

A second important factor that requires defining the key parameters for world food security in a longer term horizon has to do with the growing tightness of energy markets and associated diversion of agricultural products (and the underlying land and water resources) to the production of biofuels. The potential impacts on food security and broader development can be significant: negative ones for countries which depend on food imports and have no resources that would permit them to profit from the potential bonanza of new markets and higher agricultural prices (e.g. by producing palm oil for bio-diesel or sugar cane for ethanol) or oil prices, positive ones in the opposite case, but potentially negative ones for the sustainability of agriculture's resource base and the wider environment (further intensification of production, more deforestation, etc). The global study did not examine further this issue. However, the conventional food and agriculture projections to 2050 are a first and necessary step in addressing this issue: they can help establish how much more food and related agricultural resources the world may need and in which countries – a valuable input into any evaluation of the potential for diverting agricultural resources to other uses and what this may imply for food security and the environment.

Some of the main (year 2050) results of the WA21 study (which in part will also be shown in the sections of this paper to follow below) are: average per caput availability of food energy could increase by some 300 kcal/person/day from 2770 kcal in 2005/07 to 3070 kcal by 2050. As mentioned, this would still leave some 4 percent of the developing countries' population (or some 320 million persons) chronically undernourished by 2050. The diversification of diets towards higher value commodities would continue; for example, per caput meat consumption would increase from 40 kg per person per year now (world average) to 50 kg by 2050, while per caput direct food consumption of cereals would remain constant at about 160 kg.

Growth in total demand for agricultural products (that is effective demand as expressed in the market) will continue to slowdown mainly due to the slowdown in population growth and the fact that an ever increasing share of world population will reach medium to high levels of food consumption. Production growth will mirror growth of demand and thus slowdown. By 2050 annual world agricultural production could be some 60 percent higher than in the base year (2005/07), 77 percent in developing countries and 24 percent in developed countries. Despite the considerable higher production in developing countries, their net imports of temperate products would continue to increase. Their net cereal imports might go up from almost 120 million tons in 2005/07 to nearly 200 million tons in 2050, net imports of milk and dairy products from 19.4 to 25.3 million tons. Their net exports of vegetable oils could increase over the same period from 10.3 to 14.2 million tons, and of sugar from 12 to 21 million tons.

More than ninety percent (over 80 percent in developing countries) of the growth in crop production would be a result of higher yields and increased cropping intensity, with the remainder coming from land expansion. Arable land would expand by some 70 million ha (or less than 5 percent) up to 2050, the expansion of land in developing countries by about 110 million ha (or 11 percent) being offset by a decline of some 40 million ha (or 7 percent) in the developed countries. After 2050 however total arable land in the world would decline from 1660 to 1630 million ha in 2080 when the developed countries will be joined on a declining arable land path by South and East Asia and the Near East / North Africa. Land expansion however would continue to take place above all in sub-Saharan Africa and to a lesser extent so in Latin America.

Land equipped for irrigation would expand by some 22 million ha (7 percent) with virtually no growth anymore after 2050. The harvested irrigated area could expand by some 40 million ha (12 percent) up to 2050 but decline afterwards (the equipped area would not change as the infrastructure is in place, but its utilization – and maintenance - would decline). Nearly all of this increase would be in the developing countries. Mainly (but not only) due to slowly improving water use efficiency, water withdrawals for irrigation would grow at a slower pace but still increase by almost 6 percent (or some 165 cubic km) by 2050. After 2050 water withdrawals would start to decline due to the declining harvested irrigated area but also due to the decline in the harvested rice area which is intensive in water use for flooding paddy fields. The exceptions are sub-Saharan Africa and the Near East / North Africa where water withdrawals would continue to grow (except in some countries where yearly water withdrawals are already exceeding the annual renewable water resources).

Crop yields would continue to grow but at a slower rate than in the past. This process of decelerating growth has already been underway for some time. On average, annual growth over the projection period to 2050 would be about half (0.8 percent) of its historical growth

rate (1.7 percent; 0.9 and 2.1 percent for the developing countries), while after 2050 this could further decline to 0.4 percent p.a. Cereal yield growth could slow down to 0.7 percent per annum to 2050 (0.8 percent in developing countries; 0.4 percent after 2050), and average cereal yield (rice milled) could by 2050 and 2080 reach some 3.94 and 4.45 ton/ha, up from 2.94 ton/ha in 2005/07. Like in the past this declining yield growth seems mainly to mirror the declining growth in demand for (and thus production of) agricultural products, and not to reflect the onset of production constraints (genetic potential) to become binding.

3. European and Central Asian food and nutrition

Total food demand and its composition now and in the future is to a large extent determined by the total size of the population, average per caput income and income distribution and the degree of urbanization. Some of these factors will be discussed in section 3.1 followed by a discussion of overall food demand and its implications for nutrition in section 3.2 and of implied diets in section 3.3.

3.1 Demography and the overall economy

The population data and projections used are those of the United Nations *World Population Prospects-the 2008 Revision* (UN, 2009). For the projections the ones of the Medium variant are used. These imply a rather drastic slowdown in world demographic growth. The world population of 6.6 billion in 2005/07 is projected to grow to 9.15 billion in 2050. The annual growth rate of world population peaked in the 1960s at 2.0 percent p.a. and had fallen to 1.2 percent p.a. in the current decade. Further deceleration will bring it down to just over 0.3 percent towards the end of the projection period (Table 3.1).

Table 3.1 Population: data and projections

	1961/63	2005/07	2030	2050	2005-50	2005-10	2045-50
	million persons				annual growth (% p.a.)		
European Union	411	492	506	494	0.00	0.31	-0.17
Eastern Europe	66	73	65	57	-0.57	-0.52	-0.67
Caucasus and Central Asia	37	75	91	96	0.58	0.93	0.12
Other Europe	12	19	23	26	0.64	1.03	0.36
Russia	123	143	129	116	-0.47	-0.39	-0.51
Turkey	30	72	90	97	0.69	1.24	0.20
Europe and Central Asia	678	874	904	886	0.03	0.27	-0.16
Other developed countries*	337	539	613	641	0.39	0.73	0.16
Developing countries**	2 127	5 179	6 792	7 623	0.89	1.39	0.41
World	3 141	6 592	8 309	9 150	0.75	1.19	0.34

Source: World Population Prospects: The 2008 Revision (UN, 2009; Medium Variant)
* Canada, USA, Japan, New Zealand, Australia, South Africa
** In all tables 'developing countries' excludes Turkey

Europe and Central Asia as a region exhibits almost no demographic growth over the projection period with a slow annual growth at the beginning of the period and a declining population in the second half of the projection period after its population having reached a peak by 2028. As a consequence, its share in world population could fall from over 13 (13.2) percent in 2005/07 to less than 10 (9.7) percent in 2050. Naturally this is the sum result of rather divergent developments in individual countries with Eastern Europe and Russia already at present witnessing a declining population while Turkey and the Caucasus and Central Asia are still experiencing a considerable growth of their populations. Nevertheless towards the

end of the projection period all countries in the region will have a declining or slow growing population with growth rates below or close to the world average (Table 3.1).

The region's population is already strongly urbanized with only some 30 percent of its population classified as 'rural'. According to UN projections (UN, 2010), the share of its urban population in total will continue to increase from some 70 percent at present to over 80 percent by 2050 (Table 3.2). Again there are wide differences among the various countries and sub-regions with the share of rural population in total at present still exceeding 50 percent in Eastern Europe and the Caucasus and Central Asia, but also for these sub-regions a further decline of this share (and by implication a further urbanization) is foreseen over the projection period.

Table 3.2 Rural population: data and projections

	1960	**2005**	**2030**	**2050**	**1960**	**2005**	**2030**	**2050**
	million persons				percent of population			
European Union	143	121	91	65	35	25	18	13
Eastern Europe	51	39	29	19	78	53	44	33
Caucasus and Central Asia	20	41	45	36	55	55	49	38
Other Europe	5	4	3	3	42	19	14	10
Russia	55	39	30	20	45	27	23	17
Turkey	19	23	20	16	65	32	22	16
Europe and Central Asia	294	267	218	159	43	31	24	18
Other developed countries	126	131	105	78	37	24	17	12
Developing countries	1605	2948	3086	2627	75	57	45	34
World	2026	3346	3409	2864	64	51	41	31

Source: World Urbanization Prospects: The 2009 Revision (UN, 2010)

A small digression might be in order here to show some (unpublished) projections for the agricultural labour force (made by FAO' Statistics Division based on the UN projections for rural population). They imply an even faster decline for the agricultural labour force than for the rural population with the labour force declining from about 50 million persons (or 17 percent of the rural population) at present to only some 15 million persons (4 percent) by 2050. Although these projections should be interpreted with care (they were not officially released by FAO), they clearly show that the number of persons dependent on (primary) agriculture in the region is a very small and declining fraction of the total population (again with considerable differences among individual countries).

Table 3.3 (provisional) Agricultural labour force projections

	1961/63	2005/07	2030	2050	1960-2005	2005-50	2005-10	2045-50
	million persons				annual growth (%)			
European Union	47.5	12.9	5.1	2.4	-2.8	-3.8	-3.4	-3.6
Eastern Europe	18.1	5.6	2.2	1.0	-2.5	-3.8	-3.2	-4.1
Caucasus and Central Asia	6.8	7.8	6.0	3.8	0.6	-1.6	0.0	-2.7
Other Europe	0.7	0.3	0.2	0.1	-1.5	-1.9	-2.2	-1.4
Russia	16.5	7.1	3.2	1.6	-1.6	-3.4	-2.6	-3.6
Turkey	11.2	15.2	11.4	6.4	0.8	-2.0	0.2	-3.3
Europe and Central Asia	100.7	48.8	28.2	15.3	-1.5	-2.6	-1.6	-3.3
Other developed countries	22.8	7.2	3.5	2.1	-2.5	-2.8	-3.1	-2.3
Developing countries	735	1321	1348	1198	1.4	-0.2	0.6	-0.8
World	858	1377	1380	1215	1.2	-0.3	0.5	-0.8

Source: FAO Statistics Division, 2009 (unpublished material)

GDP projections for the main study (WA21) were provided by the Development Prospects Group of the World Bank (again this is unpublished material). They show for the region annual GDP growth rates lower than those for the world as a whole (and the developing countries) although, due to differing population growth rates the growth rates for per caput income are close to world averages (Table 3.4). The outcome for Europe and Central Asia is however heavily influenced by developments in the European Union (EU) which alone at present accounts for 86 percent of the regions' GDP. Per caput income in the EU at present is a multiple of per caput income in the other sub-regions (with the exception of 'Other Europe'). Much higher GDP growth rates are foreseen for those sub-regions which are still lagging behind in overall economic development so that their per caput income could by 2050 almost quadruple while for the EU an 'only' 60 percent increase is projected. Due to the higher GDP growth projected for the developing countries, the share of the region in world GDP could decline from 35 percent in 2005/07 (31 percent for the EU alone) to 27 percent in 2050 (20 percent for the EU). Total world GDP would by 2050 be almost two and a half times world GDP in 2005/07.

Table 3.4 GDP projections

annual growth (%)	GDP		GDP per caput	
	2005/07-30	2030-50	2005/07-30	2030-50
European Union	1.3	0.8	1.2	0.9
Eastern Europe	3.3	1.8	3.8	2.4
Caucasus and Central Asia	5.1	2.6	4.2	2.3
Other Europe	1.5	1.4	0.7	0.9
Russia	3.9	1.3	4.4	1.8
Turkey	4.7	2.7	3.7	2.3
Europe and Central Asia	1.7	1.1	1.5	1.2
Other developed countries	1.5	1.2	0.9	0.9
Developing countries	4.5	2.5	3.3	1.9
World	2.4	1.7	1.4	1.2

Source: World Bank, 2010 (personal communication from the Development Prospects Group)

3.2 The outlook for food and nutrition to 2030 and 2050

Food consumption in terms of kcal per person per day is a key variable for tracking and projecting developments in food security. It is a summary measure of the dietary energy content of the 28 individual food commodities for which projections were made (see the discussion in section 3.3). Nearly all countries in the region had by 2005/07 already reached comfortably high levels of Daily Energy Supply (DES) with the exception of a few countries in the Caucasus and Central Asia (in particular Tajikistan and Armenia)[4]. The food demand projections for the region's countries therefore foresee only a slow further increase in the DES, on average for Europe and Central Asia an additional 160 kcal from 3340 kcal in 2005/07 to 3500 kcal by 2050 (Table 3.5).

[4] The 1990s witnessed a fall in the average DES (Table 3.5) due to the contraction of the economies and agricultural sectors in the transition countries after the collapse of the ex-Soviet Union. By 2005/07 most of these countries were back to the levels of the early 1990s.

Table 3.5 Per caput food consumption (kcal/person/day)

	1961 /1963	1969 /1971	1979 /1981	1989 /1991	1999 /2001	2005 /2007	2030	2050
European Union*					3438	3462	3531	3572
Eastern Europe*					2844	3085	3330	3425
Caucasus and Central Asia*					2349	2745	2983	3122
Other Europe	3234	3275	3338	3327	3405	3469	3475	3497
Russia*					2930	3271	3403	3500
Turkey	2881	3014	3223	3600	3454	3482	3520	3525
Europe and Central Asia	3077	3236	3325	3350	3206	3338	3441	3497
Other developed countries	2772	2929	3024	3213	3356	3414	3440	3478
Developing countries	1870	2042	2222	2412	2559	2607	2848	2989
World	2231	2373	2497	2633	2719	2772	2957	3073

* no FAOSTAT data are available for individual USSR countries for the period 1961 to 1991.

Estimates of chronic under-nourishment show a fairly low incidence in most countries with the exception of the Caucasus and Central Asia and even for these countries the projections foresee a rapid decline in undernourishment (Table 3.6). In most European countries at present or in the near future one encounters a situation which on could define as one of "zero hunger"[5].

Table 3.6 Prevalence of under- and over-nourishment

	undernourishment						obesity					
	percent of population			persons (million)			percent of population			persons (million)		
	2005 /07	2030	2050	2005 /07	2030	2050	2005 /07	2030	2050	2005 /07	2030	2050
European Union	0.3	0.2	0.1	1.6	0.9	0.7	15.0	17.2	18.7	73.7	86.9	92.3
Eastern Europe	1.8	0.4	0.2	1.5	0.3	0.1	20.0	31.3	36.5	16.8	23.6	24.4
Caucasus and Central Asia	5.7	1.9	0.9	4.3	1.7	0.8	8.7	14.7	20.0	6.5	13.4	19.2
Other Europe	0.3	0.2	0.2	0.1	0.1	0.1	13.9	14.7	15.5	2.7	3.4	3.9
Russia	1.2	0.5	0.2	1.7	0.6	0.2	16.0	20.1	23.7	22.8	25.9	27.5
Turkey	1.6	1.5	1.4	1.1	1.3	1.3	16.1	17.0	17.1	11.6	15.3	16.6
Europe and Central Asia	1.2	0.5	0.4	10.2	4.9	3.2	15.2	18.4	20.5	134	169	184
Other developed countries	1.2	0.7	0.5	6.7	4.5	3.2	24.3	24.5	25.7	131	150	165
Developing countries	16.1	8.0	4.2	828	541	316	5.9	9.7	13.8	304	651	1046
World	12.9	6.7	3.5	844	551	323	8.7	11.7	15.3	569	970	1394

Notes: undernourishment for 2005/07 from SOFI 2010 (FAO, 2010); obesity is defined as BMI>30; obesity data for 2005/07 are from the WHO, OECD and the International Obesity Task Force (IOTF).

The fairly high levels of daily energy supply and further increases herein are not always an unmixed blessing as the diet transitions experienced by many countries imply changes in diets towards energy-dense ones high in fat, particularly saturated fat, sugar and salt and low in unrefined carbohydrates. In combination with lifestyle changes, largely associated with rapid urbanization, such transitions, while beneficent in many countries with still inadequate diets,

[5] Schmidhuber and Bruinsma (2011) define 'zero hunger' as: "For practical purposes the assumption is made that a country has reached a state of "zero hunger" when less than three percent of its population are chronically undernourished. A further reduction of undernourishment below this level is difficult to achieve and is often a matter of focusing more on empowering people or providing improved health care systems rather than one of promoting agricultural development. Even in developed countries pockets of poverty and undernourishment exist amid affluence and advanced social security systems."

are often accompanied by increases in the prevalence of obesity[6] and a corresponding increase in diet-related chronic Non-Communicable Diseases (NCDs).

WHO (2003) recommends for the diets of individuals that the calorie contribution from proteins be between 15 and 30 percent and the calorie contribution from fats be below 30 percent of the total daily energy intake. In the base year the calorie contribution from fats to the daily energy supply (DES) in the European Union and in the 'other European' countries exceeded the 30 percent with countries in the other sub-regions being close to this norm. These are estimates for national averages which means that, given the distribution of food consumption over the population, there will be many persons in the population with a fat consumption far exceeding this 30-percent norm[7].

