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FACTORS AFFECTING THE AVAILABILITY OF FOOD IN 2050

Abstract

Population prospects and increasing risk of emergence of limits to growth mean that food safety hazards are becoming more realistic. The goal of the study is to find the most important factors influencing the future food security.

Until 2050 the demand for food is expected to increase by at least 70%. It is due to growing number of people and rapid changes in developing countries.

Forecasts allow the conclusion that it is possible to ensure a sufficient increase in the supply of food that will satisfy the need for additional billion people, and suffering from malnutrition. However, it is associated with the need to increase the focus on economic and social aspects of the food economy, i.e., among others, greater trade openness, the growing importance of producers at the expense of intermediaries, increase the social attractiveness of work in agriculture and reducing food waste. These conditions are as important as the fight against climate change (in particular water scarcity and soil erosion) or technological improvement of agricultural productivity.

Keywords: Food in 2050; food security; climate change; agriculture

1. Introduction

Apart from access to water, shelter and health, food is one of the basic human needs. In order to fully comprehend its importance, one may just imagine the consequences of a few days without it. In large cities, it would lead to the depletion of stocks in shops. The problem of malnutrition is a significant challenge in many developing countries. It is estimated that it concerns over 800,000,000 people in the world. The issue is nearly unnoticed in highly-developed countries, as the high purchasing power of households results in a small participation of food costs in the basket of consumed goods. The wealth of these countries also causes the supply of food exceed the demand, making food easily available to customers.

However, considering the expected further growth of the world population and the increasing probability of facing developmental limits, more and more voices are warning that ensuring access to food might become one of the fundamental challenges for mankind in mid-21st century (GH, 2013; IAASTD,

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2009). Analysts point out that the fears expressed by the 19th-century economist T. Malthus, concerning the inability to feed the growing population might actually come true, as it is impossible to further increase the area of arable land (MA, 2005).

In view of the above, the search for the possibilities of long-term food provision is an important element of civilisation development. In this respect, it is not only important to determine if there will be enough food to satisfy the needs of all people, but also how economic changes will affect food consumption. Development of a global food security scenario should take into account not only the technical capacity for food production, but also social attitude. The goal of the study is to find the most probable development path of food trends in the perspective of the year 2050.

The paper was based primarily on critical analysis of existing literature and statistical data. The multi-faceted nature of the discussed topics has made the author abandon the presentation of scenarios, and rather focus on the factors most strongly influencing the future food security.

2. Preliminary Assumptions Concerning the Living Conditions in 2050

The analysis of future trends in the evolution of agriculture and food economy requires not only the knowledge of processes occurring in those sectors, but also studying the changes in their environment. Some occurrences affect not just the demand for food, but also its supply. In most cases, it concerns rather unlikely situations that may be referred to as black swans. One may list among them such event as the Earth being hit by a large meteorite destroying the human civilisation. The probability of such event is negligible, and astronomers assessing the risk of collision with various space objects have the possibility of warning people in advance, thus enabling remedial action. Another group of threats that should be eliminated from the forecast are global natural disasters. It concerns occurrences of a very large scale, affecting people all over the planet. This usually includes volcano eruptions. An adequately large scale of atmospheric pollution may cause a global reduction in agricultural production lasting a few years. In the case of so-called “supervolcanoes”, the consequences may lead to the extermination of mankind. Obviously, eruptions of such magnitude are extremely rare, but it is worth to remember that contemporary science cannot predict them. For this reason, one needs to be aware of the possibility of such occurrence, but structuring scenarios of agricultural development on the basis of such factors is not justified. Their probability is too low, and the consequences too extensive to be properly considered.

A much more probable situation is a global civilisation conflict. As the cold war ended, people got used to the thought that there are no more reasons for

a military confrontation of world powers. However, with the rapid growth of China and its assumption of a leading role in the economy, there are more and more frequent political tensions between the USA and PRC. The two countries differ profoundly in terms of culture, which makes their attitude to the same issues completely different. It is noticeable in the UN Security Council, where China often makes decisions other than expected in the Western culture. As the economic power of China is consolidating, and so are its links with other countries, e.g. in Africa or Central Asia, the political position of this country is also rising, even though the Chinese are strongly against treating them as a superpower, explaining it with incomplete transformation and internal problems. Nevertheless, their influence on the world economy is still huge (Brunet and Guichard, 2011).

