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Demand for key nutrients (NPK) in the year 2050

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DRAFT REPORT

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Abstract

In the following report priority is on the development of the NPK demand up to the year 2050. The basic factors of influence on this demand are the future development of the population and accompanied by that, the increase of demand for food and agricultural products.

Population is projected to increase primarily in Africa and mainly in the sub-Saharan countries. Europe is the only major region, for which a decline in population is projected until the end of the 21st century (63 per cent from 2010-2100). Demand for food is projected to increase by some 70 per cent and in order to ensure food security of the projected world population agricultural production needs to increase by 70 per cent globally. This will only be achievable with the growth of an adequate use of fertilizer nutrients like NPK. The fertilizer consumption is anticipated to expand in all of the major regions of the world. The highest growth is projected to occur in the Industrial countries, reaching a demand of 105 million Mt in 2050. In spite of the relatively high population growth in sub-Saharan Africa its fertilizer consumption is expected to reach only 7.7 million Mt in 2050 and hence is rather moderate.

1 INTRODUCTION

Background

Feeding a population of 9 billion people in 2050 will rely upon the availability of plant nutrients commensurate with the necessary increase in productivity, the deployment of new plant and farming technologies and the cultivation of more marginal land. The JRC anticipation study will bring together data so as to review the current forecasts of the supply and availability of essential macronutrients (nitrogen, phosphorus and potassium - NPK); it will then assess if the basic needs associated with food supply and an increase in consumer demand of a growing and more affluent world population will be met or jeopardized by the forecast.

In this context the following report aims on the assessment of forecasts on the key nutrients NPK for the major regions of the world. Data on the current population trends, the current food consumption, agricultural production and future demand was therefore reviewed, compiled and used as a basis for assessments of the future demand for NPK in the major regions of the world (compare to Fig. 1.1).

1.1. Workflow

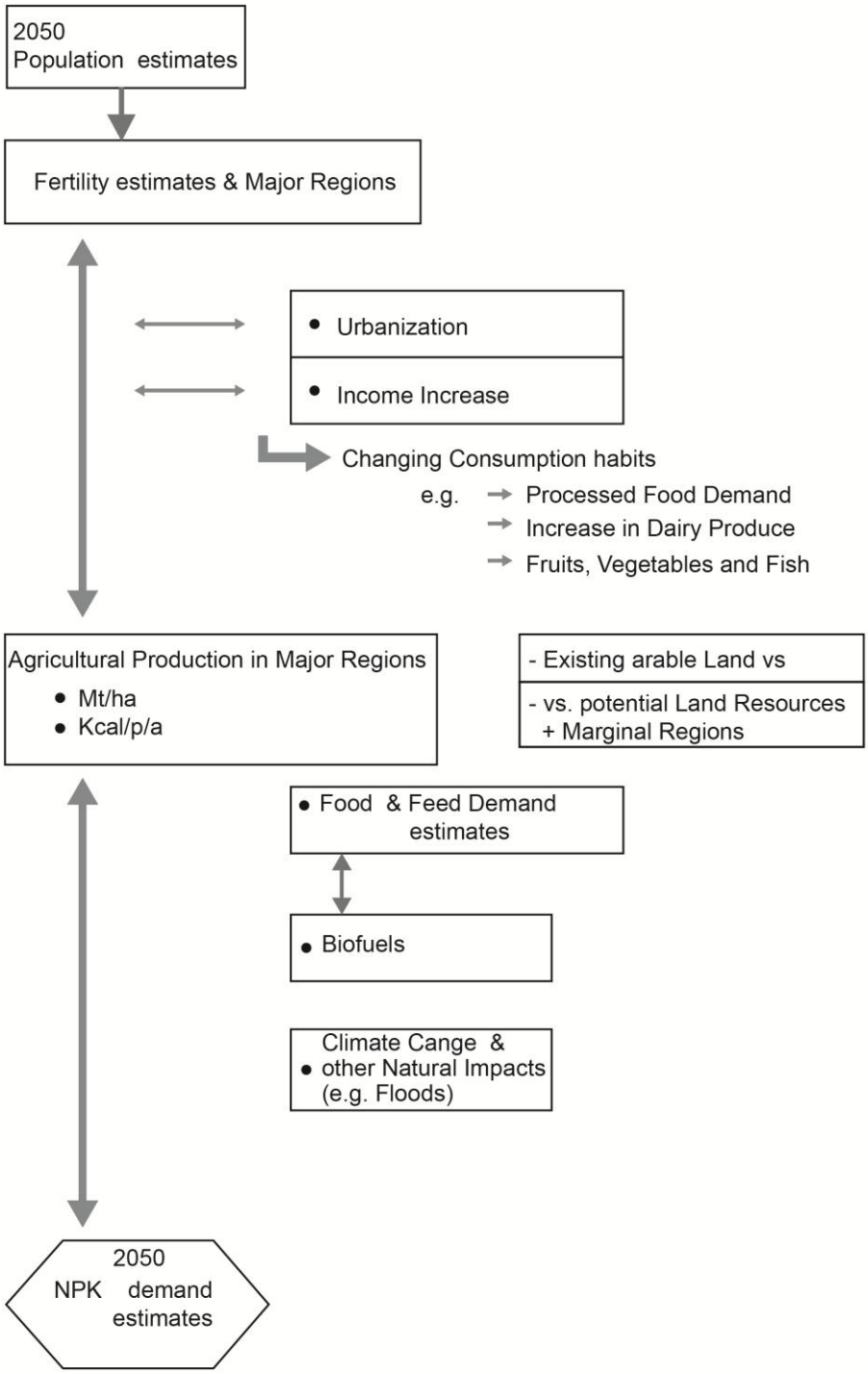


Fig. 1.1: Most important topics considered in the study

The report is divided into the main chapters of the future population development (chapter 2), the future food demand, agricultural production (chapter 3) and referring to that, the demand for the key nutrients Nitrogen, Phosphorus and Potassium (NPK) (chapter 4). The assessments for these main concerns include forecasts up to the year 2050.

2 POPULATION

According to the medium variant of the official *2010 Revision of World Population Prospects* (WPP) of the UNITED NATIONS (UN), provided by the Population Division of the Department of Economic and Social Affairs (DESA), the current world population of approximately 7 billion people is projected to reach 9.3 billion by the middle of the 21st century. The major part of this increase is projected to arise in the so called high-fertility countries. The projections of the development of the world population in the UN WPP 2010 go up to the year 2100. Therefore, in some cases the developments of the population up to 2100 are shown and mentioned in this report. Nevertheless, only the results up to the year 2050 are considered for further assessments.

2.1 World population

Fertility variants

The projection was conducted for 3 different fertility variants, which vary in the number of children per woman. Even though the variations are rather small, the influence on the size of populations in the long term can be tremendous. The high fertility variant lies only half a child above that in the medium variant and is expected to lead to a world population of 10.6 billion in 2050 and 15.8 billion in 2100 (Fig.2.1). With half a child below the medium variant, the low fertility variant predicts a world population of 8.1 billion in 2050 declining to 6.2 billion in 2100 (Fig.2.1).

The medium variant is taken as reference for long term trends. Generally, the projection for 2050 is more certain than for 2100 because people aged 40 and older in 2050 are already born. In 2050 the world population reaches 9.3 billion in the medium variant. The number of 10.1 billion people is assumed in 2100 (UN 2011b) (Fig.2.1). This variant on the one hand draws upon the continued decline of fertility in countries which have a fertility rate fertility above replacement level. On the other hand, it is based on an increase of fertility in the countries that have below-replacement fertility. Moreover, mortality would have to decline in all countries (UN 2011a).

Based on the fact that fertility would remain constant at the level of 2005-2010 for every country, the world population would increase to about 11 billion in 2050 and reach the extreme of nearly 27 billion by 2100 (Fig.2.1, constant fertility variant). Even in a scenario where “fertility of each country would reach replacement level in 2010-2015, the world population would continue to increase over the rest of the century, reaching 9.1 billion in 2050 and 9.9 billion in 2100” (Fig.2.1, instant replacement variant) (UN 2011a).

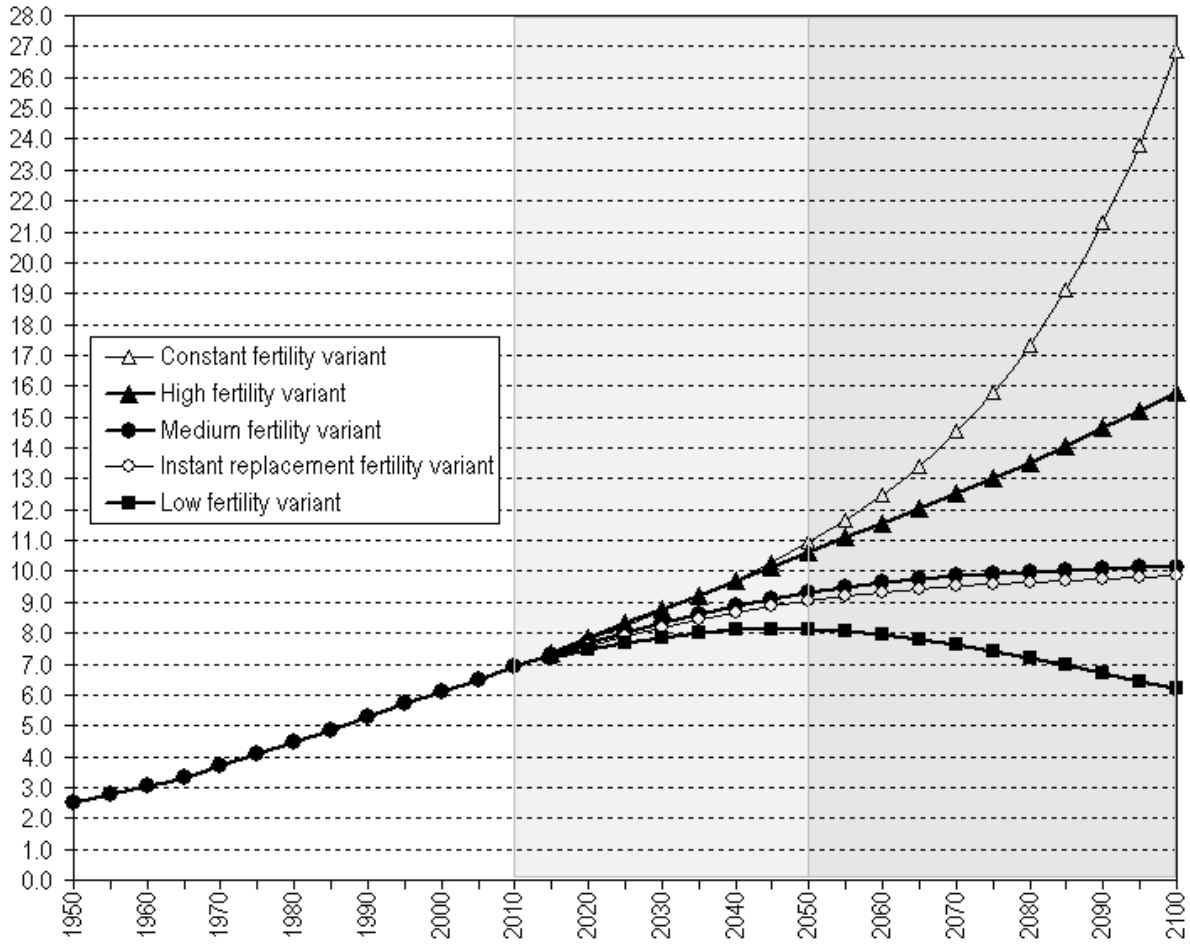


Figure 2.1: Estimated and projected world population according to different variants, 1950-2100 (billions) (UN 2011a).

Fertility levels and development of the world population

The world’s countries show a remarkable variation in fertility levels. Due to that they can be classified in three different groups (Fig.2.2):

1. low-fertility countries:
   women are not having enough children to ensure that, on average, each woman is replaced by a daughter who survives to the age of procreation
2. intermediate-fertility countries:

each woman has between 1 and 1.5 daughters on average

3. high-fertility countries:
   each woman has more than 1,5 daughters on average

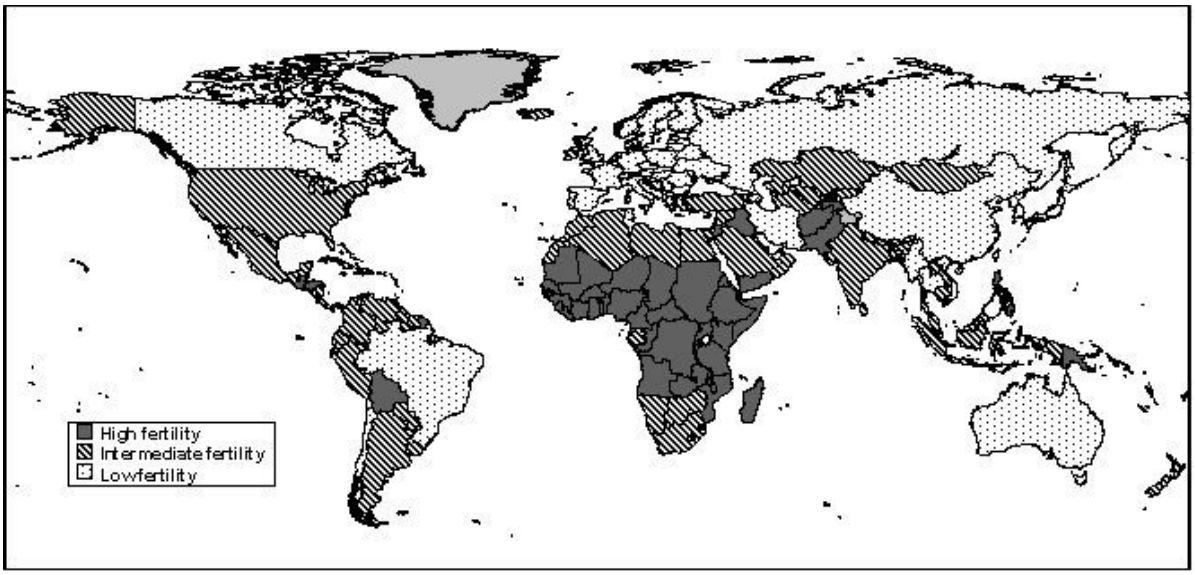


Figure 2.2: Countries and areas classified by fertility level (UN 2011b).

18 per cent of the world's population lives in high-fertility countries today, which are mostly concentrated in Africa (39 out of the 55 countries in the continent have high fertility). Besides Africa, there are nine in Asia, six in Oceania and four in Latin America. In order of population size, Pakistan, Nigeria, the Philippines, Ethiopia, the Democratic Republic of the Congo, the United Republic of Tanzania, Sudan, Kenya, Uganda, Iraq, Afghanistan, Ghana, Yemen, Mozambique and Madagascar, account for 75 per cent of the population of high-fertility countries (UN 2011a).

40 per cent of the world's population live in intermediate-fertility countries, where three-quarters of the population is located in India, the United States of America, Indonesia, Bangladesh, Mexico and Egypt, in order of population size (UN 2011a).

The remaining 42 per cent live in low-fertility countries. These are including all countries in Europe except Iceland and Ireland, 19 out of the 51 in Asia, 14 out of the 39 in the Americas, two in Africa (Mauritius and Tunisia) and one in Oceania (Australia). Countries as varied as China, Brazil, the Russian Federation, Japan, Viet Nam, Germany, the Islamic Republic of Iran, Thailand and France, in order of population size, account for 75 per cent of the population living in low-fertility countries (UN 2011a).

There is a discrepancy in the countries' contributions to future population growth due to the different fertility levels. The medium variant projects that the high-fertility countries'

population tends to more than triple between 2011 and 2100, by increasing from 1.2 billion (2010) to about 2.5 billion (2050) and 4.2 billion (2100). The population would increase by just 26 per cent in intermediate-fertility countries in the same period (Increasing from 2.8 billion (2010) to about 3.7 billion (2050), reaching its maximum at 3.8 billion (2065) and then again decreasing to 3.5 billion (2100)). Only the low-fertility countries' population is expected to decline by about 20 per cent from 2.9 billion (2010) to 2.4 billion (2100), reaching its maximum at 3.1 billion (2030) (Tab. 2.1, Fig.2.3) (UN 2011a).

Table 2.1: Population for countries grouped by fertility level (billions), medium variant, 1950-2100 (UN 2011b).

Fertility level	2010	2050	2100	Growth (%) 2010-2100
High-fertility	1,2	2,5	4,2	250
Intermediate-fertility	2,8	3,7	3,5	25
Low-fertility	2,9	2,9	2,4	-17

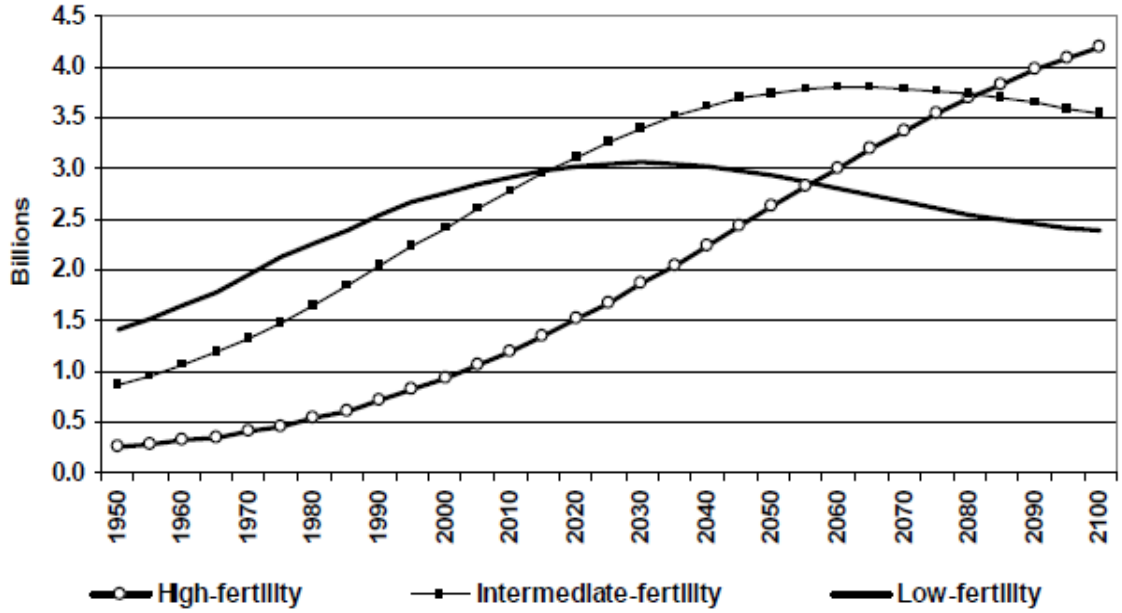


Figure 2.3: Population for countries grouped by fertility level, medium variant, 1950-2100 (UN 2011b).

The future fertility paths in the medium variant differ markedly among the groups of countries classified by fertility level (Fig.2.4). Fertility in high fertility countries is 4.9 children per woman in 2005-2010, whereas it has dropped to 2.8 children in 2045-2050, reaching 2.1 in 2095-2100. However during the whole projection period, fertility remains above replacement level.

In contrast to intermediate-fertility countries, fertility is 2.6 children per woman in 2005-2010, declining to 1.8 in 2045-2050 and reaching a minimum around 2060. Then it slightly increases again to 1.9 children per woman in 2095-2100.

For low-fertility countries, there is an increase in average fertility during the whole projection period from 1.6 children per woman in 2005-2010 to 1.8 in 2045-2050 and to 2.0 in 2095-2100. However, fertility of the low-fertility countries remains below replacement level over the whole projection period.

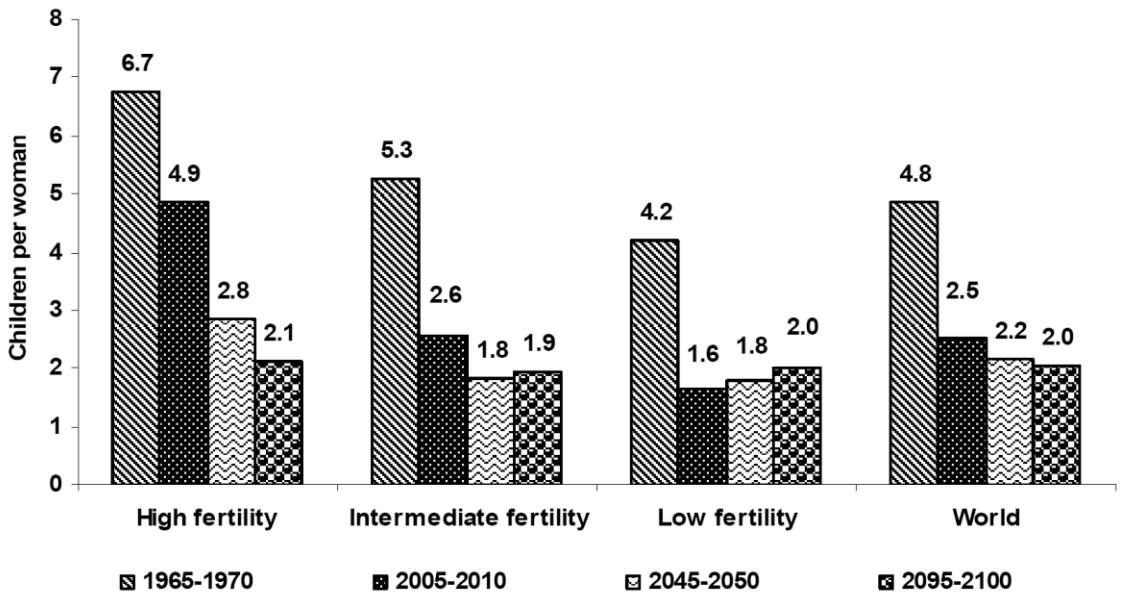


Figure 2.4: Total fertility for countries grouped by fertility level, medium variant, selected periods (UN 2011b).

As already mentioned above, “small differences in fertility levels sustained over long periods have a major impact on the future population” (UN 2011b) (Fig.2.1). The three variants (low-medium-high) differ in each with half a child during the period 2010-2100. Thus the differences within the projected population increase over time (Fig.2.5).

In high fertility countries there is a difference of 0.6 billion people between the projected populations of the high and low variant in 2050 (2.96 billion vs. 2.32 billion). The difference would have expanded to 3.3 billion in 2100 (6.1 billion vs. 2.8 billion). In conclusion, the overall population of the high fertility countries would increase four or five-fold by 2100. Even if fertility was reduced to the projections of the medium variant, the population of high-fertility countries would more than triple by the end of the century.

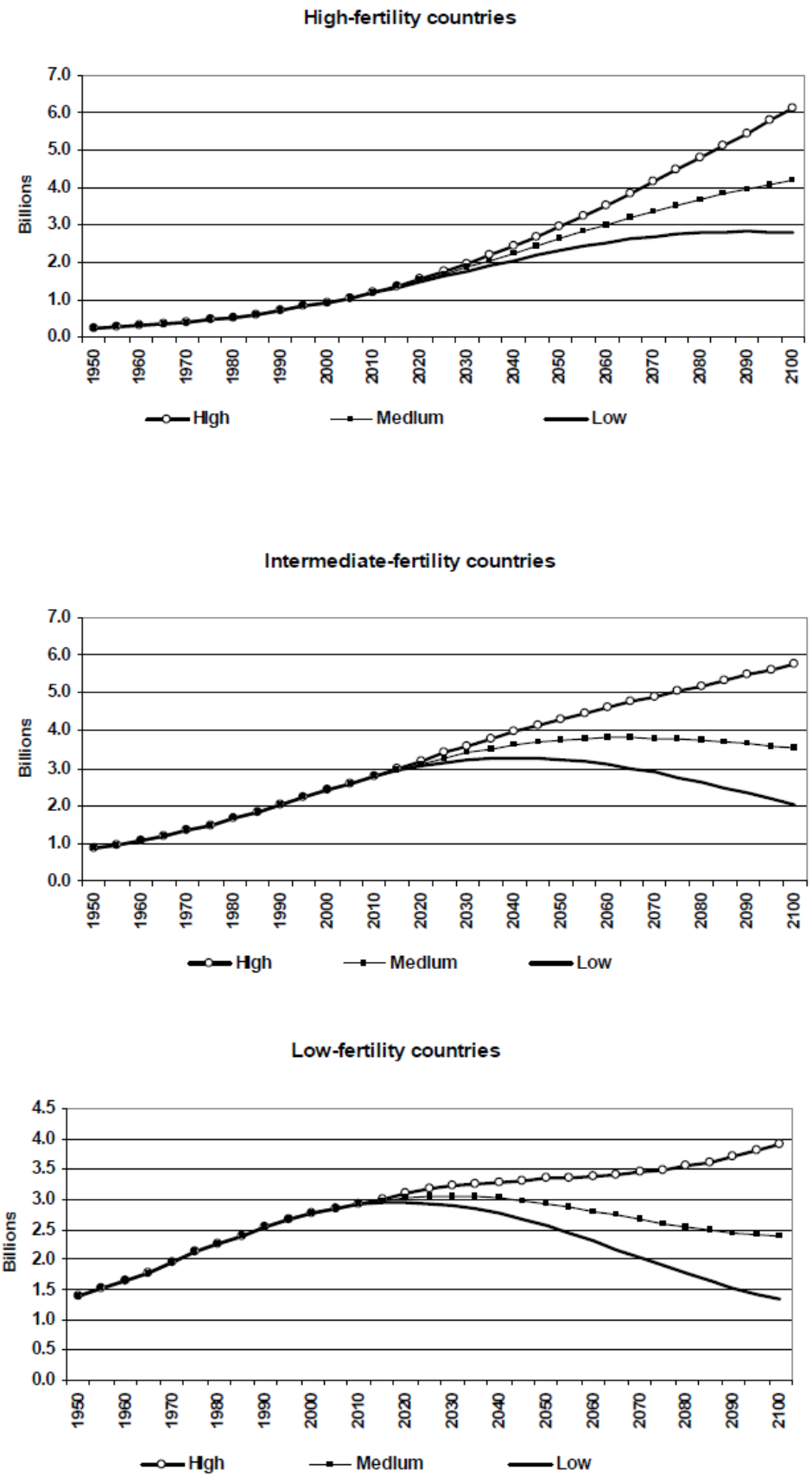


Figure 2.5: Population for countries grouped by fertility level, low, medium and high variants, 1950-2100 (UN 2011b).