Table 3.6 presents estimates of the prevalence of obesity taking into account data for obesity (for 2005/07 or nearest year) from the WHO, the OECD and the International Obesity Task Force (IOTF). These (assembled) data show that at present (i.e. 2005/07) some 15 percent of the region's population (or 134 million persons) could be obese (dwarfing the number of under-nourished persons in the region, some 10 million). Provisional projections for obesity[8] show a steady increase in the prevalence of obesity to some 20 percent of the region's population by 2050 (some 185 million persons), with the incidence being particularly severe in Eastern Europe while also the Caucasus and Central Asia could experience a rapid shift of nutritional problems from under- to over-nourishment.

3.3 The commodity composition of food consumption by 2030 and 2050

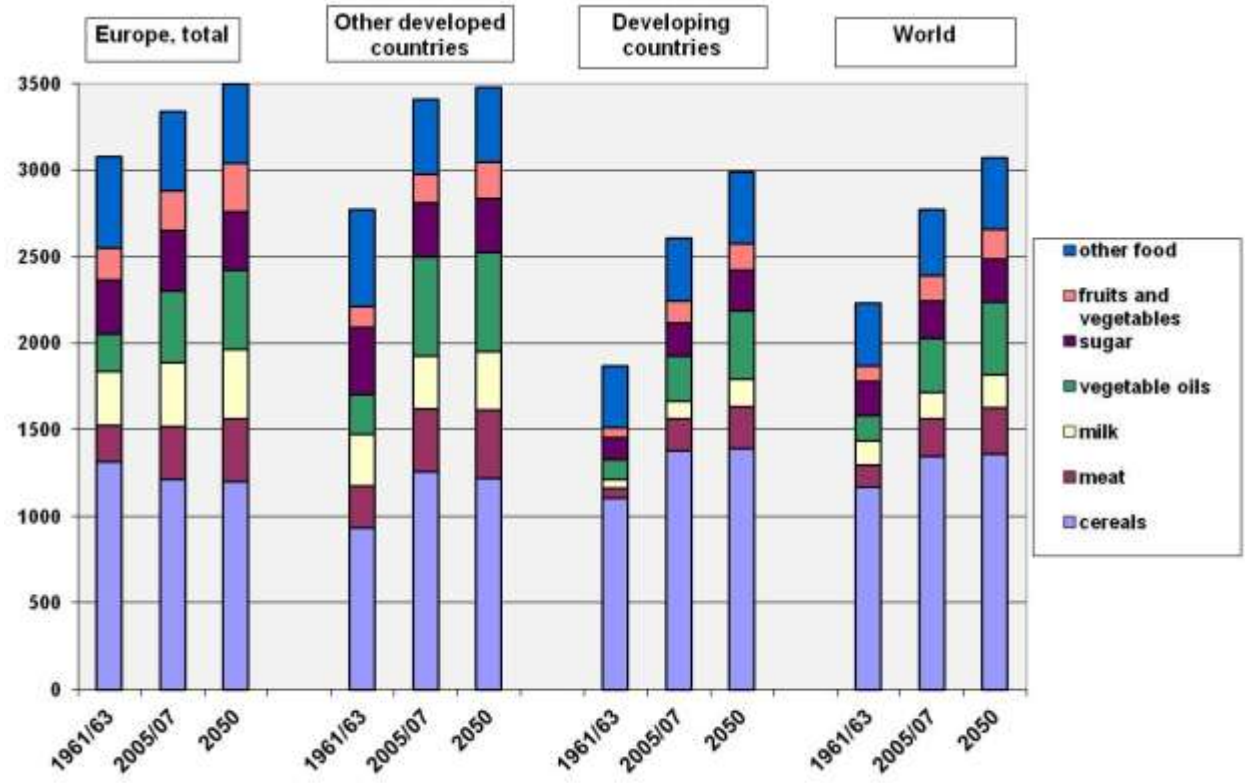
In many the region's countries, the transition of the food commodity composition to diets more typical of affluent societies was completed by 2005/07. This transition consisted of a shift away from basic foodstuffs (in particular cereals) to higher value commodities such as meat, milk and dairy products, vegetable oils and fruits and vegetables (Figure 3.1). The food demand projections to 2030 and 2050 therefore foresee only marginal further shifts in the food commodity composition (Tables 3.7 and 3.8). Per caput direct food consumption of cereals (foremost among them wheat) could remain constant or fall slightly, and the contribution of cereals to total DES (36 percent at present) could decline marginally. Per caput consumption of meat, milk and vegetable oils (34 percent of total DES) could still increase somewhat.

[6] A person is called obese if his/her Body Mass Index (BMI) exceeds a value of 30.

[7] This assumes that the ratio of fats in DES is equal to the ratio of fats in energy intake (i.e. intake = supply).

[8] Assuming the same calorie distribution as used to calculate the number of under-nourished persons, and using the derived implicit calorie threshold for the base year (2005/07) above which persons are assumed to be obese. N.B. this method is far from perfect and has not been cleared by FAO but it gives an indication of orders of magnitude and possible changes.

Figure 3.1 Average calorie supply of the main food commodities



These general statements concerning the composition of food demand commodities hold in particular for the 31 countries of the European Union and the countries in the group 'other Europe' which together account for nearly 60 percent of the region's population. Within the region however there are considerable differences among countries. The Caucasus and Central Asia, Eastern Europe, Turkey and Russia still have ample room for further changes in their diets. Cereals for example still account for well over half (54 percent) of the calorie supply in the Caucasus and Central Asia and nearly half of the calorie supply in Turkey (in spite of the fact that Turkey has a very high overall calorie supply, 3480 kcal according to the FAO Food Balance Sheets), and relatively low levels of meat and/or milk consumption. Consequently, the food demand projections for these countries see a further decline in per caput consumption of cereals and further sizeable increases in the consumption of meat, milk and vegetable oils (Table 3.8).

Table 3.7 Per capita food demand

	1961 /1963	1969 /1971	1979 /1981	1989 /1991	1999 /2001	2005 /2007	2030	2050	2005 /2007	2030	2050
	kg / capita / year								kcal / person / day		
	Europe total										
Population (million)	688	744	803	854	877	891	924	906			
Cereals, food	179	169	165	162	158	165	164	162	1213	1211	1205
of which wheat	135	127	125	127	121	124	122	119	933	911	894
Vegetable oils, oilseeds and products (oil eq.)	9	11	12	14	15	17	18	19	418	447	457
Sugar (raw sugar eq.)	32	39	41	39	36	35	35	34	346	339	337
Meat (carcass weight)	46	55	67	73	62	66	74	78	306	339	359
Milk and dairy, excl. butter (fresh milk eq.)	174	192	204	204	197	207	220	228	369	393	405
Other food (kcal/person/day)									686	712	734
Total food (kcal/person/day)	3077	3236	3325	3350	3206	3338	3441	3497	3338	3441	3497
	Other developed countries										
Population (million)	337	374	418	463	513	539	613	641			
Cereals, food	133	132	146	172	180	179	177	177	1260	1235	1221
of which wheat	61	60	63	68	74	73	71	70	539	527	516
Vegetable oils, oilseeds and products (oil eq.)	10	13	17	19	22	24	24	24	572	574	573
Sugar (raw sugar eq.)	38	43	37	30	29	30	30	30	310	306	311
Meat (carcass weight)	63	75	80	85	92	96	99	102	363	380	394
Milk and dairy, excl. butter (fresh milk eq.)	180	178	175	186	185	185	195	203	308	324	337
Other food (kcal/person/day)									601	621	642
Total food (kcal/person/day)	2772	2929	3024	3213	3356	3414	3440	3478	3414	3440	3478
	Developing countries										
Population (million)	2110	2561	3209	3962	4711	5146	6748	7574			
Cereals, food	124	139	151	159	156	154	158	158	1383	1404	1392
of which wheat	29	38	52	58	59	57	58	59	472	480	481
Vegetable oils, oilseeds and products (oil eq.)	4	5	6	8	9	10	13	15	261	340	398
Sugar (raw sugar eq.)	13	15	17	18	19	19	22	24	186	213	235
Meat (carcass weight)	9	11	14	18	26	28	36	42	183	222	245
Milk and dairy, excl. butter (fresh milk eq.)	26	27	32	36	44	51	65	75	104	134	156
Other food (kcal/person/day)									490	535	563
Total food (kcal/person/day)	1870	2042	2222	2412	2559	2607	2848	2989	2607	2848	2989
	World										
Population (million)	3133	3676	4426	5275	6095	6569	8276	9111			
Cereals, food	137	144	153	161	158	158	160	160	1350	1370	1362
of which wheat	56	58	67	70	69	67	66	65	540	531	524
Vegetable oils, oilseeds and products (oil eq.)	6	7	8	10	11	12	14	16	307	369	416
Sugar (raw sugar eq.)	20	22	23	23	23	22	24	25	218	234	250
Meat (carcass weight)	23	26	30	33	37	39	45	49	214	247	267
Milk and dairy, excl. butter (fresh milk eq.)	75	76	77	77	78	83	92	99	157	177	194
Other food (kcal/person/day)									526	560	584
Total food (kcal/person/day)	2231	2373	2497	2633	2719	2772	2957	3073	2772	2957	3073

Table 3.8 Per capita food demand by sub-region

	1969 /1971	1979 /1981	1989 /1991	1999 /2001	2005 /2007	2030	2050	2005 /2007	2030	2050
	kg / capita / year							kcal / person / day		
	European Union									
Population (million)				482	492	506	494			
Cereals, food				144	148	148	148	1086	1090	1092
of which wheat				104	107	105	103	792	777	762
Vegetable oils, oilseeds and products (oil eq.)				19	19	20	20	478	493	493
Sugar (raw sugar eq.)				36	36	35	35	352	347	347
Meat (carcass weight)				83	83	87	90	379	399	410
Milk and dairy, excl. butter (fresh milk eq.)				234	240	250	255	419	437	446
Other food (kcal/person/day)								748	765	784
Total food (kcal/person/day)				3438	3462	3531	3572	3462	3531	3572
	Eastern Europe									
Population (million)				87	84	75	67			
Cereals, food				162	166	170	167	1184	1219	1195
of which wheat				110	103	105	103	790	802	786
Vegetable oils, oilseeds and products (oil eq.)				9	13	14	16	308	343	379
Sugar (raw sugar eq.)				35	39	40	38	385	392	372
Meat (carcass weight)				40	47	61	72	232	296	342
Milk and dairy, excl. butter (fresh milk eq.)				163	179	215	230	318	382	409
Other food (kcal/person/day)								658	698	728
Total food (kcal/person/day)				2844	3085	3330	3425	3085	3330	3425
	Caucasus and Central Asia									
Population (million)				71	75	91	96			
Cereals, food				173	200	205	201	1494	1533	1503
of which wheat				156	178	180	175	1329	1343	1305
Vegetable oils, oilseeds and products (oil eq.)				8	9	11	12	227	268	292
Sugar (raw sugar eq.)				17	18	20	22	175	194	222
Meat (carcass weight)				25	32	42	50	184	230	265
Milk and dairy, excl. butter (fresh milk eq.)				142	160	180	200	286	322	358
Other food (kcal/person/day)								379	436	482
Total food (kcal/person/day)				2349	2745	2983	3122	2745	2983	3122
	Other Europe									
Population (million)	13	14	16	18	19	23	26			
Cereals, food	126	131	140	139	139	139	136	1014	1019	1001
of which wheat	98	99	98	101	102	99	94	767	742	707
Vegetable oils, oilseeds and products (oil eq.)	14	15	16	18	21	23	23	515	560	567
Sugar (raw sugar eq.)	46	42	41	47	41	33	32	405	325	314
Meat (carcass weight)	59	67	67	71	80	88	92	423	468	488
Milk and dairy, excl. butter (fresh milk eq.)	255	288	280	258	252	256	258	389	393	394
Other food (kcal/person/day)								723	710	733
Total food (kcal/person/day)	3275	3338	3327	3405	3469	3475	3497	3469	3475	3497

	1969 /1971	1979 /1981	1989 /1991	1999 /2001	2005 /2007	2030	2050	2005 /2007	2030	2050
	kg / capita / year							kcal/person/day		
	Russia									
Population (million)				147	143	129	116			
Cereals, food				163	178	164	163	1312	1210	1201
of which wheat				133	139	120	116	1071	927	898
Vegetable oils, oilseeds and products (oil eq.)				10	12	14	15	295	345	368
Sugar (raw sugar eq.)				47	44	45	45	430	437	437
Meat (carcass weight)				41	55	75	84	246	325	363
Milk and dairy, excl. butter (fresh milk eq.)				151	164	186	194	333	378	393
Other food (kcal/person/day)								655	708	738
Total food (kcal/person/day)				2930	3271	3403	3500	3271	3403	3500
	Turkey									
Population (million)	36	46	56	66	72	90	97			
Cereals, food	213	223	239	227	220	212	205	1683	1620	1566
of which wheat	177	197	211	200	189	179	171	1429	1351	1287
Vegetable oils, oilseeds and products (oil eq.)	10	13	18	18	21	22	22	519	542	541
Sugar (raw sugar eq.)	18	25	30	28	27	28	28	267	273	273
Meat (carcass weight)	15	15	21	20	23	33	40	91	127	153
Milk and dairy, excl. butter (fresh milk eq.)	160	167	142	120	135	141	149	253	265	280
Other food (kcal/person/day)								669	693	712
Total food (kcal/person/day)	3014	3223	3600	3454	3482	3520	3525	3482	3520	3525

4. Prospects for European and Central Asian agricultural production and trade

This Chapter deals with the trends and future outlook of world food and agriculture in terms of the main commodity sectors. A brief introduction to the subject is given first presenting trends and prospects for total agriculture (the aggregates of all crops and livestock products).

4.1 Prospects for aggregate agriculture

FAO (2012) states that "the historical evidence suggests that the growth of the productive potential of global agriculture has been sufficient to meet the growth of effective demand up to quite recently and before the emergence of biofuels as additional demand. This is what is suggested by the long-term term decline in the real price of food up to the mid-1980s and the near constancy afterwards up to about 2005. In practice, world agriculture had been operating for several decades in a demand-constrained environment"[9]. This certainly holds for the European and Central Asian region. Limits on the demand side reflected (a) the slowdown in population growth, and (b) the fact that a growing share of the regions' population has been attaining fairly high levels of per capita food consumption, beyond which the scope for further increases is rather limited. For example, average DES in the European Union, Other Europe and Turkey in 2005/07 exceeded already 3450 kcal (Table 3.5). As explained in the preceding chapter, these two factors will continue to operate also in the future, and annual growth in both per caput and total demand therefore will continue to slowdown (Table 4.1).

Two other factors might have an impact on developments in total demand for and production of agricultural products of the region, namely additional demand for biomass to be used as feedstock in biofuel production and developments in the rest of the world and policies affecting the net trade of the region, e.g. additional demand from the rest-of-the-world for the region's agricultural exports or policies impacting on imports, e.g. changes in the sugar regime or the EBA (Everything-But-Arms) initiative. Concerning biofuels, in 2009 in the European Union already some 9 million tons of vegetable oils (mainly rapeseed oil) are used

[9] The food price surges of recent years have created concerns that the world is facing a fundamental break from this long-term trend. In-depth analysis however shows that this increase in internationally traded food prices was caused by a confluence of factors, the most important one being the large increase in biofuels production from grains and oilseeds in the U.S. and EU.

Alexandratos (2008) states that "Frequent, and often uncritical, reference was made to the increases in the demand for food in the emerging countries, particularly China and India, as the dominant factor behind what was perceived to be a shock on the demand side. Use of crops for biofuels was listed as an additional, though not as important, factor. Yet global cereals utilization without biofuels has been growing at slowly decelerating rates, as in the past. However, the addition of biofuels resulted in its growing faster than in the past. In parallel, global production had been falling behind utilization for several years leading to declining stocks. Weather shocks, depreciation of the dollar and turbulence in the financial markets were added to these fundamentals of the demand-supply balance to generate the price surges. If energy prices continued to be high and/or rising and probiofuel policies remained in place, the diversion of crops to biofuels could continue. This could prevent the current commodity cycle from unfolding in the "normal" way over the short- to medium-term and prices trending back towards their pre-surge levels".

Mitchell (2008) concludes that "the most important factor was the large increase in biofuels production in the U.S. and the EU. Without these increases, global wheat and maize stocks would not have declined appreciably, oilseed prices would not have tripled, and price increases due to other factors, such as droughts, would have been more moderate. Recent export bans and speculative activities would probably not have occurred because they were largely responses to rising prices".

for the production of biodiesel and an equal amount of cereals for ethanol. As explained in the Introduction to this paper, given the uncertainties surrounding future developments in (and the economic viability of) the use of biofuels, in the WA21 baseline projections some expansion of biofuels was assumed up to 2020 (as given in FAO/OECD, 2010) and no further increases were assumed for subsequent projection years (i.e. biofuel demand was kept constant at its 2020 level). Additional demand for the region's agricultural exports will have an impact on the region's agricultural production growth. These issues will be discussed below but mention might be made here of the fairly strong increase foreseen for the region's cereal exports (mainly from Russia and Ukraine).