The USA, on the other hand, are slowly becoming aware of their imminent loss of economic leadership, which will probably happen around 2025 (O'Neill, 2012). It seems that they still are not ready to lose the political supremacy and become only the second power in the world. However, all forecasts of economic changes by 2050 include such option (ADB, 2011; Buiter & Rahbar, 2011; O'Neill, 2012; OECD, 2012; Ward, 2012). As a result, one may notice a growing American interest in cooperation with East Asia, most particularly the ASEAN countries. This attempt of creating an American zone of influence in East Asia is viewed by China as an endeavour to establish a new division of the world against the Middle Kingdom. It should be expected that in the future, the tension between PRC and USA intensifies. This will increase the threat of a global war, maybe even more than in the case of USRR-USA relations, as today, there are no established rules of consultation between superpowers (Goldstein, 2013). However, starting a global war seems improbable, as for both sides, the prospective benefits would be highly surpassed by the costs. In the global politics, Russia is still a great unknown. Upon introducing certain economic reforms, it may reinstate itself as a world power, or it may gradually lose its significance. From the point of view of the global food policy, transformations in this country may be of importance. It should definitely be stated that the probability of Russia initiating a global conflict is minor.

It was assumed that apart from transitory periods of regression (as in the case of the attacks of September 11, 2001 in the USA), globalisation processes will still progress. It is extremely important for our further analysis of changes in access to food, as it enables global, rather than only regional problem-solving.

From the point of view of the entire planet, local and regional wars are unimportant, as they only lead to temporary problems. Their scale may be as large as, or even larger than today, which means that hundreds of millions of people will still suffer due to limited access to food, but it will not result in permanent global perturbations.

The scenarios also assumed that by 2050, there will emerge no real global executive power with reference to food – i.e. no form of world government. It is assumed that the basic units taking action will be independent countries. On the one hand, its authority will most probably be limited by transnational corporations,

but on the other, a growing interest in authoritarian developmentalism allows the claim that the effectiveness of state power will be similar to that of today. The emergence of a global government might improve the situation of people having limited access to food, but the aforementioned civilisation differences (mainly concerning the rice versus wheat-corn civilisations[2]), the odds of such institution being established are remote.

An important element demanding analysis is the question of sustainable development. Global economic challenges connected with growth limits and the current political trends encourage many analysts to consider scenarios based on this concept (Paillard et al., 2011). Such approach seems desirable, though the forecasts of global consumption (Prandecki et al., 2013) and changes in social attitudes clearly show that in the absence of a rapid, large-scale catastrophic event, there is no chance for any change in social attitudes and uniting mankind for any idea. Sustainability is recommended, but only viable in a longer term than by 2050. Therefore, one needs to exclude a global implementation of the principles of sustainable development in food scenarios. One may only assume the performance of partial actions, e.g. reducing the emission of greenhouse gases from agriculture, increasing the efficiency of using nitrogen and other fertilisers, and better water management.

3. Changes in Demand for Food

The basic factor determining food consumption is population. It is usually estimated that by 2050, the human population will have increased by at least two billion people, reaching over 9.5 billion (United Nations, 2013b). However, in the analyses concerning food security, one should not take into account the average version of UN forecasts, but rather the most extensive one, as the issue of security should concern all people living on Earth in the mid-century. Of course, the average version is much more probable than the high one, but such policy will relieve us from the duty to take care of an additional 1.3 billion people. It is more adequate to assume – according to Table 1 – that in 2050, the planet will have to feed almost 11 billion people (United Nations, 2013b). Taking into account the changes that occurred between the recent and the previous studies on population, i.e. increasing the growth forecasts, adopting the maximum option seems justified. Such change means that the number of consumers will increase by half. It does not mean that food consumption will automatically increase proportionally.

According to Table 1, by 2050, the highest percentage-based growth in the number of people will have occurred in Africa, with its population more than

[2] It is worth noting that in the course of evolution, societies whose basic food was rice, developed a different set of properties (e.g. higher tendency for cooperation) than those whose basic food were other types of grain, e.g. wheat. The latter are characterised by greater individualism

Table 1. Prospects for changes in population – High Variant (in thous.)

	Year				
	2000	**2010**	**2030**	**2050**	**2100**
World	**6 127 700**	**6 916 183**	**8 881 519**	**10 868 444**	**16 641 244**
More developed regions	1 193 355	1 240 935	1 358 551	1 470 258	1 959 544
Less developed regions	4 934 346	5 675 249	7 522 968	9 398 185	14 681 700
Africa	808 304	1 031 084	1 714 697	2 685 586	6 007 405
South America	348 246	394 021	495 453	582 729	773 125
North America	315 417	346 501	423 688	500 480	753 838
Asia	3 717 372	4 165 440	5 160 390	5 911 979	7 558 007
Europe	729 105	740 308	773 625	804 400	1 005 317

Source: Own calculations based on United Nations, Department of Economic and Social Affairs, Population Division (2013), *World Population Prospects*, New York, http://esa.un.org/wpp/unpp/p2k0data.asp [access: 19.11 .2013].

doubling, increasing by about 1.65 billion. In absolute values, the highest growth will still concern Asia, with its estimated population growth by 1.75 billion. Because of the already large number of people living on this continent, the change will not be as perceptible as in Africa. In other regions, particularly in highly-developed countries, changes in the population will be minor.

