



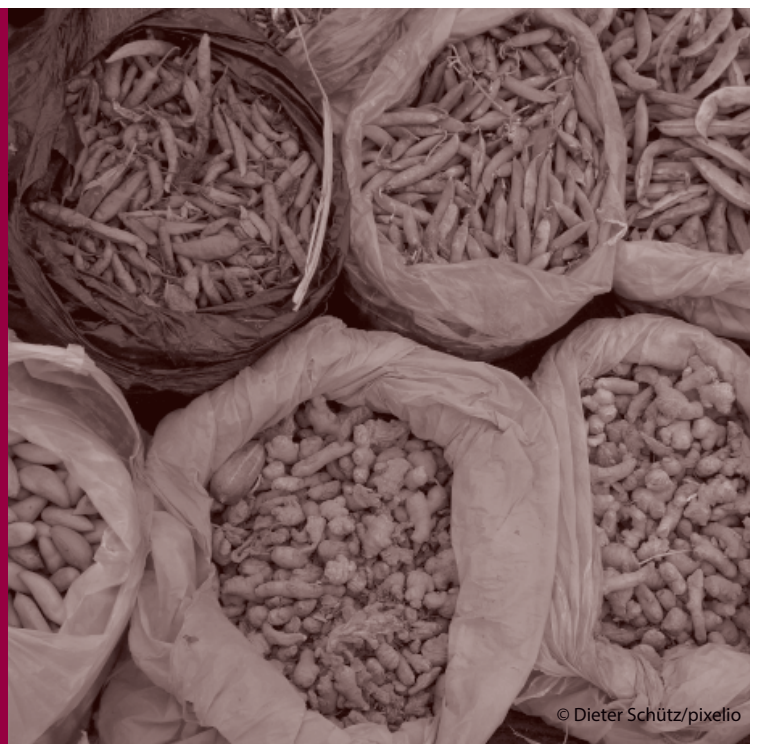
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# Possible Contributions of Research to Solve the World Food Problem — Approaches, Strategies, Implementation

Summary

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## SUMMARY

For decades now, undernourishment and malnutrition have been among the most serious problems the global community has to face. In 2009, more than one billion people worldwide suffered from hunger – more than ever before since 1970, the beginning of the United Nations' world nutrition statistics. Furthermore, several billions of people have to be added who suffer from the so-called »hidden hunger«, i. e. an inadequate supply of vital micronutrients such as vitamins or minerals.

Given the urgency of this problem, in October 2008, the Committee on Education, Research and Technology Assessment of the German Bundestag commissioned the TAB to carry out the TA project entitled »How can research contribute to solving the problem of world food?«. The assignment of tasks of the project can be defined by the following questions: What are the most important gaps of knowledge concerning the world food problem? Which research areas might offer relevant contributions to solving the problem so that a more intensive support would be justified? Where is it necessary to overcome specific restrictions or to develop new forms of interdisciplinary and transdisciplinary research?

The final report gives an overview of dimensions and influencing factors of the world food problem, an overview of selected topics for research in Germany as well as an evaluation of a public expert workshop which has been carried out by TAB within the framework of the project. In a general overview, possible priorities for future research as well as options for action aiming at a development-oriented research policy are discussed.

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## THE WORLD FOOD PROBLEM: PERSPECTIVES AND INFLUENCING FACTORS

### *Facets of the world food problem*

From 1970 until the mid-1990s, the number of people who suffered from chronic undernourishment continually decreased and their percentage of the world's total population had been reduced from 33 to 16% between 1970 and 2006. However, since 1997, the number of people suffering from undernourishment continually increases and in 2008 – for the first time since 1970 – the percentage of undernourished people in the world's total population increased as well.



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Against this background, it is obvious why the world food problem again has become a main focus of the public and political interest in recent years – which is indicated by numerous international conferences, scientific studies as well as by activities carried out by NGOs. The resurged interest in this topic as well as the relatively favourable statistics for the 1970s and 1980s must not hide the fact that the nutrition situation for large parts of the world's population is disastrous – not only recently, but for at least 40 years now. Even in 1997, at the time of the lowest number of people suffering from hunger since 1970, far more than 800 millions of people suffered from undernourishment.

Besides the problem of chronic undernourishment, i.e. the prolonged insufficient energy intake via food, the topic of malnutrition also represents a global problem of dramatic dimensions. On a global scale, the most common deficiencies are iodine deficiency with an estimated number of 2 billion people worldwide, deficiencies of zinc (1.2 to 2 billion), iron (0.8 to 1.2 billion), selenium (0.5 to 1 billion), vitamin A (200 million) as well as deficiencies of calcium and folic acid, whereas many people are suffering from multiple micronutrient deficiencies.

Undernourishment and malnutrition represent a severe violation of fundamental human needs and are associated with serious consequences. Among other things, they involve an impairment of the physical and mental development, a weakening of the immune system and increased mortality rates. Altogether, underweight is the most serious health risk worldwide: 10% of the global burden of disease are related to it. Deficiencies of iron, zinc, vitamin A and iodine contribute another 6% to the global burden of disease. Moreover, the negative consequences for the economic potential of the countries affected by hunger and malnutrition are considerable.