Tables 4.1 and 4.2 below present some summary results for increases of aggregate (domestic) demand for and production of agricultural products. The figures refer to the aggregate volumes of demand, production and trade of the 26 crop and 6 livestock commodities covered in WA21 (see Annex I). They are obtained by multiplying physical quantities of demand or production times price for each commodity and summing up over all commodities (each commodity is valued at the same average international price in all countries in all years). The resulting aggregate values at constant prices measure changes in volume of demand and production. Since the commodities included are very diverse from the standpoint of what determines their production, demand and trade, subsequent sections will discuss prospects in terms of some main commodity sectors such as cereals, livestock products, vegetable oils and sugar.

The overall result for the region is a slowdown in the annual growth of total (domestic) demand[10] for agricultural products, from 0.6 percent p.a. for the (46-year period) 1961-2007 to 0.4 percent p.a. for the (44-year period) from 2005/07 to 2050. This is well below the annual growth rates for the world as a whole (resp. 2.3 and 1.1 percent) and the ones for the 'other developed countries' and the developing countries (Table 4.1).

Again there are substantial differences between individual countries and sub-regions. For the European Union only very slow annual growth is projected for the increase in per caput demand (0.3 percent) which about equals the growth in total demand due to next to zero population growth. For "Other Europe' and Turkey, total demand is almost entirely determined by food demand and due to the high levels already attained, the projected annual per caput demand growth is very low (between 0.1 and 0.2 percent) but annual total demand growth is double that for Europe as a whole (0.8 percent) due to a much higher population growth. In Eastern Europe and Russia the situation is the reverse: 0.7 percent p.a. per caput growth and 0.2 percent total demand growth due to a declining population.

[10] Domestic demand (also termed domestic disappearance) = food + feed + industrial use + biofuel use + seed + waste (from farm gate to retail shop).

Table 4.1 Annual growth rates (%) of production and demand

	1961-2007	1970-2007	1980-2007	1990-2007	2000-2007	2005/07-2050	2005/07-2030	2030-2050
	total demand (all uses)							
European Union					0.66	0.29	0.49	0.05
Eastern Europe					1.68	0.17	0.29	0.02
Caucasus and Central Asia					5.09	1.08	1.32	0.79
Other Europe	1.18	1.06	1.02	1.17	1.05	0.82	1.00	0.61
Russia					2.36	0.18	0.42	-0.10
Turkey	2.47	2.37	2.09	1.80	1.80	0.82	1.03	0.57
Europe and Central Asia	0.63	0.21	-0.17	0.07	1.29	0.39	0.58	0.15
Other developed countries	1.47	1.38	1.32	1.23	1.06	0.62	0.80	0.40
Developing countries	3.53	3.61	3.61	3.59	2.97	1.35	1.69	0.95
World	2.25	2.19	2.15	2.31	2.33	1.08	1.35	0.75
	total demand (all uses) per capita							
European Union					0.29	0.28	0.38	0.17
Eastern Europe					2.25	0.69	0.75	0.62
Caucasus and Central Asia					4.24	0.51	0.50	0.52
Other Europe	0.09	-0.01	-0.18	-0.06	-0.05	0.18	0.21	0.15
Russia					2.85	0.65	0.84	0.42
Turkey	0.41	0.46	0.37	0.22	0.45	0.13	0.08	0.20
Europe and Central Asia	0.05	-0.28	-0.55	-0.17	1.01	0.35	0.43	0.25
Other developed countries	0.40	0.34	0.31	0.28	0.24	0.22	0.26	0.18
Developing countries	1.43	1.62	1.76	1.94	1.48	0.47	0.54	0.37
World	0.53	0.55	0.62	0.94	1.07	0.33	0.38	0.27
	total production							
European Union					-0.48	0.23	0.39	0.03
Eastern Europe					1.82	0.33	0.48	0.15
Caucasus and Central Asia					4.74	0.95	1.12	0.74
Other Europe	0.94	0.67	0.33	0.38	0.40	0.82	0.96	0.66
Russia					1.88	0.58	1.00	0.08
Turkey	2.28	2.07	1.67	1.35	1.15	0.84	1.07	0.57
Europe and Central Asia	0.62	0.15	-0.35	-0.31	0.47	0.41	0.60	0.17
Other developed countries	1.50	1.39	1.34	1.31	0.72	0.65	0.86	0.40
Developing countries	3.38	3.49	3.57	3.51	3.23	1.32	1.62	0.96
World	2.21	2.15	2.11	2.21	2.26	1.07	1.33	0.76

Taking into account projected imports and exports (or more correctly, net trade[11]), projections were made for production (by commodity). Annual growth rates for overall agricultural production are given in Table 4.1. They normally closely follow the growth rates for total demand but when in cases where increasing imports are foreseen, they are lower, e.g. for the European Union, and the reverse where increasing exports are expected (e.g. for Russia).

The resulting absolute increments by 2050 in overall (annual) agricultural production are presented in Table 4.2. They show that the total value of annual European and Central Asian agricultural production in 2050 could be some 20 percent over 2005/07 levels compared with some 60 percent for the world as a whole and some 80 percent in the developing countries. The increase would be 'only' 10 percent in the European Union, but 30 percent in Russia and 50 percent in the Caucasus and Central Asia. Due to the projected faster growth in the rest-of-

[11] Production equals domestic demand + exports – imports. In the WA21 study projections focused on demand and production for each country with the difference between the two determining net trade (= exports – imports). No separate projections were made for exports and imports for the same country.

the-world, the share of the region's agriculture in world agriculture would decline from a fifth (20.2 percent) in 2005/07 to 15.1 percent in 2050 (from 12.4 to 8.6 percent for the European Union).

Table 4.2 Increments in production

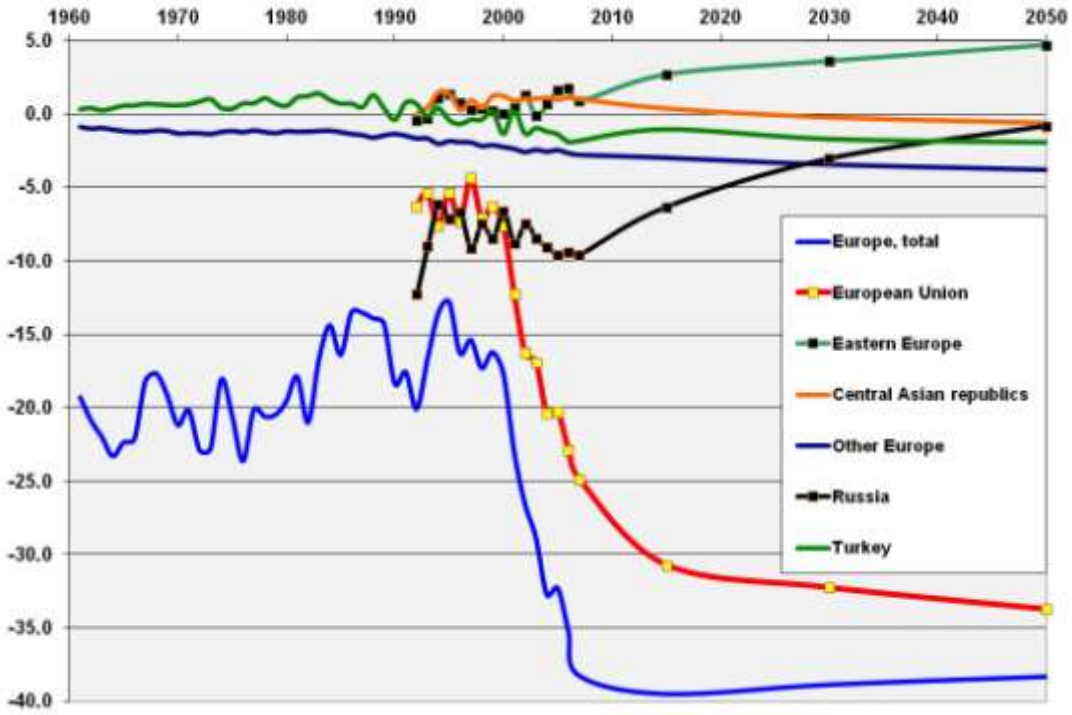
	2050 production index	share (%) in world production	
	(2005/07 = 100)	2005/07	2050
European Union	110	12.4	8.6
Eastern Europe	116	1.9	1.4
Caucasus and Central Asia	151	1.4	1.3
Other Europe	144	0.3	0.3
Russia	129	2.5	2.0
Turkey	144	1.6	1.4
Europe and Central Asia	119	20.1	15.0
Other developed countries	133	14.6	12.2
Developing countries	178	65.3	72.8
World	160	100.0	100.0

The estimates above refer to total agricultural production which is made up of production projections for individual commodities developments in which can for various reasons differ widely from each other. For example, while for the region as a whole the increase for total agricultural production (in value terms) could be 20 percent by 2050, oilseed production (in tons of oil equivalent) is projected to increase by 62 percent. Likewise, wheat and maize production are projected to rise by 32 and 35 percent respectively and poultry production by 47 percent, while no increase is foreseen for potato production and while sugar production could actually fall by some 8 percent (mainly in the European Union offset by higher sugar imports – see below).

The difference between developments in production and (domestic) demand is determined by developments in net trade. The region as a whole was a net importer of agricultural products (Figure 4.1[12]) and is expected to remain so over the projection period although it could show a marginal improvement in its importer status. The overall situation is heavily dominated by the net trade position of the European Union which recently considerably increased its net imports which are expected to rise even further in the future (mainly imports of vegetable oils and oilseeds and sugar). Within the region these increased (EU) imports would (in value terms) be offset by projected increased cereal exports from Russia and Eastern Europe.

[12] The net trade is measured in 2004/06 International Commodity Prices expressed in notional dollars not comparable to US dollars. The numbers given in Figure 4.1 therefore can not be compared with the actual dollar value of net trade, but permit comparison of volumes and changes among countries and over time.

Figure 4.1 Net agricultural trade (in billion 2004/06 ICP$)



4.2 Cereals

FAO (2012) shows that the long-term decline in the growth of global demand for cereals (mainly as a consequence of a decelerating population growth and of the fact that an ever-increasing share of the world population is reaching medium to high levels of food consumption) will most likely continue well into the future. Nearly all further increases in cereal consumption will take place in the developing countries.

In fact as seen in the preceding chapter (Table 3.8) no further increase or even a slight decline is foreseen for the direct per caput food use of cereals in all European sub-regions. Overall food use in the region is expected to remain stable over the projection period at a level of around 150 million tons (Table 4.3). It is still expected to increase in Turkey and the Caucasus and Central Asia (mainly due to population growth) but this would be offset by declines in Eastern Europe and Russia (again mainly on account of projected population decline).

Nevertheless the projections suggest a 27 percent increase (or some 130 million tons) in the region, most of this increase taking place in the first half of the projection period (i.e. up to 2030; see Table 4.3). What are the factors leading to this increase?

First of all there is the expected increase (some 28 million tons) in the use of cereals as feedstock in biofuel production, exclusively in the European Union. This would reach by 2020 some 16 million tons of wheat and 15 million tons of coarse grains. As explained earlier, this study does not take into account possible further increases of cereals in biofuel production after 2020.

Table 4.3 Cereal projections

	1961/ 1963	1979/ 1981	1989/ 1991	1999/ 2001	2005/ 2007	2030	2050	1992- 2007	2005/07- 2030	2030- 2050
	million tonnes							annual growth (%)		
	Europe and Central Asia									
Food	123	133	138	138	146	150	146	0.51	0.13	-0.13
Feed	131	295	290	234	247	274	282	0.35	0.43	0.16
Total demand	305	499	510	430	458	524	530	0.33	0.57	0.07
Production	280	431	505	451	471	576	600	0.40	0.85	0.20
Net trade	-28	-53	-12	21	28	52	69			
Self sufficiency (%)	92	86	99	105	103	110	113			
	Other developed countries									
Food	45	61	80	92	97	108	113	0.94	0.49	0.21
Feed	127	175	191	217	213	234	247	0.40	0.39	0.28
Total demand	184	253	297	347	374	497	516	1.28	1.20	0.18
Production	226	388	387	438	467	612	641	0.99	1.13	0.23
Net trade	47	123	104	93	91	114	125			
Self sufficiency (%)	122	153	130	126	125	123	124			
	Developing countries									
Food	261	486	631	736	794	1065	1195	1.32	1.23	0.58
Feed	43	129	165	249	282	455	579	2.45	2.01	1.22
Total demand	349	689	891	1111	1228	1698	1962	1.76	1.36	0.73
Production	338	624	840	995	1131	1532	1768	1.57	1.27	0.72
Net trade	-19	-74	-86	-112	-118	-165	-193			
Self sufficiency (%)	97	91	94	90	92	90	90			
	World									
Food	428	678	848	965	1036	1324	1454	1.17	1.03	0.47
Feed	301	599	645	698	742	962	1109	1.08	1.09	0.71
Total demand	837	1438	1695	1884	2060	2719	3008	1.32	1.16	0.51
Production	843	1442	1732	1884	2068	2720	3009	1.15	1.15	0.51
Net trade	1	-4	6	3	1	1	1			
Self sufficiency (%)	101	100	102	100	100	100	100			

A second factor driving to additional demand for cereals is the use of cereals in concentrate feeds for which a 14 percent (35 million tons) increase is foreseen over the projection period. Feed use of cereals already constitutes the single most important category of cereal use (54 percent of total use) and by 2050 feed use of cereals would be almost twice as much as direct food use of cereals. Of course, there are differences in the feed use developments among the sub-regions with virtually no further increase foreseen for the European Union (at present good for 68 percent of all cereal feed use in the region) where an additional source of feedstuffs might be the by-products of biofuel production, and with all the other sub-regions and countries accounting for the increase in the region's feed use of cereals. Naturally this is directly linked to livestock production (see the next section).

The third factor driving the increase in the region's cereal production is the expected increase in the region's cereal exports to the rest of the world (mainly developing countries). As explained in FAO (2012), net cereal imports of the developing countries (excl. Turkey) could increase by almost two-thirds from 118 million tons in 2005/07 to over 193 million tons by 2050 Table 4.4). Although North America (USA and Canada) would remain the largest cereal exporting region with net cereal exports going up from 101 million tons in 2005/07 to 119 million tons by 2050, over half (42 million tons) of the net additional exports to developing countries could be provided by the Europe so that its net trade in cereals could

reach nearly 70 million tons by 2050 (of which net exports of wheat and barley would reach around 60 and 20 million ton respectively in part offset by net imports of maize and rice for over 10 million tons), with the other developed countries (mainly Canada, USA and Australia) providing the remaining 34 million tons of the increase in developing countries' net cereal imports.

Table 4.4 Net trade balances for wheat, coarse grains and total cereals

	1961/ 1963	1969/ 1971	1979/ 1981	1989/ 1991	1999/ 2001	2005/ 2007	2030	2050
	wheat (million tonnes)							
European Union					15.2	9.1	7.6	11.9
Eastern Europe					0.8	3.3	13.5	16.0
Caucasus and Central Asia					0.9	1.0	1.2	2.0
Other Europe	-1.0	-1.2	-1.2	-1.2	-2.2	-2.2	-3.1	-3.4
Russia					-2.0	10.8	25.9	32.2
Turkey	-0.8	-0.8	0.5	-0.1	1.1	1.8	0.9	1.3
Europe and Central Asia	-11.3	-4.3	-9.3	4.8	13.7	23.8	46.0	60.0
Other developed countries	31.6	30.5	59.8	56.1	54.3	53.1	58.0	62.8
Developing countries	-20.4	-29.8	-56.4	-59.8	-64.5	-68.8	-95.9	-114.6
	coarse grains (million tonnes)							
European Union					12.2	1.8	4.6	5.8
Eastern Europe					0.7	5.7	11.3	14.0
Caucasus and Central Asia					0.4	0.0	-0.1	0.1
Other Europe	-1.3	-2.1	-2.6	-2.2	-2.3	-2.4	-3.2	-3.7
Russia					-1.2	0.9	0.0	0.8
Turkey	0.0	0.0	0.2	-0.3	-0.7	-0.1	-3.2	-3.8
Europe and Central Asia	-15.5	-18.4	-42.5	-14.9	9.1	5.9	9.3	13.2
Other developed countries	15.2	12.8	60.3	45.2	37.4	37.1	54.9	60.8
Developing countries	1.6	6.5	-16.0	-26.0	-49.3	-53.3	-74.6	-84.3
	all cereals (million tonnes; including rice, milled))							
European Union					26.6	10.0	10.0	14.9
Eastern Europe					1.4	8.7	24.5	29.7
Caucasus and Central Asia					1.2	0.9	1.0	2.0
Other Europe	-2.4	-3.4	-3.9	-3.5	-4.7	-4.7	-6.6	-7.4
Russia					-3.6	11.4	25.5	32.8
Turkey	-0.7	-0.8	0.6	-0.5	0.1	1.5	-2.5	-2.7
Europe and Central Asia	-27.5	-23.5	-53.4	-11.5	21.0	27.7	51.9	69.3
Other developed countries	47.5	45.3	123.3	103.6	93.4	91.3	114.3	125.1
Developing countries	-18.7	-24.2	-74.0	-85.7	-111.8	-117.9	-165.2	-193.2

Within the region it would be above all Russia and the Eastern European sub-region (mainly Ukraine) providing the additional cereal exports thus increasing their combined cereal production considerably, from 130 million tons in 2005/07 to 190 million tons in 2050 by when exports would amount to almost one-third of their cereal production. Unfortunately the analysis was only carried out at the level of sub-regions, not at the level of individual countries. It is therefore impossible to say something about the cereal production and exports of Kazakhstan. Net cereal exports of Kazakhstan varied the last few years between 6 and 8 million tons but were at the level of the sub-region (Caucasus and Central Asia) almost completely offset by the constantly increasing net cereal imports of the other republics. In the projections therefore the net cereal exports of this sub-region was kept more or less constant at its base year level.