The huge growth in the number of people in Africa and Asia may lead to a delusion that this factor will be less significant than if it would have happened in developed areas, as in poor countries, the level of food consumption is low anyway. The economic changes occurring in the world allow us to expect that both Asia and Africa will maintain the high rate of economic growth, enabling them to considerably increase the level of their wealth (Prandecki, 2013). In East Asia, the process has been observed for a long time. Its scale is so vast that the first decade of the 21st century is often referred to as the domination of BRICS. It is true that the "club" only includes two Asian countries (China and India), but they have been the driving force of the whole group. Moreover, for the last few years, there have been a rapid growth slowdown in Brazil ("Has Brazil blown it?", 2013), which further proves the leading role of Asian countries in the transformations of developing economies. Consequently, it is estimated that in 2030, over 3.2 billion Asians will have constituted a great majority of the global middle class (defined as people earning or spending between 10 and 100 USD daily, calculated according to the purchasing power of 2005). They will have accounted for about 70% of consumption expenditure of the world (Brookings Institution, 2012). W. Hutchings has estimated that in the years 2010-2025, the world will generate 500,000 of new millionaires (in USD), of which number, about 200,000 will be Chinese, and India will come second in terms of the growth rate (O'Neill, 2012). The importance of the Chinese economy for future consumption may also be supported by the fact

that one of the five priorities of the current five-year development strategy is the creation of internal consumption.

The rapid economic growth (by over a dozen percent) of a few African countries is only a prelude to the development of the whole continent. Research suggests that it may only happen over a longer period (Michailof, 2013), meaning that Africa will only start playing a bigger part in consumption processes after 2030. This may slightly reduce the high proportion of Asians in the middle class in favour of the Africans. The trend is also emphasised by Citibank specialists who have predicted (on the basis of self-developed Global Growth Generators – 3G) that in 2010-2050, Africa would be characterised by the highest GDP growth rate – about 7% per year (Buiter & Rahbar, 2011). Such a fast rate is to be driven by similar factors currently observed in East Asia, so it should be assumed that in the first stage, it will be mostly export-oriented production of labour-consuming and low-processed goods (raw materials, food), and as social wealth increases, it will generate internal demand (as it is observed today in emerging economies). Therefore, it is expected that only after 2030 will the African consumption be of global significance. Such a leap may only occur if African countries overcome the basic barriers to growth, i.e. inefficient infrastructure and institutional weaknesses. The latter factor leads to difficulties in access to financing, corruption, inefficient administration and excessive tax policies (Lubowski, 2013).

Changes in the scope of economic growth and consumption may even differ considerably from actual achievements. It results from different methodologies and tools of economic change estimation. Regardless of the specific results, analysts stress the permanence of the trend, i.e. developing countries' "catching up" on wealth. It has clearly been illustrated in Figure 1, indicating that the GDP of developing countries is not only higher than in highly-developed countries, but also exceeds the global average. The trend should be viewed as permanent. As poor countries become richer, the differences in growth rates will decrease, but the general trend should not change (OECD, 2012).

In consequence of this process, the demand for food will increase rapidly. The surge will be much higher than it could be expected from the population growth, as societies becoming richer will want to consume more. Thus it is estimated that the demand for food will grow by at least 70% (FAO, 2006, 2009b). These estimates are based not only on the above assumptions concerning economic changes, but also on dietary models. It means that the scenario considers not only the issue of increased population, but also the increased demand for calories, assuming that the average daily demand will reach 3130 calories per person. The scenario assumes that in 2050, 4% of the population will still be underfed (Bruinsma, 2009). However, one should bear in mind that these forecasts were based on the assumption of the population staying under 9 billion.

The population growth will be non-uniform, meaning that the growth in food supply will have to occur primarily in developing countries that are already suffering from the instability of supplies and limitations in access to food resulting from low farming quality and lack of funds. Moreover, the problem will be more

important in highly-populated countries that, due to their human potential, have a greater growth capacity on the one hand, and need to struggle with greater challenges related to food provision on the other.

In these regions, like in the 1990s, in post-socialist countries and nowadays in rapidly developing countries, the demand for meat and fast food will grow much faster than the demand for high-quality food products. It means that the production of food meeting these expectations will require a higher supply of water, land and power than in the case of cereal growing.

4. Food Supply Trends

The above-mentioned examples show that the demand for food is rising. In consequence, there appears a question about the possibility of meeting this demand. The discussion of this issue is determined by a number of factors. Environmental factors are a priority in this respect. First of all, they include access to land of proper quality (with limited erosion) and access to water. The latter factor is strongly linked to climate changes. Furthermore, one needs to pay attention to problems of biodiversity and the circulation of elements in the environment. Each of the said factors may cause the emergence of limits to growth. Their existence in agriculture was already identified by T. Malthus at the turn of the 18th and 19th century.