Besides undernourishment and malnutrition, also »overnourishment« and – as a result – overweight and obesity (adiposity) are among the facets of the world food problem. Worldwide, more than 1 billion people are overweight. Among them, 300 million suffer from obesity. In recent years, both overweight and obesity as well as the diseases caused by them have increased significantly. In 2003, the number of people who died of diabetes mellitus was equivalent to that of the people who died of AIDS. According to an estimate by the WHO, approximately 115 million people worldwide suffer from diseases due to obesity. The estimate says that until 2030, this group of diseases will be the number one cause of death worldwide.

The trend of an increase of overweight and obesity has its origin in the industrialized countries, but in recent years has spread to the developing and newly industrialized countries. Currently, approximately half of the population of OECD countries is overweight and one in six OECD citizens is obese. Even several developing and newly industrialized countries have a high percentage of overweight people in their population. What is remarkable is the fact that today many developing countries are not only faced with the problem of undernourishment and malnutrition, but *at the same time* also have to face the problems of overnourishment and overweight as well as resulting health problems (double burden of hunger and obesity). The increase of overweight in developing and newly industrialized countries needs to be understood in the context of a profound »global change of dietary habits« (nutrition transition), i. e. an adaptation to the dietary habits of the industrialized countries.

While the current world food situation already has to be characterized as dramatic, there are development trends giving reason to suspect a further aggravation of the situation for the decades to come. The most-discussed trends are the growth of the world population, which according to model calculations of the United Nations is likely to increase to more than 9 billion people by the year 2050, a progressive change of dietary habits in developing and newly industrialized countries towards a diet with high contents of (mainly animal) protein, sugar and fat, the effects of the climate change on agricultural productivity, which according to current knowledge will be overall negative, as well as the increasing use of agricultural land to cultivate renewable resources.

*Three perspectives: the global food situation as a problem of quantity, access or nutrition*

The discussions regarding the world food problem are characterized by two different perspectives. From the *quantity perspective*, the main focus of interest is on the total quantity produced and demanded. It is often adopted when the issue of the world population's future food demand – e.g. that of the year 2050 – is broached. The total quantity of food required is concluded from the number of people as well as from their average nutritional energy requirements.

In contrast, the *access perspective* focuses on how food is distributed among the world population or, in other terms, whether and to which extent people have access to the food produced. Here, it is emphasized that the decisive factor for evaluating the world food situation is not the calculated, but the actual availability of food for all people, because though there has been a food production surplus compared to the demand for decades now, millions of people do not



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have any access to food. Thus, the availability of a certain quantity of food is a *necessary, but not sufficient condition* to achieve that there is no undernourishment anymore.

Accordingly, it is considered unanimously that the world food problem primarily still is a problem of access and not a problem of quantity. However, this situation might change in view of the decades to come: Under the premises of a further growing world population, a progressive change of dietary habits towards the resource-intensive dietary habits of the industrialized countries as well as of an increasing pressure on agricultural production bases (degradation of fertile soils, crop failures due to the climate change, cultivation of renewable resources), in the future the world food problem might turn out to be both a problem of distribution and of quantity.

As a matter of principle, two types of access to food can be distinguished: *access to food by self-sufficiency* (subsistence) as well as *access to food by purchase*. Many small-scale farmers in developing countries are not able to manage their food supply on their own, because they have too little or only very poor areas of land and/or insufficient (i.a. financial) access to seeds, fertilizers and other means of production. They depend on purchasing food – just as people without own areas of land, particularly the majority of the urban population. In 2008, for the first time in the history of mankind, more people were living in towns and cities than in rural areas. For the future, it is assumed that almost the entire growth of the world population will take place in urban areas. For this reason, an adequate income is of vital importance for those suffering from or threatened by undernourishment and malnutrition.

If measures intended to increase the agricultural production shall result in an improved food situation, they have to be combined with an improved access to food for undernourished people. However, this combination is not necessarily given. On the one hand, the measures mentioned can involve not only an increase of food production, but also an increased production of other agricultural products – depending on which crops offer the greatest economic benefit to the farmers. Against the background of a growing demand for resource-intensive food and renewable resources, a further increase of the agricultural production runs the risk that it will benefit the types of use mentioned above and not preferentially the fight against undernourishment. On the other hand, increases of the global food production will only involve an alleviation of hunger, if they essentially improve the availability of food for the poor population e.g. due to lower prices or higher incomes. After all, measures aiming at increased quantities also can impede the access to food for undernourished people, for instance if they deprive

the poor population groups of their possibilities of pursuing subsistence agriculture or gainful employment (e.g. due to rationalization of cultivation methods).

If we have an eye on the world food problem with all its facets, it is obvious that the quantity and access perspectives alone cannot cover it completely, as the *quality* of food is not sufficiently taken into consideration. However, quality has a decisive influence on both the problems of malnutrition and overnourishment. Though, as an answer to the question of what are the causes for malnutrition and overnourishment, it would seem to be too short-sighted to refer to food quality. In this context, not only the ingredients of the food used, but also their combination and preparation for meals play an important role. In particular, the question arises for what reasons people follow certain diets involving micro-nutrient deficiencies or overweight and obesity though they have an adequate access to food. Thus, the deficiencies of the quantity and access perspectives suggest to take a look at the (individual) nutritional behaviour as well as to its (supra-individual) determinants (*nutrition perspective*).