The difference between the population produced by the high and low variant of the intermediate-fertility countries amounts to 1.1 billion in 2050 (4.3 billion vs. 3.2 billion) and reaches 3.8 billion in 2100 (5.8 billion vs. 2.0 billion). If fertility of the intermediate-fertility countries will not drop below replacement level, their population might double by 2100 as projected in the high variant. The low variant's reduced projection of population can only set in, if fertility drops to 1.5 children per woman (UN 2011b).

The difference between the high and low variant projections in 2050 accounts to 0.6 billion for the low-fertility countries (3.3 billion vs. 2.6 billion). It would have already expanded to 2.6 billion in 2100 (3.9 billion vs. 1.3 billion). The values projected by the high variant would be reached if fertility rose above replacement level while remaining generally below 2.5 children per woman. The values projected by the low variant would result from maintaining fertility below 1.6 children per woman. Then, such a persistently low level in fertility would cause a progress in population decline and population ageing, which is rather unlikely (UN 2011b).

Box: Population ageing

Global population ageing primarily depends on fertility and life expectancy in a country and therefore varies between the different fertility levels.

Because of declining fertility and increasing longevity, *low-fertility countries* show the fastest population ageing. According to the medium variant, by 2050, 26 per cent of their population will be aged 65 or over and just 24 per cent will be below age 25 (UN 2011b).

Population ageing is slower among the *intermediate-fertility countries*, resulting in a similar age structure as that of the low fertility countries.

Showing the slowest population ageing in 2050, only 6 per cent of the population in *high-fertility* countries is projected to be over 65 in 2050 (UN 2011b).

2.2 Population forecasts of the major regions of the world

To get a more detailed view on the different regions of the world and the projections of their population development, they were, divided into 3 classes each with several subsections, which represent the major regions of interest:

- the world (see chapter 2.1)
- developing countries:
    - Asia,
    - Africa,
    - North Africa and the near-East,

    - sub-Saharan Africa,
    - Latin America and Caribbean
- developed countries:
    - Japan, Europe (excluding EU 27), Northern America, Australia and New Zealand (in ,
    - European Union (EU 27) separate

(see a list of the countries of each subsection in Annex 2.1 - Annex 2.9)[1].

The forecasts for the world population up to the year 2100 were already discussed in chapter 2.1. Projections of the medium variant for the remaining classes and countries (see above) are considered below.

2.2.1 Developing countries

According to the medium variant, the population of the least developed countries is projected to exceed the population of the more developed regions by 2035, reaching about 1,75 billion by 2050 and doubling the more developed regions' population by the end of the century (Fig.2.6). The population of the least developed countries is projected to more than triple during the period 2011-2100, passing from 0.85 billion in 2011 to 2.7 billion in 2100 (Fig.2.6) (UN 2011a). This caused by their fertility, which was estimated at 4.4 children per woman in 2005-2010 and is not expected to reach replacement level before the end of the century (UN 2011a).

The population in other less developed countries, which include many of the most populous countries (China, India, Indonesia and Brazil), is expected to reach nearly 6.3 billion by 2050, culminating at about 6.4 billion around 2060 (Fig.2.6) (UN 2011a).

As data sets are of different origin than the ones for the population (cp. chapter 2), their major regions' subdivision is not always congruent. However the main classification is the same, therefore the data sets are referring to each other.

[1] As data sets for the Population section are of different origin than the ones for "Food demand and agricultural production" and "Demand for key nutrients (NPK) in the year 2050 "(cp. chapter 3 and 4) , their major regions' subdivision is not always congruent. However the main classification is the same, therefore the data sets are referring to each other.

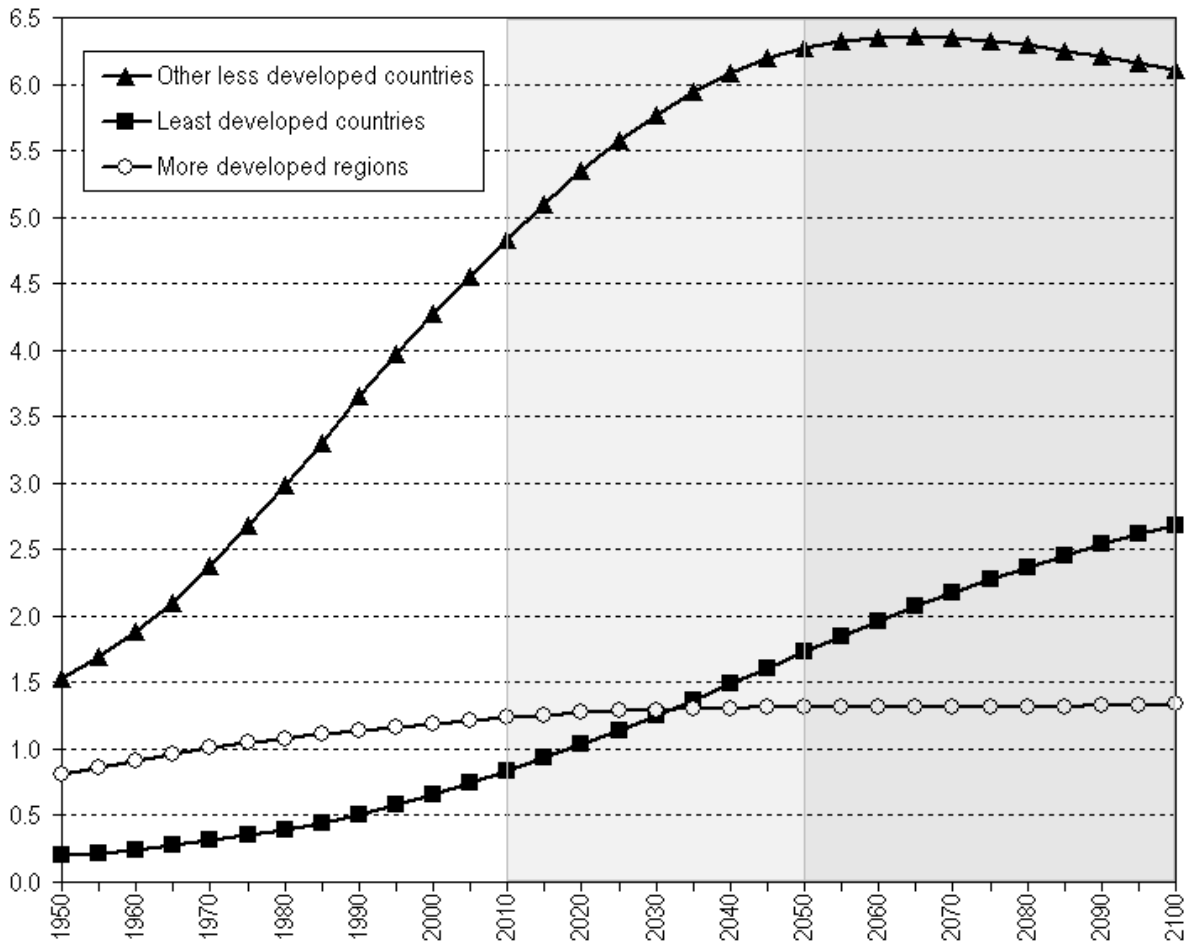


Figure 2.6: Projected population by development region, medium variant, 1950-2100 (billions) (UN 2011a).

Asia

In 2011, 60 per cent of the world population lived in Asia and although Africa's population will more than triple, Asia will keep its status as most populous major area in the world during the whole 21st century. Its population amounts to 4.2 billion currently. It is projected to reach its maximum value of 5.2 billion in 2052, followed by a slow decline thereafter. Asia's population hence will be only 28 per cent higher than that of Africa (4.6 billion vs. 3.6 billion), while in 2050 it is still expected to be more than double that of Africa by 2100 (5.2 billion vs. 2.2 billion) (Fig.2.9). However, this is a rather small ratio compared to 2010, when Asia's population was even four times as large as that of Africa (4.2 billion vs. 1.0 billion) (Fig.2.9) (UN 2011a).

According to the medium variant, the future distribution of the world population by major area is likely to change significantly. Asia's today's major share of 60 per cent is expected to

decline to 55 per cent in 2050 and diminishing even more, below 50 per cent (45 per cent in 2100), during the second half of the century (Fig.2.7) (UN 2011a).

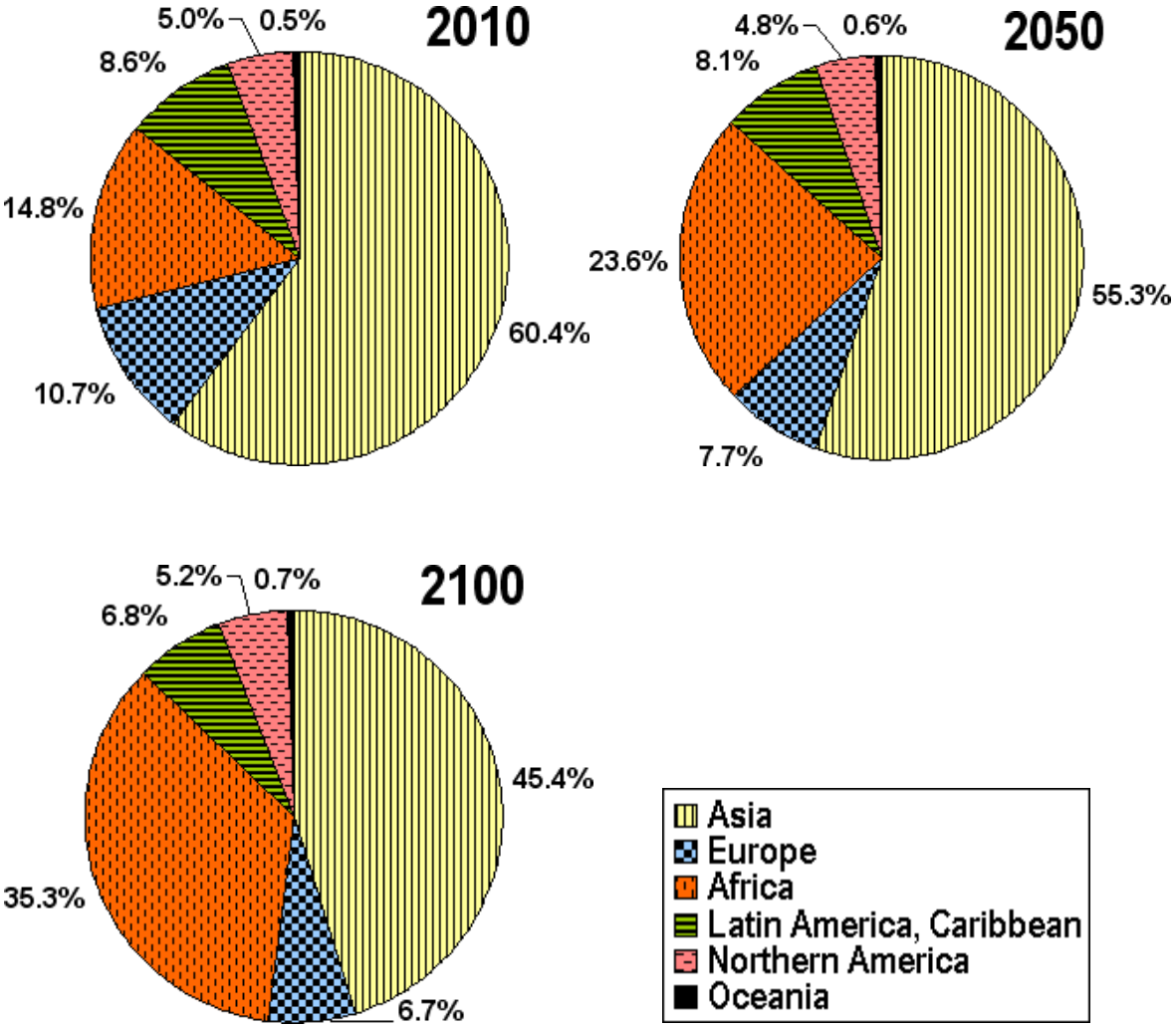
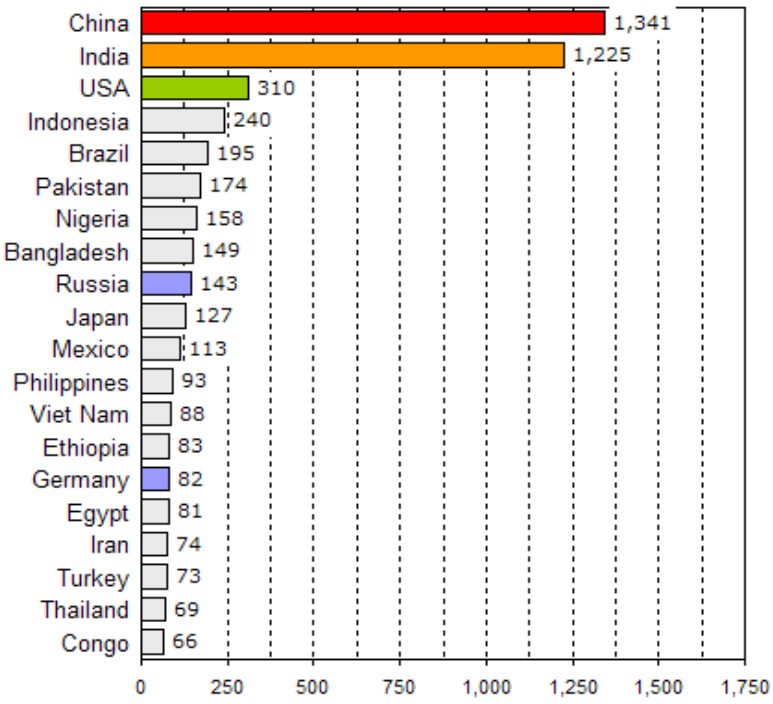


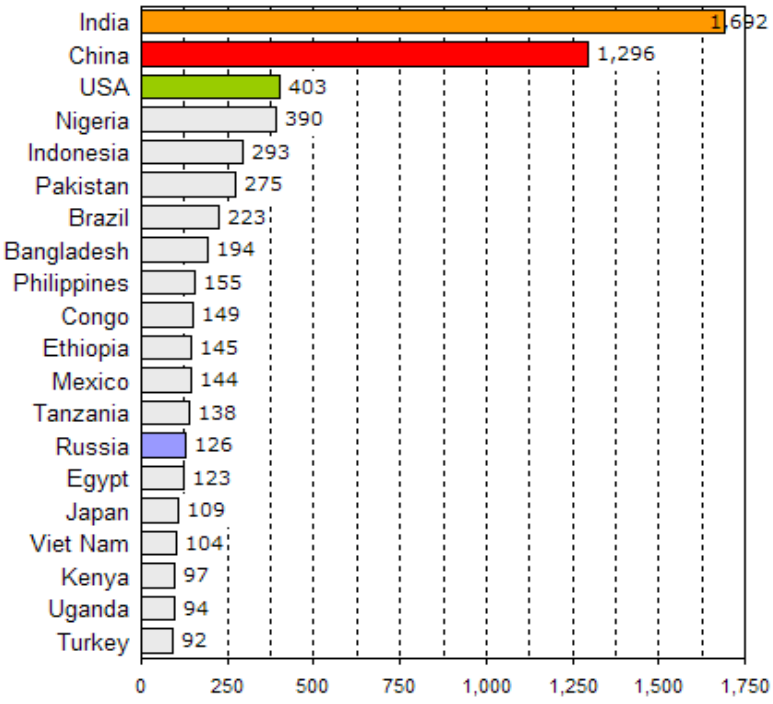
Figure 2.7: Distribution of the world population by major area, medium variant, 1950, 2010, 2050 and 2100 (UN 2011a).

The most population country was China with 1 341 million people in 2010. The first and second rank in the hierarchy will have changed by 2050 (Fig.2.8). India is then expected to exceed China with some 400 million people. China's population will then even be some 600 million smaller than that of India in 2100 (Fig.2.8) (UN 2011a).

2010



2050



2100

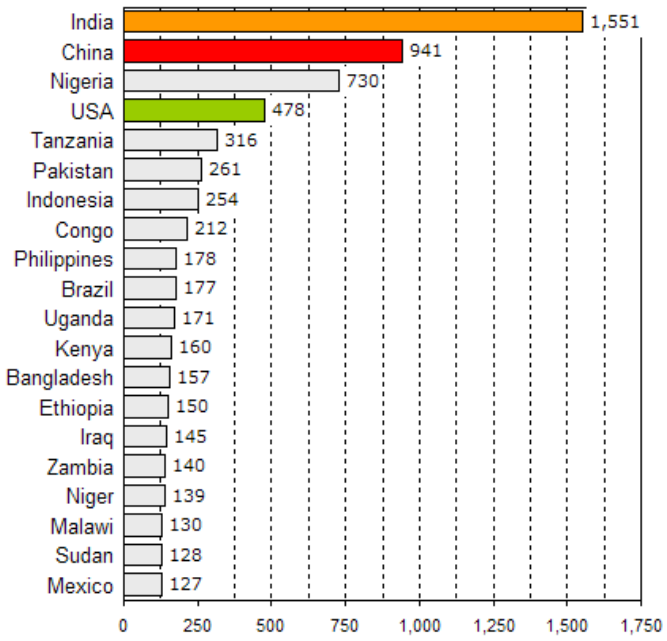


Figure 2.8: Population of the 20 most populous countries in 2010, 2050 and 2100 (millions) (UN 2011a).

Africa

During the 21st century Africa's population is projected to more than triple, passing from 1 billion in 2011 to 2.2 billion in 2050 and finally to 3.6 billion in 2100.

15 per cent of the world population lived in Africa in 2011, but **Africa's population is growing very rapidly** with a rate of 2.3 per cent per year during 2010-2015 (Asia only 1 per cent per year). Although its fertility drops from 4.6 children per woman in 2005-2010 to 3.0 children per woman in 2040-2045, Africa's population is gaining another billion people within only 35 years (by 2044). This rapid growth expects Africa's population to account for 24 per cent of the world population in 2050 and for 35 per cent in 2100 (Fig.2.7) (UN 2011a).

Seven out of the 20 most populous countries will be in Africa in 2050 (Nigeria, the United Republic of Tanzania, the Democratic Republic of the Congo, Uganda, Kenya, Ethiopia, Zambia, Niger, Malawi, Sudan). It will even be ten by 2100. Nigeria will then have replaced the United States as the third most populous country in the world (Fig.2.8) (UN 2011a).

North Africa and the Near-East

In contrast to the World Population Prospects of the UN, the required considerations of the major areas of interest in this report for the Joint Research Center of the European Commission (JRC) are divided into different groups. Therefore the western Asian countries: *Bahrain, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syrian Arab Republic, United Arab Emirates, Yemen,* appear in the group "Asia" as well as in the group "near-East" (WIKIPEDIA a) and thus are mentioned twice. According to the medium variant the population of the subsection Northern Africa and the near-East experiences a growth in population passing from nearly 421 million in 2010 to nearly 683 million in 2050 (Tab.2.1, Fig.2.9). Whereas this major region's population is characterized by the smallest share of the world population in the early 21st century, it surpasses the population of the EU 27 in 2023. Despite a continuous increase, the population of Latin America and the Caribbean is not surpassed, at least until the middle of the century (Fig.2.9).

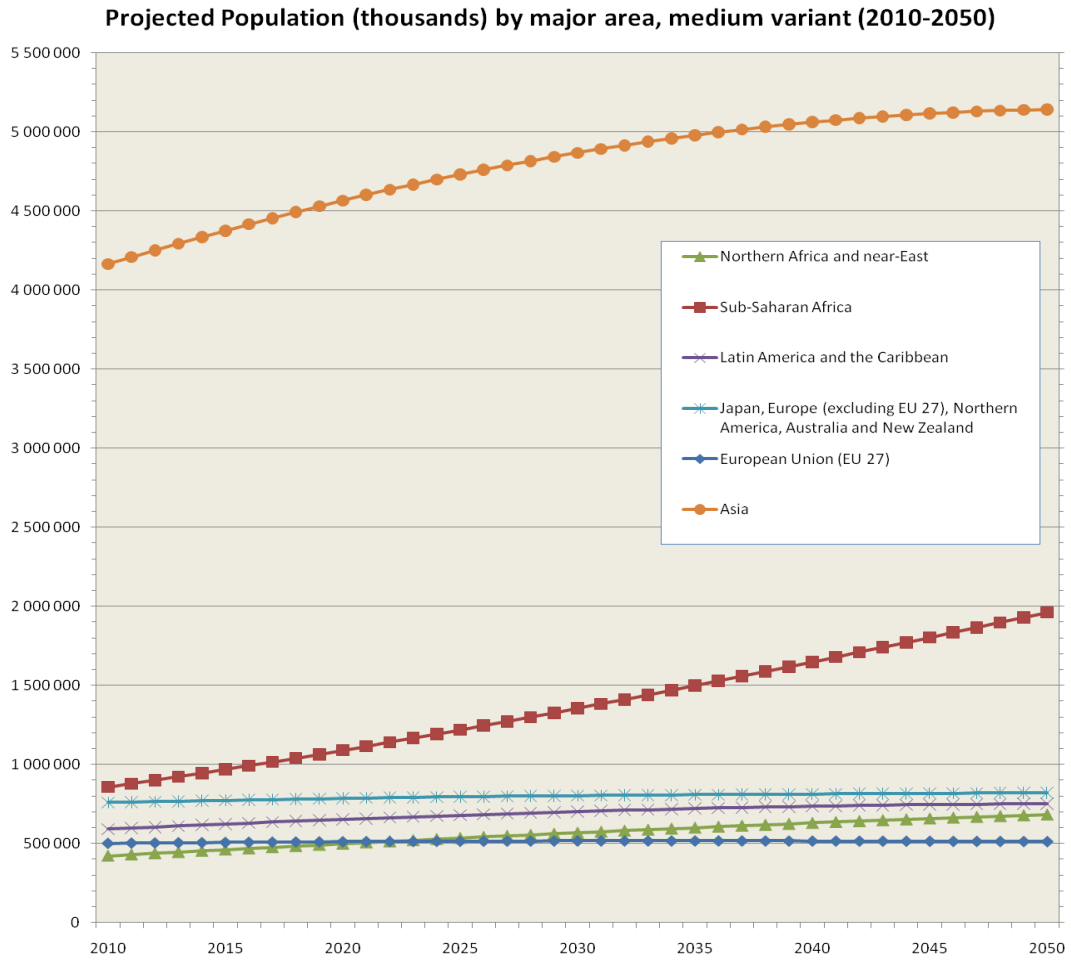


Figure 2.9: Projected Population (thousands) by major area, medium variant (2010-2050). Data source (UN 2011c).

Table 2.2: Projected population, medium variant (thousands). Data source (UN 2011c).

Major Region	Population 2010	Population 2050
WORLD	6 895 889	9 306 128
Northern Africa and near-East	420 900	682 782
Sub-Saharan Africa	856 327	1 960 102
Latin America and the Caribbean	590 082	750 956
Asia	4 164 252	5 142 220
Japan, Europe (excluding EU 27), Northern America, Australia and New Zealand	758 049	819 953
European Union (EU 27)	500 441	511 661

Sub-Saharan Africa

The population of the Sub-Saharan Africa (WIKIPEDIA b) **is projected to grow fastest among the major regions** in consideration. It passes from about 856 million in 2010 to approximately 1.96 billion in 2050. Only surpassed by the population of Asia, Sub-Saharan Africa currently has the second largest population in the world and still will have by 2050 (Tab.2.1, Fig.2.9).