If the demand for food increases continuously, and the land-area expansion capacity and productivity are limited (the formed is actually even reduced due to the rapid growth of biofuel production), the belief in the inevitability of encountering the limits to growth, also in agriculture, is very much justified. It is evident, for instance, in the drop in global food reserve that fell from 107 to 74 days over the period 2002-2011 (Brown, 2012). In the case of large urban agglomerations, the reserve is even lower.

The forecasts on food productivity are inconsistent. On the one hand, they claim that the expected consumption growth will not only be satisfied, but that the amount of calories per person will increase from 2770 in 2005 to approx. 3100 in 2050 (Bruinsma, 2009; FAO, 2009a). On the other hand, there are many studies indicating barriers to reaching that goal (Nellemann et al., 2009; Jaegerskog and Joench Clausen, 2012; Conway, 2012). The 2008 crisis has proved that scenarios need not be far from reality. In particular, they concern the limited possibilities of obtaining new land for farming, limitations to technology-assisted growing and breeding, an most of all – problems with limited access to water ("Global food crisis looms as climate change and population growth strip fertile land", 2007).

The latter issue definitely needs most attention. Water circulation disruptions result from climate changes. Despite many sceptical opinions, it should be assumed that climate warming is taking place and will be progressing. Various methods of measurement produce different results regarding the scale and possible

consequences, and the uncertainty areas are diversely interpreted (Enserink et al, 2013), but the trend remains unchanged. The causes of the phenomenon, and especially the anthropogenic responsibility for its intensification, are of secondary significance.

Regardless of the efforts made, it should be assumed that in the studied period, the temperature rise cannot be stopped. It results from the progress being made in developing countries, accompanied by increased emission of greenhouse gases and a certain inertia of climate processes, which means that even if the concentration of greenhouse gases in the atmosphere is stabilised, the temperature will keep increasing anyway for some time. It is corroborated by the latest IPCC report (2013) that predicts that around 2050, the average temperature on Earth will have risen by 1-2.5 degrees Celsius, while later on, the changes may accelerate considerably. The recent UNEP report (2013) provides information that the gap between the actual emission of greenhouse gases and the political assumptions is increasing, which suggests that higher temperature growths are more probable than careful, minimum estimates.

Moreover, it should be noted that even the attainment of the pursued goals, i.e. halting climate changes at the level of two degrees Celsius higher around 2050 will have significant consequences for agriculture. Therefore, the agriculture sector should be the first to take action to adopt to the changes and possibly prevent further ones (Serrao-Neumann et al., 2013).

Higher CO2 concentration in the atmosphere triggers greater growth and acceleration of vegetative processes. However, it is not only connected with increased harvest, but mostly with earlier and more intensive growth of leaves and an extended blossoming period. Observations show that if the temperature rises by 1 degree, there is a 4 or 5 times more intensive growth of leaves and flowers. These processes result in greater demand for water (Wolkovich et al., 2012) and heightened insect activity. The latter process entails both positive effects, such as increased pollination, and negative ones, e.g. faster spread of diseases.

However, temperature rise also has other consequences. In the case of crops, it usually reduces productivity. The scale of such reduction is hard to calculate, as estimates in this area differ significantly depending on the species and research methodology. It is estimated that a 1-degree temperature rise results in an approx. 10-percent drop in rice harvesting – one of the basic global food products (IPCC, 2007a). All in all, it is assumed that the combination of these effects will not affect production effectiveness or will reduce it slightly (Randers, 2012).

What is more, climate changes usually induce an earlier occurrence of spring. Estimates show that on the northern hemisphere, the advancing ranges from 2.3 (Parmesan & Yohe, 2003) to 5.5 day per decade (Root et al., 2003), meaning that if this rate progresses this way, the vegetation period in 2050 will start at least half a month earlier. In consequence of this shift, there arises a time gap between the activity of predators and their prey. It reduces the biodiversity of ecosystems and deteriorates food production conditions (Thackeray et al., 2010). For example,

the plankton grows faster, forestalling the migration of animals feeding on it. In effect, there first appears an excess of plankton, followed by its later shortage in the fish feeding period, resulting in its reduced population and scarcity of fish as food for humans.

The above-described circumstances will significantly affect food production, but a much graver risk is connected with access to water. The problem is already acutely experienced in various regions of the Earth (Chartres and Varma 2010). In 2009, 2.8 billion people suffered from water shortages. By 2030, they may extend to even 3.9 billion (Lean, 2009). The issue was summarised very distinctly during the Global Water Forum held in October 2013, by UN Secretary General who said that the problem will concern half of the entire population (RT, 2013), which means that taking into account the climate warming trends, the situation will aggravate severely by 2050. Its scale was presented in IPCC reports (2007b, 2013). The temperature rise will make changes in local hydrologic cycles, resulting in insufficient or excessive precipitation, as well as melting of the icecap which is the main drinking water resource for vast regions of the world. This factor and the pollution of available supplies are making water an increasingly valuable good. This matter is one of the larger global challenges.

