PLANT RESEARCH INTERNATIONAL

Wageningen views on food security

N.B.J. Koning, P.S. Bindraban & A.J.A. Essers (Eds)

WAGENINGEN UR

The Wageningen Platform for Food Security (WPFS) aims to promote the active participation of Wageningen UR in international debates, help determine priorities of research and education in Wageningen and establish a stronger position for Wageningen UR on the international market with regard to development issues. To this end, we have produced this document on Wageningen views on food security by encouraging an interdisciplinary debate within a broad panel of scientists.

The Platform is comprised of about 35 experts from Wageningen UR. These individuals contributed actively to six workshops that were held during an 18-month period. All participants assisted in realising this synthesis. Marianne van Dorp, Nico Heerink and Lida Res contributed directly to the writing of this document. In addition, Professors Arie Kuyvenhoven, Rudy Rabbinge, Eric Smaling, Piet Stam, Johan Bouma, Seerp Tamminga, Herman van Keulen and Linden Vincent provided helpful comments on the draft version.

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Wageningen Platform for Food Security
Coordinators
Prem Bindraban Plant Research International
Sander Essers Studium Generale
Niek Koning Studium Generale, Agricultural Economics and Rural Policy

Correspondence address
Studium Generale
Attn: Sander Essers
De Wereld
5 Mei plein 1
6703 CD Wageningen
Telephone : 0317-484413
Fax : 0317-484739
e-mail : sander.essers@sg.osa.wau.nl

Wageningen Platform for Food Security

Deelnemers		Instituut-departement
Bastiaans	Lammert	Crop and Weed Ecology**
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* Wageningen UR, Research Institute
** Wageningen UR, University

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Foreword

This report is the result of a series of intensive workshops involving 35 senior researchers from Wageningen UR who joined together to form the Wageningen Platform for Food Security (WPFS). As editors, the three of us combined the viewpoints that emerged during these workshops. Then, following many discussions in smaller groups, we wrote this interdisciplinary view of the world food problem. The primary aim of these interdisciplinary views is to contribute to the food security discussion within Wageningen UR and, second, to contribute to discussions with parties outside Wageningen UR. We hope in this way to contribute, albeit indirectly, to the identification of effective solutions.

We use the term 'world food problem' to refer to the current situation where 800 million people are still malnourished, nearly 2 billion people have nutritional problems and to scenarios which indicate that larger or smaller numbers of people could still be threatened with hunger and malnutrition in the future. We view the world food problem as a complex, dynamic problem that interacts with other issues such as poverty, resource degradation, underdevelopment, trade structures and armed conflicts. This complex problem can be reduced to a simple lack of access to food – after all, sufficient food is still being produced around the world. But in the future we run the risk that access to food for disadvantaged groups in the population will become even more difficult due to a global food shortage.

By definition, a complex problem cannot be described in an all-encompassing fashion. This is why it was impossible for us to be complete in proposing measures to improve the situation and in critically commenting on current policy. This paper will therefore cause many questions to be asked and discussed, questions which will depend on personal knowledge, background, social and professional position, motivation etc. But this is also our intention because we see this report as a step towards a better, or at least, more complete, vision. We do not find it appropriate to use this paper to propose research questions and define educational issues. We are happy to leave this to relevant parties. However, we do feel called upon to reflect on the points of view and assertions in this document concerning developments within our own institution, Wageningen UR.

Consequently, this paper is also a call for action. We specifically advocate a broadly supported involvement of Wageningen with the world food problem and with the development issue in general. We hope that this paper and future activities of the Platform will lead to more discussions within Wageningen, as well as to discussions with other interested parties from the government, business community and social organisations.

Niek Koning, Economist, Department of Social Sciences
Prem Bindraban, Agronomist, Plant Research International
Sander Essers, Nutritionist, Studium Generale

1. In the grip of hunger

Despite a range of measures, new technologies and political resolutions, hunger and malnutrition are still a problem. We believe the problem is so persistent because it is a complex, dynamic problem where people at the household level and at the local, national and international levels have to deal with vicious downward spirals from which it is often difficult to escape. The nature of the problem confronts scientists and policy makers with all kinds of dilemmas.