Latin America and the Caribbean

The population of Latin America and the Caribbean is 590 million currently (Tab.2.1, Fig.2.9). Within the next 39 years its growth is projected to be rather moderate. According to the medium variant it is projected to reach 751 million by 2050 (Tab.2.1, Fig.2.9). Meanwhile its share of the world population is declining from 8.1 per cent in 2010 to 8.1 per cent in 2050 and still dropping further in the second part of the century (Fig.2.7).

2.2.2 Developed countries

According to the medium variant, the population of the more developed regions will remain largely stable with a minimally growth of just 8 per cent by 2100, passing from 1.2 billion in 2011 to 1.3 billion in 2100 (Fig.2.6). This development is in stark contrast to that of the least developed countries and caused by the very different fertility levels of those two groups. Average fertility in the more developed regions is estimated at 1.7 children per woman in 2005-2010, which is considerably below replacement level (UN 2011a). In the medium variant there is an increase in average fertility projected. However, replacement level is not passed during the whole projection period 2010-2100.

Europe

The population of Europe as a whole is about 0.7 billion currently and projected to peak at 0.74 billion around 2025, declining thereafter. Europe's share of the world population is expected to decline from 10.7 per cent in 2011 to 7.7 per cent in 2050 and less than 7 per cent in 2100 (Fig.2.7) (UN 2011a). Furthermore, the number of European countries among the twenty most populous countries of the world declined from seven in 1950 to only two European nations in 2010 – Germany and the Russian Federation (Fig.2.8). In the year 2050 there will only be one European country left in the top twenty – the Russian Federation (UN 2011a).

Japan, Europe (excluding EU 27), Northern America, Australia and New Zealand

This major region of interest is characterized by the third largest population after Asia and the sub-Saharan Africa. There were about 758 million people living in Japan, Europe (excluding EU 27), Northern America, Australia and New Zealand in 2010. This number is projected to increase to nearly 820 million by 2050 (Tab.2.1, Fig.2.9). The growth within the whole period 2010-2050, is hence rather slow, though this major region's share of the world population is still ranked third in 2050, surpassing Latin America and the Caribbean, Northern Africa and the near- East and the EU 27 (Fig.2.9).

European Union (EU 27)

The population of the EU 27 shows a slight variation throughout the century. Its population was about 500 million in 2010. It is projected to reach its maximum at about 516 million in 2033, then declining to nearly 512 million in 2050 (Tab.2.1, Fig.2.9). In the second half of the century its projected to increase very slightly again, however, showing very stable conditions compared to the other major regions. The EU 27 will have the smallest share of the world population among these regions, in 2050.

2.3 Summary

Population is projected to increase primarily in Africa and mainly in the sub-Saharan countries (Fig.2.10). Europe is the only major region, for which a decline in population is projected until the end of the 21st century (63 per cent from 2010-2100) (UN 2011a). Africa's population as a whole however is projected to increase by nearly 2.6 billion people by 2100 (1.2 billion by 2050, sub-Saharan Africa: 1.1 billion), which assumes an average fertility decline from 4.64 children per woman in the 2009-2010 period to 2.13 children in the 2095-2100 period (UN 2011a). If fertility would decline only half a child less (from 4.64 to 2.62

children per woman), Africa's population would increase by 4.2 billion between 2010 and 2100 (UN 2011a).

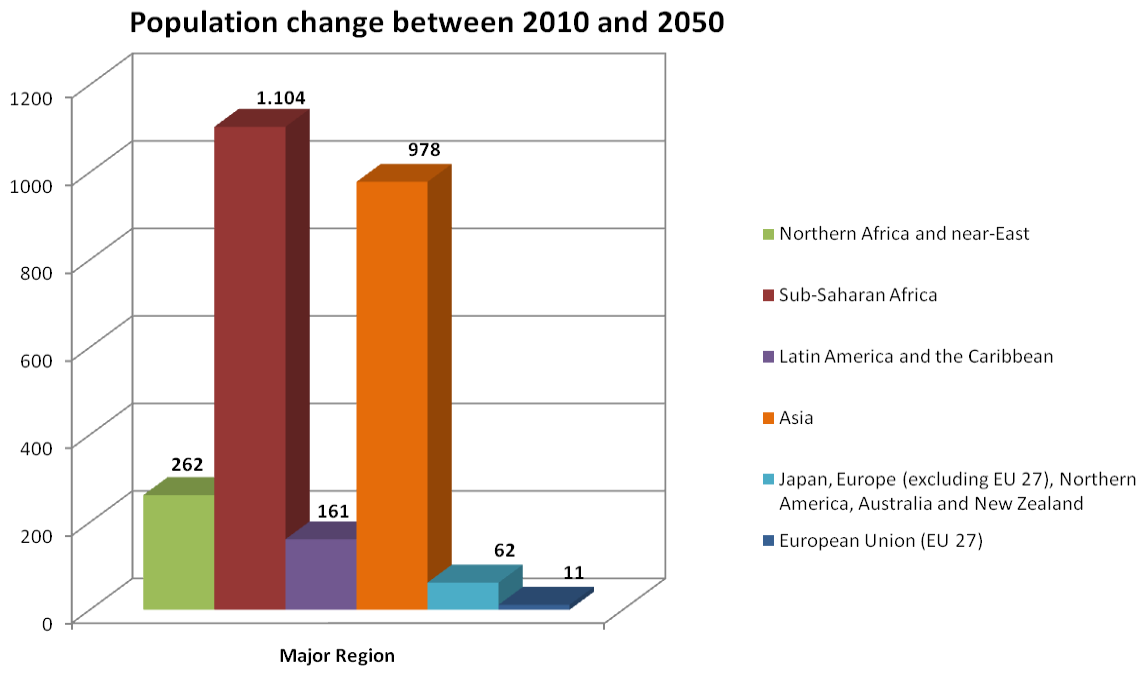


Figure 2.10: Population change between 2010 and 2050 by major region (millions). Data source (UN 2011c).

The population change in the other major regions - except the one of Asia - is projected to be quite small in the period 2010-2050, whereas the largest increase occurs in the sub-Saharan countries (Fig.2.10). Asia's population is expected to increase by 978 million, Northern Africa and the near-East by 262, Latin America and the Caribbean by 161, Japan, Europe (excluding EU 27), Northern America, Australia and New Zealand by 62 million and the EU 27 by just 11 million (Fig.2.10).

2.4 Urbanization

Since the level of world urbanization crossed the 50 per cent mark in 2009, the world population is becoming more and more urban than rural. According to the *2009 Revision of World Urbanization Prospects* (UN 2010a) the population living in urban areas is projected to gain 2.9 billion within the next 39 years, passing from 3.4 billion in 2009 to 6.3 billion 2050. At the same time the world rural population is projected to decrease at 0.5 billion passing from 3.4 billion in 2010 to 2.9 billion in 2050 (Tab. 2.3; UN 2010a, UN 2010b). The world's towns and cities, hence are going to absorb the world population growth, occurring

within this period. This urban growth is mainly expected to concentrate in urban areas of the less developed regions (Fig.2.11, Fig.2.12). Urban population is projected to increase by 1.7 billion in Asia, reaching 3.4 billion by 2050 (Fig.2.11). An increase of 0.8 billion is expected in Africa. This would lead to 1.2 billion urban dwellers (Fig.2.11), turning Africa to the second largest urban population after Asia in 2050 (Fig.2.13). Latin America and the Caribbean is projected to grow at 0.2 billion (Fig.2.11) (UN 2010a). As far as the rural population is concerned, every major region experiences a decline, except Africa (Fig.2.14), whose rural population is expected to gain 147 million. Africa is expected to have nearly 0.8 billion rural inhabitants by 2050 (Fig.2.11) and to remain the major area with the second largest rural population after that of Asia (Fig.2.14) (UN 2010b).

Tab. 2.3 Global rural and urban population estimates 2010 and 2050 (UN 2010a)

Year	Rural Population (in thousand)	Urban Population
2010	3.422.362	3.486.326
2050	2.864.103	6.285.881

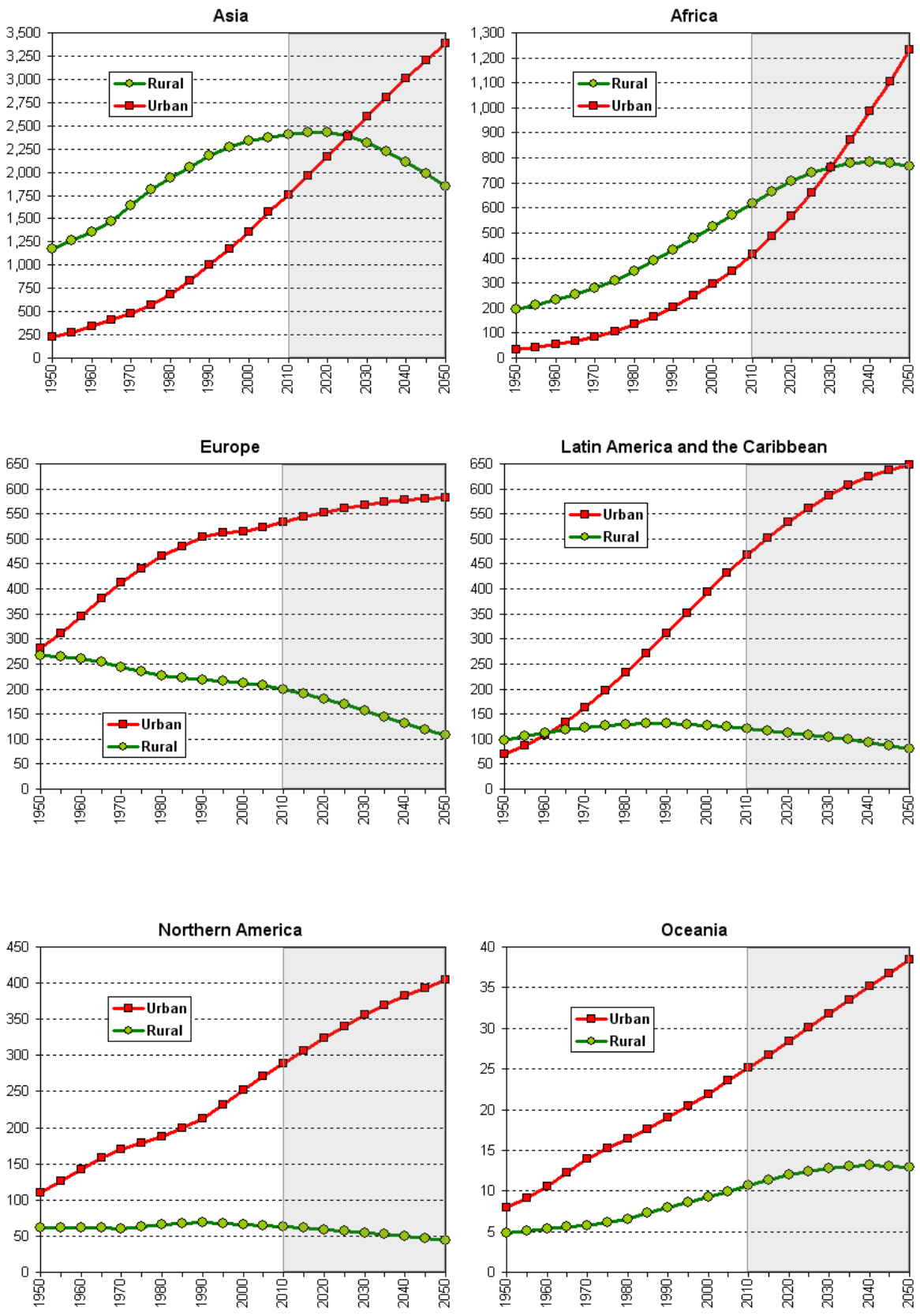


Figure 2.11: Urban and rural population by major region (in million) (UN 2010c).

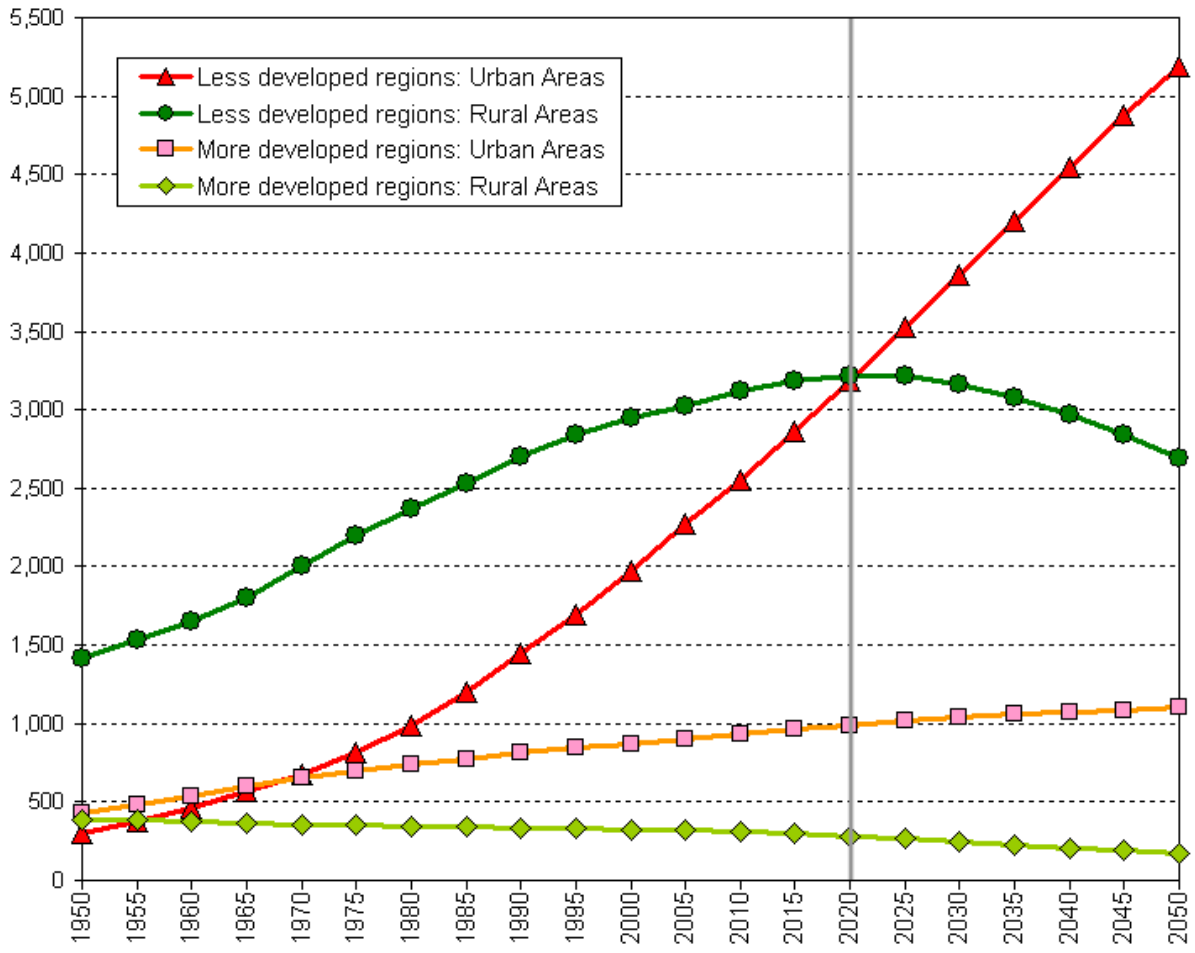


Figure 2.12: Urban and rural population by development regions (in millions) (UN 2010c).

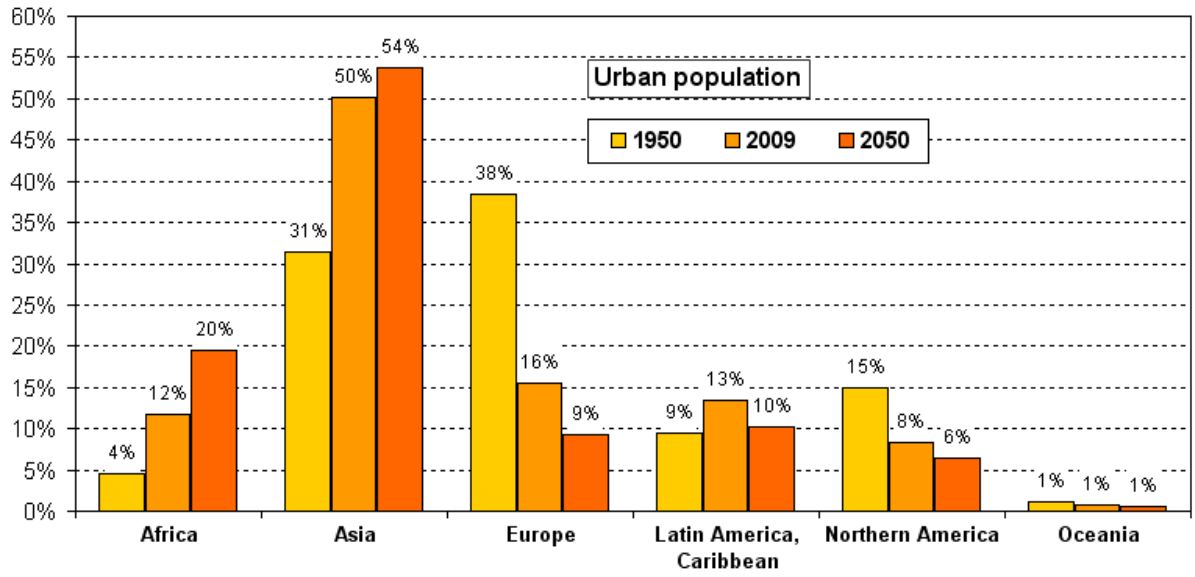


Figure 2.13: Distribution of the world urban population by major area (UN 2010c).

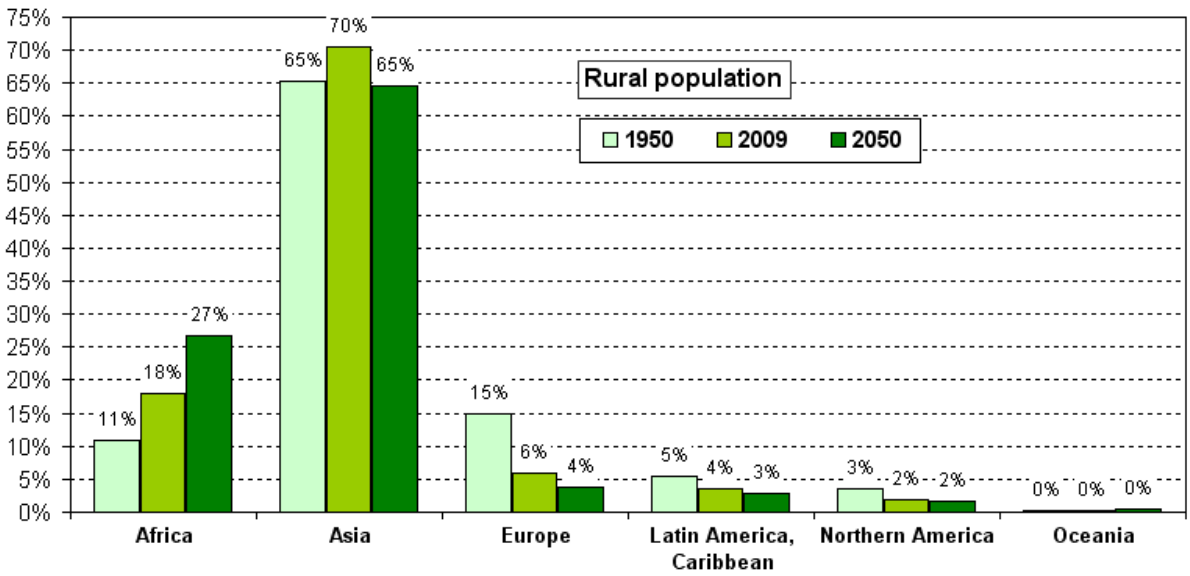


Figure 2.14: Distribution of the world rural population by major area (UN 2010c).

75 per cent of the inhabitants of the more developed regions like Northern America, Europe and Oceania, lived in urban areas in 2009 (Fig.2.15) (UN 2010b). However, the less developed regions like Asia and Africa showed only an urban fraction of 45 per cent of their population (Fig.2.15) (UN 2010b).

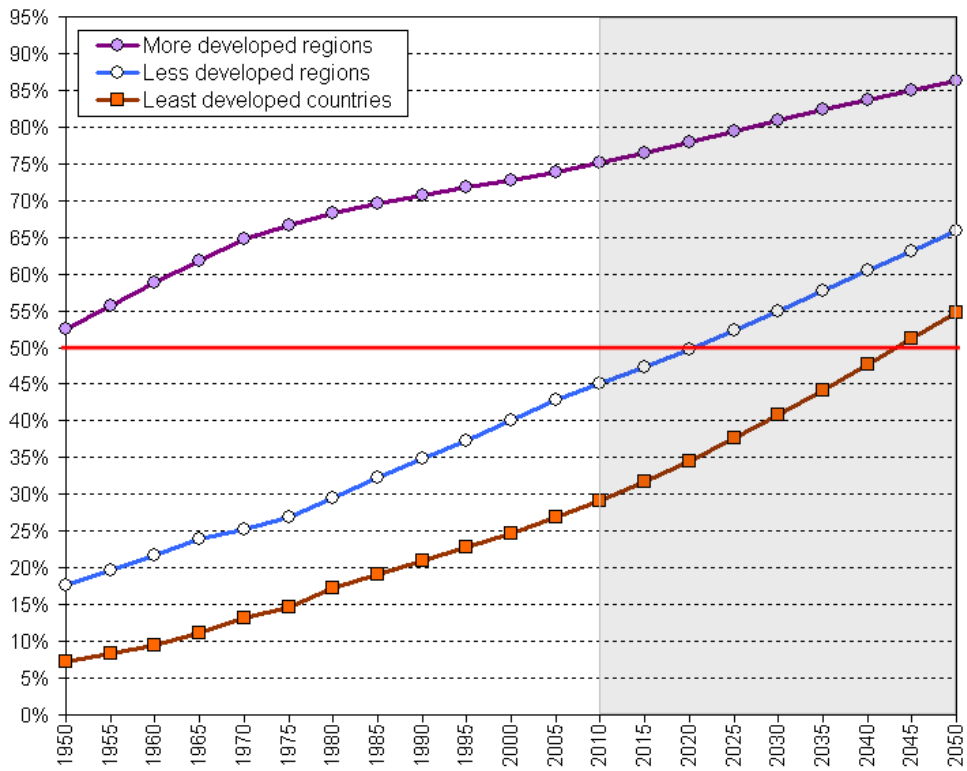


Figure 2.15: Urban population by major development regions (in per cent of total population) (UN 2010c).

The urban population is projected to grow in the more developed regions as well as in the less developed regions by 2050, so that urban dwellers will likely account for 86 per cent of the population in the more developed regions and for 66 per cent of that in the less developed regions (Fig.2.15). In total, the world population is expected to be 69 per cent urban in 2050 (UN 2010a).

The current world urban population is unevenly distributed. 52 per cent of the urban population lives in cities, having fewer than half a million dwellers. The remaining 48 per cent live in 958 cities with more than half a million inhabitants each, only 54 of them with populations over 5 million people. Among the 54 cities, 21 rank among the so called megacities, counting at least 10 million urban dwellers each (UN 2010b).

The major part of the 958 cities with at least half a million inhabitants is located in Asia (52 %), followed by Europe (14 %), Northern America (9 %) and Oceania (1 %). Africa and Latin America and the Caribbean account for 12 % each. The largest number of megacities is also found in Asia (11 in 2010) followed by Latin America (4), Africa (2), Europe (2) and Northern America (2) (UN 2010b). The number of megacities is projected to increase to 29 by 2025 with an additional five in Asia (China: Shenzhen, Chongqing, Guangzhou; Jakarta, Lahore), two in Latin America (Bogotá, Lima), and one in Africa (Kinshasa) (UN 2010b).

The fact that **most of the population growth until the middle of the century will take place in urban areas**, holding 69 per cent of the world population then, **has influence on life styles and consumption patterns. In combination with income growth it may accelerate the ongoing diversification of diets in developing countries** (cp. chapter 3) (FAO 2009). High variation in population estimates will affect NPK demands in the future; whereby **This shift in population distribution will heavily but unpredictably affect agricultural production and food demand, especially in Africa.**

3 FOOD DEMAND AND AGRICULTURAL PRODUCTION

Concerning the future world food consumption, the main socio-economic factors leading to an increased food demand are population growth, increasing urbanization, rising incomes and changes in the incidence of poverty in the population over time (FAO 2009, M&R 2009).

To reach higher levels of food availability and to increase the ability of covering a higher food demand in the different regions and countries, on the supply side either agricultural production or the net imports of food have to be increased or a combination of both.

Regarding a few other challenges such as climate change, appropriate policies are required to ensure food security for a world population of 9.1 billion people (cp. chapter 2).

The mentioned aspects are discussed below.