With reference to agriculture, not only the questions of access to water and soil humidity are of importance, but also the precipitation volume. In the former case, one can already notice a drop in water availability in areas of intensive farming. In the future, the problem will be more severe in Europe, where the effects of changes will be most visible. The problems will also affect the South of the USA and South America, mostly Brazil. In areas already suffering from water deficit, changes will not be as significant, but the situation will deteriorate in most cases. One exception from this rule may be the African Sahelu area. Observations have shown that contrary to typical trends, humidity in this dry area grows as the temperature rises, creating a tropical climate, favouring agriculture (Tierney & de Menocal, 2013). As far as precipitation is concerned, a similar situation is expected, i.e. the biggest changes will occur in the southern part of Europe, while in the northern and central parts of the continent, the amount of precipitation will increase. The phenomenon will intensify eastward, which means that the most severe changes will be recorded in Siberia. A considerable increase of precipitation is also expected in Canada (IPCC, 2013).

Other factors connected with climate changes and access to water are land erosion and salinity. If the temperature rises, and the soil humidity drops, the two above-mentioned processes occur much faster. It also increases the risk of fires resulting in agricultural losses.

Climate changes will raise the demand for irrigation systems that will be used in many regions of the world where they were hitherto not necessary. Moreover, there will be a shift in global agriculture centres. It is assumed that with an adequate economic policy, countries of the North, particularly Russia and Canada, will become the world's food reserve base. In the case of Canada, it may even make this country a superpower (Smith, 2010). The countries of Central and

Northern Europe may also play an important part, provided that they ensure proper systems of water retention and field irrigation.

Apart from a physical lack of water, there may occur technical and financial problems connected with its extraction, transport and distribution. Such deficit is referred to as economic water poverty (Parliamentary Office of Science and Technology, 2002), but its effects are as acute as a physical absence of resources. Challenges connected with access to water will be so significant they will have global consequences. Their scale is hard to predict. The mildest ones include the migration of entire nations. The most drastic solutions include armed conflicts (NIC, 2008; Wezer, 2010). It is commonly believed that limitations in water acquisition will be the farthest-reaching consequences of climate warming (Stern, 2006). However, most scenarios concerning agricultural development only consider its direct effects, i.e. decreased production capacity, while completely omitting the losses resulting from social aspects of this issue, e.g. the influence of wars on farming productivity.

Climatic changes make it hard to expect an expansion of the land area fit for agricultural use. On the one hand, there will occur the aforementioned soil desiccation and erosion in traditionally agricultural areas, and on the other, new terrains will become available for farming, where previous climate conditions prevented such activity. Also, as the climate becomes warmer, there will be a growing pressure to counteract the deforestation of further areas. An additional obstacle will arise after a part of the arable areas will be used for growing plants for the production of biofuels. This initiative lacks a rational basis, which resulted in reduced enthusiasm about this source of primary energy in the EU, but due to marketing reasons and financial benefits, in many regions of the world there still is a high interest in this form of acquisition of energy and heat. As a result, it is estimated that biofuels will most severely affect the expansion of agriculture in developing countries, particularly in Subsaharan Africa, Latin America and the Caribbean. It should be assumed that in 2050, the area of land used for food production will be slightly smaller than today. In most drastic cases, by mid-century, the drop in food supply resulting from biofuel production may reach 8% (Rosegrant et al., 2008).

As J. Randers (2012) correctly noted, the problem of biofuels should not constitute the basic dilemma in connection with food production, as the profitability of biofuel production depends on the price of petroleum. If its price goes down, biofuels will not be attractive, as their production will be unprofitable. On the other hand, if biofuel production becomes more popular, food process will go up, thus triggering interest in the cultivation of edible plants. This way, the market itself will regulate the demand for specific products. Of course, the system may be disrupted, e.g. due to relevant international regulations, countries will be interested in growing a certain amount of biofuel crops, and to achieve the desired indicators, they will offer subsidies to encourage the production. However, it still seems that it will not be of great significance.

In the analysis of food supply, one also needs to mention marine resources. Climate changes may severely affect fishing, as many migratory fish species will encounter difficulties resulting from ecosystem transformations. Moreover, it is already acknowledged today that wasteful sea exploitation has led to the overfishing of many fisheries, so deficits in fish availability need not be caused by climate changes. Therefore, the basic diet will be dominated by breeding species, while wild fish will become a synonym of luxury (Randers, 2012).

Water basins are still rich ecosystems that may easily feed humans. In this respect, one may point to the scarcely-used abundance of edible water plants and algae that, next to insects, might become the basic source of calories not only for Asians, but also for people on other continents, including the Westerners (Pauli, 2010). Such an innovative approach is still far from traditional agricultural thinking, but is an important safety exit enabling the survival of mankind, even in the face of a dramatic drop in the production of standard foods. It appears that in 2050, a common use of these resources will not be necessary or popular due to the present consumption habits of societies.