4.3 Livestock

Developments in diets and food consumption have been heavily influenced by the shift towards consumption of livestock products. In particular in the developing countries meat production and consumption have shown a spectacular growth exhibiting annual growth rates of close to 5 percent over extended periods (Table 4.5), although this 'livestock revolution' was dominated by developments in a few major countries (e.g. China and Brazil) and certainly not all countries participated in this 'revolution'. One main consequence of this growth in livestock production was the increasing share of crops (cereals and oilseeds) used for animal feeding purposes. FAO (2012) shows that these developments are highly unlikely to continue in the future and that annual growth will be much lower than in the past. Main reasons are the ones mentioned before, namely slowing population growth and the already relatively high level of consumption reached in many countries, but also religious considerations and cultural habits militating against beef and pork consumption (South Asia and Muslim countries).

In Europe and Central Asia (and the group of 'Other Developed countries') the situation was quite different with per caput meat consumption in the early 60s already at a level (46 kg per person per year) which the developing countries are projected to reach only towards 2050 (Table 3.7). Per caput meat consumption reached 73 kg in 1989/91 to drop to only 62 kg ten years later (Table 3.7) due to the systemic changes in the former centrally planned economies, to recover to 66 kg in the base year (2005/07). Experience shows that even at high levels of consumption (e.g. as in the USA with around 100 kg per person) growth still continues (albeit at a very slow rate), an important reason for which could be post-retail waste and of course over-consumption. This study projects for the region a further 18 percent increase in per caput consumption (78 kg by 2050) which combined with an almost stationary population would lead to a 20 percent increase in total demand, from 59 million tons in 2005/07 to 71 million tons by 2050 (Table 4.5). Production would respond (although Europe and Central Asia would remain a small net importer of meat; see below) but given the faster growth in the rest of the world, the region's share in world meat production would fall from 22 percent in 2005/07 to 15 percent in 2050.

Naturally there is a strong variation in meat consumption between the countries and sub-regions in the region. Consumption in the European Union and the group of Other Europe countries is at present already a high 80 kg per year and only a slow further increase is projected for these countries (Table 3.8). Most of the decline in meat consumption in the countries of the former USSR has by now been recovered but the level of consumption remains relatively low, from 32 kg in the Caucasus and Central Asia to 55 kg in Russia and much stronger growth is projected to 2030 and 2050. Meat consumption in Turkey (mainly mutton and poultry) is a low 23 kg per person and the country therefore would show a much higher growth in meat demand and production than the other countries in the region (Table 4.5).

Like in most regions and countries, the fastest growth has been seen in the poultry sector, followed by growth in pigmeat (Table 4.6). In part this took place in substitution for beef consumption (both for economic and health reasons). The share of poultry meat in the region's meat production is expected to growth from 27 percent in 2005/07 to 33 percent in 2050 (pigmeat's share would decline from 46 to 43 percent).

Table 4.5 Meat projections

	1961/ 1963	1979/ 1981	1992/ 1994	2005/ 2007	2030	2050	1961-2007	1981-2007	1992-2007	2005/07-2030	2030-50
	thousand tons						annual growth (%)				
	Europe and Central Asia										
demand	31689	53901	57099	58881	67774	70605	1.25	-0.06	0.31	0.59	0.20
production	30758	54003	57234	55874	65443	68212	1.26	-0.29	-0.12	0.66	0.21
net trade	-963	167	113	-3193	-2331	-2392					
SSR (%)	97	100	100	95	97	97					
	Other developed countries										
demand	21358	33737	42589	52125	61304	66049	1.92	1.74	1.60	0.68	0.37
production	21583	34453	43705	54430	67947	73692	2.05	1.98	1.71	0.93	0.41
net trade	184	720	1076	2179	6643	7643					
SSR (%)	101	102	103	104	111	112					
	Developing countries										
demand	18772	44177	87621	145173	242718	316028	4.94	4.95	3.89	2.16	1.33
production	19363	43421	87120	147273	240317	312654	4.86	5.06	4.05	2.06	1.32
net trade	580	-799	-526	2123	-2402	-3374					
SSR (%)	103	98	99	101	99	99					
	World										
demand	71818	131815	187310	256179	371796	452681	2.90	2.64	2.44	1.56	0.99
production	71704	131876	188058	257577	373707	454558	2.92	2.67	2.43	1.56	0.98
	European Union										
demand			38403	41310	44618	44865			0.62	0.32	0.03
production			40274	42110	44750	44823			0.35	0.25	0.01
net trade			1927	675	132	-42					
SSR (%)			105	102	100	100					
	Eastern Europe										
demand			4951	4015	4624	4822			-1.52	0.59	0.21
production			5138	3531	4270	4590			-2.81	0.80	0.36
net trade			187	-485	-354	-232					
SSR (%)			104	88	92	95					
	Caucasus and Central Asia										
demand			2430	2479	3901	4887			0.11	1.91	1.13
production			2303	2129	3270	4032			-0.36	1.80	1.05
net trade			-137	-357	-631	-855					
SSR (%)			95	86	84	83					
	Other Europe										
demand	585	968	1103	1564	2077	2364	1.93	1.97	2.92	1.19	0.65
production	525	883	995	1297	1726	1990	1.88	1.52	2.36	1.20	0.71
net trade	-60	-85	-108	-268	-351	-374					
SSR (%)	90	91	90	83	83	84					
	Russia										
demand			8616	7888	9621	9748			-0.63	0.83	0.07
production			6909	5135	8455	8815			-2.09	2.10	0.21
net trade			-1768	-2808	-1166	-933					
SSR (%)			80	65	88	90					
	Turkey										
demand	470	697	1155	1624	2934	3918	3.01	2.54	2.72	2.50	1.46
production	488	724	1141	1673	2972	3962	2.95	2.28	3.20	2.42	1.45
net trade	18	27	-14	49	39	44					
SSR (%)	104	104	99	103	101	101					

Note: SSR = Self-Sufficiency Ratio = production / domestic demand.

The region is a major player in the world market for meat. In 2005/07 meat imports amounted to 19.3 million tons (or 54 percent of world imports) and exports to 16.1 million tons (or 43 percent of world exports). The European Union alone accounted for 42 percent of world imports and exports (15.0 and 15.7 million tons respectively) but is net trade position came down to only 0.7 million tons of mainly pigmeat exports. The biggest net importer in the region was (and is expected to remain) Russia with net imports of 2.8 million tons in 2005/07 (poultry, beef and pigmeat). These imports amounted to about a third of its meat consumption (self-sufficiency rate of 65 percent; Table 4.5) and although a strong production growth is projected (an annual 1.2 percent over the entire period), Russia would by 2050 still have to import about 10 percent (0.9 million ton) of its consumption. Likewise substantial and increasing net imports (mainly poultry) are foreseen for the Caucasus and Central Asia.

Table 4.6 Meat projections by meat type

	1961/63	2005/07	2030	2050	1961-2007	2005/07-30	2030-50	1961/63	2005/07	2030	2050
	production in million tons				annual growth (%)			net trade in thousand tons			
	bovine meat							bovine meat			
Europe and Central Asia	10.6	12.8	13.8	14.0	0.30	0.32	0.06	-501	1316	1207	1389
Other developed countries	9.8	16.6	19.5	19.8	0.97	0.68	0.08	-207	-22	1621	1590
Developing countries	9.8	33.8	53.7	72.5	2.91	1.96	1.51	707	2156	827	1020
World	30.2	63.2	87.1	106.3	1.54	1.35	1.00	-1	819	1242	1221
	ovine meat							ovine meat			
Europe and Central Asia	2.3	2.2	2.5	2.6	-0.01	0.62	0.21	-358	-183	-191	-192
Other developed countries	1.6	1.2	2.0	2.2	-0.28	2.32	0.35	342	250	1042	1126
Developing countries	2.3	9.1	14.4	19.8	3.35	1.92	1.59	45	-229	-640	-726
World	6.1	12.5	19.0	24.6	1.73	1.76	1.30	29	-163	211	208
	pig meat							pig meat			
Europe and Central Asia	14.6	26.1	29.2	29.8	1.26	0.47	0.11	-17	108	341	925
Other developed countries	6.4	13.4	15.7	16.1	1.63	0.68	0.11	-61	75	833	693
Developing countries	5.1	60.5	86.9	97.0	5.66	1.52	0.55	-84	-106	-1094	-1540
World	26.1	99.9	131.8	142.9	3.09	1.16	0.40	-162	76	79	78
	poultry meat							poultry meat			
Europe and Central Asia	3.2	14.8	19.9	21.8	3.29	1.24	0.45	-86	-1802	-1274	-1736
Other developed countries	3.8	23.3	30.7	35.6	4.34	1.16	0.74	110	1876	3148	4234
Developing countries	2.2	43.9	85.2	123.4	7.47	2.80	1.87	-88	-303	-1495	-2129
World	9.2	82.0	135.8	180.8	5.18	2.13	1.44	-64	376	379	370

Consumption of milk and milk products (like cheese and milk powder but excluding butter, all in whole milk equivalent) in the region is and has been (since data are available, i.e. since the early 60s) among the highest in the world and stands now at over 200 kg per person per year (Table 3.7). There is therefore, on average, only little scope for further increases in per caput consumption, but as for meat consumption there are considerable differences among sub-regions and countries. While annual consumption in the European Union and Other Europe is over 250 kg, consumption in Russia, Eastern Europe and the Caucasus and Central Asia is in the range for 160 to 180 kg with still ample room to increase (Table 3.8).

Table 4.7 Milk and dairy products projections (in whole milk eq.)

	1961 /63	1992 /94	2005 /07	2030	2050	1961-2007	1992-2007	2005/07-2030	2030-50
	total demand (all uses; million tons)					annual growth (%)			
European Union		139.8	144.6	154.4	153.2		0.27	0.27	-0.04
Eastern Europe		28.9	20.4	22.0	21.4		-2.59	0.33	-0.14
Caucasus and Central Asia		12.9	16.0	21.7	25.3		2.09	1.27	0.77
Other Europe	5.0	6.5	6.5	7.7	8.4	0.66	-0.07	0.74	0.45
Russia		45.4	32.9	34.2	32.2		-2.15	0.17	-0.31
Turkey	6.7	10.5	11.9	15.4	17.3	1.09	0.59	1.08	0.58
Europe and Central Asia	200.9	245.2	232.2	255.4	257.8	0.14	-0.35	0.40	0.05
Other developed countries	75.4	99.2	112.9	132.8	143.6	1.02	1.03	0.68	0.39
Developing countries	65.7	183.5	312.3	516.8	669.6	3.66	4.07	2.12	1.30
World	342.0	527.9	657.4	905.0	1071.0	1.39	1.70	1.34	0.85
	production (million tons)					annual growth (%)			
European Union		153.4	153.5	166.2	160.6		-0.02	0.33	-0.17
Eastern Europe		29.1	24.3	26.5	27.5		-1.33	0.35	0.19
Caucasus and Central Asia		12.7	15.6	20.6	23.7		1.96	1.17	0.70
Other Europe	5.2	7.1	6.9	7.8	8.7	0.72	-0.24	0.53	0.51
Russia		45.3	31.6	34.3	32.3		-2.41	0.34	-0.29
Turkey	6.7	10.4	11.8	15.5	17.4	1.08	0.59	1.14	0.57
Europe and Central Asia	201.5	259.7	243.7	270.8	270.1	0.27	-0.44	0.44	-0.01
Other developed countries	82.2	103.9	126.5	149.5	162.5	1.07	1.54	0.70	0.42
Developing countries	61.1	164.5	293.6	490.5	644.2	3.66	4.43	2.16	1.37
World	344.7	528.2	663.7	910.8	1076.8	1.38	1.76	1.33	0.84
	net trade (thousand tons)								
European Union		14720	9153	11762	7351				
Eastern Europe		123	3983	4483	6092				
Caucasus and Central Asia		-196	-462	-1119	-1626				
Other Europe	299	580	152	131	254				
Russia		-59	-1297	31	112				
Turkey	0	-67	-81	119	67				
Europe and Central Asia	334	15594	11448	15408	12250				
Other developed countries	6002	4097	13594	16621	18932				
Developing countries	-4611	-18916	-19276	-26280	-25381				
World	1725	776	5765	5749	5801				

Production in the region is projected to increase slowly from 244 million tons in 2005/07 (or 37 percent of world production) to 270 million tons in 2050 (25 percent of world production) (Table 4.7). As for meat, the region's share in world trade is considerable (57 percent of imports and 66 percent of exports). In particular in the European Union one finds the world's biggest exporters (France, Germany, Ireland, Netherlands and Poland) and biggest importers (UK, Italy and Greece), but it should be noted that since 2000 also Belarus and Ukraine became big exporters of milk. Overall the region's net trade position is expected to remain more or less unchanged over the projection period with net exports in the order of 11 to 15 million tons, while among the developed countries Australia but above all New Zealand are expected to strengthen their exports of milk (about 5 and 15 million tons respectively).

4.4 Vegetable oils and oil crops

The oilcrops sector has been one of the most dynamic parts of world agriculture in recent decades with total production[13] growing at 4.6 percent p.a. against 2.2 percent for total agriculture. This dynamism was mainly underpinned by strong increases in food use of vegetable oils in developing countries and in the use of oilcrops in animal protein feeds both in developing and developed countries. In addition the last few decades witnessed a strong increase in the use of oils for non-food purposes, above all in the developed countries.

Similar developments were seen in the Europe and Central Asia region with total demand for vegetable oils (and oilcrops in oil equivalent) almost tripling since 1970 from 11 to 32 million tons (Table 4.8). The projections show still a healthy increase in total demand to over 50 million tons in 2050. The underlying factors influencing this growth differ however from the past.

Table 4.8 Vegetable oil balances and oilseed production in Europe and Central Asia

	1969 /71	1989 /91	2005 /07	2030	2050	1970-2007	1990-2007	2005/07-2050	2005/07-2030	2030-2050
vegetable oils*	**million tons**					**annual growth (%)**				
food	7.86	12.25	14.94	16.50	16.53	1.7	1.6	0.2	0.4	0.0
industrial use**	2.65	5.01	8.65	11.51	13.93	4.4	7.4	1.1	1.2	1.0
biofuel use			5.35	16.95	16.95			2.7	4.9	0.0
total demand	11.10	19.11	32.08	48.53	51.05	2.8	3.8	1.1	1.7	0.3
production	7.05	13.49	20.07	29.45	32.54	2.8	3.1	1.1	1.6	0.5
net trade	-3.85	-5.65	-12.75	-19.07	-18.51	2.6	5.4	0.9	1.7	-0.1
oilcrop production	**million tons of seed**					**annual growth (%)**				
soybeans	0.65	3.44	3.21	4.08	4.65	3.9	1	0.8	1.0	0.7
groundnuts	0.09	0.13	0.16	0.19	0.24	1.3	0.5	1.0	0.9	1.1
sunflower	8.38	13.71	19.01	26.78	30.18	2.3	2.3	1.1	1.4	0.6
rapeseed	1.90	9.33	18.25	31.07	33.33	6.3	4.7	1.4	2.2	0.4
sesame seed	0.05	0.04	0.05	0.06	0.08	0.9	0	1.3	1.1	1.4
cotton seed	8.47	10.99	9.43	8.33	8.99	-0.4	-0.5	-0.1	-0.5	0.4
other oilcrops	7.43	9.42	13.87	17.12	19.71	1.8	3.3	0.8	0.9	0.7
oilcrop production	**thousand tons of oil equivalent**									
soybeans	115	610	569	723	824					
groundnuts	25	35	42	55	70					
sunflower	3685	6025	8361	11757	13208					
rapeseed	776	3816	7464	12711	13640					
sesame seed	20	17	19	25	33					
cotton seed	861	1120	965	869	947					
other oilcrops	1439	1823	2683	3311	3819					

* oilseeds, oils and products in oil equivalent.

** the historical data include biofuel use in 'industrial use'; the projected annual growth rates for biofuel and industrial use together would be 3.0 and 0.4 percent for 2005/07–2030 and 2030-50 respectively, compared with 7.4 percent for 1990-2007.

Increases in the food use of vegetable oils have in most cases run their course so that only 8 percent (or 1.6 million ton) of the additional demand would come on account of additional food use. On average per caput food use would increase only marginally in the region from 17

[13] All oilseeds and their products are added up in terms of their oil equivalent. This study distinguishes nine oilseeds, the seven shown in Table 4.8 and palm and coconut oil. The latter two figure prominently in the region's imports.

to 19 kg (Table 3.7). The European Union, Other Europe and Turkey have per caput food uses of 20 kg or more, while this in the Caucasus and Central Asia still is a low 9 kg and in Russia 12 kg leaving room for stronger increases. Combined with expected population growth (or decline), this leads to a total change in food use of 1.6 million ton (over 600 thousand tons in Turkey alone).