Box: Urbanization and income growth

A growing urbanization, taking place mainly in less developed regions (cp. chapter 2.3), will be accompanied by changes in life styles and consumption patterns. In combination with growing incomes the ongoing diversification of diets in developing countries may be even more accelerated (FAO 2009).

According to the projections of growth used by a number of key policy centers, incomes, measured by GDP per capita, are expected to grow strongly in recently industrialized nations and most rapidly in East Asia and the Pacific (M&R 2009, World Bank, 2007a; UNEP, 2007). Growth rates in Asia will be the highest, ranging from 2.1 to 5.2 percent per year, whereas Eastern European incomes are expected to rise by 4.1 percent per year. In contrast rapid population growth in Sub-Saharan Africa is projected to depress per capita growth rates to approximately 0.8 to 1.7 percent per year (M&R 2009). Rapidly rising incomes in the developing world has led to the increase in the demand for livestock products. Moreover a change in diet has been detected. **Urbanized populations consume less basic staples and more processed foods and livestock products, like vegetables, fruits, meat, dairy, and fish** (M&R 2009, ROSEGRANT et al. 2001, FAO 2009). In addition to the continuing dynamic change towards a further concentration of supermarkets and due to the consumption of semi-processed or ready-to-eat foods, these inadequate diets often cause a variety of diet-related chronic Non-Communicable Diseases (NCDs) (WHO 2003, SCHMIDHUBER & SHETTY 2005, ALEXANDRATOS 2006, FAO 2006a, 2009). The diets with a higher meat content put additional pressure on land resources and pasture and coarse grain markets for feed, including maize. As a result of these trends, it is predicted that more than 60 percent of meat and milk consumption will take place in the developing world by 2020, and the production of beef, meat, poultry, pork, and milk will at least double considering the 1993 levels (M&R 2009, DELGADO et al. 1999). This growing demand of urbanized areas can only be covered by rural areas linked to them and again could furthermore exceed the potential of the arable land (M&R 2009). The current trend goes back to urban subsistence production and regional food systems. The argument to import food is pretty unvalid for the case of Africa because there is no purchasing power to import food and even if - nobody can buy the eventually more expensive food. Still in most regions the cities are fed from the periurban and rural areas in situ. A more challenging issue will be shifting NPK markets due to a huge shift in wolrd population distribution. This affects Africa heavly and needs to be addressed very soon by the international community

3.1 Food Demand

According to the FAO the pattern of food demand will be changing until the middle of the century. FAO's 2006 *Interim Report on World Agriculture towards 2030/2050* (IR) provided a first view on future developments of food demand and agricultural production (Tab.3.4, Tab.3.5). This data was reviewed, updated and adjusted by different authors and presented on the 2009 FAO Expert Meeting on How to Feed the World in 2050 in Rome. Table 3.1 shows the projections of the IR and some new and adjusted data (ALEXANDRATOS 2009) respectively. Once again, the figures are divided into the major regions of interest:

- the world (see chapter 2.1)
- developing countries:
    - South Asia, East Asia,
    - North Africa and the near-East,
    - sub-Saharan Africa,
    - Latin America and Caribbean
- developed countries:
    - Industrial countries,
    - Transition countries

As data sets are of different origin than the ones in chapter 2, their major regions' subdivision is not always congruent. However the main classification is the same, therefore the data sets are referring to each other.

Per capita food consumption in the FAO 2006a IR shows a gradual rise in the developing countries (Tab.3.1), e.g. from 2580 kcal/person/day in 99/01 to 2620 kcal in 2003/05. Hence the numbers of undernourished would be gradually falling, from 811 million in 99/01 to 582 million in 2015, declining even further by 2030 and 2050 (FAO 2006a, ALEXANDRATOS 2009). Taking the revised data as a basis, in 2050 fewer developing countries than reported in the IR will have reached mid-high levels of per capita food consumption (over 2700 kcal/person/day) reaching an average of almost 3000 kcal/person/day in total. While in the IR this corresponds to 85 countries accounting for 90 percent of the population, the revised estimates show 73 countries, accounting for 80 percent of the developing country population in 2050 (FAO 2009, ALEXANDRATOS 2009). The world average will be approaching 3000 kcal/person/day between 2030 and 2050, ending up at about 3050 kcal/person/day in 2050, an 11 percent increase over its level in 2003. At the regional level food availability will still vary widely between countries. For example, Sub-Saharan Africa will not have reached the mark of 2700 kcal/person/day until 2050. The disparity between sub-Saharan Africa and the other regions is even more pronounced if Nigeria is excluded from the regional total. Compared to that, South Asia is projected to reach the mid-high level of 2700

kcal/person/day already by 2030. In contrast, Industrial countries will already have average availability levels of nearly 3600 kcal/person/day by 2050 (FAO 2009, ALEXANDRATOS 2009).

According to calculations of two different scenarios of AGRIMONDE 2009 the world average per capita food consumption in 2050 either reaches 3,590 kcal/cap./day (Agrimonde GO) in ascenario where economic growth boosts consumption in total, or 3000 kcal/cap./day (Agrimonde 1) in a world where a sustainable food and agricultural system could have been implemented (Fig.3.1). Sustainable food and agriculture systems will lower the NPK demand in a long run.

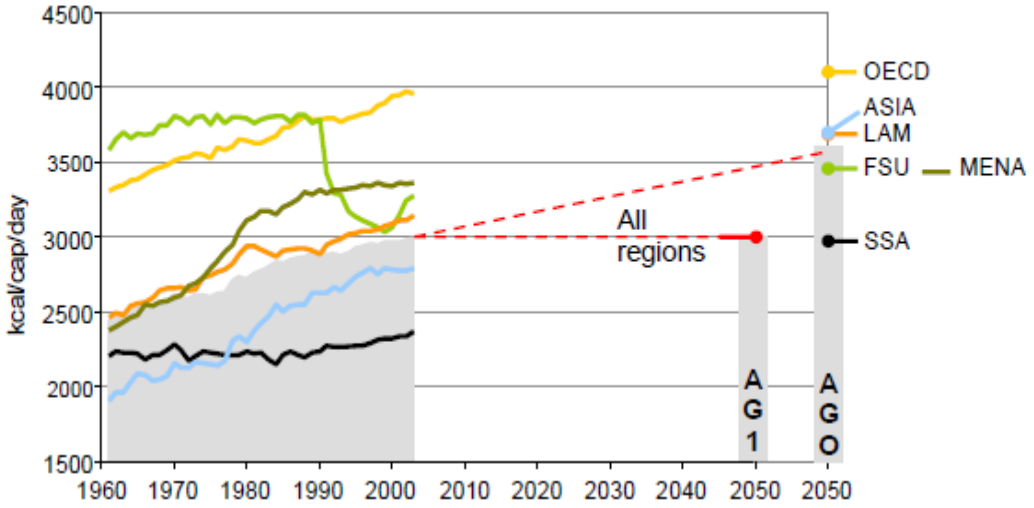


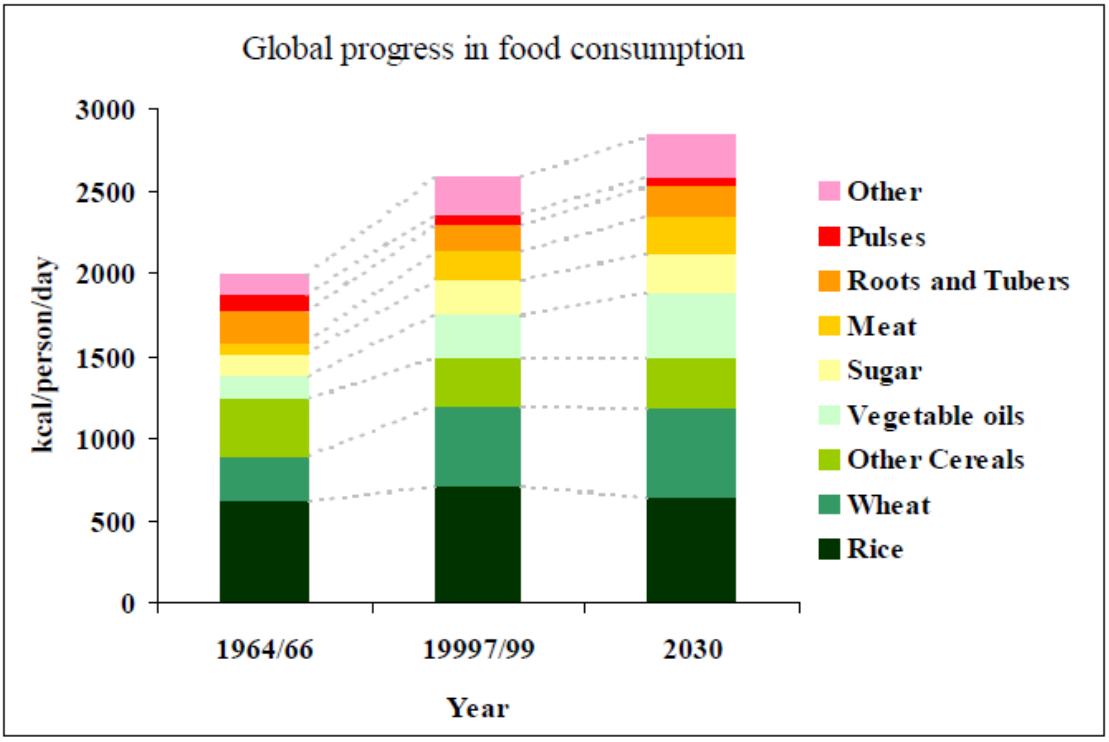
Figure 3.1: Mean regional food availability from 1961 to 2003 and in 2050 in the Agrimonde scenarios (AGRIMONDE 2009). *(OECD: OECD 1990 countries, ASIA: Asian countries, LAM: Latin America, FSU: Former Soviet Union, MENA: Middle East and North Africa, SSA: Sub-Saharan Africa).*

With respect to the different projected data in the first half the century, global demand for food, feed and fibre is expected to grow by some 70 percent, while, increasingly, crops may be increasingly used for bio-energy and other industrial purposes. **This consistent growth of food demand is a combined consequence of the population growth (cp. chapter 2), continuing strong income growth, urbanization in many of the developing countries and the associated changes in consumption patterns (see above)**. Moreover another reason for growing food demand is stepwise food saturation in many developing countries, as is already the case in developed countries. Although the growth rate of demand will be lower than during recent decades the projected total demand increase is still significant in absolute terms. The expected food and feed demand will require a considerable increase of global food production of 70 percent by 2050, which implicates an additional quantity of nearly 1 billion Mt of cereals and 200 million Mt of meat (FAO 2009).

Table 3.1: Per capita food consumption in the different major regions of the world (ALEXANDRATOS 2009).

	Interim Report Table 2.1				New data and adjusted Projections			
	99/01	**2015**	**2030**	**2050**	**99/01New**	**03/05**	**2015**	**2030**	**2050**
World	2789	2950	3040	3130	2725	2771	2884	2963	3047
Developing countries	2654	2860	2960	3070	2579	2622	2770	2864	2966
sub-Saharan Africa	2194	2420	2600	2830	2128	2167	2319	2494	2708
- excluding Nigeria	*2072*	*2285*	*2490*	*2740*	*2016*	*2061*	*2206*	*2406*	*2643*
Near East / North Africa	2974	3080	3130	3190	2991	2995	3072	3134	3197
Latin America & Carib.	2836	2990	3120	3200	2798	2899	2953	3084	3151
South Asia	2392	2660	2790	2980	2334	2344	2532	2656	2843
East Asia	2872	3110	3190	3230	2764	2839	3034	3112	3144
- excluding China	*2698*	*2835*	*2965*	*3100*	*2475*	*2538*	*2614*	*2740*	*2870*
Industrial countries	3446	3480	3520	3540	3429	3462	3501	3548	3569
Transition countries	2900	3030	3150	3270	2884	3045	3043	3159	3283

Figure 3.2 shows a projected distribution of several commodities up to 2030. Apparently the demands for wheat, other cereals, vegetable oils and meat are expected to increase, while the need for rice is projected to decline.



Source: FAO (2002)

Figure 3.2: Projection of future demand in different commodities (FAO 2009).

Table 3.2 shows the breakdown of the total cereals demand in its two largest components (food and feed uses) (M&R 2009). The total food demand for cereals shows an increase in all regions, whereas the major absolute demands still remain highest in North America and Europe, and East Asia and the Pacific. **Without considering biofuels**, much of the increase in the demand for cereals will be for animal feed to support the growing consumption of livestock products (FAO 2009). Regarding food use, **sub-Saharan Africa shows the strongest demand growth**, however the food consumption volumes are higher in other regions such as South Asia, East Asia, the Pacific and Latin America. The Middle East/ North Africa region has similar food demand growth for cereals as South Asia, and those regions with the lowest levels of growth are Eastern Europe and Central Asia, as well as the East Asia and Pacific regions (M&R 2009). Considering the feed uses of cereals, the North American and European regions are the world's leading factions in the total volume of feed consumption. Their consumption patterns are linked to high incomes and high urbanization (see above). East Asia is expected to have the second largest feed use, followed by Latin America and the Caribbean as well as the Middle East and North Africa.

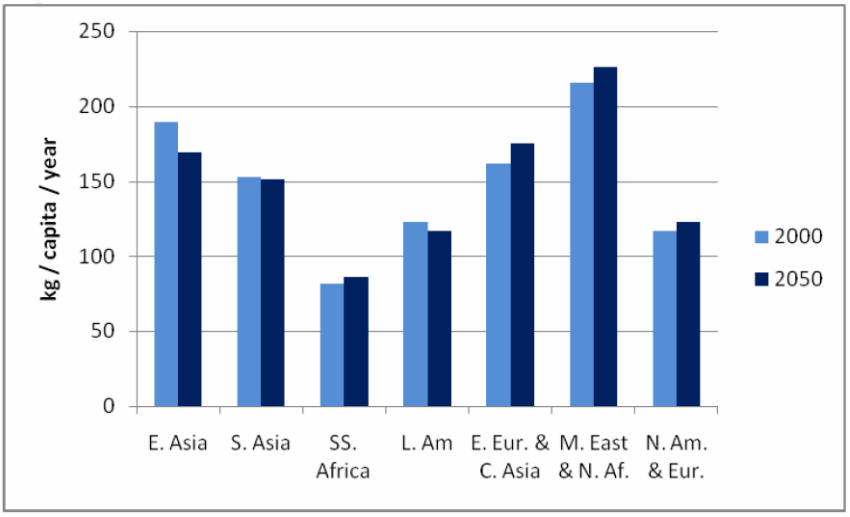
Table 3.2: Total Feed and Food Demand for Cereals (millions of metric tons (Mt)) (M&R 2009).

	Total			Food			Feed		
	2000	2050	% chg	2000	2050	% chg	2000	2050	% chg
South Asia	250	427	71%	218	360	66%	3	12	266%
East Asia and Pacific	524	688	31%	347	376	8%	102	205	100%
Europe and Central Asia	235	267	13%	79	80	1%	108	124	14%
Latin America and Caribbean	180	287	60%	63	88	40%	50	112	122%
Middle East and North Africa	90	182	103%	56	102	83%	23	58	147%
Sub-Saharan Africa	84	243	190%	65	187	189%	7	18	155%
North America and Europe	619	853	38%	114	148	30%	324	401	24%

Source: IFPRI IMPACT projections.

Note: N America = North America, SSA = Sub-Saharan Africa, S Asia = South Asia, MENA = Middle East & North Africa, LAC = Latin America & the Caribbean, ECA = Europe & Central Asia, EAP = East Asia & Pacific.

The per capita food demand provides a basis on which the change in consumption patterns can be analyzed among the major regions (M&R 2009). Regarding the demand for cereals, the per capita demands of East and South Asia as well as of Latin America tend to decrease, compared to the other major regions of the world (Fig.3.3).

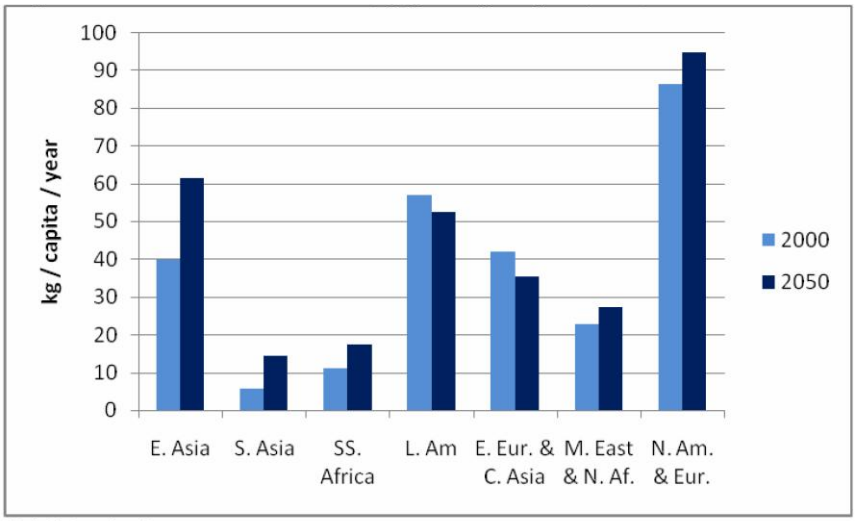


Source: IFPRI IMPACT projections.

Note: Nrt Am & Eur = North America and Europe, SS Africa = Sub-Saharan Africa, S Asia = South Asia, C&W Asia N Af = Central and West Asia & North Africa, L Am & C = Latin America & the Caribbean, SE Asia & P = SouthEast Asia & Pacific.

Figure 3.3: Per capita Cereal Demand to 2050 (kg per capita per year) (M&R 2009).

With regards to the meat consumption and demand as the main driving force for feed demands for cereals, East Asia shows the largest increase to over 60 kg/cap./year. This is goes along with its rapid growth in per capita income compared to other developing and developed regions. Also large increases in per capita consumption of meat are held by North America and Europe, South Asia and sub-Saharan Africa. The latter regions' demand growth starts at relatively low levels of less than and about 10 kg/cap./year respectively. Caused by their steady income growth over this period, North America and Europe have with more than 85 kg/cap./year (in 2000) by far the highest level in per capita meat demand (Fig.3.4) (M&R 2009). By 2050 their demand is expected to grow to about 95 kg/cap./year. **On a global scale the average consumption of meat per capita is projected to rise from 41 kg at present to 52 kg in 2050** (from 30 to 44 kg in the developing countries) (FAO 2009).



Source: IFPRI IMPACT projections.

Note: Nrt Am & Eur = North America and Europe, SS Africa = Sub-Saharan Africa, S Asia = South Asia, C&W Asia N Af = Central and West Asia & North Africa, L Am & C = Latin America & the Caribbean, SE Asia & P = SouthEast Asia & Pacific.

Figure 3.4: Per capita Meat Demand to 2050 (kg per capita per year) (M&R 2009).

Box: Biofuels

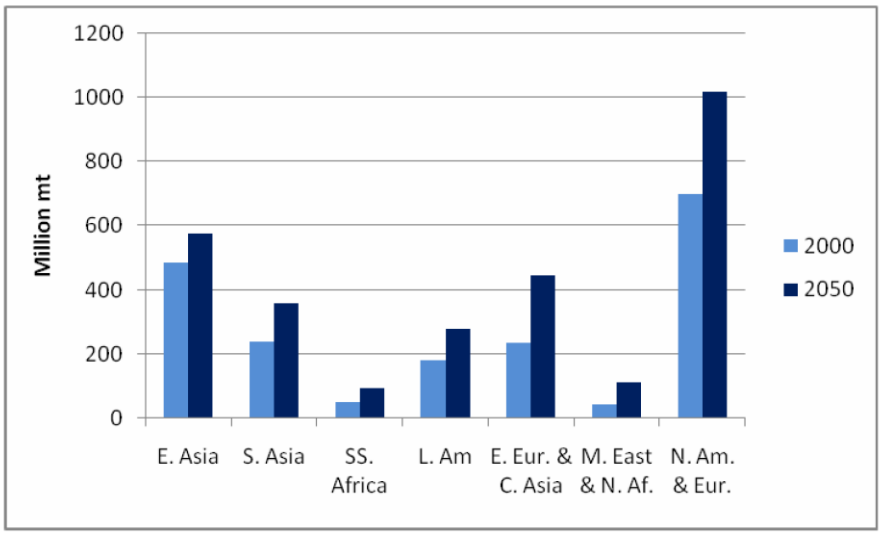
Besides the demand for agricultural commodities applied as food and feed, the future total demand is also determined by the demand for biofuels. This will influence the ability to meet the growing demand with the available resources and at affordable prices considerably. **Biofuel production based on agricultural commodities increased more than threefold from 2000 to 2008**. In 2007-08 total usage of coarse grains for the production of ethanol reached 110 million Mt, about 10 percent of global production. If the use of food crops for biofuel production is continuing to increase, serious implications for food security might be the consequences. The advent of biofuels has the potential of pushing up the world demand of agricultural commodities and its prices, depending on the energy prices and government policies (FAO 2009). The demand for biofuels, such as ethanol and biodiesel, tends to be strong when fossil-based fuel prices are high, and when national fuel policies push for increased levels of blending to reduce the cost of fuel imports (M&R 2009). "The drastic increases in prices of key food commodities such as maize, wheat, rice and soybeans in 2007/2008 mirrored the increase in prices of energy products and strengthen the recognition that energy and agricultural markets are becoming more closely linked" (FAO 2009). Besides a reconsideration of policies promoting the use of food based biofuels, a possible way to reduce the biofuels' negative implications on food availability and security are **investments in research & development for productivity growth.**

3.2 Agricultural Production

In order to reach the projected levels of food availability and per capita consumption (cp. chapter 3.1), countries can either increase agricultural production or increase their net imports. A combination of both ways is also possible. Today's group of development countries is projected to provide the major part of the future demand by expanding their own production (FAO 2009). Additionally, their food imports will be increased significantly. For instance net imports of cereals are projected to more than double from 135 million metric tons (Mt) in 2008/09 to 300 million Mt in 2050. According to that net cereal exports of developed countries will also be able to grow. Developing countries will be able to increase their export potential of commodities like vegetables, oils and sugar. As mentioned above (cp. Biofuels), biofuels will possibly have influence on these projections, as all three commodity groups are used as biofuel feedstocks (FAO 2009).

Looking at the cereal production, Table 3.4 and 3.5 show an overview of the projections obtained in the FAO 2006a IR. Future production levels accompany the expected increase in demand (cp. chapter 3.1).

The IMPACT model of the International Food Policy Research Institute (IFPRI) (ROSEGRANT et al. 2001, 2002, 2005) shows steady growth of production across all seven major regions of the world (Fig.3.5) (M&R 2009). The largest production is held by North America and Europe with about 700 million Mt in 2000 and more than 1 billion projected Mt in 2050. At the same time the region shows the highest growth rate in this period.

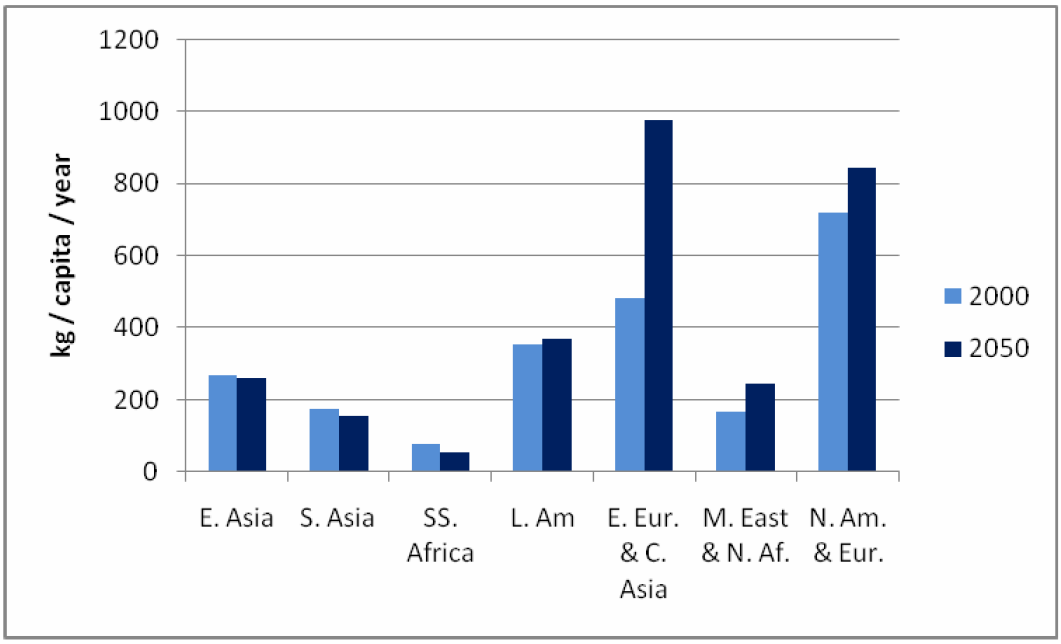


Source: IFPRI IMPACT projections.