1.1 Hunger is a persistent problem

Since 1970, the percentage of malnourished people has fallen significantly. But in absolute terms, the amount of malnutrition remains high: at least 820 million people still do not have enough to eat.[1] Still more people have shortages of essential micronutrients such as iron or vitamin A or do not have access to sufficient clean water.

Despite the green revolution, despite a strong increase in food assistance and despite all kinds of measures to improve the access to food, hunger and malnutrition have not disappeared. Neither have international political initiatives succeeded in putting an end to the problem. In 1996, 186 countries decided at the World Food Summit that the number of malnourished people in 2015 must be reduced to 400 million. Five years later, it appears that this objective will not be attained.[2] Hunger and malnutrition are therefore more unmanageable problems than originally thought. We believe this has to do with the nature of the problem itself.

Around 1960, experts often approached the world food problem using a simple form of systemic thinking. Some of these experts believed it was a problem of inadequate production that could be solved by using high-yielding varieties. Others saw it as a problem of inadequate purchasing power that could be solved with large-scale *food for work* programmes. In both cases, the solution was sought in policy intervention and modernisation processes that were imposed over the heads of the hungry.

In the meantime, it has been realised that the hungry and malnourished people themselves play a central role in solving these problems. In all kinds of ways, people attempt to improve their lives and tackle problems that threaten their existence. If things go well, their efforts succeed and their lives and nutritional situation improve. The best way for governments and other organisations to assist this process is to make sure their initiatives link up with the aspirations of the people for whom they are intended. Measures or projects that do not take account of these aspirations are frequently counterproductive. This is why more and more attention has been paid in recent years to the *livelihood* and *coping* strategies of those involved. These are the strategies followed by people to provide themselves with a living in normal times (livelihood) and difficult times (coping).

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1 According to the FAO (2000a), between 1996 and 1998 there were 792 million malnurished people in developing countries and 30 million in the ex-COMECON countries, which totals approximately 820 million. This number may be too low, as undernourishment in China (especially in the cities) may be underestimated. In 1970 there were about 960 million malnurished people in developing countries. The number of malnurished people in the COMECON countries during this period is not known, but was significantly lower than now. We therefore estimate this number at 10 million, which makes a total of 970 million.

2 FAO (1999; 2000b).

Box 1.1 Still too much malnutrition

In a world of plenty, approximately 800 million people still do not have enough to eat. Although per capita food production has increased in recent decades, and the percentage of undernourished people has also decreased significantly, in absolute terms malnutrition is still too high. Since 1970, the number of undernourished people has decreased only slightly, from 970 to 820 million.[3] These people eat too little to provide for their minimum energy requirements.

Even more people suffer from nutritional problems caused by shortages of essential nutrients and micronutrients. More than 3.5 billion people in developing countries have iron deficiencies or anaemia; around 2 billion are at risk of illnesses caused by iodine deficiencies; several hundred million suffer from vitamin A deficiencies. Moreover, such deficiencies often affect pregnant and nursing women, children, the elderly and the chronically ill. Their need for micronutrients is large in relation to their need for energy; they may also have problems with the physiological utilisation of nutrients; as a result, their micronutrient supply tends to be more deficient than that of other population groups.[4] Water is also essential to an adequate food supply. Millions of people do not have access to sufficient amounts of clean water. In addition, the food security of many people is vulnerable. Their food situation is currently acceptable, but could be easily eroded due to developments for which they have no adequate response.