Developments in the non-food use of vegetable oils (including oilcrops) show a completely different picture. Use of oils in biofuel production (mainly rapeseed oil in the EU) would account for 61 percent of the additional demand, while industrial use of vegetable oils (for the production of paints, detergents, lubricants, oleochemicals, etc.) would account for 28 percent of the additional demand. By 2050 non-food use would absorb almost 31 million ton or 60 percent of total use (up from 14 million ton in 2005/07). As said biofuel use of agricultural crops has been projected up to 2020 (mainly based on the projections given in FAO/OECD, 2010) and there is great uncertainty about further developments after 2020 although recent FAPRI projections to 2025 (quoted in FAO, 2012) are less than optimistic about further increases in the use of vegetable oils in biofuel production.

The lower part of Table 4.8 shows the developments in oilcrops production (both in crop and oil equivalent) in Europe and Central Asia. It shows that the bulk of oil production in the region originates in sunflower and rapeseed followed by 'other oilcrops' (mainly olive oil). Sunflower and rapeseed account for 79 percent of the oil production in the base year, with this share slowly creeping up to 83 percent by 2050.

Production of vegetable oils is concentrated in a few major producing countries (e.g. soybeans in Brazil and palm oil in Malaysia and Indonesia) while demand originates in nearly all countries. The explosive growth in demand was therefore made possible by a similar rapid expansion in international oilseed and oil trade. In 2005/07, Europe and Central Asia took in 37 percent of world imports and provided some 21 percent of world exports of oils. On average the region depends for almost 40 percent on (net) imports for is its oil uses (the EU for almost half of its oil use) and this is expected to remain virtually unchanged over the projection period. Among the countries, the strong production growth and ensuing exports of oil in the Ukraine in particular over the last decade stand out, making the group of Eastern European countries a (growing) net exporter of oil.

4.5 Sugar

Per caput sugar consumption in Europe and Central Asia has (on average) reached a high level of 35 kg per person per year. It used to be even higher in the early 90s but the collapse of the former Soviet Union brought consumption levels in the ex-USSR countries down (Table 3.7). Still in Russia it remains at a very high level of 44 kg. In all the sub-regions no further increase or even a decline in per caput consumption of sugar is projected with the exception of the Caucasus and Central Asia where consumption is still at a relatively low level of 18 kg (Table 3.8). These projections for per caput consumption combined with a stagnating or declining population leads to projected constant or declining food use of sugar with the exception of the Caucasus and Central Asia and Turkey where mainly due to population growth total food use of sugar would still grow considerably. The overall result for the European region is a net decline of about 0.5 million ton in food use of sugar by 2050 (from 31.2 milllion tons in 2005/07 to 30.7 million tons in 2050).

Table 4.9 Sugar projections (in raw sugar eq.)

	1961 /63	1992 /94	2005 /07	2030	2050	1961-2007	1992-2007	2005/07-2030	2030-50
	total demand (all uses; million tons)					**annual growth (%)**			
European Union		18.0	19.3	21.1	20.7		0.54	0.38	-0.10
Eastern Europe		3.6	4.7	4.6	4.2		1.94	-0.12	-0.48
Caucasus and Central		1.1	1.8	2.2	2.6		3.79	0.96	0.78
Other Europe	0.5	0.9	1.2	1.2	1.2	1.69	2.53	-0.09	0.19
Russia		6.0	6.8	6.3	5.8		1.32	-0.27	-0.48
Turkey	0.3	1.8	2.0	2.6	2.7	3.82	0.55	1.03	0.37
Europe and Central Asia	23.2	31.6	35.8	38.0	37.2	0.60	1.01	0.26	-0.11
Other developed	13.1	14.8	17.2	19.1	20.3	0.22	1.21	0.45	0.29
Developing countries	33.0	105.1	133.4	238.1	274.9	3.44	1.63	2.44	0.72
World	69.2	151.5	186.3	295.2	332.4	2.24	1.46	1.94	0.59
	production of sugar crops in sugar eq.					**annual growth (%)**			
European Union		20.9	19.2	16.0	15.0		-0.79	-0.75	-0.32
Eastern Europe		4.5	4.7	4.5	4.1		-0.71	-0.15	-0.46
Caucasus and Central		0.1	0.1	0.2	0.3		3.21	2.23	2.22
Other Europe	0.1	0.1	0.2	0.3	0.3	2.50	3.76	0.14	0.00
Russia		2.5	3.5	5.3	4.7		2.94	1.69	-0.55
Turkey	0.5	1.9	2.1	2.7	2.9	3.64	0.77	1.06	0.36
Europe and Central Asia	19.9	30.3	29.8	28.9	27.3	0.60	-0.31	-0.13	-0.29
Other developed	7.8	13.7	16.1	18.0	17.5	1.56	1.17	0.47	-0.15
Developing countries	41.4	108.3	148.9	256.6	295.9	2.98	2.34	2.29	0.72
World	69.1	152.2	194.8	303.5	340.7	2.29	1.77	1.86	0.58
	net trade (thousand tons)								
European Union		3448	1668	-5141	-5726				
Eastern Europe		194	-149	-89	-66				
Caucasus and Central		-1289	-1633	-2016	-2277				
Other Europe	-498	-768	-992	-933	-979				
Russia		-4277	-2966	-1087	-1060				
Turkey	156	572	141	149	152				
Europe and Central Asia	-3141	-2088	-3931	-9117	-9955				
Other developed	-4927	-1313	222	-1107	-2758				
Developing countries	8124	4302	11987	18525	21043				
World	57	901	8278	8301	8331				

Total demand for sugar in the region however could rise by some 1.5 million tons over the projection period to 37.2 million tons in 2050 (Table 4.9). This comes mainly on account of a projected increase of 1.6 million ton for use in biofuel production in the European Union[14]. Production is expected to follow quite different development paths within the region. Heavily protected and subsidized production of sugar in the EU turned the Union from a net importer to a net exporter in the late 70s. Policy reforms however have changed this and the EU gradually became a bigger importer and declining producer and exporter of sugar, turning back into a net importer again in 2007. The projections assume these developments to continue with the EU facing a declining production and increasing net imports (Table 4.9). Opposite developments are seen in Eastern Europe where both Belarus and Serbia recently increased their production and exports of sugar. Due to a growing net import status of the other countries in this sub-region however, the sub-region as a whole would not become a net exporter. Also Russia would continue to increase its production and thus reduce its net imports (from 3 million tons in 2005/07 to 1 million ton in 2050). The overall result for the region is a decline by about 2.5 million ton in its production (from 29.8 to 27.3 million tons over the projection period), and as a consequence the region's net imports could increase from about 4 million tons in 2005/07 to nearly 10 million tons in 2050 (Table 4.9).

[14] N.B. sugar in this study includes both sugar cane and sugar beet in raw sugar equivalent.

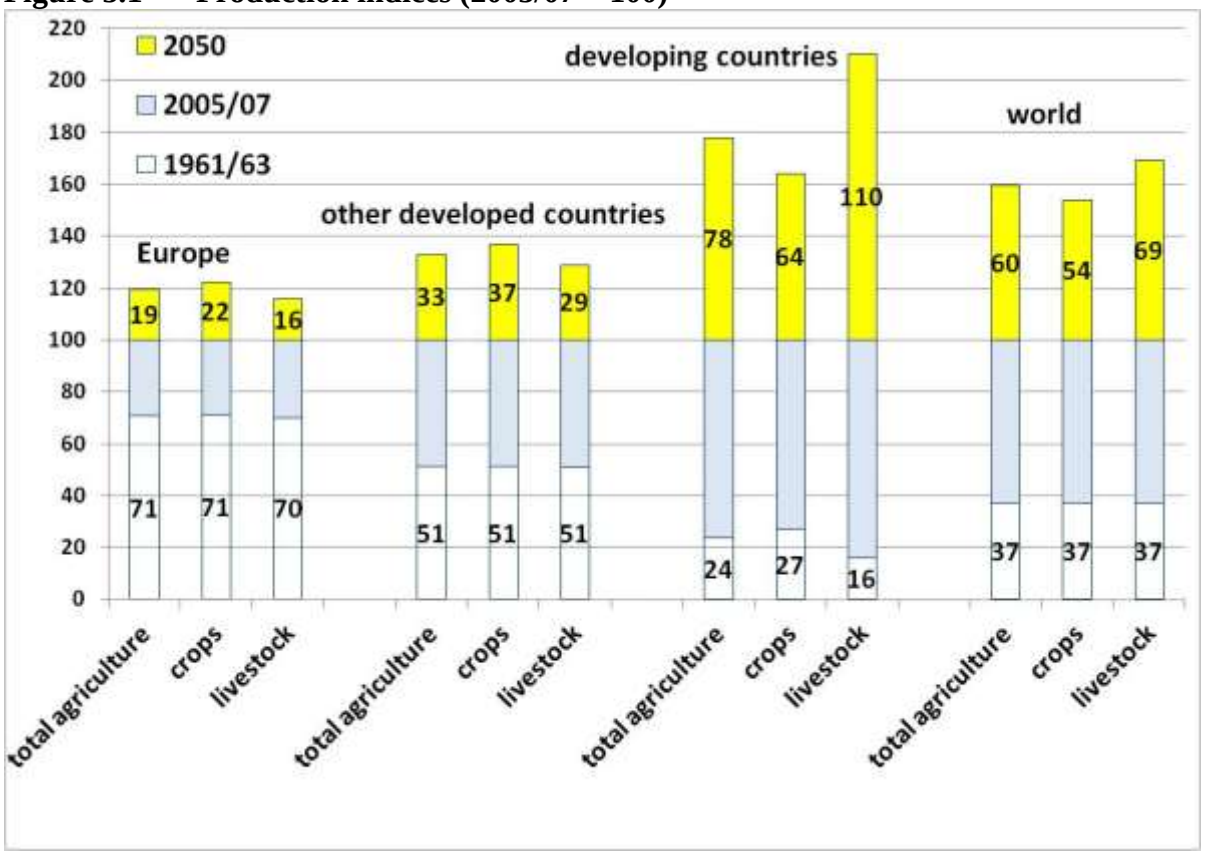
5. European and Central Asian agricultural production and resource use

This chapter discusses the main agronomic factors underlying the projections of crop and livestock production presented in the preceding chapter 4. The focus is on crop production for which the projections were unfolded into land and yield projections under rainfed and irrigated conditions. The discussion here is often limited to presenting the results at the level of the region which unavoidably masks wide inter-country differences. The parameters underlying the livestock production projections will be discussed a subsequent section while the final section will present some projections for fertilizer use in the region.

5.1 Production growth

Overall agricultural production growth was already discussed in section 4.1. For the region as a whole annual growth would decelerate from 0.6 percent p.a. over 1961-2007 to 0.4 percent over 2005/07 to 2050 (Table 4.1). The reasons for this continuing slowdown in growth are to be sought in the slowdown (or even decline) in population growth and the fact that already two-third of the region's population lives in countries with on average at present a food energy supply of over kcal 3400 per day per person not leaving much room for further increases.

Figure 5.1 Production indices (2005/07 = 100)



Overall annual agricultural production could in 2050 be nearly 20 percent higher than in 2005/07 (Table 4.2). Figure 5.1 shows similar indices for the crop and livestock sectors separately (livestock includes all meats, milk and dairy products and eggs). It is interesting to note that on average the region's annual crop production would increase more (+ 22 percent)

than livestock production (+16 percent). This however is heavily determined by developments in the European Union where annual crop production growth (0.35 percent; see Table 5.1) would far exceed annual livestock growth (0.11 percent). This is entirely due to increased crop production to meet additional demand for biofuels. Excluding this, annual crop production growth in the EU would be a mere 0.10 percent (i.e. marginally lower than livestock growth). Similar considerations hold for the group of 'Other developed countries' (see Figure 5.1).

Table 5.1 Annual growth rates (%) of crop and livestock production

	1961-2007	1992-2007	2000-2007	2005/07-2050	2005/07-2030	2030-2050
Crops						
European Union		0.21	-0.84	0.35	0.51	0.15
Eastern Europe		-0.05	2.35	0.32	0.49	0.12
Caucasus and Central Asia		2.02	5.00	0.81	0.91	0.68
Other Europe	0.66	-0.08	-0.04	0.99	1.19	0.74
Russia		0.60	2.83	0.61	0.99	0.15
Turkey	2.45	1.39	0.44	0.64	0.84	0.41
Europe and Central Asia	0.56	0.43	0.48	0.46	0.65	0.23
Other developed countries	1.53	0.91	0.69	0.72	0.95	0.44
Developing countries	3.04	3.17	3.10	1.13	1.43	0.77
World	2.21	2.35	2.35	0.99	1.26	0.66
Livestock						
European Union		0.06	-0.14	0.11	0.27	-0.08
Eastern Europe		-2.03	1.09	0.35	0.48	0.19
Caucasus and Central Asia		0.86	4.33	1.15	1.43	0.82
Other Europe	1.09	0.64	0.60	0.75	0.86	0.62
Russia		-2.36	0.75	0.55	1.02	0.00
Turkey	1.80	1.40	3.37	1.34	1.68	0.95
Europe and Central Asia	0.67	-0.41	0.44	0.34	0.53	0.10
Other developed countries	1.47	1.45	0.77	0.58	0.77	0.35
Developing countries	4.38	4.07	3.54	1.70	2.03	1.31
World	2.22	2.11	2.11	1.20	1.44	0.92

In most other countries and sub-regions projected livestock growth rates exceed crop production growth rates reflecting the expected shift in diets towards a consumption of more livestock products. The slightly higher crop production growth in Russia can be explained by additional production to meet increased exports (mainly of wheat).

5.2 Crop production and land use

The world's arable land area has been steadily expanding since the early 60s by about 4 million ha per year (Figure 5.2). This trend is made up however from very divergent developments. While in the developing countries land expanded by over 5 million ha per year, the arable area in developed countries peaked in the late 60s and has been declining ever since at over 1 million ha per annum. Before discussing future developments, a little digression will be made on estimates for potential arable areas.

A new version of the FAO/IIASA Global Agro-Ecological Zone (GAEZ) study was recently completed (see Fischer *et al.*, 2011). This detailed study offers, based on inventories of climates, soil and terrain conditions and taking into account physical and chemical

requirements for crop production growth for a great number of crops, estimates of land suitability in terms of extents and attainable crop yields for various levels of farm inputs and management[15]. Table 5.2 shows some overall estimates for land extents of various degrees of suitability (for rainfed agriculture over all crops and input levels).

Table 5.2 Land with rain-fed crop production potential (million ha)

	total land surface	suitable land*	of which		of which in use as		gross balance	not usable**	net balance
			prime land	good land	rainfed land	irrigated land			
European Union	423	182	79	103	86	15	80	47	33
Eastern Europe	109	91	49	42	44	3	43	22	21
Caucasus and Central Asia	414	103	4	99	25	7	71	7	65
Other Europe	46	2	1	1	1	0	1	1	0
Russia	1667	404	141	263	111	4	289	208	81
Turkey	77	34	4	30	17	4	13	3	10
Europe and Central Asia	2738	816	277	539	284	34	498	287	210
Other developed countries	2826	810	223	587	229	28	553	306	247
Developing countries	7340	2834	803	2032	545	135	2154	1208	947
Rest-of-world***	391	35	12	23	4	0	31	23	8
World	13295	4495	1315	3180	1063	197	3236	1824	1412

Source: GAEZ v3.0 in Fischer *et al.* (2011)

* Crops considered: cereals, roots and tubers, sugar crops, pulses and oil-bearing crops.

** land under forest, built-up or strictly protected.

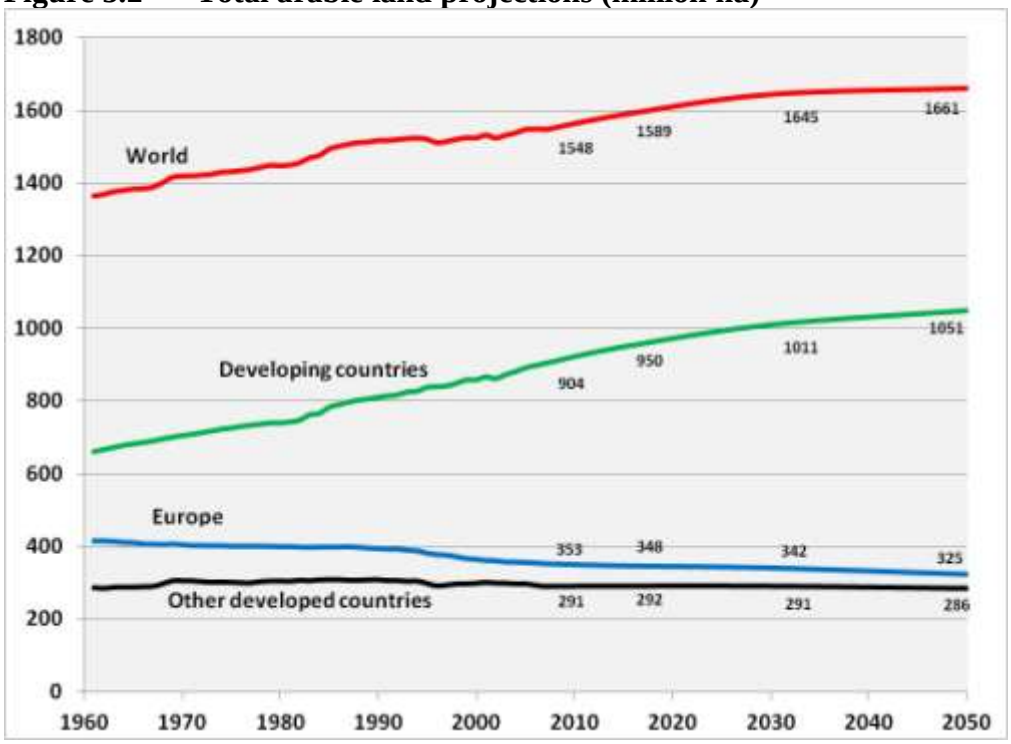
*** countries not included in the regions above.