Note: Nrt Am & Eur = North America and Europe, SS Africa = Sub-Saharan Africa, S Asia = South Asia, C&W Asia N Af = Central and West Asia & North Africa, L Am & C = Latin America & the Caribbean, SE Asia & P = SouthEast Asia & Pacific.

Figure 3.5: Total Cereal Production to 2050 (millions of metric tons (Mt)) (M&R 2009).

However, the per capita production of the specific regions shows a rather static picture, excluding the aggregate Eastern Europe and Central Asia region (Fig.3.6). It is evident that North American, European and Central Asia regions make significant increases in production, relative to own population growth in particular, with respect to the projected population growth (cp. chapter 2). With these surpluses in production, a covering of food and feed needs of the rest of the world is within the bounds of possibility (M&R 2009). The Middle East and North Africa as well as the Latin America and the Caribbean region are also able to increase their per capita production levels over the projected period, even though to a minor degree. By contrast, the South and East Asian regions decrease their per capita production over time, as does sub-Saharan Africa.



Source: IFPRI IMPACT projections.
Note: Nrt Am & Eur = North America and Europe, SS Africa = Sub-Saharan Africa, S Asia = South Asia, C&W Asia N Af = Central and West Asia & North Africa, L Am & C = Latin America & the Caribbean, SE Asia & P = SouthEast Asia & Pacific.

Figure 3.6: Per Capita Cereal Production to 2050 (kg per capita per year) (M&R 2009).

In total, the world agricultural production would need to increase by some 70 percent over the period from 2005/07 to 2050, to meet the projected daily calorie availability and per capita food consumption (Tab.3.3) (cp. chapter 3.1) (BRUINSMA 2009).

Table 3.3 illustrates the increments in production for past and future periods. The drastic slowdown in expected production growth as compared with the past for the country and commodity groups listed is obvious. This of course mirrors the projected deceleration in demand for agricultural products which in turn is a reflection of two different facts: First of the decelerating growth of population and second of the fact that an ever increasing share of population gradually attains mid to high levels of food consumption (FAO 2006a) (BRUINSMA 2009). The decline of growth in cereals for the major groups of countries and regions applied in FAO 2006a, is presented in Table 3.4 and 3.5. This slowdown mainly applies to the group of developed countries, but is also expected to occur for the better off developing countries (defined as having 2005 a supply of over 3000 kcal/cap./day) (BRUINSMA 2009).

Table 3.3: Increases in agricultural production, past and future (BRUINSMA 2009).

	1961/63	2005/07	2050	1961/63 to 2005/07	2005/07 to2050
	million tonnes / persons			increment in percent	
World (146 countries)					
population#	3133	6372	8796	103	38
total production*				148	70
crop production*				157	66
cereals**	843	2012	3009	139	49
livestock production*				136	76
meat production	94	249	461	165	85
(93) Developing countries					
population	2139	5037	7433	135	48
total production				255	97
crop production				242	82
cereals	353	1113	1797	215	61
livestock production				284	117
meat production	42	141	328	236	132
(53) Developed countries					
population	994	1335	1362	34	2
total production				63	23
crop production				64	30
cereals	490	900	1212	84	35
livestock production				62	17
meat production	52	108	133	108	23

2005/07 = 2005; 2050 from the UN 2002 Assessment; the 2050 projection from the UN 2008 Assessment amounts to 9056 million for the 146 countries covered.
* in value terms.
** including rice in milled form. The latest (CCBS) data show a world cereal production of 2138 million tons for 2006/08 implying an increment to 2050 of less than 900 million ton if measured from the 2006/08 average.

Table 3.4: Cereal balances, world and major country groups (FAO 2006a).

	Demand						SSR[a]	Growth rates			
	per capita (kg)		total (million tonnes)				(percent)	(percent p.a.)			
year	food	all uses	food	all uses	production	net trade		period	demand	production	populati
	1	2	3	4	5	6	7	8	9	10	11
					World						
1969/71	149	303	547	1114	1118	3	100	**1961-2001**	2.1	2.1	1.8
1979/81	160	325	708	1436	1442	3	100	**1971-2001**	1.7	1.7	1.7
1989/91	171	329	897	1727	1732	4	100	**1981-2001**	1.2	1.2	1.6
1999/01	165	309	1000	1865	1884	3	101	**1991-2001**	0.9	1.1	1.4
2030	165	331	1334	2677	2680	3	100	**1999/01-30**	1.2	1.2	1.0
2050	162	339	1439	3010	3012	3	100	**2030-50**	0.6	0.6	0.5
								1999/01-50	1.0	0.9	0.8
					Developing countries						
1969/71	146	192	381	499	483	-20	97	**1961-2001**	3.1	2.9	2.1
1979/81	162	219	526	711	649	-66	91	**1971-2001**	2.8	2.7	2.0
1989/91	174	238	693	951	868	-89	91	**1981-2001**	2.2	2.2	1.9
1999/01	166	238	784	1125	1026	-112	91	**1991-2001**	1.6	1.6	1.7
2030	166	268	1112	1799	1567	-232	87	**1999/01-30**	1.6	1.4	1.2
2050	163	279	1226	2096	1800	-297	86	**2030-50**	0.8	0.7	0.6
								1999/01-50	1.3	1.1	0.9
					Industrial countries						
1969/71	132	531	96	386	409	21	106	**1961-2001**	1.3	1.8	0.8
1979/81	139	542	110	427	551	111	129	**1971-2001**	1.1	1.2	0.7
1989/91	154	543	130	459	581	130	127	**1981-2001**	1.1	0.8	0.7
1999/01	162	592	147	536	647	114	121	**1991-2001**	1.6	1.4	0.6
2030	159	641	160	643	845	203	132	**1999/01-30**	0.6	0.9	0.3
2050	156	665	159	678	926	248	137	**2030-50**	0.3	0.5	0.1
								1999/01-50	0.5	0.7	0.2
					Transition countries						
1969/71	201	653	70	229	226	2	98	**1961-2001**	0.7	0.5	0.7
1979/81	189	778	72	297	242	-41	81	**1971-2001**	-0.7	-0.6	0.5
1989/91	179	769	74	317	282	-37	89	**1981-2001**	-2.3	-1.4	0.3
1999/01	169	499	69	205	211	2	103	**1991-2001**	-3.7	-2.2	-0.1
2030	164	618	62	235	267	32	113	**1999/01-30**	0.5	0.8	-0.3
2050	158	688	54	236	287	51	121	**2030-50**	0.0	0.4	-0.5
								1999/01-50	0.3	0.6	-0.4

Table 3.5: Cereal balances, developing regions (FAO 2006a).

	Demand						SSR[a]	Growth rates			
	per capita (kg)		total (million tonnes)				(percent)	(percent p.a.)			
year	food	all uses	food	all uses	production	net trade		period	demand	production	populatic
	1	2	3	4	5	6	7	8	9	10	11
					Sub-Saharan Africa						
1969/71	115	144	30	38	37	-3	98	**1961-2001**	2.9	2.4	2.8
1979/81	114	137	40	48	41	-8	85	**1971-2001**	3.2	2.7	2.9
1989/91	119	145	55	67	58	-8	86	**1981-2001**	3.3	3.0	2.8
1999/01	123	149	75	90	72	-16	80	**1991-2001**	2.9	2.3	2.6
2030	142	169	161	192	153	-39	81	**1999/01-30**	2.5	2.5	2.1
2050	155	186	234	280	220	-60	79	**2030-50**	1.9	1.8	1.4
								1999/01-50	2.3	2.3	1.8
					Near East/North Africa						
1969/71	179	293	33	53	46	-7	86	**1961-2001**	3.3	2.3	2.7
1979/81	200	332	48	80	58	-24	73	**1971-2001**	3.2	2.2	2.6
1989/91	212	354	67	111	77	-39	69	**1981-2001**	2.3	2.0	2.5
1999/01	204	343	80	135	80	-54	59	**1991-2001**	2.1	-0.4	2.2
2030	199	387	128	249	142	-106	57	**1999/01-30**	2.1	1.9	1.7
2050	193	408	150	316	173	-142	55	**2030-50**	1.2	1.0	0.9
								1999/01-50	1.7	1.6	1.4
					South Asia						
1969/71	150	169	106	120	116	-5	97	**1961-2001**	2.6	2.9	2.2
1979/81	151	170	134	150	147	-2	98	**1971-2001**	2.6	2.8	2.2
1989/91	164	185	181	204	203	-3	99	**1981-2001**	2.4	2.6	2.1
1999/01	157	180	210	241	254	-1	105	**1991-2001**	1.7	2.5	1.9
2030	167	198	328	390	370	-20	96	**1999/01-30**	1.6	1.3	1.3
2050	169	208	372	459	428	-31	95	**2030-50**	0.8	0.7	0.6
								1999/01-50	1.3	1.0	1.0
					East Asia						
1969/71	152	192	178	225	219	-8	97	**1961-2001**	3.3	3.3	1.8
1979/81	181	239	258	340	316	-24	93	**1971-2001**	2.8	2.8	1.5
1989/91	200	273	333	455	433	-27	95	**1981-2001**	1.9	2.0	1.4
1999/01	187	271	350	509	487	-21	96	**1991-2001**	1.0	1.1	1.1
2030	176	318	396	718	656	-62	91	**1999/01-30**	1.2	1.0	0.6
2050	162	332	365	749	682	-68	90	**2030-50**	0.2	0.2	0.0
								1999/01-50	0.8	0.7	0.4
					Latin America and Caribbean						
1969/71	119	224	33	63	66	3	104	**1961-2001**	3.2	2.6	2.2
1979/81	130	262	46	94	87	-8	93	**1971-2001**	2.8	2.2	2.0
1989/91	130	257	57	112	97	-12	86	**1981-2001**	2.3	1.7	1.8
1999/01	133	291	68	150	133	-20	89	**1991-2001**	2.7	3.0	1.6
2030	140	357	99	252	246	-5	97	**1999/01-30**	1.7	2.1	1.1
2050	139	383	106	292	296	4	100	**2030-50**	0.7	0.9	0.4
								1999/01-50	1.3	1.6	0.8

Considering the Agrimonde scenarios (cp. chapter 3.1) (AGRIMONDE 2009) the developments and projections are presented more detailed for the major regions applied there. According to Agrimonde GO, by 2050, Asia's food crop yields will have grown by 85 per cent in the period 2000-2050 to 46,000 plant kcal/ha/day (Fig.3.7 and Tab.3.6). It will then still represent the most productive region in the world without comparison. Even if the OECD-1990 remains the number three most productive region, its increase in yields has been the lowest in the world (+48%). In contrast, Sub-Saharan Africa will have the largest growth in production over that period (+144%). The Middle East and North Africa will gain

nearly the same level of production in 2050, with about 23,000 plant kcal/ha/day the yield level of the OECD-1990 in 2000. Holding a production of about 13,000 plant kcal/ha/day and a growth rate of 71 per cent between 2000 and 2050, the former Soviet Union will remain the least productive region in the world. The gap between the least productive and the most productive regions grows slightly compared to 2000, from 1 to 3.6 in 2050 (Fig.3.7 and Tab.3.6) (AGRIMONDE 2009).

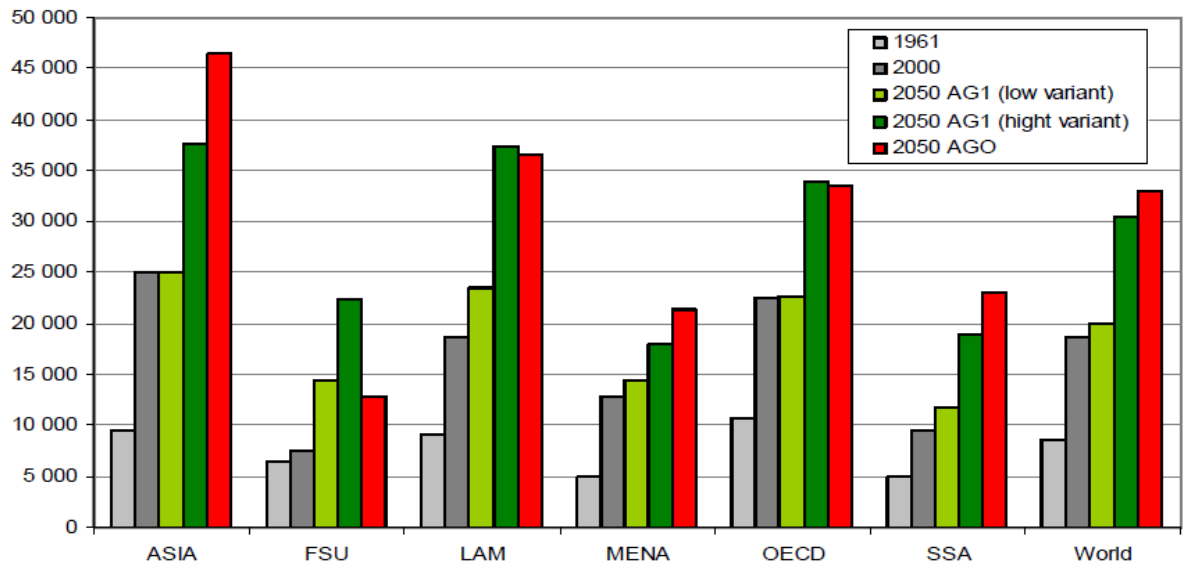


Figure 3.7: Regional food yields in the Agrimonde scenarios: Production of plant food calories per hectare of cultivated land (kcal/ha/day) (AGRIMONDE 2009). *(OECD: OECD 1990 countries, ASIA: Asian countries, LAM: Latin America, FSU: Former Soviet Union, MENA: Middle East and North Africa, SSA: Sub-Saharan Africa).*

The Agrimonde 1 scenario shows a slightly different picture (AGRIMONDE 2009). The panel considered that there was little potential for increasing yields in Asia, OECD-1990 and Middle East-North Africa countries. Their growth of food crop yields between 2000 and 2050 is therefore relatively slow (0 to 20% for the low variant of yields selected and 40 to 50% for the high variant) (Fig.3.7 and Tab.3.6). The yield growth in Latin America and sub-Saharan Africa is as the result of a higher probability of an increased production, projected to gain 30% and 100% of yields, respectively, in the low and high variants.

In the former Soviet Union in the high variant even a tripling of the level of its food crop yields is projected, compared to a doubling in the low variant. The gap between the yields of the least productive and the most productive regions has narrowed down compared to the situation in 2000. In 2050 the ratio is 1 to 2, which corresponds to the yield disparities found in 1961 (Fig.3.7 and Tab.3.6) (AGRIMONDE 2009).

Table 3.6: Food crop yields: levels and annual growth rates: 1961-2000 and 2000-2050 in the Agrimonde scenarios. (AGRIMONDE 2009). *(OECD: OECD 1990 countries, ASIA: Asian countries, LAM: Latin America, FSU: Former Soviet Union, MENA: Middle East and North Africa, SSA: Sub-Saharan Africa).*

	1961-2000			2000-2050					
				AG1, low variant		AG1, high variant		AGO	
	Food crop yields kcal/ha/day		Annual growth rate	Food crop yields kcal/ha/day	Annual growth rate	Food crop yields kcal/ha/day	Annual growth rate	Food crop yields kcal/ha/day	Annual growth rate
Region	1961	2000	1961-2000	2050	2000-2050	2050	2000-2050	2050	1997-2050
ASIA	9,485	25,130	2.53	25,100	0	37,700	0.81	46,416	1.15
FSU	6,549	7,480	0.34	14,500	1.33	22,430	2.22	12,825	0.75
LAM	9,041	18,690	1.88	23,500	0.46	37,380	1.40	36,493	1.45
MENA	4,921	12,840	2.49	14,500	0.24	17,970	0.67	21,362	1.05
OECD	10,742	22,590	1.92	22,600	0	33,880	0.81	33,507	0.73
SSA	5,027	9,450	1.63	11,750	0.44	18,920	1.40	23,133	1.81
World	8,607	18,705	2.01	20,027	0.14	30,466	0.98	32,940	-

With respect to a minor difference in the period in consideration (AGRIMONDE: 2000-2050, BRUINSMA: 2006/07-2050) similar projections for the annual growth of agricultural production as in AGRIMONDE 2009 are encountered in BRUINSMA 2009 (cp. Tab.3.6 & Tab.3.7).

According to BRUINSMA 2009, the annual growth of the world's agricultural production is projected to fall from 2.2 percent over the last decade to 1.3 percent over the period to 2030 and 0.8 percent over the period 2030 to 2050 (Tab.3.7). The highest annual growth in the latter period is projected to occur in Sub-Saharan Africa (1.7 per cent) as well as in the period 2005/07-2050 (2.1 per cent). Agrimonde GO, for instance, expects an annual growth of 1.81 for sub-Saharan Africa (AGRIMONDE 2009). The lowest annual growth in BRUINSMA 2009 is projected for East Asia (0.5 per cent). Even though the figures show a slowdown in annual growth compared to former periods (Tab.3.7), the absolute incremental quantities are still very considerable, as an additional billion tonnes (Mt) of cereals and another 200 million tonnes of meat would need to be produced annually by 2050 (BRUINSMA 2009). Especially the meat production would require abundant increases in concentrated feeds like maize and soybeans (BRUINSMA 2009). Furthermore the share of biofuels would have to be taken into account additionally.

Table 3.7: Annual crop production growth (per cent per year) (BRUINSMA 2009).

	1961-07	1987-07	1997-07	2005/07-30	2030-50	2005/07-50
Developing countries	3.0	3.0	2.9	1.5	0.9	1.2
idem, excl. China and India	2.7	2.8	3.1	1.8	1.3	1.6
sub-Saharan Africa	2.5	3.2	2.9	2.5	1.7	2.1
Near East / North Africa	2.6	2.3	2.1	1.7	1.0	1.4
Latin America and Caribbean	2.6	2.9	3.6	2.1	1.3	1.8
South Asia	2.6	2.2	2.0	1.6	0.9	1.3
East Asia	3.5	3.4	3.3	1.0	0.5	0.8
Developed countries	0.9	0.2	0.7	0.9	0.4	0.7
World	2.2	2.1	2.2	1.3	0.8	1.1
14 developing countries with over 3000 kcal/person/day in 2005*	3.3	3.3	3.2	1.3	0.7	1.0

* these countries account for 40 percent of the population in developing countries

Box: Climate Change

Although the projected growth and production rates in agriculture seem to be able to meet the future demand of food availability and per capita food consumption, challenges such as the hardly predictable development in the use of biofuels have to be faced. One major challenge for the future is also the impact of climate change on crop production, which is very multifaceted and displays a strong variation among geographically different regions (FAO 2009). Especially regions in the Southern hemisphere, which are not mainly responsible for climate change, may suffer the major negative impacts in form of a decline in yields and more frequent extreme weather events causing draughts and floods (FAO 2009). According to integrated assessment models the effects of climate change on temperature and rainfall will have positive effects on agricultural production in cooler climates (EASTERLING et al. 2007, M&R 2009). Regions in the Northern hemisphere may benefit by expanding the potential cropland, an increasing length of growing periods, and therefore leading to rising crop yields (FAO 2009). In contrast, low latitude regions, predominantly the geographical location of most developing countries, will suffer the decreasing cereal yields (EASTERLING et al. 2007, M&R 2009). As a result the regions that benefit from increases in yields will increase their export potential, while the rest will be dependent on food imports, in order to meet their demands (FISCHER et al. 2005). M&R 2009 estimate that cereal imports will increase in developing countries by 10 to 40 percent by 2080. Moreover, food prices are expected to rise on average, due to climate change.

Nevertheless, climate change is not the main factor determining the future developments of crop yields. PARRY et al. 2005 have shown that the regional variation in the number of food insecure is better explained by population changes than climate impacts on food availability (M&R 2009).

Finally agriculture will have to adapt to climate change, but has also the ability to reduce and to mitigate its effects, mainly through soil carbon sequestration and largely in the developing countries (FAO 2009).

Fresh Water Reserves

Another challenge is the irrigation of arable lands with sufficient capacities of fresh water reserves. Nearly 50 per cent of crop production are carried out by irrigated agriculture. As the water resources are very unevenly distributed over the different regions an increasing number of countries already has to face alarming levels of water scarcity. 1.4 billion people live in areas with sinking ground water levels (FAO 2009). The most affected regions are the Near East and North Africa and South Asia. As a result of climate change water scarcity is probably even on the rise. Due to the conflicts and water competition with other sectors, many large water basins, including the Yellow River and Ganges, are expected to pump relatively less water for irrigation over the next 20 years. Irrigated cereal yields are therefore expected to decline between 11 and 22 per cent by 2025 in relation to 1995 (ROSEGRANT et al. 2005, M&R 2009). One appropriate measure might be to apply the broad opportunities to increase water use efficiency.

Policy

Policy definitely has a key role in controlling developments of agricultural production, prices and the development of the population.

There are many political instruments that can lead to higher yields and an improved food security. Many developing countries could already enhance food security. They all follow the pattern of political stability, good governance, strong economic growth, very much based on growth of agriculture in several of these countries, twin-track food security strategies and integration into world markets (FAO 2009). The realization of higher growth rates of yields can for instance be achieved by policies that accelerate the improvement of crop technologies. Such as through improved seed technologies which might enhance the productivity and resilience of plant varieties or through the expansion of areas of irrigated agriculture, which generally provide higher yields than rain fed alternatives (M&R 2009). In order to guarantee a supply with sufficient quantities of cereals and the stability of prices, the management of grain storage should be improved, so that an adequate buffer could compensate times of shortage (M&R 2009). With regard to the problem of overpopulation affecting food security, a solution lies in better educational opportunities for women, education in general, access to contraceptives and social safety (DER SONNTAG 2011).

Furthermore, a proper socio-economic framework, which provides sufficient employment, structural reforms creating an adequate income and social safety nets, is also indispensable for the population's access to food (FAO 2009).

3.3 Conclusion

According to FAO 2009 the world has the resources and technology to ensure food security for the projected world population in 2050. In order to achieve this, agricultural production needs to increase by 70 per cent globally, which in turn needs to be fostered by policy. Its instruments involve creating conditions like strong economic growth and relatively high production growth in many developing countries. These are achievable through growing capital stock, higher productivity and global trade helping the low income food deficit countries to close their import gaps for cereals and other food products at affordable prices (FAO 2009). This will bring significant progress in raising food consumption levels, improving nutrition and hence reductions in the relative prevalence of undernourishment (percent of population affected). Because of population growth the reduction of absolute numbers of undernourished people will pass off slowly (FAO 2006a). Desirable higher caloric input will of course increase demand for more production.

But increasing production is not sufficient to achieve food security. It must go along with policies to enhance food access by fighting poverty, as well as effective safety net programs (FAO 2009). This applies to both rural and urban areas.

Moreover, a variety of challenges and risks has to be faced on the way to an adequate food supply of the world population. Among those are rising scarcity and land degradation, water and biodiversity, pressures resulting from urbanization, changes in consumption patterns, rising incomes, energy demands and climate change. A main competition concerning land and water will emerge between agriculture and the growing urban areas.

Furthermore, the role of agriculture will also be important in terms of the adaptation to and mitigation of climate change, helping to preserve natural habitats and maintaining biodiversity.

4 DEMAND FOR KEY NUTRIENTS (NPK) IN THE YEAR 2050

As seen in chapter 3, food production will need to increase to meet the demands of a larger and more affluent population. With regard to limited arable land, this food production increase will require intensified production. Besides genetics, biotechnology and other inputs, fertilizer use will be essential for increasing yields (IPNI 2009). Moreover, large P and K

applications for example in Brazil, are an essential part of putting new land into crop production (SCHNEPF et al. 2001).

An evaluation of several long term studies with a total of 362 seasons of crop production in the USA and England showed an average percentage of 40 to 60 percent of yield attributable to fertilizer. The evaluation for the tropics even tended to be a lot higher (STEWART et al. 2005, ROBERTS 2009, IPNI 2009). Hence long term fertilizer requirement forecasts are the key to the success of long term plans for global food security and help planning future plant sizes of the fertilizer industry (T&L 2008).

In order to forecast the demand for key nutrients like N (Nitrogen), P (Phosphate) and K (Potassium) up to the year 2050, in the following different studies were taken into account and compared with each other.

Nutrient Balance

Soil nutrient balance is, due to increased pressure on food demand and land resources, fundamental when looking at the future fertilizer demand (GROTE et al. 2005). The global annual removal of plant nutrients was estimated to be 230 million metric tons (Mt) in 1997, compared to a global fertilizer consumption of just 130 million Mt in the same year (VLEK et al. 1997). According to different fertilizer application rates in different regions of the world (e.g. 9 kg/ha in sub-Saharan Africa and over 250 kg/ha in Western Europe and the U.S. (MOLDEN 2007)), nutrient balance varies enormously and causes impacts on soil fertility. The demand for fertilizer therefore is derived from whether soil fertility is built up or drawn down (T&L 2008). As P and K persist in the soil long after their application nutrient drawdown or buildup is closely connected with their occurrence.