In absolute terms, the biggest problems are in southern and eastern Asia. More than 520 million people are undernourished in these regions. Sub-Saharan Africa occupies second place, with 180 million undernourished individuals. But the percentage of undernourished individuals is larger in this latter region and is hardly decreasing. Moreover, population growth is higher. It is expected that the share of this region in global undernourishment will increase greatly in the near future.[5] The degree of undernourishment is also more serious.[6] Besides developing countries, the situation in the Commonwealth of Independent States (the former Soviet Union) is also worrying. The number of undernourished people in this region has increased greatly during the past ten years and now totals about 26 million.[7]

Nutritional problems occur primarily in certain urban areas and vulnerable rural areas. They are also concentrated in certain groups: refugees and displaced persons, ethnic minorities, specific professional groups, people with specific family situations, small children, pregnant women, the elderly and so forth.[8]

Relatively speaking, undernourishment is most prevalent in rural areas. But due to urbanisation, the undernourishment balance (in absolute terms) is shifting towards the cities. Especially in heavily urbanised regions such as Latin America and the Commonwealth of Independent States, a large percentage of undernourished people live in cities. In Asia, as well, urban malnutrition is a significant problem. In Sub-Saharan Africa, 70% of the population still live in the countryside. But rapid urbanisation is also taking place there, resulting in more malnourished people living in cities and many people becoming vulnerable to malnutrition.

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3 See footnote 1.

4 ACC/SCN (2000). FAO (2000b). Leemhuis-De Regt (1995). Regarding dieficiencies of specific amino acids, see Young *et al.* 1989.

5 FAO (2000a).

6 According to FAO data, the energy shortage among undernourished people in Sub-Saharan Africa is greater than in South Asia (FAO 2000b). According to the ACC/SCN (2000), the proportion of stunted and underweight pre-school children in South Asia is greater than in Sub-Saharan Africa, but in the former region, this proportion is decreasing, while in the latter it is increasing.

7 FAO (2000b).

8 FAO (1999; 2000b).

However, the livelihood and coping strategies of individuals and households do not always lead to improvements. Especially in vulnerable rural areas and urban slums, hunger and malnutrition affect many people. This frequently concerns specific groups such as some professional groups, displaced persons, ethnic minorities or single mothers and their children. These people, too, do everything possible to deal with their problems, but they do not succeed for all kinds of reasons. This is partly the result of natural disasters, lack of work, health problems and discrimination. But it is also partly the result of the coping strategies themselves. These can play a role in the continuation of the problems. For example, farmers can use less fertiliser to reduce their losses if drought causes the crop to fail. But as a result, the fertility of their soil decreases. Or farmers may eat their sowing seed in order to escape starvation if their crop fails. But this means that next season they will again have no harvest.

Box 1.2 Irreversible consequences

The effects of nutritional problems can already be noticed in pregnancy. Malnutrition in pregnant women leads to malnutrition of their unborn children, which in turn leads to a higher risk of prenatal death, and possibly of chronic illness as the child grows up.[9] The results of foetal malnutrition are amplified by malnutrition in young children. More than half of the high death rate of children up to five years old in developing countries is related to malnutrition.[10] Moreover, malnutrition of children leads to stunted growth, retarded cognitive development and learning disabilities. Among adolescents and adults, the effects of moderate malnutrition are less striking because the body reacts by slowing down physical processes. The effects, however, include reduced concentration, endurance and strength, and impaired resistance to disease.

Unbalanced nutrition due to shortages of micronutrients also has serious consequences.[11]

- Iodine deficiency has negative effects on brain development. As a result, around 6 million people suffer from cretinism (mental retardation and dwarf-like growth) and 20 million others have serious mental handicaps. Less drastic effects on mental functioning are even more widespread. Exact data are not available, but the fact that 740 million people suffer from goitre provides some indication about the magnitude of the problem.
- Iron deficiency is one cause of anaemia, which affects approximately half of the pregnant women, children and older adults in developing countries. Anaemia is the most important cause of women dying in childbirth. Other effects include low birth weight, increased infant mortality, retarded growth and reduced cognitive performance in children, and reduced physical condition in all age groups.
- Vitamin A deficiency has negative effects on epithelial barriers and the immune system, and it leads to a large increase in infections and child mortality. In addition, it causes night blindness in 14 million young children. Five hundred thousand children per year become blind, of which most die within a few months.
- Zinc deficiency also affects the immune system. It leads to increased risk of infection and may play a role in the process of HIV infections developing into AIDS.