In Europe and Central Asia there would be some 816 million ha with rainfed production potential, of which by now some 318 million ha (or nearly 40 percent) are in agricultural use. Of this potential area, a third would be of prime quality (i.e. very suitable with attainable yields between 80 and 100 percent of the maximum-constraint-free yield the latter being defined as the yield that, given the climate, could be reached in the absence of soil and terrain constraints). The other two-thirds would be 'good' land (Suitable and Moderately Suitable with attainable yields respectively between 60 and 80 and between 40 and 60 percent of the maximum).

The gross balance (i.e. not yet in use) would be some 500 million ha. However nit all of this area is available for agricultural use: subtracting the land under forest, built-up or strictly protected, the net balance would be 'only' 210 million ha most of it in Russia and the Caucasus and Central Asia with virtually no land left in the group Other Europe. Even much of this net balance is not readily available to agriculture as lands may suffer from ecological fragility, be remote and inaccessible and lack infrastructure. Overall however it is fair to say that there are considerable areas with agricultural potential left certainly seen against the expected needs for arable land (see below).

[15] See Fischer *et al.* (2011) for a description of the methodology.

Figure 5.2 Total arable land projections (million ha)



As said, the arable land area in developed countries has been on a continuing decline since the late 60s (figure 5.2). This also holds for Europe and Central Asia (and most countries within the region) so that the arable land area declined by some 15 percent from 417 million ha in 1961.63 to 355 million in 2005/07 (Table 5.3). The overall result of the crop production projections (in terms of harvested land, cropping intensities and yields[16]) of this study would lead to a further 10 percent decline in the arable area over the period to 2050 to 325 million ha (Table 5.3). The decline could be witnessed in all the sub-regions certainly in the second half of the projection period. It should be emphasized that all the estimates for expansion of arable land presented here are estimates of net expansion of arable area, i.e. they do not take into account the development of additional hectares of arable land needed to compensate for land taken out of production due for example to severe land degradation.

Although the arable area could decline by some 30 million ha, the actually harvested area would fall by less (from 272 million ha in 2005/07 to 266 million ha in 2050; see Table 4.6) due to a somewhat more intensive use of the arable area (an increase in the cropping intensity).

[16] Starting with the production projections for each crop, the land and yield projections were derived drawing on expert judgement and taking into account: (a) base year (2005/07) data on total harvested land and yield by crop; (b) data or often estimates for harvested land and yield by crop for rainfed and irrigated land; (c) data on total arable rainfed and irrigated land and their expected increases over time; (d) likely increases in yield by crop and land class; (e) plausible increases in cropping intensities, and (g) the (net) land balances for rainfed and irrigated agriculture (see Bruinsma (2009) for an explanation of the method followed).

Table 5.3 Total arable land in use: data and projections

	1961 /63	1992 /94	2005 /07	2030	2050	1961-2007	1992-2007	2000-07	2005/07-30	2030-50
	million ha					annual growth (%)				
European Union		132	122	115	104		-0.67	-0.68	-0.24	-0.51
Eastern Europe		51	48	52	50		-0.42	-0.32	0.30	-0.13
Caucasus and Central Asia		47	35	33	32		-2.36	0.03	-0.15	-0.17
Other Europe	2	2	2	2	2	0.17	-0.50	-0.83	0.25	-0.01
Russia		132	123	115	113		-0.50	-0.36	-0.28	-0.13
Turkey	26	28	26	25	24	-0.02	-0.50	-0.58	-0.15	-0.17
Europe and Central Asia	417	392	355	342	325	-0.33	-0.75	-0.45	-0.16	-0.26
Other developed countries	287	307	295	291	286	0.04	-0.19	-0.44	-0.05	-0.10
Developing countries	668	824	942	1011	1051	0.67	0.63	0.76	0.30	0.19
World	1372	1522	1592	1645	1661	0.28	0.13	0.25	0.13	0.05

5.3 Irrigated land and water use in irrigation

The world's land area equipped for irrigation has been steadily expanding since the early 60s by about 3.8 million ha per year (Figure 5.3). As was the case for total arable land, this trend is made up however from divergent developments. While in the developing countries the irrigated area expanded by some 3 million ha per year, in the developed countries the area expanded only slowly and in Europe and Central Asia there has been virtually no growth since the early 80s (Figure 5.3). Irrigation plays on average a minor role in European agriculture with only 11 percent of the arable area being irrigated. An important exception is the Caucasus and Central Asia where almost 40 percent of the arable area is irrigated. For the future an only very slow expansion of the area equipped for irrigation is projected (supplemented with improvements on existing areas), from some 40 million ha in 2005/07 to 42 million ha in 2050 (Table 5.4).

Table 5.4 Area equipped for irrigation: data and projections

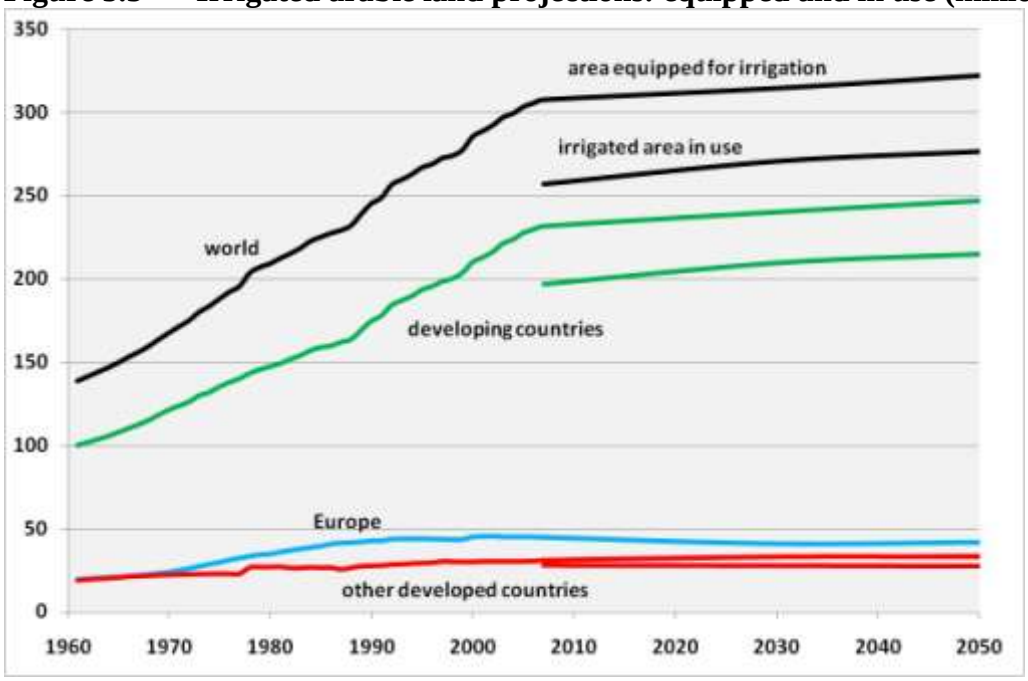
	1961 /63	2005 /07	2030	2050	1961-2007	1997-2007	2005/07-50	2005/07-30	2030-50
	million ha				annual growth (%)				
European Union		15.2	15.2	15.2		0.6	0.0	0.0	0.0
Eastern Europe		1.4	1.4	1.4		-0.8	0.0	0.0	0.0
Caucasus and Central Asia		13.4	13.4	13.6		-0.1	0.0	0.0	0.1
Other Europe	0.2	0.4	0.4	0.4	1.6	0.7	0.0	0.0	0.0
Russia		4.5	5.1	5.1		-0.7	0.3	0.6	0.0
Turkey	1.3	5.0	5.7	6.3	3.4	2.3	0.5	0.6	0.5
Europe and Central Asia	20.0	39.8	41.1	41.9	2.0	0.3	0.1	0.1	0.1
Other developed countries	19.6	33.0	33.1	33.1	1.0	0.2	0.0	0.0	0.0
Developing countries	101.9	229.6	240.2	247.0	1.9	1.7	0.2	0.2	0.1
World	141.6	302.3	314.4	322.0	1.8	1.3	0.1	0.2	0.1

A distinction is made between the area equipped for irrigation and the irrigated area actually in use (which is the area to be used in the production analysis). Areas equipped might be temporarily or even permanently out of use for various reasons, including for maintenance, or because of degradation of irrigation infrastructure or since the area does not need to be irrigated in a particular year (the latter occurs often in developed countries with temperate climates where sprinkler irrigation is practiced only in dry summers). The percentage of the area equipped

actually in use differs from country to country, but is on average for Europe some 81 percent (expected to remain virtually constant - 82 percent in 2050; see also Figure 5.3). Although the irrigated area in use would increase by only 2 million ha (from 32 million ha in 2005/07 to 34 million ha in 2050), the actual harvested irrigated area could increase by 5 million ha due to a more intensive use (Table 5.6).

As for the total arable land area, it is important to bear in mind that the projected expansion of irrigated land presented here is an increase in net terms. It assumes that losses of existing irrigated land due to, for example, water shortages or degradation because of salinization and waterlogging, will be compensated for through rehabilitation or substitution by new areas for those lost. The few existing historical data on such losses are too uncertain and anecdotal to provide a reliable basis for drawing inferences about the future. In investment terms, rehabilitation of existing irrigation schemes will represent the bulk of future expenditure on irrigation: if it is assumed that 2.5 percent of existing irrigation must be rehabilitated or substituted by new irrigation each year, that is, if the average life of irrigation schemes were 40 years, then the total irrigation investment activity over the projection period to 2050 would be a multiple of the investment in net expansion.

Figure 5.3 Irrigated arable land projections: equipped and in use (million ha)



The withdrawals of fresh water used in irrigation amount at present in Europe to some 300 cubic km or 11 percent of global water withdrawals for irrigation (Table 5.5). Taking into account monthly water balances, developments stages and cropping calendars for the 34 crops covered in this study, estimates were made of the consumptive water use in irrigation (i.e. the volume of water needed to compensate for the deficit between potential crop evapo-transpiration and effective precipitation[17]). These estimates together with assumed marginal improvements in the water use efficiency leads to projections for water use in irrigation[18].

[17] See Hoogeveen (2011) for an explanation of the methodology.

[18] *Water use efficiency* can be defined as the ratio between the crop water requirements, estimated as consumptive water use in irrigation and irrigation water withdrawal. Irrigation water withdrawal normally far exceeds the consumptive water use in irrigation because of water lost during transport and distribution from its source to the crops.

Overall fresh water withdrawal for irrigation would increase only marginally in the region (to 310 cubic km by 2050). Since the region is relatively well-endowed with renewable water resources, the pressure on water resources due to irrigation (also called stress) would remain very low, around 4 percent (Table 5.5). The big exception is the Caucasus and Central Asia which use almost half (48-49 percent) of their renewable water resources in irrigated agriculture, a situation which by experts is considered critical (the threshold for calling water use 'critical' is a stress factor of 40 percent). This concerns mainly the countries around the Aral Sea which has been subject to continuing depletion. In fact the shrinking of the Aral Sea has often been called "one of the planet's worst environmental disasters".

Table 5.5 Annual renewable water resources and irrigation water withdrawal

	renewable water resources	water withdrawal for irrigation			pressure on water resources due to irrigation (stress)		
		2005/07	2030	2050	2005/07	2030	2050
	cubic km				**percent**		
European Union	1498	64	68	71	4.3	4.5	4.7
Eastern Europe	201	23	24	24	11.2	12.1	12.1
Caucasus and Central Asia	287	140	139	141	48.6	48.3	49.0
Other Europe	606	1	2	2	0.2	0.3	0.3
Russia	4404	42	41	40	1.0	0.9	0.9
Turkey	232	30	31	32	12.8	13.4	13.9
Europe and Central Asia	7228	300	305	310	4.1	4.2	4.3
Other developed countries	7109	280	283	283	3.9	4.0	4.0
Developing countries	27663	2182	2274	2334	7.9	8.2	8.4
World	42000	2761	2862	2926	6.6	6.8	7.0

5.4 Crop yields and yield gaps

It is expected that growth in crop yields will continue to be the mainstay of crop production growth. Although the deceleration of crop production growth foreseen for the future (Table 5.1) points to a similar deceleration in growth of yields, such growth will continue to be needed. Questions often asked are: will yield increases continue to be possible and what is the potential for a continuation of such growth? Although the scope for one-off quantum jumps in yields looks rather limited, empirical evidence has shown that the cumulative gains in yields over time due to slower, evolutionary annual increments in yields, have been far more important than quantum jumps in yields, for all major crops.

Such concerns are often based on the observed slowdown in yield growth for major crops, in particular cereals. Figure 5.4 shows the annual growth rates of cereal yields over sliding 25-year periods, which indeed confirm a gradual slowdown in such growth. The reasons for such slowdown however are more likely to be found in the observed slowdown in world cereal production than in certain resource constraints (including the genetic potential) becoming binding. As explained in the preceding chapter, growth in cereal production, which at the global level equals demand for cereals, is decelerating in response to a slowing population growth and to an ever-increasing share of world population attaining medium to high levels of food intake. Recently, growth in cereal yields even exceeded the growth in cereal production permitting a decline in the area allocated to cereals.

Figure 5.4 Annual growth rates of world cereal production and yields

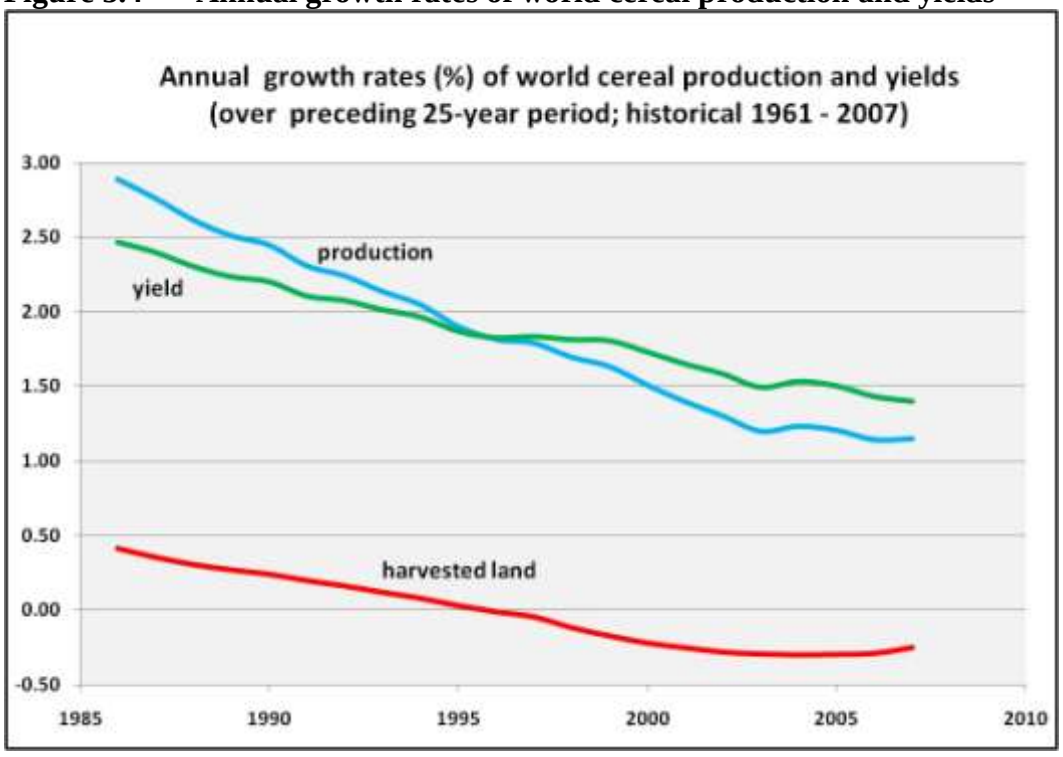


Table 5.6 shows the land/yield projections for selected crops for Europe and Central Asia. The overall result for yields of all the crops covered in this study[19] (aggregated with standard price weights) is a more than halving of the average annual rate of growth over the projection period as compared to the historical period, from 1.2 percent annually over 1961 to 2007 to 0.5 percent p.a. over 2005/07 to 2050. This slowdown in the yield growth is a gradual process which has been under way for some time and is expected to continue in the future. It reflects the deceleration in crop production growth explained earlier.