From this point of view, the world food problem is neither primarily a problem of quantity nor a problem of mere access, because »access« only refers to the fact that the respective food is available, but not to the question of what type of food actually is consumed and which factors determine the individual nutritional behaviour. For this reason, the world food problem essentially is considered to be a problem of nutritional behaviour which is characterized by insufficient access to healthy food, but also by insufficient knowledge of a healthy diet and appropriate preparation of the available food.

#### *Influencing factors of the world food situation*

In the following, influencing factors will be described which essentially determine the world food situation and which, at the same time, represent potential approaches regarding measures to alleviate the world food problem and thus also represent approaches for research. Systematization is based on the perspectives mentioned above regarding the world food problem. First, influencing factors of the quantity perspective are described which can be classified as factors on the production side (agricultural land, soil fertility, input factors, weather phenomena, farming systems) and as factors on the demand side (demographic development, dietary habits, post-harvest losses). Then, poverty as well as land ownership and land rights are described as influencing factors of the access perspective.



*Agricultural land: land-use competition due to settlements and renewable resources.* The worldwide limited agricultural land areas (1.4 billion ha of arable land and 3.4 billion ha of pasture land) are subject to processes having negative consequences for food production. Thus, agricultural land is converted into areas used for settlement and transportation (currently approx. 500 million ha) to a large extent and virtually irreversibly. This is particularly important, because settlements often are located in fertile river valleys and coastal plains and their expansion thus has disproportionate negative consequences for agricultural use. Furthermore, fertile soils are used to cultivate renewable resources (currently, approx. 20 to 30 million ha or 1 to 2% of the arable land worldwide are used for energy crops). Because many countries have ambitious development goals concerning the use of energy crops, the involved land area occupied might be of a considerably larger extent in the future (2 to 12% of the arable land worldwide by 2050 according to an estimate of the »Millennium Ecosystem Assessment«).

*Soil fertility:* erosion and other degradation processes. Also in the course of food production itself, soils might be subject to processes which restrict their further usability or even make it impossible to use them any further (particularly erosion, salinization, acidification, compaction, contamination with toxic substances as well as loss of soil organic matter). On the global scale, the degradation of fertile soils has taken on a disastrous dimension. According to estimates, 38% of the arable land as well as 21% of the permanent grassland worldwide are affected by soil degradation. Approximately 10 million ha of land area per year are likely to be lost for agricultural use only due to erosion as the major degradation process.

*Input factors:* plant breeding and scarcity of resources. The differences of the yield per unit area, which are considerable in a worldwide comparison, are mainly due to differences regarding the use of agricultural input factors (irrigation, fertilizers, plant protection products etc.). As those do not determine the growth of the plant independently of each other, but only as a whole, it is quite difficult to determine the contribution of individual input factors with regard to the yield. According to a survey, it was said that the percentage of the increase of the yield per unit area with regard to plant breeding had been 21% in the early phase of the so-called »green revolution« and 50% in a later phase. Overall, the annual productivity increase amounts to approx. 4% for the period from the 1960s to the 1980s, but to only 0.5 to 1% in recent years. Based on the existing data, it is impossible to answer the question whether or to which extent this decrease has to be attributed to reduced activities in the field of research on plant breeding or mainly to the fact that a further increased use of input factors is not economical or just is not effective anymore.



Water also is one of the central input factors in agriculture. Nearly 20% of the arable land worldwide (270 million ha) are irrigated. From this percentage, 200 million ha are in developing countries for which a further increase of this area by 40 million ha is assumed by the year 2030. Approximately 70% of the freshwater consumption worldwide account for agriculture. In many places, the use of water for agricultural purposes is not sustainable, for instance if the groundwater withdrawal rate exceeds the recharge rate. Moreover, the nutrient supply of the soil is one of the major influencing factors with regard to the yield per unit area. As the agricultural practice involves a net loss of nutrients from the land areas used (particularly in case of an organizational and spatial separation of plant and animal production), nutrients have to be added by means of organic or mineral fertilizers. It is assumed that the costs for mineral fertilizers (which already now are very expensive for farmers in developing countries) will increase in future, because increasing energy costs will also influence the energy-intensive production of fertilizers and because phosphorus as major mineral for plant nutrition is available in limited quantities only from mineable deposits, which according to estimates might be exhausted in 50 to 100 years already.