The reduction of the duration and the quality of life is a serious loss in itself. In addition, there are economic losses caused by illness and death, higher cost of health care, reduced effectiveness of education and reduced productivity of people. Moreover, nutritional problems are an important link in the vicious circles that trap large groups of people in poverty and prevent them from benefiting from general economic growth.[12]

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9 The descriptions of the physical effects of malnutrition in this section are largely based on ACC/SCN (2000: Ch. 1).
10 Pelletier *et al.* (1993).
11 ACC/SCN (2000: Ch. 1). Leemhuis-de Regt (1995). For zinc deficiencies, see Black (1998).
12 Dasgupta (1993).

1.2 Hunger is a complex problem

Coping strategies give a higher priority to surviving today and avoiding risks than to investing in the future. As a result, these strategies can lead to vicious downward spirals, such as the spiral poverty: no more money for fertilisation – soil exhaustion – poor harvest – poverty. This concerns vicious spirals that ensure the continuation of hunger and poverty. To get a grip on the world food problem, we therefore believe it is important to not only understand the individual strategies of people, but also the way in which the strategies interact with factors in the surroundings and with each other. We believe the best way to do this is by viewing the world food problem as a complex problem.

In a complex problem, vicious spirals affect each other at various levels. This process begins at the level of the household. For example, inadequate nutrition causes illnesses, which lead in turn to nutrient losses, nutrient utilisation problems and incorrect nutritional behaviour, all of which aggravate malnutrition. People with nutritional problems are less fit, develop fewer skills, remain poor and therefore retain their nutritional problems. Nutritional problems in pregnant women lead to nutritional problems for their foetus, which in turn increases the risk of health problems later on in life. And parents with nutritional problems do not care as well for their children, leading to a continuation of nutritional problems, stunted development and reduced performance in school.

Many people who are affected by hunger and malnutrition are struggling in a kind of maelstrom, from which only the strongest swimmers can escape. Local conditions can make escape more difficult or even drive more people into the maelstrom. For example, shortage of land, water, money or schools puts more people at risk of being caught up in the maelstrom. The lower status of women can lead to households investing fewer means into nutrition. Micronutrient deficiencies in local food crops can cause health problems,[13] resulting in people being drawn into the maelstrom's current. Failing governmental policy causes people to be treated with contempt, discrimination and to be exploited, so that they are again and again pushed back into the maelstrom instead of being helped to escape from it. Calamities such as illness, the death of close relatives, natural disasters and armed conflicts can push people permanently into the maelstrom.

It is especially the poor, with few possessions and possibilities, who are affected by calamities – resulting in them remaining poor. Poverty can result in coping behaviour that leads to vicious downward spirals such as that of poverty and soil degradation in vulnerable, rural areas. Poverty can also cause people to improve their own situation at the expense of others instead of working productively together.[14] This leads to vicious circles of conflicts, group and individual egoism and mistrust, all of which can frustrate development.[15] The same mechanism can promote misrule and armed conflict, which can also lead to an increase in hunger and malnutrition. If the conditions are bad, coping strategies can therefore even lead to a worsening of the situation.

Besides local events and local relationships, national factors are also important: the natural resources of a country, its population growth, its social structure, its economic development and its national politics. These can also make it easier or more difficult for people to escape from the maelstrom of hunger and malnutrition. The same applies to international factors such as the global economy, world market prices, transnational corporations, foreign governments, international institutions such as the World Bank and the IMF, and international agreements such as GATT/WTO. National and international relationships influence the local relationships, but the reverse is also true. Low world market prices or flawed national policies can amplify vicious downward spirals of poverty, resource degradation and poor government at the local level. Looked at the other way, these local vicious downward spirals can contribute to national development problems and failure of government, and consequently to ineffective participation in international negotiations.

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13 One cause of such nutritional deficiencies is shortages of micro-nutrients in the soils of specific regions.