Elasticities for the 2005 fertilizer and output levels are reported in Table 4.1, where values less than one represent a drawdown in soil P and K reserves and organic matter, which is evident for most regions. The region Near East shows an elasticity of P that is bigger than one and hence seems to build up P nutrient. Estimated elasticities that are not statistically different from “1” indicate that soil nutrients may be being maintained in those regions (T&L 2008). For potash this applies for the Rest of Asia and the Rest of Europe, for phosphate for the Rest of Europe and Africa. The majority of the elasticities is estimated very small (less than 0.3), which requires differentiated interpretations. In the poor regions, it suggests a severe nutrient drawdown, but in the advanced regions nutrient use efficiency may be a contributing factor (T&L 2008).

For nitrogen the values estimated need to be interpreted in a different way, as this nutrient is not as persistent in the soil as P and K. All of the elasticities are less than one, except in

North America. This suggests that in North America increasing output by 1% requires more than a 1% increase in nitrogen use, while in the rest of the world other sources of nitrogen supply an important part of the nutrient. In sub-Saharan Africa (SSA) the N elasticity estimate is particularly small, suggesting that organic matter draw down may be most serious there (T&L 2008). **Regarding NPK demand these observations imply a closer look on the regional and local level, natural resource base, management strategies and policies.**

Table 4.1: Fertilizer Nutrient Buildup or Drawdown Elasticities 2005 (T&L 2008).

Fertilizer Nutrient Buildup or Draw down Elasticities, 2005

Region	N	P	K
EU	0.26*	0.24*	0.53*
SSA	0.15*	0.69	0.15*
Latin America	0.22*	0.11*	0.02*
Near East	0.19*	1.82*	0.70**
East Asia	0.59*	0.82*	0.40*
Rest of Asia	0.86	0.69**	1.22
North America	1.19*	0.26*	0.01*
Oceania	0.21*	0.22*	0.06*
Rest of Europe	0.42*	1.08	0.97

Source: Author's derivation from estimated models
*Elasticity is statistically significantly different from 1 at 5% level, 2-tail z test
** Elasticity is statistically significantly different from 1 at 10% level, 2-tail z test
Alternative hypothesis: Ha: $E > 1$ => buildup;
$E < 1$ => draw down

4.1 Projections of Global Fertilizer Nutrient Demand

The projections for fertilizer demand reach from forecasts until 2014 by FAO 2010 over forecasts until 2015/16 by IFA 2011, to forecasts until 2015 and 2030 respectively by TENKORANG & LOWENBERG-DEBOER (2008).

Based on existing cereal output data of FAOSTAT and the FAO 2006a IR a model calculation was conducted to estimate NPK needs in 2050. A causal calculation model, with agricultural cereal production as the relevant independent variable was used. The projections were calculated from applying the anticipated cereal production growth rate to the fertilizer quantity consumed in the 1996 base year. Essentially the output/input relationship between fertilizer use and crop production present in 1996 is assumed to remain constant throughout to 2050 (FAO 2000).

Based on the following relationship *(1)*, established by TENKORANG & LOWENBERG-DEBOER 2008 from a previous study (FAO 2000), the projections were calculated:

$$(1) \qquad F_t = F_{t-1} + (Y_1 - Y_{t-1})/(Y_{t-1}/F_{t-1})$$

where

F	is unadjusted fertilizer application rate (by nutrient)
Y	is output
t	is a time index

Considering the medium-term projections of IFA 2011, there was a breakdown of 7.6 percent in 2008/09 after a global fertilizer consumption record of 168.2 million Mt (Metric tons) in 2007/08 (Tab.4.2). In 2009/10 it started to recover again (+5.4%) reaching 163.9 million Mt. On a regional scale all the major regions increased their fertilizer demand, except Latin America and Oceania. World demand in 2010/11 is estimated up 5.0 percent, to 172.1 million Mt and hence surpasses the 2007/08 value (IFA 2011). Looking at the nutrients in detail, nitrogen (N) and phosphate (P) would also surpass their records of 2007/08 in 2010/11, while potassium (K) although increasing by 14.9 percent, would still remain below its record of 2007/08 (Tab.4.2). After rising more modestly by 2.5 percent, the forecast for global fertilizer demand in 2011/12 is projected to 176.4 million Mt. In the medium term, as a result of the projected growth in agricultural production (cp. chapter 3), fertilizer demand is also anticipated to rise further. By 2015/16 world demand is expected to reach 191.1 million Mt, corresponding to an average annual growth rate of 2.6% from the base year (average consumption between 2008/09 and 2010/11) (IFA 2011).Because of its depressed level in 2008/09 and 2009/10, K fertilizer demand is forecast to grow much faster (+4.7% per annum) than demand for N (+1.9% p.a.) and P fertilizers (+3.1% p.a.) (IFA 2011).

Table 4.2: Global Fertilizer Demand (million Mt nutrients) (IFA 2011).

	N	P_2O_5	K_2O	Total
07/08	100.7	38.5	29.0	168.2
08/09	98.4	33.6	23.4	155.4
09/10	101.6	38.3	24.0	163.9
Change	*+3.3%*	*+13.9%*	*+2.4%*	*+5.4%*
10/11 (e)	103.7	40.9	27.5	172.1
Change	*+2.1%*	*+6.7%*	*+14.9%*	*+5.0%*
11/12 (f)	105.6	41.7	29.0	176.4
Change	*+1.8%*	*+2.1%*	*+5.5%*	*+2.5%*
15/16 (f)	113.0	45.2	32.9	191.1
*Average Annual Change**	*+1.9%*	*+3.1%*	*+4.7%*	*+2.6%*

Considering the medium-term Outlook of FAO 2010 the total fertilizer nutrient ($N+P_2O_5+K_2O$) consumption was estimated at 161.7 million Mt in 2009 and forecasted to 169.7 million Mt in 2010 (Tab.4.3). Growing successive by 2.6 percent p.a. (like the forecasts in the IFA Outlook) the total fertilizer nutrient demand is expected to reach 179.4 million Mt in 2012 and 187.9 million Mt in 2014.

Table 4.3: World Demand for Fertilizer Nutrients 2010-2014 (thousand Mt) (FAO 2010).

Year	2010	2011	2012	2013	2014
Nitrogen (N)	103 877	106 054	107 901	109 835	111 638
Phosphate (P_2O_5)	39 148	40 445	41 594	42 791	43 876
Potash (K_2O)	26 655	28 542	29 882	31 218	32 413
Total ($N+P_2O_5+K_2O$)	169 680	175 041	179 377	183 844	187 927

TENKORANG & LOWENBERG-DEBOER 2008 (T&L 2008) used for their Global Long-term projections for fertilizer demand causal models like simple linear regression models. They are preferable when projections of the exogenous variables are available (ALLEN and FILDES 2001). In this case relevant variables available were crop production and cropland.

Figure 4.1 depicts a comparison between the global actual fertilizer nutrients consumption and model estimated consumption. The run of the forecast curves represents the historical data well (T&L 2008). The T&L 2008 study aims on determining fertilizer requirement projection in relation to the status of soil nutrient build up or draw down in nine fertilizer consuming categorized regions (Annex 4.4).

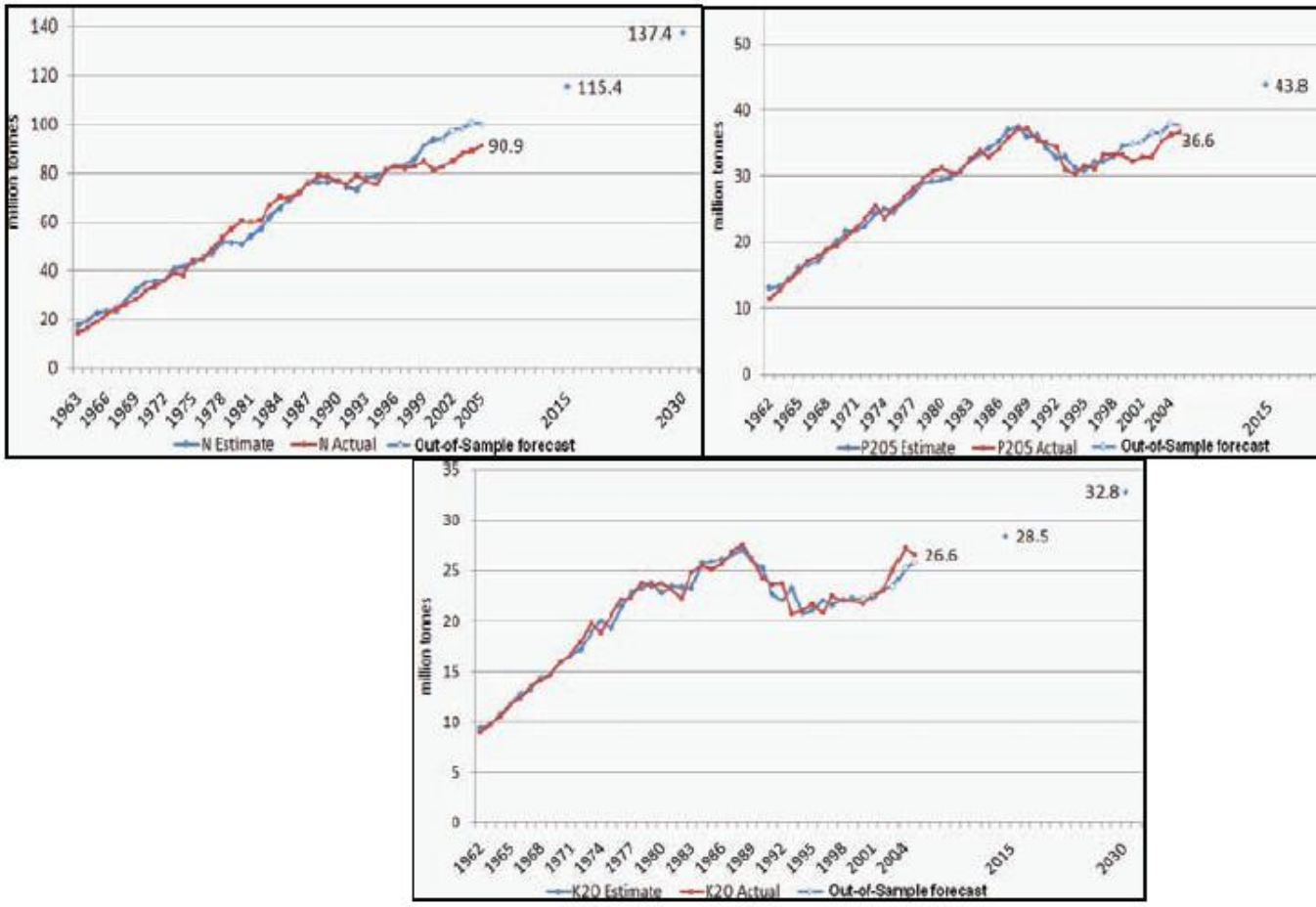


Figure 4.1: World Fertilizer Nutrients (NPK): Actual versus in-sample forecast and 2015 and 2030 Fertilizer Requirement Forecasts (T&L 2008).

The results of the T&L 2008 long-term projections are 187.7 million Mt for 2015 and 223.1 million Mt for 2030, respectively.

Figure 4.2 and Table 4.4 show a comparison of the forecasts of world demand for total fertilizer nutrients of the three studies in consideration. The similaritiy of the projections for the years 2011/12 to 2015/16 is obvious. The forecasts show a certain trend line in their arrangement. T&L 2008 is the only study with long-term forecasts of NPK and was used as a basis for the further projections up to 2050.

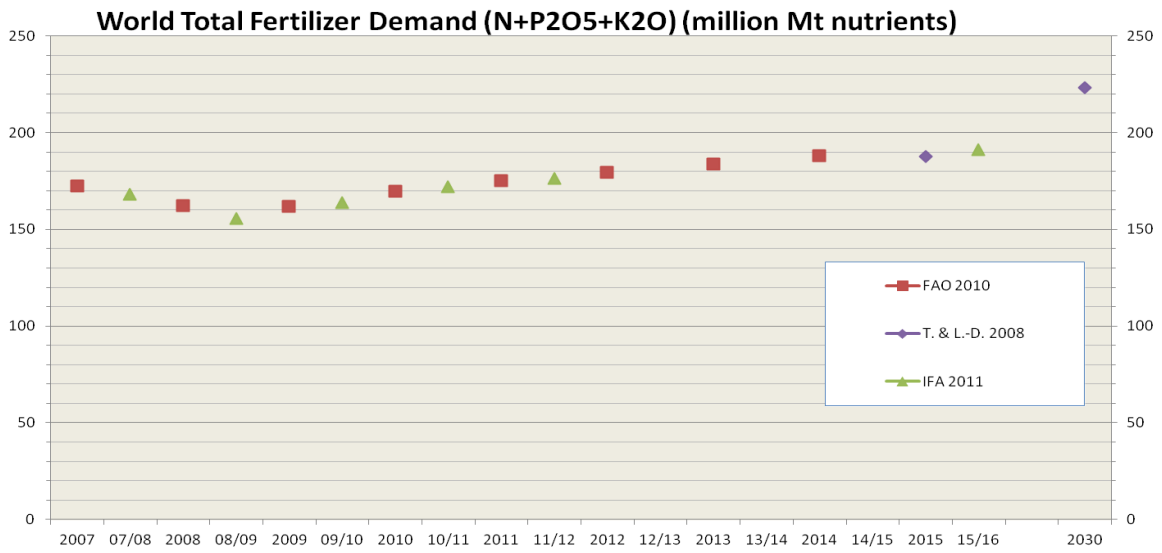


Figure 4.2: World Total Fertilizer Demand (N+P2O5+K2O) (million Mt nutrients). Data sources (FAO 2010, IFA 2011, T&L 2008).

Table 4.4: Comparison of the World Total Fertilizer Demand ($N+P_2O_5+K_2O$) (million Mt nutrients). Data sources (FAO 2010, IFA 2011, T&L 2008).

Study	2007	07/08	2008	08/09	2009	09/10	2010	10/11	2011	11/12	2012	12/13	2013	13/14	2014	14/15	2015	15/16	2030
IFA 2011		168,2		155,4		163,9		172,1		176,4								191,1	
FAO 2010	173		162		162		170		175		179		184		188				
T. & L.-D. 2008																	188		223

In a synthesis, the results of the calculations for the total fertilizer consumption in 2050 based on the formula of T&L (2008), are shown in Figure 4.3. As cereal production is projected to increase, the global demand for fertilizer nutrients (NPK) would also show further growth. According to the forecast it is expected to reach about 324 million Mt in 2050.

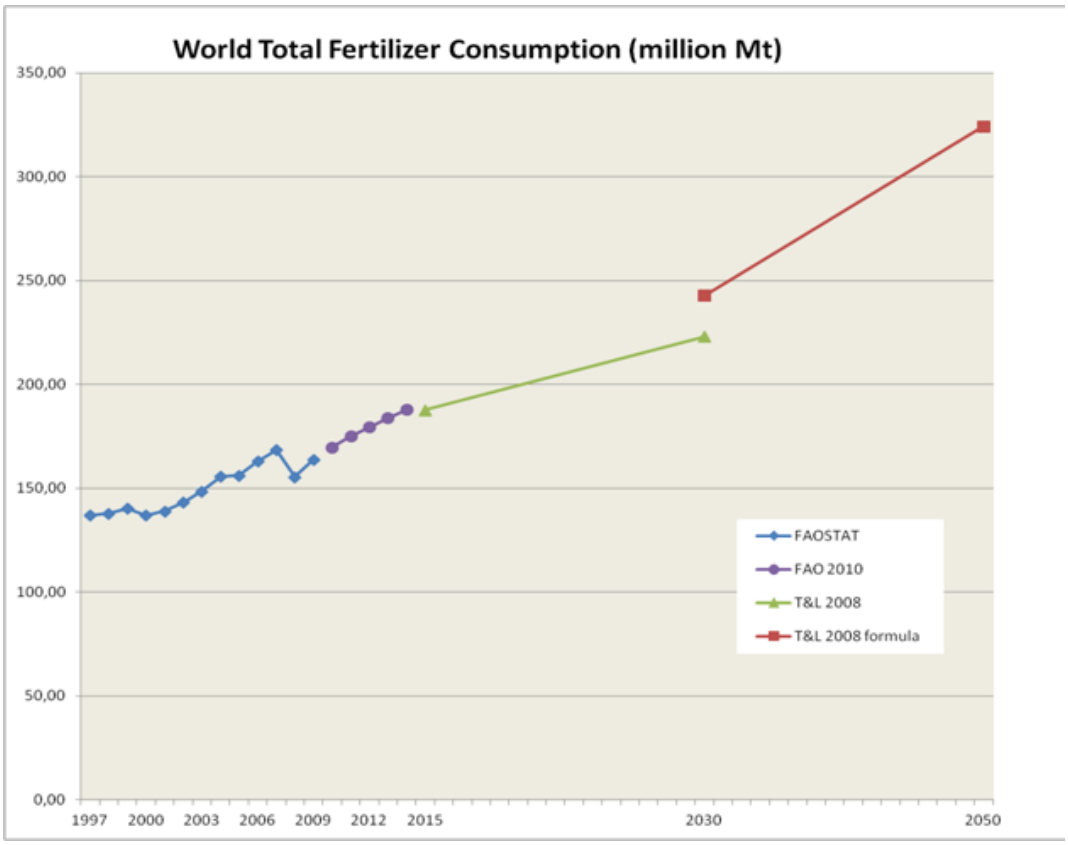


Figure 4.3: World Total Fertilizer Consumption (million Mt). Data sources (FAOSTAT, FAO 2010, T&L 2008, Calculations based on T&L 2008's formula).

In order to get an overview of the developments in a regional scale, the studies in consideration use different classifications. Furthermore, as data sets are of different origin than the ones for the population (cp. chapter 2) and food demand and agricultural production (cp. chapter 3), their major regions' subdivision is not always congruent. With respect to regional comparisons of the studies' forecasts that aspect has to be taken into consideration.

The world and regional annual growth rate in fertilizer demand between 2010 and 2014 is given in Table 4.5 (FAO 2010). As mentioned above, the world demand for total fertilizer nutrients is estimated to grow at 2.6 percent p.a. from 2010 to 2014. The annual growth rates for nitrogen, phosphate (P_2O_5) and potash (K_2O) are forecast to 1.8, 2.9 and 5 percent, respectively during the period (Tab.4.5) (FAO 2010). The IFA 2011 projections expect average annual changes of 1.9, 3.1 and 4.7 percent for nitrogen, phosphate and potash, respectively (Tab.4.2).

Table 4.5: World and regional growth in Fertilizer Demand between 2010 and 2014 (FAO 2010).

Region	Annual growth rate (Compound)			
	N	P_2O_5	K_2O	Total ($N+P_2O_5+K_2O$)
World	**1.8%**	**2.9%**	**5.0%**	**2.6%**
Africa	3.6%	3.2%	4.5%	3.6%
America	1.9%	3.5%	4.9%	3.0%
- North America	1.1%	2.1%	3.8%	1.8%
- Latin America	3.6%	4.7%	6.0%	4.6%
Asia	1.7%	2.6%	5.4%	2.4%
- West Asia	1.4%	2.9%	7.7%	2.2%
- South Asia	2.8%	3.9%	4.8%	3.3%
- East Asia	1.2%	1.7%	5.6%	1.9%
Europe	1.9%	3.1%	4.0%	2.5%
- Central Europe	3.2%	2.8%	5.4%	3.5%
- West Europe	0.7%	1.9%	3.8%	1.4%
- East Europe & Central Asia	3.5%	5.1%	3.5%	3.8%
Oceania	1.9%	4.2%	4.7%	3.2%

Looking at the NPK components in detail, only existing references were taken into account. Calculations were only conducted for global and regional total NPK demand, as a splitting into components is too complex and not within the framework of this study.

Nitrogen (N)

Nitrogen Fertilizer Consumption up to 2030

The world nitrogen fertilizer demand is expected to increase by an annual growth rate of 1.8 percent during the period 2010 to 2014, passing from 103.9 million Mt in 2010 to 111.6 million Mt in 2014 (Tab.4.3, Tab.4.5) (FAO 2010). 58 percent of the overall increase of 7.7 million Mt nitrogen would be in Asia, 20 percent in America, 15 percent in Europe, 6 percent in Africa and 1 percent in Oceania (Fig.4.4) (FAO 2010).

The projections for nitrogen fertilizer demand are 115.4 million Mt for 2015. It is expected to reach 137.4 million Mt by 2030 (Fig.4.1, Tab.4.13) (T&L 2008).

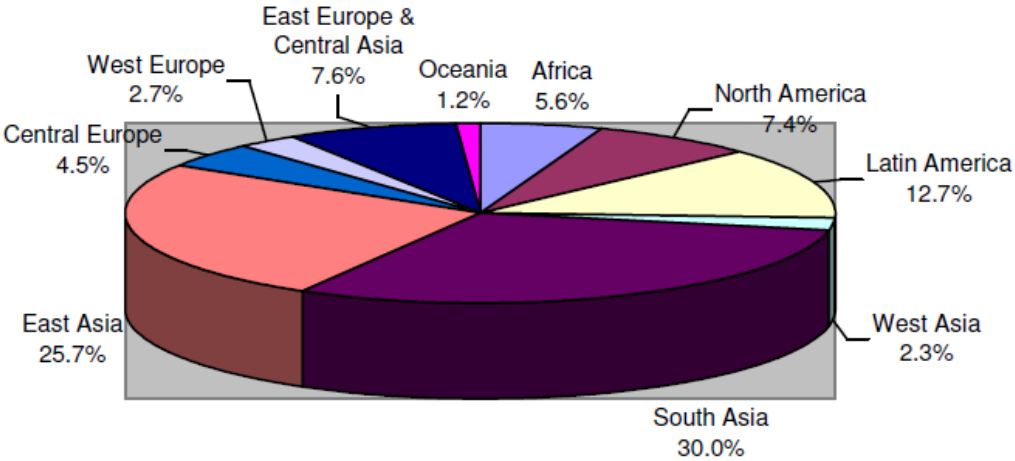


Figure 4.4: Regional and sub-regional share of World Increase in Nitrogen Fertilizer Consumption 2010-2014 (FAO 2010).

Nitrogen Supply / Demand Balance up to 2015

According to IFA 2011 the global nitrogen supply will grow at an annual rate of 3.7% between 2010 and 2015, compared to an increase of 2.3 percent in total demand p.a. (fertilizer + non-fertilizer demand) (Fig.4.5, Tab.4.6).

Figure 4.5: World Nitrogen Supply / Demand Balance 2010-2015 (million Mt) (IFA 2011).

During the whole period there is a potential N surplus, moving from 3.8 million Mt N in 2010, rising to 6-7 million Mt N in 2012/13, then accelerating after 2014 to reach 15 million Mt in 2015 (Fig.5, Tab.6) (IFA 2011).

Table 4.6: World Nitrogen Supply / Demand Balance 2011-2015 (million Mt) (IFA 2011).

	2011	2012	2013	2014	2015
Supply					
Capacity	163.2	171.5	175.9	182.7	188.8
Total Supply*	**134.5**	**140.2**	**143.7**	**149.9**	**156.3**
Demand					
Fertilizer Demand	105.2	107.0	108.8	110.6	112.4
Non-fertilizer Demand	**23.2**	**24.3**	**25.2**	**26.0**	**26.3**
Distribution Losses	2.2	2.3	2.3	2.4	2.4
Total Demand	130.7	133.6	136.4	139.0	141.2
Potential Balance	**3.8**	**6.6**	**7.3**	**10.9**	**15.1**
% of Supply	*2.8*	*4.7*	*5.1*	*7.2*	*9.7*

** Supply is capability, equating to the maximum achievable production. It is derived by multiplying capacity by the highest achievable operating rate.*

Source: Prud'homme, IFA, May 2011

Phosphate (P_2O_5)

Phosphate Fertilizer Consumption up to 2030

Phosphate fertilizer consumption/demand include H_3PO_4 (phosphoric acid) based fertilizer demand + non-H_3PO_4 fertilizer demand. The non-H_3PO_4 fertilizer demand includes P_2O_5 through single super phosphate, rock phosphate, etc. The growth rate of the world fertilizer demand is forecast to 2.9 percent p.a. between 2010 and 2014. It is expected to increase from 39.1 million Mt in 2010 to 43.9 million Mt in 2014, hence the overall increase amounts to 4.8 million Mt P_2O_5 (Tab.4.3, Tab.4.5) (FAO 2010). 54 percent of these are anticipated to be in Asia, 29 percent in America, 10 percent in Europe, 4 percent in Oceania and 3 percent in Africa (Fig.4.6) (FAO 2010).

The phosphor fertilizer demand is projected to 43.8 million Mt in 2015 and 52.9 million Mt in 2030 (Fig.4.1, Tab.4.13) (T&L 2008).