Discussing yield growth at this level of aggregation however is not very helpful, but the above-mentioned overall result is a pattern common to most crops covered in this study with only a few exceptions such as sunflower and sesame for which past growth rates have been sluggish. For cereals, which account for 56 percent of the region's harvested land, the slowdown in yield growth would be particularly pronounced: down from 1.8 percent p.a. in 1961-2007 to 0.5 percent p.a. in the period 2005/07 to 2050. Again this is a gradual process that has been underway for some time now (e.g. annual cereal yield growth during 1997-2007 was down to 0.8 percent).

[19] The crop production projections are unfolded into and tested against what FAO experts think are "feasible" land-yield combinations by agro-ecological rainfed and irrigated environment, taking into account whatever knowledge is available. A major input into this evaluation are the estimates regarding the availability of land suitable for growing crops in each country and each agro-ecological environment which come from the FAO Agro-Ecological Zones work. In practice they are introduced as constraints to land expansion but they also act as a guide to what can be grown where. It is emphasized that the resulting land and yield projections, although they take into account past performance, are not mere extrapolations of historical trends since they take into account all present-day knowledge about changes expected in the future.

Table 5.6 Crop production, land use and yields in Europe and Central Asia

		rainfed land			irrigated land			total land		
		area	yield	production	area	yield	production	area	yield	production
		mln. ha	mt/ha	mln. ton	mln. ha	mt/ha	mln. ton	mln. ha	mt/ha	mln. ton
wheat	2005/07	77.2	2.92	225.2	4.3	3.94	17.1	81.6	2.97	242.3
	2030	72.0	3.80	273.8	6.7	4.46	29.9	78.8	3.86	303.8
	2050	69.5	4.05	281.6	7.8	4.75	36.9	77.3	4.12	318.4
maize	2005/07	11.0	4.73	52.0	3.6	8.39	30.2	14.6	5.63	82.3
	2030	11.2	5.97	66.6	3.5	10.87	38.2	14.7	7.14	104.9
	2050	11.5	6.02	69.4	3.6	11.38	40.6	15.1	7.28	110.0
barley	2005/07	33.3	2.82	93.6	0.9	3.58	3.2	34.1	2.83	96.8
	2030	34.5	3.10	107.1	1.0	4.12	4.0	35.5	3.13	111.1
	2050	34.7	3.18	110.2	1.1	4.38	4.7	35.8	3.21	114.9
other cereals	2005/07	18.9	2.34	44.2	2.2	3.43	7.6	21.1	2.45	51.8
	2030	21.8	2.28	49.7	2.1	4.00	8.4	23.9	2.43	58.0
	2050	18.8	2.60	48.8	2.2	4.36	9.6	21.0	2.78	58.4
sunflower	2005/07	13.9	1.31	18.3	0.4	1.95	0.7	14.3	1.33	19.0
	2030	16.5	1.54	25.4	0.5	2.53	1.4	17.1	1.57	26.8
	2050	17.1	1.66	28.4	0.6	2.92	1.8	17.7	1.71	30.2
rape seed	2005/07	6.3	2.63	16.6	0.5	3.58	1.6	6.8	2.69	18.3
	2030	8.4	3.41	28.5	0.5	4.81	2.6	8.9	3.50	31.1
	2050	8.9	3.45	30.6	0.5	5.06	2.7	9.4	3.54	33.3
potatoes	2005/07	7.2	16.79	121.2	0.8	25.25	20.6	8.0	17.65	141.8
	2030	6.2	19.38	121.1	0.7	32.17	23.0	7.0	20.69	144.1
	2050	5.2	21.53	112.3	0.8	37.50	28.6	6.0	23.57	140.9
sugar beet	2005/07	3.4	44.21	149.9	0.8	52.45	39.8	4.1	45.71	189.7
	2030	2.4	44.23	104.2	1.2	68.57	84.2	3.6	52.57	188.3
	2050	1.7	44.14	77.2	1.4	74.34	100.5	3.1	57.31	177.7
pulses	2005/07	3.8	1.69	6.4	0.9	2.12	1.9	4.7	1.77	8.3
	2030	3.7	1.91	7.0	0.9	2.50	2.2	4.5	2.02	9.1
	2050	3.4	2.06	7.0	0.8	2.82	2.4	4.2	2.21	9.3
vegetables	2005/07	4.2	19.90	83.8	1.5	26.75	39.2	5.7	21.67	123.0
	2030	3.8	22.19	85.4	1.6	33.51	52.1	5.4	25.45	137.5
	2050	3.5	23.82	83.8	1.6	36.70	56.9	5.1	27.77	140.7
citrus fruit	2005/07	0.1	12.46	1.0	0.6	21.45	13.7	0.7	20.42	14.7
	2030	0.1	17.39	1.6	0.6	29.49	16.9	0.7	27.79	18.6
	2050	0.1	18.44	1.8	0.6	31.76	18.8	0.7	29.91	20.5
other fruit	2005/07	7.5	7.83	58.8	2.8	11.42	32.4	10.3	8.82	91.3
	2030	7.8	8.49	65.9	3.1	12.92	40.7	10.9	9.77	106.6
	2050	7.7	8.98	68.9	3.3	13.87	45.1	10.9	10.44	114.0
seed cotton	2005/07	0.3	2.44	0.7	3.4	2.56	8.7	3.7	2.55	9.4
	2030	0.1	2.62	0.3	2.9	2.79	7.9	3.0	2.78	8.3
	2050	0.1	2.78	0.3	2.7	3.23	8.7	2.8	3.21	8.9
total harvested land	2005/07	243			29			272		
	2030	240			32			272		
	2050	230			34			264		
cropping intensity (%)	2005/07	75			90			76		
	2030	78			96			80		
	2050	79			99			81		
total arable land	2005/07	323			32			355		
	2030	309			33			342		
	2050	290			34			325		

Improved farming practices, irrigation, improved varieties, modern inputs, etc. all contributed to the growth of yields that underpinned many of the increases in agricultural production. This trend is expected to continue. How far can this process go? Intensification and yield growth are subject to limits for reasons of plant physiology and because of environmental stresses

associated with intensification. Moreover, in many circumstances it is simply uneconomical to attempt to raise yields above a certain percentage of the maximum attainable.

In considering the prospects and potentials for further growth in crop agriculture, below the question will be addressed: what are the gaps between the *actual* yields of any given crop in the different countries and those that are *agronomically attainable* given the countries' specific agro-ecological endowments for that crop? Naturally, what is agronomically attainable changes over time as agricultural research produces higher-yielding varieties and farming practices improve.

Table 5.7 Actual and potential land and yields for selected crops

	rainfed land in use	suitable land		attainable yield		actual and projected yields		as percent of attainable yield	
	2005/ 2007	prime	good	prime	good	2005/ 2007	2050	2005/ 2007	2050
	million ha			ton/ha		ton/ha		percent	
wheat									
European Union	25.2	72.9	103.3	9.15	6.07	5.02	5.98	68	81
Eastern Europe	7.7	36.8	39.5	9.06	6.85	2.71	3.13	34	40
Caucasus and Central Asia	13.7	3.0	53.2	8.69	4.22	1.25	1.52	28	34
Other Europe	0.2	0.5	1.7	8.39	5.24	4.26	4.76	72	81
Russia	23.4	95.0	325.6	7.14	3.99	1.96	3.94	42	84
Turkey	7.0	3.6	21.9	7.03	5.92	2.03	2.44	33	40
Europe and Central Asia	77.2	211.6	545.2	8.19	4.70	2.92	4.05	51	71
barley									
European Union	13.5	68.3	107.5	9.10	6.03	4.07	4.58	56	63
Eastern Europe	5.6	40.1	48.0	9.11	6.99	2.07	2.81	26	35
Caucasus and Central Asia	1.8	3.0	52.1	8.65	4.04	1.15	1.64	27	38
Other Europe	0.2	0.4	1.7	8.39	5.08	3.63	3.96	63	69
Russia	8.8	81.0	339.5	6.83	4.00	1.83	2.20	40	48
Turkey	3.4	4.4	21.0	6.98	5.91	2.46	2.45	40	40
Europe and Central Asia	33.3	197.2	569.7	8.12	4.71	2.82	3.18	50	57
sunflower									
European Union	3.4	38.8	99.7	2.90	2.52	1.62	2.10	56	73
Eastern Europe	4.1	25.3	50.8	3.04	2.81	1.29	1.51	41	48
Caucasus and Central Asia	0.5	0.7	27.3	2.65	1.96	0.67	1.16	34	58
Other Europe	0.0	0.2	0.7	2.76	2.45	0.92	2.48	34	91
Russia	5.5	37.4	246.4	2.39	2.21	1.15	1.47	51	64
Turkey	0.5	0.1	9.9	2.91	2.09	1.67	1.90	79	90
Europe and Central Asia	13.9	102.4	434.7	2.60	2.33	1.31	1.66	52	65

Note: based on GAEZ estimates for rainfed high-input agriculture. 'Prime land' is GAEZ Very Suitable land with attainable yields between 80 and 100 percent of maximum; 'good land' is GAEZ Suitable land (yields between 60 and 80 percent of maximum) and GAEZ Moderately Suitable land (yields between 40 and 60 percent of maximum). Actual and projected yields as a percentage of attainable yields were calculated as a percentage of the average weighted attainable yield on prime and good land.

Intercountry differences in average yields can be very large, but they do not always denote potential for growth in countries with low yields. The reasons why country average yields differ from one another are many. Some are agro-ecological, others socio-economic. In addition, agro-ecological and demand factors influence the mix of varieties of the same crop grown in each country, for example, low-yielding durum wheat versus common or soft wheat with higher yields. Given that we are interested in the physical/agronomic potential for yield

growth, we need to separate out the part of these intercountry yield gaps that is caused by agro-ecological diversity from the part caused by other factors. The results of the global agro-ecological zone (GAEZ) analysis provide a way of controlling agro-ecological diversity in such intercountry comparisons.

The agro-ecologically attainable yields can be used to draw inferences about the scope for raising yields in countries where actual yields are "low" in relation to what is attainable for their agro-ecologies. Table 5.7 shows the agro-ecologically attainable yields (for high input rainfed farming) on prime and good land for some of the most important crops in the region, namely wheat, barley and sunflower (which together use more than half of the region's harvested land) and compares them with actual prevailing yields. It is obvious that in most cases actual yields are still far below potentially attainable ones.

For example, average wheat yields in the region are at present some 50 percent of the agro-ecologically attainable ones, and this could go up to some 70 percent by 2050. This statement needs two important qualifications which elucidate that these ratios are upper limits. First, the attainable yield used here is an average of the yields on prime and good land. If, for example, we assume that all of the 77 million ha currently under wheat would be on prime land, then the actual and projected yields would be 'only' 36 and 49 percent respectively of the attainable yield on prime land. Second, the attainable yield concept used in the GAEZ is a static one, i.e. they are yield estimates based on current knowledge. It is reasonable to assume that given the resource base, technical progress will cause attainable crop yields by 2050 to be considerably higher than what they are at present.

The yield gap in relation to agronomic potential is an important element when discussing agronomic potentials for yield growth. For the countries in which we find large differences between actual and attainable yields, it seems probable that factors other than agro-ecology are responsible. Yields in these countries could grow some way towards bridging the gap between actual and attainable if some of these factors could be changed, e.g. if prices rose.

5.5 Livestock production

Like for crop production, growth in livestock production (meats, milk and eggs) mirrors growth in total agricultural production although the observed deceleration in growth is slightly less than for crop production as the consumption of livestock products continues to increase its share in total food consumption. No or hardly any growth is foreseen for several countries, with even a slight decline in the European Union in the second half of the projection period (Table 5.1). Naturally, growth prospects differ among countries and livestock sectors with, in general, slow growth foreseen for beef and pig meat and somewhat more vigorous growth for poultry and mutton (Table 4.6). The share of livestock production in total agricultural production is in the region on average 47 percent, going from a low 25 percent in Turkey to over half (52 percent) of total production in the EU.

Table 5.8 Livestock production: historical and projected

	number of animals (million)				annual growth (%)		carcass weight (kg/animal)		
	1961/63	2005/07	2030	2050	1961-07	2005/07-2050	1961/63	2005/07	2050
Europe and Central Asia									
Cattle and buffaloes	214	161	166	164	-0.72	0.04	137	226	231
Sheep and goat	349	246	273	277	-0.79	0.26	13	15	16
Pigs	176	197	202	202	0.32	0.05	74	87	91
Poultry	1521	2567	3453	3827	1.14	0.91	1.3	1.7	1.7
Other developed countries									
Cattle and buffaloes	152	167	175	174	-0.04	0.10	200	315	334
Sheep and goat	285	174	216	227	-1.06	0.60	17	20	22
Pigs	72	91	93	93	0.50	0.05	63	88	94
Poultry	1076	2997	3630	4055	2.42	0.69	1.4	2.0	2.1
Developing countries									
Cattle and buffaloes	679	1204	1474	1694	1.30	0.78	152	165	209
Sheep and goat	722	1494	2008	2435	1.67	1.12	12	13	17
Pigs	176	629	785	846	2.47	0.67	49	74	81
Poultry	1838	13596	22422	29148	5.00	1.75	1.1	1.4	1.6
World									
Cattle and buffaloes	1045	1532	1815	2032	0.81	0.64	158	202	227
Sheep and goat	1356	1915	2497	2939	0.78	0.98	14	14	17
Pigs	424	917	1080	1141	1.58	0.50	65	79	84
Poultry	4435	19160	29504	37030	3.56	1.51	1.3	1.6	1.7

Increased production can be achieved by a combination of expansion in animal numbers and increased productivity. Higher productivity is a compound of higher off-take rates (shorter production cycles by, for example, faster fattening), and higher carcass weight and milk or egg yields. The projections (Table 5.8) show that in the region the increase in livestock numbers could be only marginal except for poultry and mutton. There was a drastic decline in the cattle and sheep numbers in the historical period probably caused by the collapse of livestock production in the ex-USSR. Also carcass weights could continue to increase marginally, while higher off-take rates (shorter production cycles) will be more important in pig and poultry meat production.

There are considerable problems in getting reliable data for off-take rates and carcass weights. To circumvent these, meat production can be compared directly with herd sizes. For example, over the period 1961-2007), Europe's beef production increased by 0.3 percent p.a., while cattle numbers declined 0.7 percent, implying an annual productivity improvement of 1.0 percent (Table 5.9). Pig meat production increased by 1.3 percent p.a., while the number of animals increased by only 0.3 percent, suggesting a 1.0 percent annual productivity improvement. Similar numbers for poultry are a 3.4 and 1.2 percent in meat production and poultry numbers respectively, suggesting a high productivity growth of 2.2 percent p.a. Further productivity growth over the projection period is expected but at a much attenuated pace. Like for crop yields this slowdown in productivity growth has been underway for some time (for example, poultry productivity growth was down to 0.8 percent p.a. over the last decade, 1997-2007).

Table 5.9 Livestock production: historical and projected productivity

	1961 -07	1997 -07	2005/07 -30	2030 -50	1961 -07	1997 -07	2005/07 -30	2030 -50	1961 -07	1997 -07	2005/07 -30	2030 -50
	annual growth rates in percent											
	meat production				animal numbers				productivity			
Europe and Central Asia												
Cattle and buffaloes	0.30	-1.04	0.30	0.06	-0.72	-1.71	0.13	-0.07	1.02	0.68	0.17	0.12
Sheep and goat	-0.01	-1.04	0.69	0.21	-0.79	-0.40	0.42	0.07	0.79	-0.64	0.26	0.14
Pigs	1.26	0.20	0.50	0.11	0.32	-0.50	0.11	-0.02	0.93	0.71	0.39	0.13
Poultry	3.35	2.41	1.17	0.45	1.14	1.61	1.06	0.38	2.18	0.79	0.11	0.07
Other developed countries												
Cattle and buffaloes	0.96	0.35	0.53	0.08	-0.04	-0.09	0.21	-0.02	1.01	0.44	0.33	0.11
Sheep and goat	-0.24	0.42	1.36	0.35	-1.06	-2.40	0.91	0.24	0.83	2.89	0.45	0.11
Pigs	1.63	1.89	0.68	0.11	0.50	0.72	0.10	0.00	1.12	1.16	0.58	0.12
Poultry	4.37	2.82	1.06	0.74	2.42	1.26	0.80	0.56	1.90	1.54	0.26	0.19
Developing countries												
Cattle and buffaloes	2.94	2.58	1.91	1.51	1.30	0.94	0.85	0.70	1.62	1.63	1.05	0.80
Sheep and goat	3.37	3.27	1.94	1.59	1.67	1.82	1.24	0.97	1.67	1.42	0.69	0.61
Pigs	5.65	2.45	1.52	0.55	2.47	1.20	0.92	0.38	3.10	1.23	0.59	0.17
Poultry	7.47	5.01	2.66	1.87	5.00	3.58	2.11	1.32	2.35	1.39	0.54	0.54
World												
Cattle and buffaloes	1.56	1.15	1.28	1.00	0.81	0.52	0.71	0.57	0.74	0.63	0.57	0.43
Sheep and goat	1.74	2.07	1.68	1.30	0.78	1.06	1.11	0.82	0.96	1.00	0.57	0.48
Pigs	3.10	1.75	1.17	0.40	1.58	0.76	0.68	0.27	1.49	0.98	0.48	0.13
Poultry	5.22	3.87	2.01	1.44	3.56	2.91	1.82	1.14	1.60	0.94	0.19	0.29

5.6 Fertilizer use

As discussed in the preceding sections, the bulk of the projected increases in crop production will have to come from higher yields, with the remaining part coming from an expansion in harvested area. Both higher yields, which normally demand higher fertilizer application rates, and land expansion will lead to an increase in fertilizer use. Management techniques such as precision agriculture however offer opportunities to substitute information for fertilizer. It is expected that this trend of increasing efficiency of nutrient use through better nutrient management, by improving the efficiency of nutrient balances and the timing and placement of fertilizers, will continue in the future.