Considering the limited possibilities of acquiring new arable land and the uncertainty connected with climate changes, the only solutions increasing the supply of food may be of technological nature. Here, priority goes to genetics and genetically modified organisms that are able to quickly boost the efficiency of farming and accelerate the growth of animals. Genetic modifications may be introduced in two ways: in laboratories, employing the latest technologies, or by cross-breeding adequate species. In both cases, it is possible to achieve spectacular success, exemplified by the "golden rice" (fruit of pure genetics) and the Mexican wheat (grown naturally by Norman Borlaug). The use of these products has saved millions of lives. However, the latter path of technological modifications is more socially acceptable.

Technological modifications concern not only the development of new kinds of plants and animals, and the improvement of the existing ones, but also the implementation of more efficient growing, harvesting and breeding processes. In highly-developed countries, the majority of food is wasted in the final links of the sales chain, i.e. in stores and directly by customers. Developing countries are still struggling with the issue of efficient harvesting of crops and their industrial-scale storage, e.g. in proper cold rooms. Reducing the scale of this problem may produce much greater success than many technologies designed to increase the productivity of farming and breeding.

Some authors estimate that technological modifications offer a fundamental solution to the food problem, as they would enable the recovery of losses caused by climate changes and ensure food for an additional billions people. This particularly concerns Europe (Ewert et al., 2005). One might recall that in consequence of technological progress, the harvest index of many cereal species has improved considerably, but observations show that the amount of available grains per capita is constantly shrinking. This makes an impression that technology

is not able to ensure a food supply growth rate proportional to population growth (Pimentel & Pimentel, 2008). In practice, such impression is deceptive, as the number of calories per person rises simultaneously with population growth. It results from the changes in consumption models, i.e. an increased consumption of non-wheat foods, mostly meat and fish.

A problem connected with technology is the consumption of energy. It is necessary for agriculture, but its use is also an important contribution in the development of crop-increasing fertilisers, as well as pest-control preparations. It is expected that the crucial technological changes in agriculture will be brought about by solutions that enable simultaneous reduction of energy consumption and increase of productivity. Operations aimed at reducing the demand for certain resources, such as nitrogen, are of similar importance. It is assumed that significant achievements in this area may occur in 20-30 years. However, there are currently no grounds to believe that technologies will help reduce water consumption by 2050. Therefore, the questions of water availability should be regarded as the fundamental challenge of agriculture in this time perspective.

5. Social Aspects of Civilisation Changes and Food Problems

Basic discussions on the possibilities of feeding mankind are usually limited to problems with technical barriers to achieving sufficient production capacity.

Analyses focus on such issues as demand for food, productivity (both in absolute and calorific values), production technologies, etc. Such approach, as said before, seems to fit perfectly within the problem of limits to growth. However, it is worth to mention that the key element of the food issue is the market. In the last 30 years, there have occurred both population growth and a 17% increase of the number of calories per person. Moreover, the value of this rise is much higher than the needs of all human kind (Harkness, 2011). The number of people struggling for access to food is constantly dropping. According to FAO estimates, in 2011-2013, the shortage of calories was suffered by 842 million people, which is a reduction in comparison to previous studies from the 2010-2012 period, when the number was determined at 868 million. The trend has been visible for a long time, as when compared to the early 1990s, the amount of underfed people has fallen by 17% The rate of this trend is fast enough to attain the Millennium Development Goals (MDG) in food availability in the 2000-2015 period (thus halving the share of people suffering from hunger in the population – from 23.2% to 11.6%). Considering a simultaneous population growth, it means that the number of starving people will be reduced by 150 million, corresponding to 15% of the total population (United Nations, 2013a). It is definitely not enough to reach the goals of the World Food Summit of 1996, namely, to reduce the problem by half (FAO, 2013).

Continuation of this trend gives hope for further reduction of malnutrition, but no simple evaluation of the trend is possible. It stems from the population

growth trends and climate change forecasts. Both factors overlap, meaning that the number of people will grow mainly in areas currently regarded as poor, and frequently having rather unoptimistic developmental prospects. Although the latter situation has significantly improved in comparison to the previous decades. In addition, these countries are already struggling with numerous problems connected with food availability. They mostly arise from difficult climate conditions and obsolete agricultural technologies. In view of the predicted intensification of climate change processes, it should be expected that in most cases, the possibilities of food acquisition in these areas will deteriorate, resulting in rising food prices and increasing economic exclusion. Poor farmers experiencing difficulties with access to small capital will not (and often they already cannot) afford crisis insurance which are necessary for recreating farm production capacities, and neither will they obtain funds for implementing technological modifications requiring the purchase of expensive equipment. It should be emphasised that not all processes of adjusting to climate changes require high expenditure. Some of them, as the use of aftercrops, only rely on knowledge, but financial limitations often constitute a fundamental barrier to the development of education in rural areas.