*Weather phenomena:* impacts of the climate change on agriculture. There are five different impacts of the climate change which are relevant for the agricultural sector: The elevated concentration of carbon dioxide (CO<sub>2</sub>) in the atmosphere might involve a fertilization effect which depends on the plant species and on local conditions and which currently can be estimated only roughly to approx. 5%. Presumably, increased average temperatures will have regionally very different impacts (rather positive in northern latitudes due to an expansion of cultivable acreage and a prolongation of the vegetation period; rather negative in the tropics, because the optimum temperature for some cultivated plants is exceeded which results in crop failures). The availability of water as well will be subject to region-specific changes which might involve an increasing water deficit particularly in semiarid and arid areas. An increase of extreme weather conditions such as heat waves and heavy precipitation might result in considerable crop losses. After all, an increased soil degradation can be assumed. Overall, the climate change is likely to have slightly positive consequences for agricultural production in industrialized countries. In Africa and Asia, however, it is likely to entail a rather dramatic reduction of yields. At the global aggregate level, it is assumed that the production losses of 5 to 15% in developing countries can be compensated for by production increases mainly in North America and Russia.

*Farming systems:* high-external-input vs. low-external-input agriculture approaches. Farming systems are relevant as influencing factors for the world food situation particularly with regard to the productivity per unit area and



to resource conservation. In industrialized countries, the area-specific yields of organic farming generally are considerably lower than those of conventional farming. In developing countries, however, it is possible to produce higher yields (on average approx. 80%) by means of organic farming than by means of conventional farming. Among other things, this can be attributed to the fact that the means of production used for conventional agriculture cannot be used by farmers in developing countries for reasons of cost, that the effectiveness of mineral fertilizers on soils with a low nutrient retention capacity is very low and that high-yield crop varieties are not appropriate for being cultivated in suboptimal areas. With regard to resource conservation, organic farming is advantageous insofar as it is based on the principle of closed nutrient cycles and thus requires only a relatively low nutrient supply from external sources. Moreover, it is advantageous with regard to the conservation of scarce energy resources, of soil and of biodiversity.

*Demographic development:* The demographic development is a major influencing factor for the future world food situation. Currently, the world population is growing by 78 million people a year. According to calculations of the United Nations, the number of people is likely to be more than 9 billion people by the year 2050. According to estimates, this increase will vary greatly from one region to another. Almost the entire population growth is supposed to take place in developing countries, mainly in the least developed countries. The population of many countries in Africa, in the Middle East and in parts of Asia will increase by more than 50%. According to the assumptions, the population of many African countries will more than double.

*Dietary habits:* an element of global change. Dietary habits determine the type and quantity of the demanded food to a very large extent. The dietary habits of the industrialized countries, which are characterized by a generally high calorie intake, a high percentage of food of animal origin, a high energy density and a high degree of processing, involves a high per capita demand of agricultural land. Currently, approximately one third of the total arable land worldwide (470 million ha) are used for the production of animal feed. Another 3.5 billion ha are used as pasture land. If the animal feed consists of cereals or similar products which are also suited for human food or which are produced on land which can also be used for the production of human food, the production of animal-derived food products has a direct negative impact on the total human food quantity that can be produced.

For some time now, a change of dietary habits in developing and newly industrialized countries can be observed (nutrition transition) which essentially consists

in an adaptation to the dietary habits of the industrialized countries. Its causes must be seen in the context of globalization processes which also influence food industry (increasing foreign direct investments in the food industry of developing and newly industrialized countries which are mainly used for processed food products as well as activities of transnational food companies, both resulting in a change of the food supply). In the developing countries, the average annual per capita consumption of meat doubled from 14 to 28 kg between 1980 and 2002. For the future, a strong increase of the worldwide consumption of animal-derived food products is expected (regarding the meat consumption from 229 million tonnes between 1999 and 2001 to 465 million tonnes by the year 2050).

*Post-harvest losses:* spoilage and wastage. The category of post-harvest losses comprises all losses of food occurring from the moment it is harvested until the moment it is consumed by the end consumer. According to estimates, post-harvest losses account for approximately one third of the total quantity harvested. In the developing countries, this is mainly due to inadequate harvesting methods, incorrect handling of the harvested crops, inadequate transport, incorrect storage as well as to an insufficient infrastructure. In industrialized countries, the losses are mainly a consequence of incorrect logistics as well as of wastage in households and in case of consumption outside home.

*Poverty:* the major risk factor for undernourishment and malnutrition. Poverty is considered to be one of the essential influencing factors regarding undernourishment and malnutrition with their manifold consequences. Poverty is contrary to the acquisition of adequate quantities of food and affects the population of cities which is likely to increase due to urbanization processes in the decades to come, but also affects poor people without land in rural areas as well as small farmers with insufficient resources. For the latter, poverty often inhibits a virtually possible improvement of production, because they cannot purchase any means of production. Moreover, poverty comes along with little chance of education, inadequate access to the health care system and many other factors which impede gainful employment and subsistence agriculture («vicious circle of poverty and hunger»). In developing countries, the number of people living in absolute poverty decreased from 1.8 billion (46% of the population) in 1990 to 1.4 billion (27%) in 2005. In some regions of the world, however, the poverty rate is considerably higher, particularly in Sub-Saharan Africa where more than half of the population were living in absolute poverty in 2005.

*Land ownership and land rights.* The unequal distribution of land property as well as insecure land tenure are considered to be important causes for rural poverty, hunger and malnutrition in developing and newly industrialized countries.