The overall result, aggregated over all crops and countries, is that fertilizer consumption in the region could increase from 25 million tons in 2005/07 to 31 million tons in 2050 (Table 5.10). Fertilizer consumption in Europe and Central Asia fell considerably over the last few decades mainly due to the collapse of agriculture in the ex-Soviet countries, but also because of the maturing of fertilizer markets during the 1980s in Western Europe, a major fertilizer consuming region, which accounted for much of the slowdown in fertilizer consumption growth. In the more recent past, changes in agricultural policies, in particular reductions in support measures, contributed to a slowdown or even decline in fertilizer use in this group of countries. Increasing awareness and ensuing regulations to address adverse impacts of nutrient losses on the environment are also likely to hold back future growth in fertilizer use. Fertilizer applications however are expected to shift more to oilseeds for which a relatively strong growth is foreseen, and consequently, fertilizer consumption could therefore show some recovery in first half of the projection period.

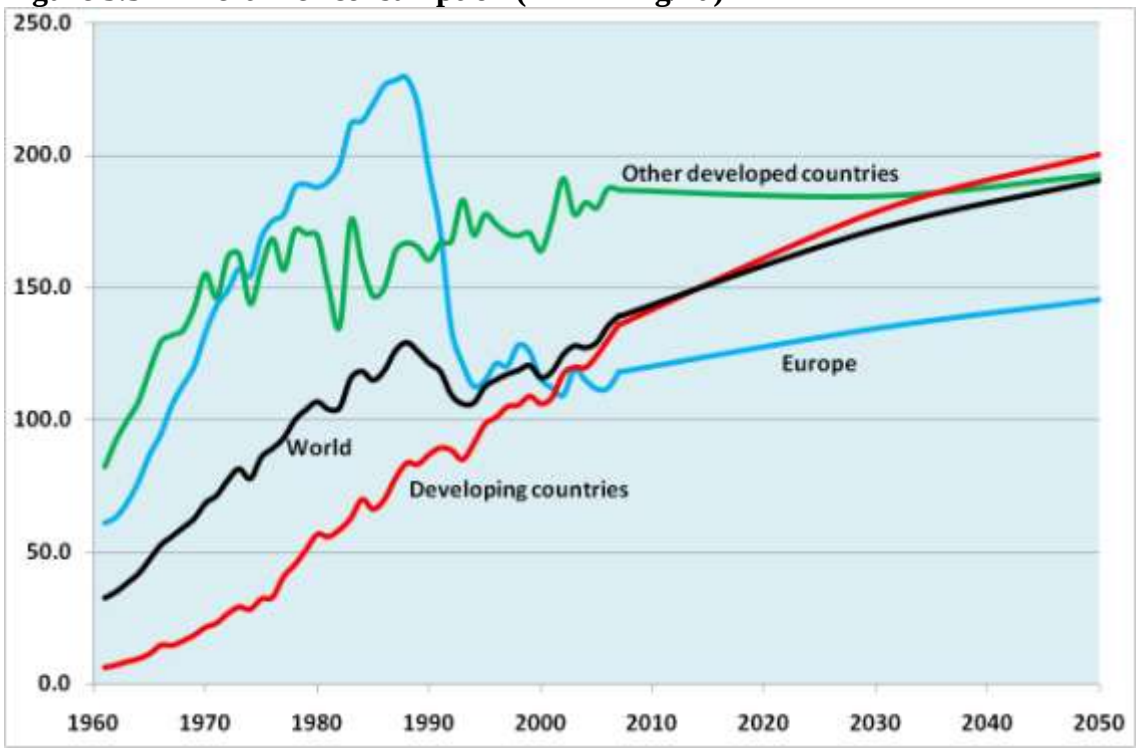
Table 5.10 Fertilizer consumption: historical and projected

million tons	1961/ 1963	1999/ 2001	2005/ 2007	2030	2050	1961- 2007	1992- 2007	2005/07- 30	2030- 50
European Union		19	17.6	19.5	20.0		-1.1	0.4	0.1
Eastern Europe		2	2.7	3.8	4.0		-0.5	1.5	0.4
Caucasus and Central Asia		1	0.5	0.7	0.9		-13.6	1.7	1.2
Russia		1	1.6	2.4	2.7		-4.6	1.9	0.5
Turkey	0	2	2.5	2.9	3.3	6.6	2.4	0.6	0.5
Europe and Central Asia	18	26	25	30	31	-0.1	-1.5	0.7	0.3
Other developed countries	12	27	29	32	34	1.5	0.5	0.4	0.3
Developing countries	4	85	112	169	198	7.2	3.9	1.7	0.8
World	34	137	166	231	263	3.0	2.1	1.4	0.7
kg/ha (harvested land)	**1961/ 1963**	**1999/ 2001**	**2005/ 2007**	**2030**	**2050**	**1961- 2007**	**1992- 2007**	**2005/07- 30**	**2030- 50**
European Union		206	199	222	239		-0.7	0.4	0.4
Eastern Europe		57	83	98	104		-0.6	0.7	0.3
Caucasus and Central Asia		45	19	29	37		-12.5	1.7	1.2
Russia		28	29	48	55		-2.7	2.2	0.6
Turkey	5	97	133	153	170	6.2	3.0	0.6	0.5
Europe and Central Asia	64	118	115	134	145	0.5	-0.6	0.6	0.4
Other developed countries	91	170	184	185	193	1.1	0.5	0.0	0.2
Developing countries	7	108	127	179	200	6.3	2.8	1.4	0.6
World	35	118	132	172	191	2.5	1.6	1.1	0.5

Since the early 1960s, the use of mineral fertilizers has been growing rapidly in developing countries admittedly starting from a very low base (Table 5.10 and Figure 5.5). This has been particularly so in East and South Asia following the introduction of high-yielding varieties. By now high application rates have been reached (127 kg/ha) even exceeding those in Europe (115 kg/ha). Within Europe and Central Asia there are considerable differences in fertilizer application rates going from a low 19 and 29 kg/ha in the Caucasus and Central Asia to a high 200 kg/ha in the EU (Table 5.10). Although average fertilizer application rates in the EU have been more or less constant since the early 1990s (after haven fallen from much higher levels), such rates could edge up again due to a shift in production towards oil crops and fruits and vegetables which require on average higher fertilizer applications per hectare.

Average fertilizer productivity, as measured by kg of product obtained per kg of nutrient, shows considerable variation across countries. This reflects a host of factors such as differences in agro-ecological resources (soil, terrain and climate), in management practices and skills and in economic incentives. Fertilizer productivity is strongly related to soil moisture availability. Furthermore, a high yield/fertilizer ratio may also indicate that fertilizer use is not widespread among farmers (e.g. wheat in Russia), or that high yields are obtained with nutrients other than mineral fertilizer (e.g. manure is estimated to provide almost half of all external nutrient inputs in the EU). The degree to which such productivity gains will be pursued depends to a great extent on economic incentives. There is also an increasing concern about the negative environmental impact of high rates of mineral fertilizer use, and the spread of organic agriculture and the increasing availability of non-mineral nutrient sources. All these factors will tend to reduce growth in fertilizer consumption, but given their uncertain developments it is impossible to quantify them.

Figure 5.5 Fertilizer consumption (NPK in kg/ha)



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Annex I Crops and commodities included

Crops	*Livestock*
Wheat	Beef, veal and buffalo meat
Rice	Mutton, lamb and goat meat
Maize	Pig meat
Barley	Poultry meat
Millet	Milk and dairy products (in whole milk equivalent)
Sorghum	Eggs
Other cereals	
Potatoes	
Sweet potatoes and yams	
Cassava	
Other roots	
Plantains	
Sugar, raw [1]	
Pulses	
Vegetables	
Bananas	
Citrus fruit	
Other fruit	
Vegetable oil and oilseeds (in vegetable oil equivalent) [2]	
Cocoa	
Coffee	
Tea	
Tobacco	
Cotton lint	
Jute and hard fibres	
Rubber	

[1]Sugar production is analyzed separately for sugar cane and sugar beet.
[2]Vegetable oil production is analyzed separately for soybeans, groundnuts, sesame seed, coconuts, sunflower seed, palm oil/palm-kernel oil, rapeseed and all other oilseeds.

Note on commodities

All commodity data and projections in this report are expressed in terms of primary product equivalent unless stated otherwise. Historical commodity balances (Supply Utilization Accounts - SUAs) are available for about 160 primary and 170 processed crop and livestock commodities. To reduce this amount of information to manageable proportions, all the SUA data were converted to the commodity specification given above in the list of commodities, applying appropriate conversion factors (and ignoring joint products to avoid double counting: e.g. wheat flour is converted back into wheat while wheat bran is ignored). In this way, one Supply Utilization Account in homogeneous units is derived for each of the commodities of the study. Meat production refers to indigenous meat production, i.e. production from slaughtered animals plus the meat equivalent of live animal exports minus the meat equivalent of all live animal imports. Cereals demand and trade data include the grain equivalent of beer consumption and trade.

The commodities for which SUAs were constructed are the 26 crops and 6 the livestock products given in the list above. The production analysis was, however, carried out for 34 crops because sugar and vegetable oils are analyzed separately (for production analysis only) for the 10 crops shown in the footnote to the list.

Annex II The approach followed

In projecting the likely evolution of the key food and agricultural variables, a 'positive' approach has been followed, aiming at describing the future as it is likely to be (to the best of our knowledge at the time of carrying out the WA21 study), and not as it ought to be from a normative point of view. A second aspect of the approach followed in the WA21 study was to draw to the maximum extent possible on FAO's in-house knowledge available in the various disciplines present in FAO. The quantitative analysis and projections were carried out in considerable detail in order to provide a basis for making statements about the future concerning individual commodities and groups of commodities as well as agriculture as a whole. Another reason for the high degree of detail has to do with the interdisciplinary nature of the study and its heavy dependence on contributions provided by FAO specialists in the different disciplines. Such contributions can find expression only if the relevant questions are formulated at a meaningful level of detail.

The variables projected in the study are the demand (different final and intermediate uses), production and net trade balances for each commodity and country and the key agro-economic variables, i.e. for crops: area, yield and production by country and by agro-ecological zone (rain-fed, irrigated), and for the livestock products: animal numbers (total stock, off-take rates) and yields per animal. A significant part of the total effort is devoted to the work needed to create a consistent set of historical and base year data. For the demand-supply analysis, the overall quantitative framework for the projections is based on the Supply Utilization Accounts (SUAs). The SUA is an accounting identity showing for any year the sources and uses of agricultural commodities in homogeneous physical units, as follows:

Food (Direct consumption) + Industrial Non-food Uses + Feed + Seed + Waste =
Total Domestic Use =
Production + (Imports - Exports) + (Opening Stocks - Closing Stocks)

The data base has one such SUA for each commodity, country and year (1961 to 2007). The data preparation work for the demand-supply analysis consists of the conversion of the about 350 commodities for which the primary production, utilization and trade data are available into the 32 commodities covered in this study, while respecting the SUA identities (see the "Note on commodities" in Appendix II). The different commodities are aggregated into commodity groups and into "total agriculture" using as weights world average producer prices of 2004/06 expressed in "international dollars". The growth rates for heterogeneous commodity groups or total agriculture shown in this study are computed from the thus obtained value aggregates.

A major part of the *data* preparation work is the unfolding of the SUA element 'production' (for the base year only, in this case the 3-year average 2005/07) into its constituent components of area, yield and production which are required for projecting production. For the crops, the standard data in the SUAs contain, for most crops, also the areas (harvested) and average yields for each crop and country. These national averages are not considered by the agronomists to provide a good enough basis for the projections because of the widely differing agro-ecological conditions in which any single crop is grown, even within the same country. An attempt was therefore made to break down the base year production data from total area under a crop and an average yield into areas and yields for rainfed and irrigated categories. The problem is that such detailed data are not generally available in any standard data base. It became necessary to piece them together from fragmentary information, from both published and unpublished documents

giving e.g. areas and yields by irrigated and rainfed land at the national level or by administrative districts, supplemented by a good deal of guesstimates.

The bulk of the *projection* work concerns the drawing up of SUAs (by commodity and country) for the years 2030 and 2050, and the unfolding of the projected SUA item 'production' into area and yield combinations for rainfed and irrigated land, and likewise, for livestock commodities into the underlying parameters (number of animals, off-take rates and yields).

The overall approach is to start with projections of demand, using Engel demand functions and exogenous assumptions on population and GDP growth (as explained in section 3.1). Subsequently, the entry point for the projections of production is to start with provisional projections for production for each commodity and country derived from simple assumptions about future self-sufficiency and trade levels. There follow several rounds of iterations and adjustments in consultation with specialists on the different countries and disciplines, with particular reference to what are considered to be 'acceptable' or 'feasible' levels of calories intakes, diet composition, land use, (crop and livestock) yields and trade. Accounting consistency controls at the commodity, land resources (developing countries only), country and world levels have to be respected throughout. The end-product may be described as a set of projections which meet conditions of accounting consistency and to a large extent respect constraints and views expressed by the specialists in the different disciplines and countries.

The projections of crop yields and land were carried out for as large a number of individual commodities and countries as practicable (105 countries and country groups and 34 crops - see Annex I - and two land classes, rainfed and irrigated agriculture).

A major part of the data preparation work is the unfolding of the data for production (i.e. the FAOSTAT data for area harvested and average yield for each crop and country for the three-year average 2005/07, converted into the crop classification used in this study) into its constituent components of area, yield and production for rainfed and irrigated land. Such detailed data come in part from AQUASTAT but are not generally available in any standard database. It became therefore necessary to piece them together from fragmentary information, from both published (e.g. from EUROSTAT for the EU countries) and unpublished documents giving, for example, areas and yields by irrigated and rainfed land at the national level or by administrative districts, supplemented by a good deal of guesstimates. For a number of countries (e.g. for the USA, China, EU27, India and Indonesia) the data for irrigated agriculture were assembled at the sub-national level.

No data exist on total harvested land, but a proxy can be obtained by summing up the harvested areas reported for the different crops. Data are available for total arable land in agricultural use (physical area, called in FAOSTAT "arable land and land under permanent crops"). It is not known whether these two sets of data are compatible with each other, but this can be evaluated indirectly by computing the cropping intensity, i.e. the ratio of harvested area to arable land. This is an important parameter that can signal defects in the land use data. Indeed, for several countries (in particular for sub-Saharan countries but not only) the implicit values of the cropping intensities did not seem to be realistic. In such cases the harvested area data resulting from the crop statistics were accepted as being the more robust (or the less questionable) ones and those for arable area were adjusted.

Data reported in FAOSTAT on arable irrigated land refer to 'area equipped for irrigation'. What is needed is the 'irrigated land actually in use' which is often between 80 and 90 percent of the area equipped. Data for the 'area in use' were taken from FAO's AQUASTAT data base.

The bulk of the projection work concerned the unfolding of the projected crop production for 2030, 2050 and 2080 into (harvested) area and yield combinations for rainfed and irrigated land, and making projections for total arable land and arable irrigated area in use.

An initial mechanically derived projection for rainfed and irrigated harvested area and yield by crop (constrained to arrive at exactly the projected production) was evaluated against such information as recent growth in land and yield (total by crop) and the 'attainable yield' levels for most crops from the Global Agro-Ecological Zone (GAEZ) study (Fischer *et al.*, 2011), and adjusted were needed. A similar projection was made for total arable rainfed and irrigated area which were then evaluated against estimates for the (maximum) potential areas for rainfed agriculture (from the GAEZ) and for irrigated agriculture (from AQUASTAT) and adjusted where needed. In addition, for irrigated area cropping patterns were checked against and made to obey certain cropping calendars (i.e. not all crops can be grown in all months of the year). A final step was to derive the implicit cropping intensities for rainfed and irrigated agriculture (by comparing harvested land over all crops with the arable area) and again adjusting areas (and yields) where needed. Normally it required several iterations before arriving at an 'acceptable' picture of the future.

Since the whole exercise is heavily dependent on expert-judgement and requires an evaluation of each and every number, it is a time-consuming exercise. The projections presented in this study are certainly not trend extrapolations as they take into account all knowledge available at present as to expected developments that might make evolutions in major variables deviate from their trend path.

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