The above-presented climate change processes suggest that countries classified as highly-developed will also be threatened by the negative effects of temperature rise. It will be particularly noticeable in the Mediterranean region. However, their wealth and globalisation will enable them to implement expensive adjustment processes and possible import of food. What is more, many highly-developed countries may become the main global food exporters. It will further obstruct access to food in developing countries because of higher food prices. Therefore, it is estimated that in mid-century, the share of underfed people may be similar to the current one, ranging from 10% to 20%. In absolute values, it should be interpreted as doubling or tripling the number of people facing this problem.

The data provided above show that from the technical point of view, feeding the entire human population in 2050 will be possible. A real problem is encountered when it comes to food distribution (Paillard et al., 2011). In highly--developed countries, food is relatively cheap, encouraging people to consume much more of it. In consequence, the problem of obesity dramatically increases. According to FAO reports, the global costs of health threats resulting from excess of consumed food are as serious as the ones caused by malnutrition, reaching about 1.4 trillion USD in both cases (corresponding to around 2% of the global GDP). It is estimated that the problem of malnutrition concerns about 868 million people (12.5% of the population). On the other hand, over 1.4 billion people are suffering from excessive weight, including 500 million from obesity, or pathological overweight (FAO, 2013). Paradoxically, the problem of obesity is also connected with regions of malnutrition. It frequently happens that children of parents struggling with problems with access to food are overfed after the problems end, in

order to ensure their safe growth. It is estimated that the situation concerns about 7% of children under the age of five. A quarter of them live in Subsaharan Africa (United Nations, 2013a). Forecasts about the increased daily ration of calories per person suggest that in the future, one should expect an aggravation of problems with obesity, considerably affecting the quality of life. Already nowadays attention is brought to the fact that in many countries, e.g. in the USA and the European countries, the current generation of children may live shorter than their parents, due to improper diet.

Another important challenge concerning food is its wasting. The problem may occur both in the process of production, and consumption. The latter issue is particularly alarming. FAO estimates show that food wasting is connected with wealth. The more developed a country is, the higher the inefficiency. In the case of highly-developed countries (Europe and North America), annual losses amount to 280-300 kg per person, of which 95-115 kg is wasted by the consumer (about 40% of consumption). This gives a total of 222 million tons, which is comparable to the entire production of Subsaharan Africa. In poor regions, like the said Subsaharan Africa and Southeast Asia, a consumer wastes only 9-11 kg of food in a year. The wasting problem is caused not just by incorrect household management, but also by a low quality of food. Because of this, the agreeable periods of food storage, especially in somewhat substandard conditions, have shortened dramatically.

Social problems related to food production also include living standards. Obviously, they are much better in cities than in rural areas. Even decades of EU policy have not managed to change this tendency (though they have improved it considerably). This situation has led to the migration of people from villages to urban areas. The trend mostly concerns dynamic and innovative individuals who are not afraid of challenges and are ready to face difficulties and uncertainty. Consequently, people who stay in the country are those representing more conservative behaviour. This hampers the introduction of new technologies and changes resulting from the necessity to adapt to new circumstances, as in many communities it is hard to find leaders willing to take up the challenge. It is not just a matter of controversial solutions entailing the risk of failure, but even changes that are recognised in the world but unknown in a given region. As a result, the introduction of modern solutions regarding resource use efficiency and improvement of productivity encounters a barrier of conservative attitude. Due to a slow rate of social changes and the outflow of the most active individuals from rural areas, the trend may aggravate further. One has to bear in mind that the tempo of global changes is increasing. It also concerns technological changes in agriculture, including the employment of the latest technologies for optimum proportioning of water and fertilisers.

A question that becomes vital is how to keep young and active people in the country in order to optimise the use of land for food production? Already today, the problem of aging farmers has become a global issue. Young people treat living in the country as a last resort, only when all other possibilities of development fail.

Furthermore, one needs to think of a way to convince the young to make decisions based on long-term analysis, i.e. to take action aimed at avoiding the limits to growth similar to climate problems. It seems necessary not only from the point of view of individuals, but also entire generations and their families (Barbieri Masini, 2013). Will young people be interested in staying in the country and working in agriculture if they do not have easy access to basic tools used by their peers living in cities, such as the Internet and social media? How to persuade active young people that hard work in farming may be just as attractive as a few times better-paid jobs in production, not requiring such responsibility and attachment to the farm? It seems possible, as it is not always the money that wins, but it is important to believe that work in agriculture can be modern and based on cutting-edge technologies. It does not guarantee that the process of farmers aging as a social group is stopped, but it does give hope that it can be slowed down.