Worldwide, people who have no access to land are most affected by undernourishment and malnutrition. Almost 100 million families of small farmers in developing countries comprising approximately 500 million people do not have any land ownership or any rights similar to land ownership. Land ownership or secure long-term tenancy contracts are major approaches in order to provide small farmers with a ladder out of poverty and undernourishment. However, investments in new methods, in seeds and other means of production can only be expected, if the tenure status for the small farmers has been clarified.

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### POSSIBLE PRIORITIES FOR FUTURE RESEARCH

Corresponding to the diversity of influencing factors determining the world food situation, there are numerous potential approaches for research in order to find a solution to the world food problem. If the world food problem is considered to be a problem of quantity, on the one hand there are approaches primarily aiming at an increase or maintenance of the producible food quantity and on the other hand there are approaches concerning the total food quantity demanded. If, however, the access perspective is taken as a basis, research approaches aiming at improved incomes or at an improved situation for landless farmers come to the fore. If the world food problem is mainly considered to be a problem of individual dietary habits, we have to focus on approaches which can influence these dietary habits or their determinants in a positive way.

Due to the large extent of potential influencing factors, it has not been possible to deal with all factors in detail within the framework of the project. For this reason, the objective of providing short expert analyses within the framework of a non-thematic call for proposals was to develop a selection of relevant fields of research without devaluating other topics which have not been dealt with. In the report, the following fields of research will be presented separately: »Plant breeding for marginal areas«, »Use of underutilized plant species«, »Contribution of organic farming to global food supply«, »Adaptation of agriculture to climate change«, »Change of global dietary habits«, »Post-harvest technology« as well as »Strategies to eliminate micronutrient deficiencies« (chapter III).

The evaluation of the short expert analyses as well as that of further relevant literature resulted in three main issues of the project's topic which first of all became topics of a public expert workshop: »In the focus of research: production or consumption?«, »Controversial strategies to increase production« and »Research organization: lessons learned from the transfer problem for funding insti-

tutions and research policy?«. Based on the results of the workshop (chapter IV), conclusions have been drawn regarding possible priorities for future research.

*Consideration of production and consumption approaches for research*

Although the world food problem currently is not due to the global food quantity being too low, there will also be challenges in this regard which research will have to deal with in the future. These challenges result from two development trends: worsening conditions of production (loss of fertile agricultural land, competing uses, negative impacts of the climate change) and an increasing demand for food worldwide (population growth, change of dietary habits) compared to the status quo. In this context and in view of the decades to come, it is important to ensure that an adequate quantity of healthy food will be available for the world's entire population. As mostly a further expansion of agricultural land is not taken into consideration i.a. for reasons of protecting the natural bases for life, two fundamental approaches remain: to secure or even increase food production on the existing agricultural land and to change the structure of the demand for food.

*Consideration of different approaches:* Very often, the opinion is put forward that the productivity per unit area has to be increased in order to satisfy an increasing demand for food as a result of population growth and nutrition transition. In contrast, it is pointed out that changes of consumption patterns towards resource-conserving food would do (at least partly) without an increase of the productivity per unit area and that a reduction of post-harvest losses could compensate (at least partly) a further increasing demand for food in the future. In many cases, such suggestions are characterized by the fact that individual influencing factors are considered to be invariable, whereas others are considered to be variable and politically manageable. However, to find an effective research strategy for solving the world food problem, it seems to be expedient to make a reasonable and comprehensible selection of research topics based on the variety of potential approaches. Therefore it has to be considered – among other things – to what extent the individual influencing factors determine the world food situation and how promising their political manageability seems to be, but also with what kind of insecurities the success of the associated strategies is afflicted with and which approaches could involve an alleviation of the urgent world food problem already on relatively short notice. In the following, first steps of such a process of consideration and – based on the results – possible priorities for research topics are outlined.



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*Comparison of influencing factors* with regard to production and consumption: Based on the assumption that it is difficult to reduce the area currently used for settlement and transportation, to minimize the current extent of soil degradation, and to control the future development of the world population, the following issues for alleviating the world food problem have to be addressed:

- > If the current development trends will continue in the decades to come, the area used for settlement and transportation will involve an annual loss of fertile soil of 2.8 million ha (0.2% of the current arable land worldwide) which will total 110 million ha (almost 8%) by 2050.
- > According to scenario calculations, the arable land required to cultivate energy crops could increase by 0.4 to 5 million ha a year (corresponding to 0.03 to 0.4% of today's arable land worldwide) and thus would total up to 14% of the global arable land by 2050.
- > Processes of soil degradation also have considerable negative consequences for food production. Due to soil erosion alone (as the major degradation process), approximately 10 million ha a year are likely to be lost for agricultural use (0.7% of the current arable land worldwide).
- > Improved input factors (plant breeding) as well as generally improved farming systems can result in a further increase of the productivity per unit area. In recent years, the global average of this increase has been 0.5 to 1% a year.
- > There is an enormous potential for improvement with regard to post-harvest losses. 17% of the arable land worldwide could be spared by reducing these losses by half which – with the lost quantity being reduced constantly by 2050 – would equal an additionally available area of 0.4% of the currently available arable land per year.
- > The assumed doubling of meat consumption by the year 2050 would correspond to an annual growth rate of almost 1.4% for the next 40 years. If it is assumed that the production of animal-derived products comes along with a four times higher demand for land compared to vegetable products of the same nutritional value, this can also be interpreted as a calculated annual loss of arable land available for human food of almost 1.1%. As currently one third of the arable land worldwide – i. e. approximately 500 million ha – are used for the production of animal feed, this corresponds to approximately 5.5 million ha of arable land a year (or 0.4% of the entire arable land currently available).