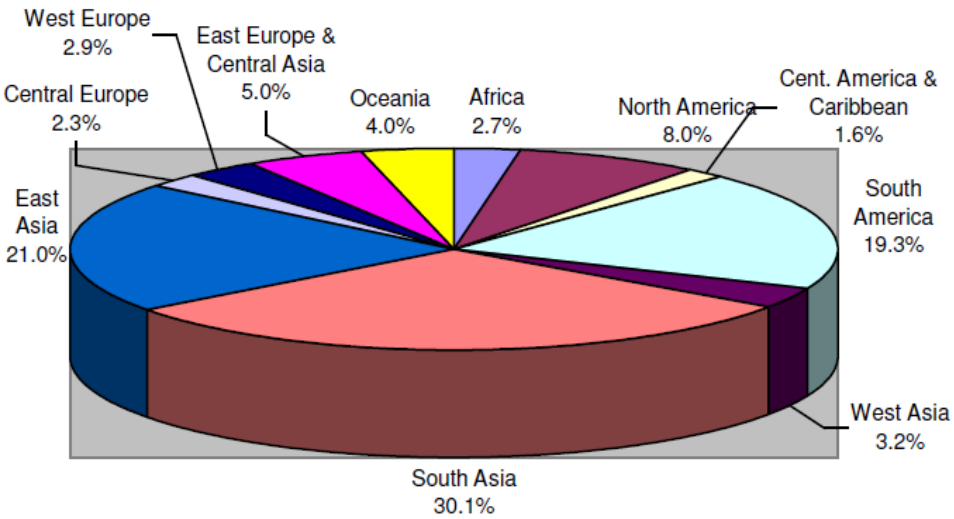


Figure 4.6: Regional and sub-regional share of World Increase in Phosphate Fertilizer Consumption 2010-2014 (FAO 2010).

Phosphate Supply / Demand Balance up to 2015

By 2015, the global supply of phosphoric acid is projected to reach 47.8 million Mt P_2O_5, increasing at 3.9 percent p.a. over 2010. On the demand side (fertilizer + non-fertilizer demand), the global annual growth is forecast to 2.9 percent over 2010, reaching 44.9 million Mt P_2O_5 in 2015 (Fig.4.7, Tab.4.7).

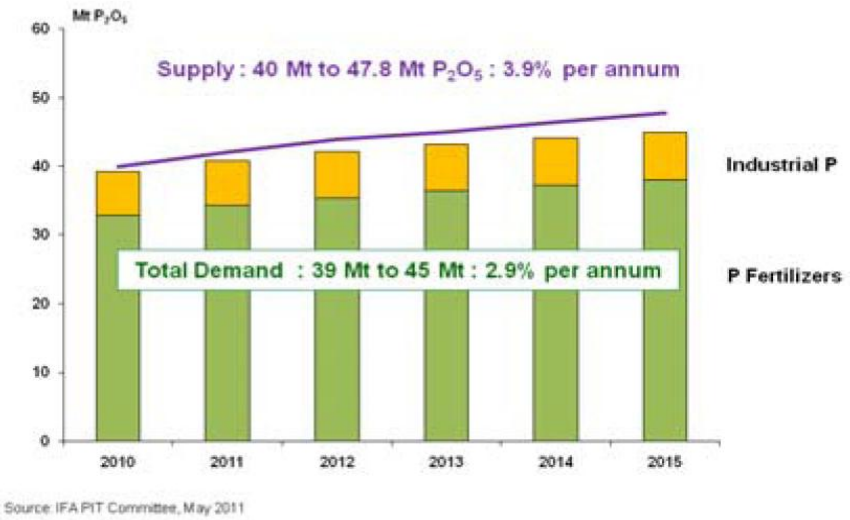


Figure 4.7: World Phosphoric Acid Supply / Demand Balance 2010-2015 (million Mt) (IFA 2011).

During the period 2011-2015 the global phosphoric acid supply/demand balance shows a very small potential surplus in 2011 of less than 3% of the available supply. This tight balanced imbalance will increase to 1.8-2.3 million Mt P_2O_5 between 2012 and 2014. By 2015, 2.9 million Mt P_2O_5 are forecast (Fig.4.7, Tab.4.7). This expansion is traced back to the initiation of large-capacity projects planned in Morocco (IFA 2011).

Table 4.7: World Phosphoric Acid Supply / Demand Balance 2011-2015 (million Mt) (IFA 2011).

	2011	2012	2013	2014	2015
Supply					
Capacity	51.4	52.9	54.9	56.6	57.6
Total Supply*	**42.1**	**44.0**	**45.0**	**46.4**	**47.8**
Demand					
Fertilizer Demand	34.3	35.4	36.3	37.2	38.0
Non-fertilizer Use	5.6	5.9	6.0	6.1	6.0
Distribution Losses	0.8	0.8	0.8	0.9	0.9
Total Demand	**40.7**	**42.1**	**43.1**	**44.1**	**44.9**
Potential Balance	**1.4**	**1.9**	**1.9**	**2.2**	**2.9**
% of Supply	*3*	*4*	*4*	*5*	*6*

Source: Prud'homme, IFA, May 2011

Potash (K2O)

Potash Fertilizer Consumption up to 2030

The global potassium fertilizer consumption decreased successively in 2008 and 2009. The potash use contracted with impacts on global import in most countries. Many NPK manufacturers, which faced lower demand and low profitability, reduced the potassium content in their fertilizer formulations. Global potash sales collapsed because major carry-over stocks were made in several consuming countries at the beginning of 2009 (FAO 2010). In 2010, potassium fertilizer was projected to recover with an increase of 16 percent. Passing from 26.7 million Mt in 2010, by 2014, the world potash fertilizer demand is expected to have reached 32.4 million Mt (Tab.4.3). 54 percent of this 5.7 million Mt overall increase in demand for potash is expected to be in Asia, 32 percent in America, 12 percent in Europe, 2 percent in Africa and 1 percent in Oceania (Fig.4.8) (FAO 2010).

In 2015 there is a potassium fertilizer demand of 28.5 million Mt expected, by 2030 it is expected to reach 32.8 million Mt (Fig.4.1, Tab.4.13) (T&L 2008).

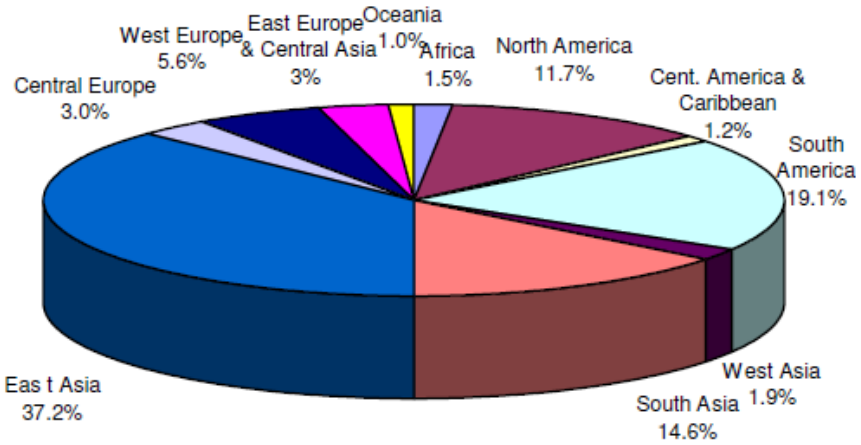


Figure 4.8: Regional and sub-regional share of World Increase in Potash Fertilizer Consumption 2010-2014 (FAO 2010).

Potash Supply / Demand Balance up to 2015

With regards to potash the supply / demand balance is growing very fast. Between 2010 and 2015, the global potash demand is projected to grow by an overall 20 percent, reaching 32.6 million Mt potash, while supply is expected to expand even faster, by 34 percent (Fig.4.9, Tab.4.8).

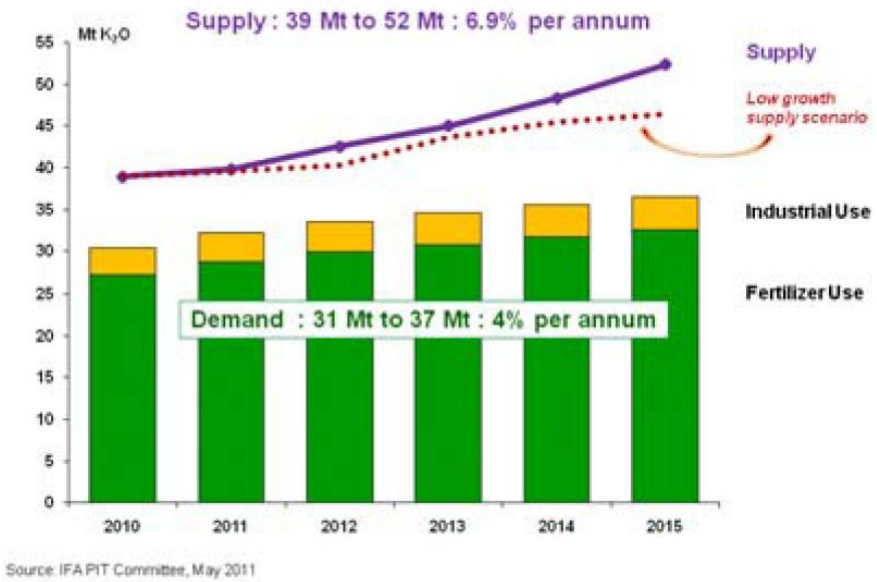


Figure 4.9: World Potassium Supply / Demand Balance 2010-2015 (million Mt) (IFA 2011).

After a small reduction of potential surpluses in 2011, potential surpluses after 2012 are expected to grow quickly. A potential surplus of close to 16 Mt K_2O may emerge in 2015, assuming all planned projects are completed on schedule. However, if demand expands above the current forecast growth and capacity increment suffers from delays, the combination of these two factors would lead to a tightening supply/demand balance in 2011 and 2012, moving towards a static potential surplus of 6-7 million Mt/a K_2O from 2013 to 2015 (IFA 2011).

Table 4.8: World Potash Supply / Demand Balance 2011-2015 (million Mt) (IFA 2011).

	2011	2012	2013	2014	2015
Supply					
Capacity	43.7	48.0	51.2	56.0	59.7
Total Supply*	**39.8**	**42.5**	**45.0**	**48.3**	**52.3**
Demand					
Fertilizer Demand	28.7	29.9	30.8	31.7	32.6
Non-fertilizer Demand	2.6	2.7	2.8	2.9	2.9
Distribution Losses	0.9	0.9	1.0	1.0	1.0
Total Demand	**32.2**	**33.5**	**34.6**	**35.6**	**36.5**
Potential Balance	**7.6**	**9.0**	**10.4**	**12.7**	**15.8**
% of Supply	*19*	*21*	*23*	*26*	*30*

Source: Prud'homme, IFA, May 2011

Total Demand for Primary Nutrients

Besides the use of fertilizer in agricultural terms, primary nutrients are also applied for other purposes, such as industrial use. Other fields of application of nitrogen and phosphate are feed for cattle, poultry and fish. A projection of the global total demand (fertilizer + non-fertilizer) for primary nutrients up to 2014 is shown in Table 4.9 (FAO 2010).

According to the projections up to 2030 by T&L 2008, the N:P:K ratio remains fairly constant in the next 20 years. The ratio, which was 1:0.40:0.29 in 2005 is projected to be 1:0.38:0.25 and 1:0.39:0.24 in 2015 and 2030 respectively. This means the future demand for nitrogen is expected to be slightly higher in comparison to the other nutrients (T&L 2008).

Table 4.9: World total demand for primary nutrients 2010-2014 (thousand tonnes (Mt)) (FAO 2010).

Year	2010	2011	2012	2013	2014
Nitrogen (N)	130 039	133 545	136 319	139 070	141 697
Phosphate (P_2O_5)[1]	45 351	46 765	48 018	49 567	50 924
Phosphate (P_2O_5)[2]	37 962	39 573	40 790	42 448	43 811
Potash (K_2O)	29 949	32 063	33 570	35 004	36 311
Total (N+ P_2O_5+K_2O)	197 950	205 181	210 679	216 522	221 819

[1] = Total P_2O_5 demand (H_3PO_4 based fertilizer + non-fertilizer, and non-H_3PO_4 fertilizer).

[2] = Total H_3PO_4 demand (fertilizer + non-fertilizer) expressed as P_2O_5.

4.2 Projections of Fertilizer Demand of the Major Regions of the World

As mentioned above, the classification of the major regions of the world differs between T&L 2008 and the two studies of FAO 2010 and IFA 2011. This makes a direct comparison difficult. A list of the regions and subdivisions can be found in Annex 4.3 and 4.4. The studies' results are presented below, each with regard to its own classification for the regions:

- developing countries:
  - Asia: West Asia, South Asia, East Asia
  - Africa: Sub-Saharan Africa
  - Latin America and Caribbean
- developed countries:
  - North America
  - Europe
  - Oceania

Further considerations of total NPK demand up to 2050 were computed with the same causal calculation model, used for the projections of the global fertilizer nutrient demand (cp. chapter 4.1). The only appropriate data set for the forecast was the cereal output data of the FAO 2006a IR. Therefore the following classification of the FAO 2006a IR (cp. chapter 3) (Annex 4.1. and 4.2) was applied as reference classification for the regions and subdivisions:

- developing countries:
  - South Asia, East Asia,
  - North Africa and the near-East,
  - sub-Saharan Africa,
  - Latin America and Caribbean

- developed countries:
    - Industrial countries

Detailed nutrient forecasts by regions for 2009-2014 and for 2015 and 2030 are presented in Table 4.10, 4.11, 4.12 for FAO 2010 and Table 4.13 for T&L 2008, respectively. Figure 4.10 shows a medium-term projection of regional fertilizer demand in 2015/16 for IFA 2011.

The detailed regional forecast for 2050, done by the calculation model, is shown in Table 4.14 and Figure 4.11, respectively. As the input data set of the FAO 2006a IR provides only one value for 2050 for the regions of interest, the forecast is also limited to one value for each region. A variation of the projections therefore cannot be specified.

4.2.1 Developing countries

Asia

Asia is the largest consumer of fertilizer nutrients in the world. Its current share is 61 percent of the world's total, with major shares in East Asia and South Asia (FAO 2010). Its total consumption of fertilizer in 2014 is projected to 113 million Mt (Tab.4.10, 4.11, 4.12), with a small increase by 2015/16 (Fig.4.10).

T&L 2008 used a different definition of the region. According to their classification "East Asia" and the "Rest of Asia" is expected to have a demand of 16.8 million Mt in 2015 and 18.6 million Mt in 2030 (Tab.4.13).

West Asia

The West Asian shares of the total world consumption of nutrients are 3.1 percent nitrogen, 3.6 percent phosphate and 1.3 percent potash (FAO 2010). The fertilizer demand in West Asia is growing moderately as the potential for increasing crop production in the region is limited (IFA 2011). Total fertilizer consumption is expected to grow by 2.2 percent p.a. in the period 2010-2014. The nutrient demands are projected to grow by 1.4., 2.9 and 7.7 percent for nitrogen, phosphate and potash, respectively. The total demand of NPK fertilizer is projected to 5.3 million Mt in 2014 (Tab.4.10, 4.11, 4.12), with a small increase by 2015/16 (Fig.4.10). West Asia is a major contributor to the global nitrogen supply. The phosphate capacity is also anticipated to increase so that the surplus will enable exports (FAO 2010).

Further projections do not exist for the sub-region as T&L 2008 use a different classification.

South Asia

South Asia is the second largest fertilizer consuming region in the world. Its share in the world's consumption of nitrogen, phosphate and potash is 19.4, 21.7 and 16.6 percent, respectively (FAO 2010). The growth of regional demand in South Asia is seen as remaining strong. Up to 2015/16 the demand is forecast to increase by 3.4% p.a. to meet the requirements of the fast expanding regional population (IFA 2011). Nitrogen, phosphate and potash consumption is expected to grow at 2.8, 3.9 and 4.8 percent, respectively per annum during 2010 to 2014. The total fertilizer consumption is anticipated to 37.6 million Mt in 2014 (Tab.4.10, 4.11, 4.12). For 2015/16, the demand is forecast to about 40 million Mt (Fig.4.10). India for example has introduced nutrient based subsidy on P and K fertilizers with regard to balanced fertilization. Due to the great demand of NPK, East Asia is likely to have deficits in all three nutrients during the forecast period. However, the negative nitrogen balance would recover slowly by the end of 2014, as new plants are planned (FAO 2010).

Projections of T&L 2008 for 2030 do not exist for the sub-region as they use a different classification.

The calculations for 2050 show a regional demand of about 72 million Mt NPK, hence South Asia still would have the second largest demand after the Industrial countries (Tab.4.14, Fig.4.11).

East Asia

The East Asia sub-region is the largest fertilizer producing and consuming region in the world. Any development in East Asia and South Asia in regard to fertilizer application affects the global demand/supply situation significantly. East Asia has a share of 39 percent of the world fertilizer consumption. The share of the sub-region in nitrogen consumption is 40.8 percent, phosphate 36.9 percent and potash 30.8 percent. The growth of regional N (1.2 %) and P (1.7%) demand is slowing down by 2014 in East Asia, compared to the historical trend since demand for these two nutrients is expected to increase only modestly in China. In contrast, K demand is projected to sharply increase (by 5.6%), particularly in China, Indonesia and Malaysia. The total fertilizer consumption is anticipated to be 70.2 million Mt in 2014 (Tab.4.10, 4.11, 4.12). The demand forecasts of IFA 2011 for 2015/16 are slightly less than 70 million Mt (Fig.4.10). The nitrogen capacity is anticipated to increase and therefore likely to reach a balanced level of supply/demand by 2014. While East Asia is expected to

continue to be a net exporter of phosphate, the increasing demand for potash would cause a significant growth of the import demand during the period.

T&L 2008 used a different definition of the region and the countries in consideration. According to their classification “East Asia” would only have a demand of 10.1 million Mt in 2015 and 11.5 million Mt in 2030 (Tab.4.13).

Their projections for the “Rest of Asia” would show a continuing dominance in fertilizer consumption in the future. It is forecast to be about 43% of global consumption (T&L 2008).

Taking the FAO 2010 forecast for 2014 as a basis for further calculations, East Asia’s regional fertilizer demand is projected to be about 94 million Mt in 2050 (Tab.4.14, Fig.4.11).

Africa

Due to greater investments in the farming sector in Africa, an increase in agricultural production is projected (cp. chapter 3). This consequently requires increasing fertilizer consumption (IFA 2011).

According to FA0 2010 rates for nitrogen, phosphate and potash are expected to be 3.6, 3.2 and 4.5 percent, respectively between 2010 and 2014. IFA 2011 assumes a growth of 4 percent until 2015/16, but with large differences among countries. In 2014 Africa’s demand for the key nutrients NPK reaches about 5 million Mt (Tab.4.10, 4.11, 4.12), slightly growing by 2015/16 (Fig.4.10) (FAO 2010, IFA 2011). Main consumers of fertilizer are Egypt, Morocco, Nigeria and South Africa. According to the supply/demand balance Africa would remain a major exporter of phosphate and nitrogen until 2014. Potash use would still depend solely on import (FAO 2010).

Sub-Saharan Africa

Soil nutrient depletion in this region is a consequence of continuous cropping with little or no fertilizer application, causing further food shortages. Fertilizers have a significant role to play in this (T&L 2008). The fertilizer consumption in Sub-Saharan Africa will remain lowest in spite of the over 100 percent expected increase by 2030. Demand was 1.4 million Mt in 2005 and is expected to reach 1.9 million Mt by 2015 and 2.7 million Mt by 2030, respectively (Tab.4.13) (T&L 2008).

In 2050, Sub-Saharan Africa is projected to have a demand of 7.7 million Mt, which then still would account for the lowest consumption of NPK (Tab.4.14, Fig.4.11).

Near East and North Africa

This sub region was applied in FAO 2006a and therefore used for further calculations. As the growth rate is rather moderate in this region, by 2050 its regional demand is expected to increase to 33 million Mt NPK. This would be the second lowest consumption after Sub-Saharan Africa (Tab.4.14, Fig.4.11).

America

2010 America's share of overall world consumption of fertilizer is 22 percent, of which North America constitutes 13 percent and Latin America 9 percent. A surplus in potash and deficit in nitrogen will remain until 2014. As a result of growing demand in phosphate its low surplus may turn into a deficit from 2013 on (FAO 2010).

Latin America & Caribbean

Latin America's share in world consumption of nutrients is 6.1 percent nitrogen, 12.6 percent phosphate and 17.6 percent potash. The per annum growth in demand for nitrogen, phosphate and potash is expected to be at 3.6, 4.7 and 6.0 percent, respectively between 2010 and 2014 (FAO 2010). In 2014 there is total demand of NPK fertilizer of 19 million Mt projected (Tab.4.10, 4.11, 4.12). By 2015/16, slightly more than 20 million Mt are expected (Fig.4.10). Main consumers of fertilizer in Latin America are Brazil and Argentina in South America and Mexico in Central America and the Caribbean. Brazil and Argentina will capture a large share of the anticipated increase in world cereal, oilseed, sugar, and ethanol trade (IFA 2011). By 2014 there is a growth of export of nitrogen projected, while import of phosphate and potash are anticipated to continue to decline (FAO 2010).

T&L 2008 assume a total demand of NPK of 13.9 million Mt in 2015 and 15.5 million Mt in 2030 (Tab.4.13). Again the differences in the projections of FAO 2010 and T&L 2008 for 2015 are caused by their different definitions of the region.

Taking T&L 2008 as a basis, the regional fertilizer demand is projected to reach 37 million Mt of NPK by 2050 (Tab.4.14, Fig.4.11).

4.2.2 Developed Countries

North America

The current share of North America in world's consumption of nitrogen is 12.8 percent, phosphate 11 percent and potash 15.5 percent. With respect to projections of growing maize production, fertilizer demand is expected stay strong. The growth rates in the period 2010-2014 are 1.1 (N), 2.1 (P) and 3.8 (K) percent, respectively (FAO 2010). The growth until 2015/16 is projected to 2.3 percent with higher growth rates for P and K (IFA 2011). The total demand of NPK fertilizer in the region in 2014 is projected to 23.6 million Mt (Tab.4.10, 4.11, 4.12) with a small increase by 2015/16 (Fig.4.10). The main consumers of fertilizer are USA and Canada. Looking at the supply/demand balance, a dependency on nitrogen imports is obvious. The surplus in phosphate is expected to shrink due to increase in demand and almost static supply. The potash balance of the region is expected to increase due to addition in potash capacity mainly in Canada.

According to T&L 2008, the regional fertilizer demand is projected to reach 33 million Mt in 2015 and 42 million Mt in 2030 (Tab.4.13). Thus, by 2030 North America will account for about 18 percent of global fertilizer consumption (T&L 2008). The differences in the projections of FAO 2010 and T&L 2008 for 2015 can be traced back to their different definitions of the region.

Eastern Europe & Central Asia

In response to export opportunities and supportive policy, agricultural production is expanding in Eastern Europe and Central Asia, particularly in Russia and Ukraine (IFA 2011). As a result fertilizer demand is expected to grow. Regional demand is forecast to increase by 3.8% p.a. until 2014, with growth rates of 3.5, 5.1 and 3.5 percent for nitrogen, phosphate and potash respectively. The total demand of NPK fertilizer is projected to 7.3 million Mt in 2014 (Tab.4.10, 4.11, 4.12), with a small increase by 2015/16 (Fig.4.10).

Further projections do not exist for the sub-region as T&L 2008 use a different classification.

Europe

Europe's share in global fertilizer consumption is about 13 percent. The share of the region in nitrogen fertilizer consumption is 13.9 percent, phosphate 9.3 percent and potash 15.7 percent. Nitrogen, phosphate and potash consumption is expected to grow in the region at 1.9, 3.1 and 4 percent, respectively per annum during 2010 to 2014. The total fertilizer demand projected for 2014 is 24.5 million Mt.

Fertilizer demand in Western and Central Europe has only partly recovered from its sharp contraction in 2008/09. It is seen as remaining depressed in the next five years, with an anticipated increase of 1.5% p.a. (IFA 2011). While the West European fertilizer consumption is highest within the region, the future growth rates of East Europe & Central Asia and Central Europe are seen to be higher (FAO 2010). By 2014, total demand for NPK fertilizer is expected to be 12.3 million Mt in West Europe, 7.3 million Mt in East Europe & Central Asia and 4.9 million Mt, respectively (Tab.4.10, 4.11, 4.12). The East Europe & Central Asia sub-region exhibits a surplus in all the three nutrients. It has the largest potential balance of nitrogen and potash in the world (FAO 2010).

The forecasts of T&L 2008 are divided into the regions "European Union" and the "Rest of Europe".

The total fertilizer nutrients projections for the "European Union" are 24.2 million Mt in 2015 and 26.4 million Mt in 2030. Consumption in EU is expected to be next to that of North America (T&L 2008).

In the "Rest of Europe" 6.7 million Mt are expected in 2015, 7.1 million Mt are anticipated in 2030.

Oceania

The agriculture in Oceania is progressively recovering from consecutive droughts and the economic downturn (IFA 2011). Fertilizer consumption in Oceania hence is expected to grow by 3.2 percent annually from 2010 until 2014. Nitrogen, phosphate and potash consumption is likely to grow by 1.9, 4.2 and 4.7 percent, respectively during the period (FAO 2010). The region's total fertilizer consumption is projected to 2.9 million Mt in 2014 (Tab.4.10, 4.11, 4.12) with small increases by 2015/16 (Fig.4.10). In 2014, the current nitrogen deficit is likely to be overcome and turn into surplus. With regard to phosphate and potash, the region is expected to continue to remain deficit during the period.