Against this background, there emerges another future dilemma, namely, the shape of agriculture. In most cases, modern technologies increase the economies of scale and introduce an intensive monocultural model of agriculture. It is more profitable due to the distribution of costs and difficulties with estimating external effects in farming. However, this global trend leads to the destruction of traditional, family-ran farms that had been the foundations of many societies, providing the basis for the upkeep of entire multigenerational families. The concentration of land and increasing competitiveness further impoverish the smallest farms, depriving them of access to the market.

These considerations lead to the conclusion that the fundamental factors determining the global alimentary situation are economic, social and political issues. The anticipated climate changes will make food production in densely-populated areas insufficient, imposing a global trade of food products. It should be expected that the progressing regional integration processes will eventually abolish customs barriers in the world economy. The only exception from this rule will be the emergence of permanent, global shortages in food supply, but in view of the presented analyses, such probability is minor.

6. Conclusion

It is hard to predict the future in the perspective of forty years. Taking into account the multiplicity of aspects that should be discussed, one is unable to develop precise quantitative analyses. They may only be used as a tool illustrating the most probable trends. This way, the holistic assessment of the food problem in the mid-21st century should be based primarily on qualitative evaluations indicating possible threats and possibilities of their neutralisation.

Estimates show that the demand for food will rise, resulting from the expected population growth, malnutrition combating and the increasing demand for calories in human diet. In consideration of these factors and the rapid economic

growth in developing countries, it should be assumed that the demand for food will surge by at least 70%, probably it will double.

Numerous analyses suggest that from the point of view of technology, ensuring such a huge amount of food is only determined by natural conditions, i.e. access to water. This factor will be of key importance to further development of agriculture. Forecasts concerning climate changes support the belief that the process of climate warming is an inevitable process, and only the scale and consequences of this phenomenon may be imprecisely estimated. This entails global consequences regarding food production, i.e. the shifting of the main production areas towards the poles. It mostly concerns the northern hemisphere, where climate warming will open new possibilities for farming in Canada, Russia and the Scandinavian countries.

Therefore, it seems that the key to safeguarding global food security lies in socio-political relations. The increased demand for food will mostly appear in the "Poor South". With the simultaneous rise of supply in the north, it forms new poles of international trade. The situation makes the globalisation of farm product trade and further elimination of barriers the basic prerequisites for ensuring global alimentary balance. Assuming that the low purchasing power of the South will improve gradually over the next 40 years, the freedom of trade will provide a sufficient solution in many densely-populated areas (e.g. China, India, Indonesia, Nigeria). In the case of countries without strong development prospects, one should consider empathy-based initiatives, such as "work for food" programmes, making food a form of support for the poorest societies. However, as there is no real possibility of establishing a global institution holding adequate executive power in this respect, one should view such initiatives as utopias. Thus, it should be assumed that by 2050, the percentage of the population suffering from malnutrition may again rise to about 20%, corresponding to 1.5 to 2.5 billion people, depending on the total world population. Reaching such a high number will mark a failure of mankind's idea of humanitarianism.

One way of combating such trends is a holistic approach to the food issue, i.e. not just the analysis of food supply questions, but also of the circumstances of the operation of entire rural-area ecosystems, where the quality of human life will be as much important as the problems of environmental protection and food supply. The first notable expression of such a sustainable approach to the subject was the Global Landscapes Forum, a conference accompanying COP19 in Warsaw, when persons responsible for agriculture and forestry started a joint debate.

In addition, it should be emphasised that the occurrence of environmental limits to growth by 2050 is quite probable. However, contrary to the visions frequently presented in the literature, it will not cause an abrupt, immediate disaster, but only impede economic growth (with its rate determined by the type of limit). Assuming that globalisation processes and open trade are continued, they will further increase the gap between the rich and the poor, as the market will raise the prices of rare commodities only affordable by the wealthy. Consequently, in highly-developed countries, the crisis symptoms will be visible much later than

in developing ones. Ensuring access to food is a primary necessity. Therefore, if limits are encountered (such as rising prices of fuel), the increasing costs of food will reduce the purchasing of other consumer goods and transform the structure of food purchasing, i.e. high-quality products will be replaced by less expensive substitutes of lower quality.

However, in view of the anticipated growth of wealth in developing countries, it is more probable that the demand for quality products, typically bought by the middle class, will actually go up. The trend is derived from the proportion of food costs in the budget of individuals. People often buy larger amounts of food that – for various reasons – become unfit for consumption and are being thrown away.

Taking into consideration the above arguments, one should take note that the global rationality in the field of food acquisition should be more based on the issues of distribution and the employment of adequate policies, than on the production capacity itself. By implementing relevant programmes connected with distribution and limiting food wasting, it is possible to achieve much higher efficiency of using the existing resources (and thus feeding a larger number of people) without the need to transform food production. Technological improvements promoting the increase of productivity should be treated as supplementary to the primary approach.

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