A gross quantitative comparison of the influencing factors regarding production and those regarding consumption reveals that the factors on both sides determine the world food situation to a high degree. Against this background, it seems likely to attach the same importance to both kinds of influencing factors

within the framework of research. However, the results of the project indicate that up to now the consumption side has been given relatively little attention and support. Thus, it seems to be promising to consider an increased support of research on the demand side, particularly because dietary habits and post-harvest losses represent research areas of a high social relevance not only due to their significance for the world food situation, but also for health and environmental reasons.

A scientific task of fundamental significance is an improved quantification of the losses so far in order to be able to identify particularly suitable points of intervention. It seems to be very important to focus on the level of smallholder agriculture taking into consideration the entire processing and value chains. There is a particular need for research regarding the development and implementation of standards for food safety and quality as a prerequisite for economically profitable sales which, in turn, represent a decisive stimulus for producers to keep their post-harvest losses as low as possible.

*Productivity increase: focusing in access to food and resource conservation*

The majority of experts is of the opinion that an increase of the productivity per unit area has to make an important contribution to solving the world food problem. Among the possible strategies for increasing the productivity per unit area, mainly two approaches are being discussed: a further high external input intensification of high performance areas as well as a low external input intensification of rather marginal areas in developing countries. The results of the project indicate that both strategies might be helpful and that the decision whether they are appropriate or not depends on the respective context. Here, it has to be taken into consideration that productivity increases are associated with two major challenges: On the one hand, it has to be ensured that through this measure the people most affected by undernourishment have an improved access to food. On the other hand, it is urgent to reduce the current resource consumption (of soil, water, fertilizers) of agricultural practices significantly, last but not least because otherwise global food production would be deprived of its economic basis.

*Promotion of smallholder agriculture in developing countries:* combining productivity and access. A major approach to increase global food production is the improvement of (mostly smallholder) agriculture in marginal areas of developing countries. The yields per unit area obtained there are much lower than the yields per unit area obtained by means of intensive agriculture in favourable areas. However, there is a potential for considerable increases. For the development of adapted measures aiming at an increase of productivity, it has to be taken into



consideration that the respective farmers have almost no financial resources for purchasing external inputs. Therefore approaches trying to increase productivity with only few external inputs (such as conservation agriculture, the system of rice intensification, agroforestry systems as well as organic farming) might be promising. At the same time, it is thus possible to face the urgent challenge of preserving and cultivating the agricultural production bases. The advantage of the strategy outlined is not only that it requires only few resources, but also that productivity increases can involve an improved access to food (improved food self-sufficiency as well as improved incomes due to the sale of surplus food). This combination of increased quantities and an improved access seems to be necessary since the agricultural sector represents the primary source of income for the rural population in developing countries.

There are numerous approaches for a low-input intensification of agriculture in developing countries. Conservation agriculture, the system of rice intensification, agroforestry systems as well as organic farming are some of these approaches. The latter is likely to make important contributions to global food security mainly by a reorientation both geographically and in terms of content. As considerable potentials for an increase of food production can be found in the tropics and subtropics, research with regard to organic farming should focus more and more on these climate regions. Here, the main priorities are, among other things, an improved organic fertilization, rehabilitation of nutrient-poor soils as well as an improved water management in rain-fed agriculture. With regard to the content, more importance than in the past should be given to the aspects of yield increase and food security with plant breeding and soil productivity as high-priority fields of research. Underutilized crops might also play an important role for low-input intensification. In this context, among other things, it is important to create or to complete inventories as starting point for a use which is more targeted, economically efficient and effective in terms of health.

*Intensification of high-performance areas resource conservation:* In principle, a further intensification of production in high performance areas is appropriate to realize an increase of the productivity per unit area. To achieve an effective and sustainable improvement of the world food situation, such intensification strategies have to meet two challenges: Agriculture must become much more environmentally compatible and resource-conserving than it is today and access to food must be ensured for people suffering from undernourishment and malnutrition. Agricultural practice is considered to be one of the biggest emitters of greenhouse gases and one of the biggest consumers of freshwater and involves severe soil degradation, a serious loss of biodiversity as well as a high consumption of fossil energy sources. Against this background, future world food secu-



rity has to be realized with the intention of not only ensuring a decrease of the negative impact on the economic bases, but also of improving and sustainably cultivating these economic bases, if possible. Moreover, the food supply of large parts of the world population must not continue to depend on the availability of low-priced fossil energy sources in the long term. Realizing productivity increases and considerable improvements regarding the impacts on resources and on the environment at the same time is a tremendous challenge, because intensive farming is based to a high degree on high external inputs (synthetic fertilizers and plant protection products, fuel etc.). Among other things, approaches consist in a more efficient irrigation management, in an improved use of fertilizers, in measures to reduce pre-harvest losses (such as an improved management of plant diseases and pests) as well as in plant breeding in order to increase the potential yield.