According to T&L 2008 the regional prospects for 2015 are 4.8 million Mt. By 2030, 5.3 million Mt NPK fertilizers are anticipated.

Industrial Countries

The sub region “Industrial Countries” comprises the EU 15, other European countries, North America and parts of Oceania (Annex 4.2). This classification was applied in FAO 2006a. Its fertilizer demand was the second largest in 2015 and is projected to reach the largest demand in 2050 (105 million Mt NPK) (Tab.4.14, Fig.4.11).

Table 4.10: World and regional Nitrogen Fertilizer Demand Forecasts (thousand Mt) (FAO 2010).

	2009[1]	2010	2011	2012	2013	2014	CAGR (%)
WORLD	**101 664**	**103 877**	**106 054**	**107 901**	**109 835**	**111 638**	**1.82**
AFRICA	**2 809**	**2 919**	**3 025**	**3 131**	**3 246**	**3 357**	**3.56**
AMERICA	**19 142**	**19 746**	**20 237**	**20 597**	**20 945**	**21 314**	**1.93**
North America	12 988	13 319	13 497	13 650	13 773	13 897	1.07
Latin America	6 154	6 428	6 741	6 947	7 172	7 417	3.64
- Central America & Caribbean	*1 740*	*1 778*	*1 805*	*1 833*	*1 860*	*1 888*	*1.51*
- South America	*4 414*	*4 650*	*4 936*	*5 115*	*5 312*	*5 529*	*4.43*
ASIA	**64 418**	**65 506**	**66 725**	**67 815**	**68 963**	**70 013**	**1.68**
West Asia	3 164	3 213	3 248	3 275	3 338	3 394	1.38
South Asia	19 758	20 305	20 896	21 465	22 046	22 635	2.75
East Asia	41 496	41 989	42 582	43 075	43 579	43 983	1.17
EUROPE	**14 135**	**14 495**	**14 821**	**15 083**	**15 389**	**15 647**	**1.93**
Central Europe	2 574	2 629	2 720	2 799	2 887	2 981	3.19
West Europe	7 737	7 891	7 964	8 017	8 068	8 103	0.66
East Europe & Central Asia	3 824	3 975	4 137	4 267	4 434	4 563	3.51
OCEANIA	**1 160**	**1 211**	**1 246**	**1 275**	**1 292**	**1 307**	**1.93**

[1] *= Estimated consumption; CAGR = Compound annual growth rate 2010 to 2014.*

Table 4.11: World and regional Phosphate Fertilizer Demand and Forecasts (thousand Mt) (FAO 2010).

	2009[1]	2010	2011	2012	2013	2014	CAGR (%)
WORLD	**36 952**	**39 148**	**40 445**	**41 594**	**42 791**	**43 876**	**2.89**
AFRICA	**901**	**938**	**975**	**1 004**	**1 034**	**1 064**	**3.20**
AMERICA	**8 719**	**9 352**	**9 764**	**10 046**	**10 417**	**10 713**	**3.46**
North America	4 068	4 442	4 556	4 639	4 736	4 818	2.05
Latin America	4 651	4 909	5 209	5 407	5 681	5 895	4.68
- Central America & Caribbean	*335*	*360*	*385*	*405*	*420*	*435*	*4.84*
- South America	*4 316*	*4 549*	*4 824*	*5 002*	*5 261*	*5 460*	*4.67*
ASIA	**23 009**	**24 055**	**24 722**	**25 362**	**25 997**	**26 626**	**2.57**
West Asia	1 336	1 280	1 324	1 357	1 400	1 433	2.86
South Asia	8 021	8 538	8 874	9 234	9 597	9 963	3.93
East Asia	13 652	14 237	14 524	14 770	15 000	15 230	1.70
EUROPE	**3 420**	**3 751**	**3 864**	**4 001**	**4 116**	**4 233**	**3.07**
Central Europe	860	940	970	1 000	1 030	1 050	2.81
West Europe	1 535	1 734	1 774	1 809	1 844	1 871	1.92
East Europe & Central Asia	1 025	1 077	1 120	1 192	1 242	1 312	5.06
OCEANIA	**903**	**1 053**	**1 120**	**1 181**	**1 227**	**1 240**	**4.17**

[1] = Estimated consumption; CAGR = Compound annual growth rate 2010 to 2014.

Table 4.12: World and regional Phosphate Fertilizer Demand and Forecasts (thousand Mt) (FAO 2010).

	2009[1]	2010	2011	2012	2013	2014	CAGR (%)
WORLD	**23 044**	**26 655**	**28 542**	**29 882**	**31 218**	**32 413**	**5.01**
AFRICA	**412**	**459**	**488**	**514**	**530**	**547**	**4.51**
AMERICA	**7 563**	**8 695**	**9 266**	**9 712**	**10 136**	**10 539**	**4.93**
North America	3 579	4 208	4 406	4 588	4 746	4 882	3.79
Latin America	3 984	4 488	4 860	5 124	5 390	5 657	5.96
- Central America & Caribbean	*355*	*384*	*400*	*416*	*434*	*453*	*4.22*
- South America	*3 629*	*4 104*	*4 460*	*4 708*	*4 956*	*5 205*	*6.12*
ASIA	**11 198**	**13 232**	**14 357**	**15 041**	**15 765**	**16 324**	**5.39**
West Asia	290	320	340	370	410	430	7.67
South Asia	3 818	4 112	4 327	4 536	4 745	4 954	4.77
East Asia	7 090	8 800	9 690	10 135	10 610	10 940	5.59
EUROPE	**3 617**	**3 991**	**4 132**	**4 295**	**4 455**	**4 668**	**4.00**
Central Europe	630	730	766	804	844	900	5.37
West Europe	1 784	1 980	2 050	2 120	2 200	2 300	3.82
East Europe & Central Asia	1 203	1 281	1 316	1 371	1 411	1 468	3.47
OCEANIA	**254**	**279**	**300**	**321**	**332**	**335**	**4.68**

[1] = Estimated consumption; CAGR = Compound annual growth rate 2010 to 2014.

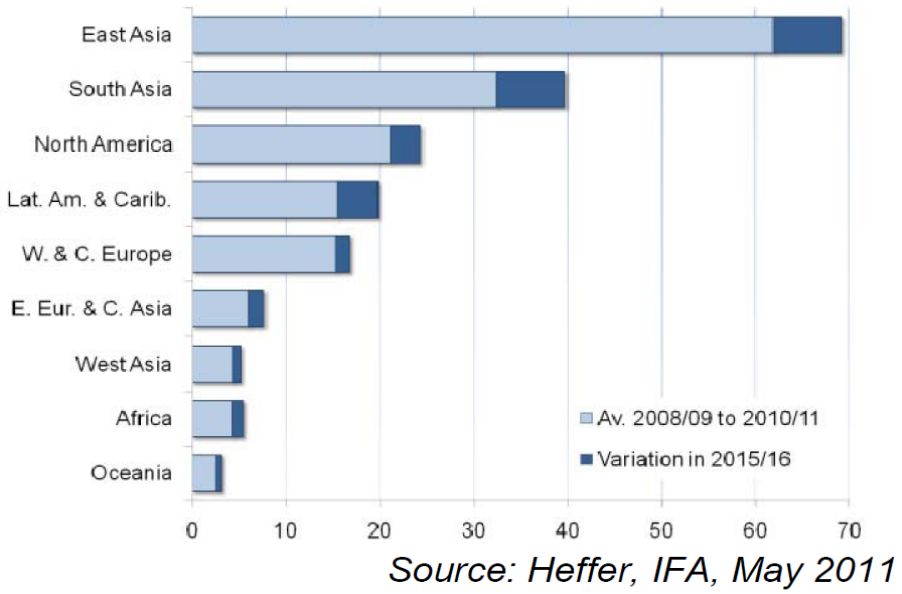


Figure 4.10: Projected Medium-Term Evolution of Regional Fertilizer Demand (Mt nutrients) (IFA 2011).

Table 4.13: Annual Fertilizer and Nutrients Projections for 2015 and 2030 by Region (T&L 2008).

Region	Year	N	P	K	Total
			Million Mt		
EA	2005	4.9	1.6	2.6	9.2
	2015	5.6	1.8	2.6	10.1
	2030	6.6	2.1	2.9	11.5
EU	2005	10.4	3.1	3.2	16.7
	2015	14.9	4.3	5.0	24.2
	2030	15.3	5.2	6.0	26.4
LA	2005	4.7	3.9	4.2	12.7
	2015	5.3	4.4	4.1	13.9
	2030	6.1	5.3	4.1	15.5
NA	2005	13.7	5.0	4.8	23.6
	2015	21.2	6.6	5.2	33.0
	2030	28.1	8.2	5.8	42.0
NE	2005	6.0	2.1	0.4	8.5
	2015	8.4	2.8	0.6	11.8
	2030	11.7	3.4	0.7	15.8
OC	2005	1.8	1.7	0.4	3.9
	2015	2.4	1.9	0.6	4.8
	2030	2.7	1.9	0.7	5.3
RA	2005	44.3	17.6	9.5	71.4
	2015	52.3	20.2	8.7	81.2
	2030	61.0	25.1	10.7	96.8
RE	2005	4.2	1.1	1.0	6.4
	2015	4.4	1.2	1.2	6.7
	2030	4.6	1.1	1.4	7.1
SSA	2005	0.7	0.4	0.4	1.4
	2015	0.9	0.6	0.5	1.9
	2030	1.2	0.8	0.6	2.7
Total	2005	90.7	36.6	26.6	153.8
	2015	115.4	43.8	28.5	187.7
	2030	137.4	52.9	32.8	223.1

Source: 2005 – FAOSTAT database; 2015 and 2030 - Author's computation

Table 4.14: Regional Fertilizer Demand (N+P2O5+K2O) in 2050 (million Mt nutrients). Data sources (FAO 2000, FAO 2006a, IFA 2011, T&L 2008, Calculations based on T&L 2008's formula).

Region	2005	2015	2030	2050	Growth (%) 2015-2050
Sub-Saharan Africa	1,4	1,9	2,7	7,7	307
Near East & North Africa	8,5	11,8	15,8	32,9	179
South Asia		38		71,6	88
East Asia		68		94,2	39
Latin America & Caribbean	12,7	13,9	15,5	36,7	164
Industrial countries	44,2	62	73,7	104,7	69

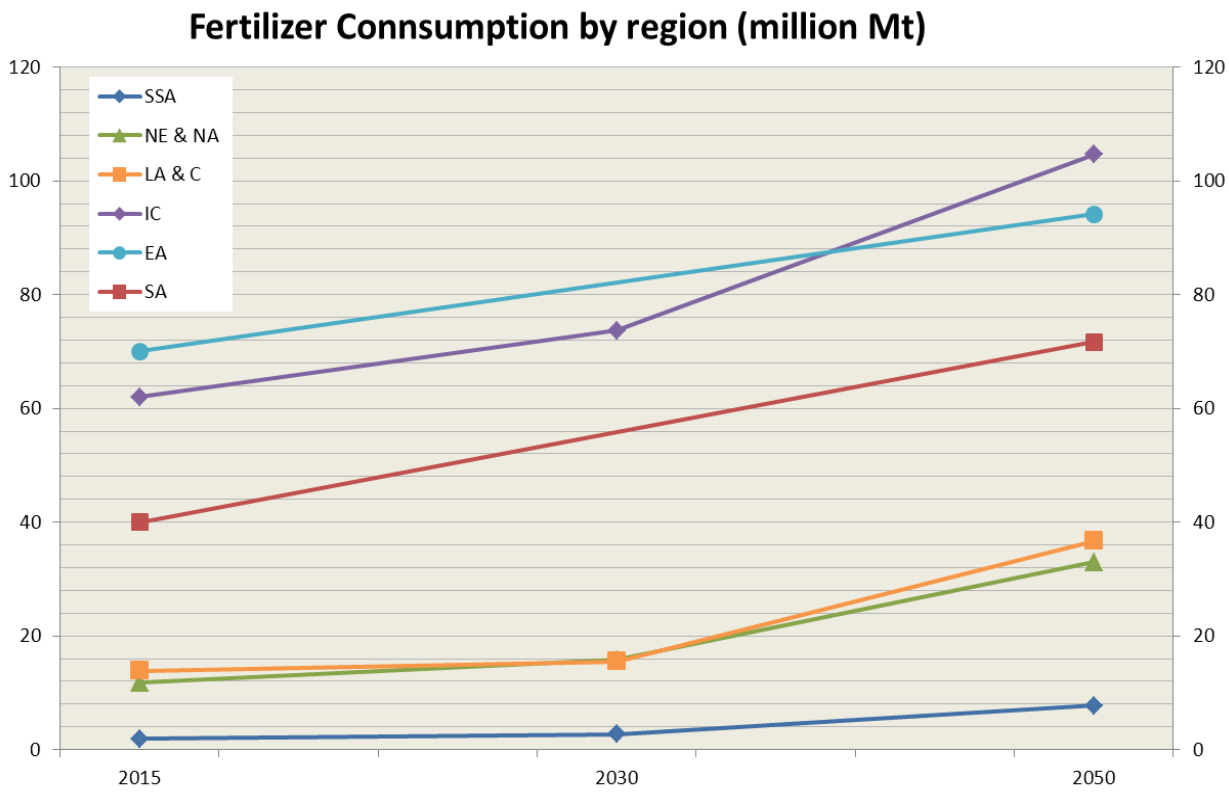


Figure 4.14: Regional Fertilizer Demand (N+P2O5+K2O) in 2050 (million Mt nutrients). Data sources (FAO 2000, FAO 2006a, IFA 2011, T&L 2008, calculations based on T&L 2008's formula). *(SSA: Sub-Saharan Africa, SA: South Asia, EA: East Asia, LA & C: Latin America & Caribbean, NE & NA: North East & North Africa, IC: Industrial Countries).*

5 CONCLUSION

According to the UN the world population is projected to rise from the current 7 billion to 9.3 billion by 2050. Asia's population is expected to grow quickly, reaching 5.2 billion by the middle of the century. Hence it would be still more than double that of Africa in 2050 (2.2 billion). However **the highest population growth is projected to occur in the region of sub-Saharan Africa**. Europe is the only major region, for which a decline in population is projected until the end of the 21st century (63 per cent from 2010-2100). The major part of the world population growth is going to be absorbed by the world's towns and cities. Africa is forecast to have the second largest urban population (1.2 billion) after Asia (3.4 billion) in 2050. In contrast, the Industrial countries' urbanization is declining. In total, the world population is expected to be 69 per cent urban in 2050.

This population growth and progressive urbanization accompanied by rising incomes are the main socio-economic factors leading to a **70 per cent increase of food demand within the next 40 years**. The urbanization and income growth are mainly in less developed regions the reasons for an ongoing diversification of diets. **Less basic staples and more processed foods and livestock products, like vegetables, fruits, meat, dairy, and fish are going to be consumed**. This in turn puts higher pressure on land resources.

Between 2030 and 2050 the world average will be approaching 3000 kcal/person/day ending up at about 3050 kcal/person/day in 2050. Sub-Saharan Africa is projected to reach the mid-high level of 2700 kcal/person/day in 2050. South Asia is expected to already accomplish that level by 2030. The level in Industrial countries is forecast to be nearly 3600 kcal/person/day in 2050.

The new consumption patterns involve a growing meat demand, of which East Asia shows the largest increase to over 60 kg/cap./year. Also large increases in per capita consumption of meat are held by North America and Europe, South Asia and sub-Saharan Africa. North America and Europe by far the highest level in per capita meat demand, reaching about 95 kg/cap./year in 2050. The global average consumption of meat per capita is projected to rise from 41 kg at present to 52 kg in 2050 (from 30 to 44 kg in the developing countries). This increase in turn is the main driving force for feed demands for cereals. Additionally, the growing demand for biofuels is going to have influence on the future demand for cereals.

A steady growth of agricultural production is projected across all seven major regions. North America and Europe are expected to have the largest production. More than 1 billion Mt are projected in 2050. East Asia's production is forecast to be about 680 million Mt. While the lowest production is projected to be in the Near East and North Africa, the Sub Saharan

countries are projected to produce 220 million Mt. They will have the largest growth in production in the period 2000 to 2050 (+144%) (to 23 000 plant kcal/ha/day).

The global staple food production would only be about half as efficient without the use of fertilizer nutrients. That is why the projected increase of 70 per cent of the world's rising food demands in 2050 could not be met without fertilizers. In order to compensate a possible deficit more forested land would have to be changed into cropland (ROBERTS 2009).

For planning future fertilizer plant size and for optimizing its use with regard to food security and environmental concerns, improved forecasts of fertilizer demand are therefore necessary (T&L 2008). The inappropriate use of fertilizers could lead to soil nutrient drawdown. This could result in missing biofuels production plans and intensifying food shortages. In order to mitigate these problems regions with fertilizer nutrient drawdown may need more fertilizer to achieve social and economic goals. The apparent draw down of soil nutrients presents an opportunity and a challenge for fertilizer businesses in many regions of the world (T&L 2008).

The highest population growth is projected to occur in the region of sub-Saharan Africa. Even though the projections for NPK growth in this section are rather moderate, the necessary basis for countering the problems that occur from soil nutrient depletion is already conceivable, as the world and all of the major regions are projected to expand their fertilizer consumption. The global NPK demand was calculated to experience a big leap from 223.1 million Mt in 2030 to about 324 million Mt in 2050. The regional demands are also projected to increase. In sub-Saharan Africa with a growth of 307 per cent (7.7 million Mt in 2050) the highest growth rate from 2015 to 2050 is expected to occur. This is followed by the Near East & North Africa with a growth of 179 per cent (32.9 million Mt in 2050) and Latin America & the Caribbean with a growth of 164 per cent (36.7 million Mt in 2050). The Industrial countries on the contrary show a relatively moderate growth of 69 per cent (104.7 million Mt in 2050). The region with the smallest growth rate is East Asia (39 per cent and 94.2 million Mt in 2050).

Box: Outlook

All of the calculated projections are subject to several uncertainties which need to be considered additionally (compare Fig 5.1). Within the overall context of Global Change and Globalization there are natural and socio-economic forcings which had to be taken into consideration:

Soil degradation is one of the major concerns in the context of Global Change. Soil capacity and soil fertility is in large parts of the world and the EC declining due to multifold overuse resulting in compaction, sealing of soils, chemical alteration, brownfields etc.. Land

degradation and Desertification are also an overall thread. Soil and its capacity have to be taken into account carefully playing a major role for food production.

Climate Change and its regional effects will have an enormous impact on food production by direct changes in temperature and precipitation as well by alterations of the vegetation period, which is having an effect on harvest security and crop selection. Recent climatic extremes likewise the flooding in Pakistan but also the droughts of 2003 and 2010 in Europe clearly showed there devastating effect on food production. There will also be a considerable change in the overall spatial pattern concerning the possibilities of food production especially in higher latitudes. However estimates on the future alterations of the global NPK demand would be mere speculations.

Climate Change is having a direct link to the availability of water. Irrigation is expanding in many parts likewise Turkey or Southern Spain. Overuse and mismanagement are resulting in salination of groundwater and soils. In many countries water rights are not part of written laws but the outcome of historically based complex daily practice. Stakeholder as well as land tenure and ownership have a distinct influence on it. Access to land and ownership are changing rapidly on a global scale. Foreign investors of the rich north and south are buying land of the poorer countries in the south ("land grabbing"). In the meantime countries like Bolivia 25% of the land is hold by foreign investors. Large quantities of this land are used for biofuel production, such affecting national and local food security.

There should also be a paragraph on ecological farming within sustainable farming systems. It depends from the overall value system and the future consumer attitude to which part this will be requested. Food consumption will influence food production to a higher degree as during the past.

Especially within the EC like in other economic mega-systems (ASEAN, Mercosur, NAFTA…) food production is manifold influenced by market subsidies and policies.

In this context the global economic concerns are the main factors that could influence the forecasts. The economic growth in developing countries, the development and increase of biofuels and energy demands, agricultural commodity prices, fertilizer prices relative to crop prices, fertilizer subsidies, and new policies aiming at increasing nutrient use efficiency and recycling organic nutrient sources should always be taken into account when talking about future NPK conditions.

Another important factor which should attract interest is not only the application of artificial fertilizers, but also the use, availability and recycling of organic fertilizers. This may influence the long-term predictions for NPK demand.

As far as the southern African countries are concerned, access to fertilizer is limited as the required infrastructure is barely existent. Future purchasing power of African farmers is rather unpredictable. In view of the quickly accelerating urbanization process the economic growth currently lacks. The local knowledge on fertilizer application is poor or non-existent in many African regions. In these countries subsistence production and home gardening is a widespread type of cultivation. Moreover, an increased use of fertilizers would be incompatible with the often applied concept of eco-farming. It might be difficult to convince the great number of small holders producing for subsistence to apply fertilizers. The overcoming of regional traditions and socio-cultural terms is another aspect that is closely connected to that. Furthermore, the local composition of soils and the widespread problem of soil exploitation could hamper the application of fertilizers. Crop fertilizer requirements are highly divers, depending on the type and varieties of crops (high yield varieties vs. traditional crops) as well as on the cropping pattern (mixed cropping vs. mono-cropping, use of leguminous plants, etc.). Waste water use is common in many regions of the world, providing famers with recycled nutrients. All these factors make it difficult to predict the NPK demand in absolute figures.

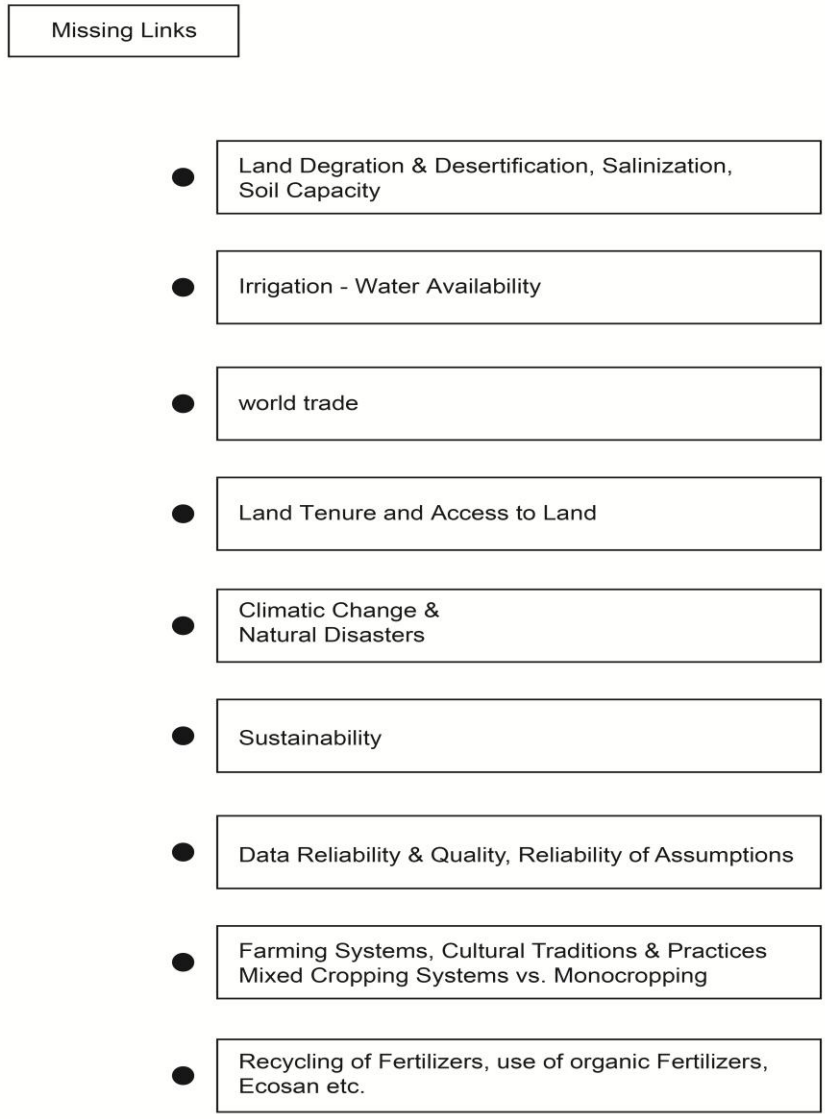


Fig. 5.1: Missing links for a reliable NPK demand prediction in 2050

In order to counter the estimated soil nutrient depletion and regarding all of the mentioned influences the focus lies on a food and fertilizer policy reform, farmer education and technology development. GROTE et al. (2005) have suggested a number of policy measures. As far as developed countries are concerned production subsidies should be reduced and nutrient trading permits should be implemented. In developing countries the increase of input subsidies, the implementation of credit schemes and extension and training programs would be appropriate measures to encourage fertilizer consumption.

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