If productivity increases in high-yield areas shall result in an alleviation of the world food problem, people suffering from undernourishment and malnutrition must be given better access to food at the same time, i. e. they must have the financial resources required for purchasing food. Theoretically, an increase of the food supply should result in a reduction of food prices and thus should alleviate access to food for the poor. However, it is questionable whether productivity increases will really lead to permanently low world market prices for food, because lower prices for agricultural products also make their energetic and material use more attractive. There is a high demand for multifaceted research with regard to the questions whether low or rather higher world market prices are favourable in order to improve the world food situation and how governance systems can be shaped ensuring that the measures taken will benefit hungry people both in rural and urban areas.

#### *Developing research on global nutritional behaviour*

So far, the world food problem is mostly considered to be a problem of quantity or of access. However, it has to be assumed that the »nutrition perspective« is of major significance for solving the problem, notably in order to be able to consider undernourishment and malnutrition as facets of the problem in an adequate way. For this reason, it is obvious to ask which contribution could be made by research focusing on global nutritional behaviour in order to find a solution to the world food problem. Possible topics could be the determinants of individual nutritional behaviour, changes of dietary habits and the consequences involved as well as possible strategies for shaping a more sustainable world food situation. Knowledge of the determinants, changes and consequences mentioned



above represents a necessary prerequisite for a policy which aims at successfully supporting an improvement of the world food situation.

To date, only rudimentary research is conducted in the field of global food security in Germany. In this context, a perspective for German research for solving the world food problem should be to strengthen neglected fields (e.g. nutrition research focusing on developing countries) and to further develop them to become a research area called »research on global nutritional behaviour«. The – at least partly – observable convergence of dietary habits in developing and newly industrialized countries towards those of industrialized countries implicates that meanwhile nutrition research referring to industrialized countries seems to be easily combinable with a respective research referring to developing countries. Thus, the outlined research might simultaneously lead to a deeper understanding of our local dietary habits in the context of globalization which also confront society with major challenges (overweight, obesity and other diet-related diseases).

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#### OPTIONS FOR ACTION IN TERMS OF RESEARCH POLICY

##### *Research on global food security as an interdepartmental task*

There should be an open exchange not only between researchers and promoters, but also with other interested and competent social groups regarding the question of which individual research issues and projects result e.g. from an increased consideration of the demand side, from a more consistent linkage of strategies regarding intensification and productivity increase and questions of access and resource conservation as well as in the context of comprehensive research on global nutritional behaviour.

Since the Federal Government's report called »Globale Ernährungssicherung durch nachhaltige Entwicklung und Agrarwirtschaft« (Achieving global food security by sustainable development and agriculture) was adopted in June 2008, important programmatic changes of different character could be observed in the three mainly relevant German departments: in the field of the Federal Ministry of Education and Research particularly the adoption of the »National Research Strategy BioEconomy 2030« which – as a part of the interdepartmental high-tech strategy – will be funded with a total of 2.4 billion euros during the next six years and which explicitly addresses aspects of a development-oriented agricultural research; the promotion of the establishment of the »Deutsche Agrarforschungsallianz« (DAFA) by the Federal Ministry of Food, Agriculture and Consumer Protection as a joint project of German (public) agricultural re-

search aiming at an improved networking of departmental research institutions, but also of individual (sub)divisions of the agricultural and food sector; and with particular programmatic relevance the new concept »Rural development and its contribution to food security« by the Federal Ministry for Economic Cooperation and Development. All three activities focus on a problem-oriented approach. At the same time, ambitions with regard to interdepartmental action are expressed explicitly which gives reason to expect a better cooperation and – in view of the field of development – perhaps also a better coherence in this policy area.

Corresponding to the commitments and demands made on an international level, the Federal Government should intensify its support for both international agricultural research centers and the national agricultural research in developing countries. Besides financial assistance, the thematic orientation of research promotion and an improved combination of funds from different sources in joint programmes and projects are of particular interest.

The »National Research Strategy BioEconomy 2030« covers a large thematic and financial framework involving different departments and programmes. In order to be able to work on the fields of action defined in the strategy in a development-related way, i. e. with regard to the recipients and to the implementation, a systematic combination of disciplinary basic research, application-oriented agricultural research and transdisciplinary competence based on practical experience from development cooperation is required. With the new structure of DAFA, a novel and organizational structure is available for departmental research institutions which seems to be most suitable to merge their respective forces. In view of global problems, a targeted integration of scientific and institutional expertise in the field of development and cooperation within the framework of international projects would be important. The conceptual advancement of research programmes is a continuous task of all parties involved, mainly of the ministries, funding institutions, departmental research, university-based and non-university research as well as of research-oriented public and private development organizations. Objectives include a definition of thematic priorities as well as procedural and organizational questions regarding a closer combination of different competencies.

In view of the many different protagonists, an improved coordination of the individual projects is not an easy task to accomplish. Following the programmatic efforts made by the Federal Ministry of Education and Research, the Federal Ministry of Food, Agriculture and Consumer Protection and the Federal Ministry for Economic Cooperation and Development, a potential next step would be



a well-prepared, open and equitable discourse between the different »cultures« from the research areas of the three departments. It should be clarified in the course of the discussion whether – on this basis – a committee with power of decision should be established later in order to ensure a systematic coordination of publicly funded projects. It should also be considered whether a central contact point for projects and topics of development-oriented agricultural research and related fields should be established in addition to existing structures at universities and existing institutions of development research or whether it would be more appropriate to establish several decentralized, virtual centers of excellence with regard to different subquestions or regional aspects of a development-oriented research of global food security.

*Improved keys to success for participatory user-oriented research*

The research organization, i.e. the way research is done, is a decisive factor regarding the success of research in solving the world food problem. The failure of many research projects in the past was not primarily due to a selection of inadequate approaches, but basically due to an inappropriate research organization. The protagonists of development-oriented (agricultural) research are well-aware of the limits of linear technology transfer models and the resulting necessity of systematically integrating the recipients of the research efforts in terms of a transdisciplinary and participatory research. For many researchers from basic research as well as from primarily theoretical disciplines (e.g. agricultural economics), recipient orientation – or even a systematic process participation of future users – means entering new territory. In view of a desirable closer combination of different scientific cultures, »lessons learned from the transfer problem« must be a core topic of the conceptual advancement of research programmes and research cooperation regarding world food security.

For years, it has been criticized that too little significance has been given to interdisciplinary/transdisciplinary and to participatory capacities and competencies and that those disciplines in faculties of agricultural science and research institutions have been marginalized which are considered to be indispensable for a participatory and recipient-oriented research (i.a. rural sociology, agricultural policy and agricultural economics as well as integrative disciplines such as crop cultivation and animal husbandry in the field of agricultural production) – both in Germany and in the institutions of the CGIAR (Consultative Group on International Agricultural Research) system. In order to (re)establish and to develop capacities in terms of social sciences in faculties of agricultural science focusing on developing countries, a more consistent redirection by the Federal Government and the Länder would be required.

Interdisciplinary and participatory research should be established as a fundamental methodical approach in academic studies and success in practice should be a relevant criterion for filling job vacancies for young researchers as well as in appointment negotiations. It is necessary to consider the creation of a central body (in terms of a »center of excellence for participatory agricultural research«) at an adequate research institution. At the European level, the creation and promotion of a European network called »Participatory Research for Global Food Security« would be an option. Within the 8th Framework Programme for Research of the European Commission as well, the application of participatory methods in projects referring to global food supply should be supported by means of targeted measures.

Besides the creation or development of capacities in universities and research institutions, it would be necessary to adapt the conditions of research promotion. Research promotion by DFG (Deutsche Forschungsgemeinschaft), which predominantly is focusing on basic research, but also other public research programmes offer only little chances of success to applicants representing research projects which are based on a participatory approach. Obstacles result both from the requirements with regard to the academic proof of excellence of the applicant and from the type of funding (mainly of the duration of grants and of success evaluation). In order to improve opportunities for participatory projects, it would be necessary, among other things, to allow a project planning which is more open, to make the allocation of funds more flexible and to establish other methods to verify the efficiency of the funded projects.

Precisely because participatory approaches for research are considered to be particularly worthy of support due to their practical orientation, it is necessary to critically scrutinize and to further develop them. Due to the partly low significance that has been given to them in the past, there are many methodical challenges which offer a potential for improvement and thus represent topics of research themselves. This concerns a more systematic participation of underprivileged groups in the developing countries (instead of concentrating on comparatively well-organized, innovative »local elites«), the expansion of successful local projects to larger areas or more comprehensive value chains as well as an increased integration of pools of knowledge and problem perspectives from basic research.

*A potential next step: cooperative »flagship projects«*

An option for action which can be implemented on a short notice results from the combination of considerations regarding the strengthening of participatory



## SUMMARY

research and options for action in terms of an advancement of research policy programmes: the conception and development of »flagship projects« in terms of »joint contributions of German research institutions to food security of marginalized population groups by ensuring a sustainable development of rural areas« – with an explicit participatory orientation and as interdepartmental, interdisciplinary and inter-institutional examples for problem and recipient orientation. These projects should not be centrally pre-structured by funding institutions in terms of the content and topics dealt with, but should be developed as joint research projects following a bottom-up approach – as a first tangible form of the discourse mentioned above between institutions from research and development cooperation which up to now have been linked to each other only marginally. The objective should be to combine – following a problem-oriented approach – development-related activities of universities, non-university institutes, professional organizations and NGOs with institutions of agricultural science, life sciences, social sciences and economic sciences predominantly focusing on national and European issues. Financing would be in line with the framework of the »National Research Strategy BioEconomy 2030«. The concept »Rural development and its contribution to food security« by the Federal Ministry for Economic Cooperation and Development should serve as an orientation. Departmental research of the Federal Ministry of Food, Agriculture and Consumer Protection could make its contribution via DAFA. An active participation of DFG as a major funding institution of basic research would also be important.

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