14 It is known from game theory that the results of evolutionary cooperative games depend on the payment structure. An example of an evolutionary cooperative game in the context of resource degradation is given by Sethi and Somanathan (1996).

15 For the interaction between distribution conflicts and distrust in a theoretical game setting, see Ostrom (1998). This mechanism undermines the *social capital* (cf. Putnam 1993).

1.3 Hunger is also a dynamic problem

We therefore view inadequate food security as a complex problem. Besides, it is also a dynamic problem. Over the short term, food insecurity is maintained by vicious downward spirals such as those described above, including the coping behaviour of people who are caught up in the spirals. Over the longer term, endogenous shifts in conditions can occur, resulting in the vicious spirals becoming destabilised. For example, when the soil becomes totally exhausted, people can no longer survive by means of over-cropping. This leads to local tension. If at the same time the national or international situation is unstable, this can have serious consequences such as wars, epidemics or mass migration. Following such events, space may be created for innovations and new growth, ultimately leading to a reduction of hunger and malnutrition. But before this improvement occurs, there has often been a serious crisis.

In this way, the historical interaction of population, soil use, technology and institutions has led to certain wave-like motions in the development of agricultural societies.[16] During the expansion phases, such as those between 1100 and 1300 or 1450 and 1650 in Europe, an accelerated population growth led to the emergence of a rich upper class and to a rise in agricultural prices. This stimulated investments in sustainable land management, technological innovations and new institutional solutions, which prevented a Malthusian crisis. During such prosperous phases, most people were assured of having sufficient food. This lasted until the demand for further adjustment ran up against the more slowly increasing technological and institutional possibilities of society. The growth of production could then no longer keep up with the population growth, resulting in drastic increases in food prices. The upward spiral of population growth and sustainable agricultural intensification changed into a downward spiral of poverty, soil degradation and conflicts. This happened in Europe in the 14th century when it was ravaged by war and the plague.

In Europe, the Industrial Revolution brought about a change in these secular trend variations. In its first phase, this led primarily to increased demand for agricultural products. Consequently, until 1875 international agricultural prices remained at fairly high levels, facilitating investment in agriculture. The availability of food was no major problem, and even the lower social classes could afford increasingly better food. During the course of the 19th century, however, industrial development accelerated in an unprecedented fashion.[17] In international food markets, mild scarcity was replaced by oversupply, which forced prices downwards. This effect was amplified by a protectionist reaction in western countries, one that was not accompanied by any significant production control. As a result, non-western countries were limited in how much they could market in the West. Moreover they had to deal with the dumping of surplus products from the West.

Distorted dynamics

In developed countries today, the maelstrom of food insecurity has been reduced to a harmless whirlpool. But the industrialising countries are faced with a more complex situation. On the one hand, low international prices ensure more and cheaper food for the growing cities, but on the other hand, low agricultural prices do not stimulate farmers to invest in fertilisation and other forms of sustainable land management. As a result, it is frequently more difficult to compensate for increased population pressure than was the case in pre-industrialised Europe. During this era in Europe, when population pressure increased, food prices also increased and the farmers were able to invest. In developing countries, the relationship between population growth and agricultural prices has been distorted. Consequently, growing population pressure can more easily lead to vicious downward spirals of poverty and soil degradation.

16 See, for example, Abel (1978) or Slicher van Bath (1963) for the secular trend variation during the middle ages and in early modern Europe.
17 Schultz (1945). Koning (1994).

It is uncertain how the world food situation will develop in the decades to come. Global demand for food will increase strongly due to the growth of the world population and the increased incomes in successful developing countries. At the same time, a number of traditional sources of agricultural growth start to diminish. Classical plant breeding is now leading to negligible increases in productivity, the amount of fertile agricultural land is decreasing in many regions due to salination, soil exhaustion and urbanisation, while a shortage of water can be expected in more and more regions. Biotechnology and ICT can tap new biophysical reserves for food production, but it is uncertain how easy this will be. Should the scarcity in the international agricultural markets increase in the future, then the price of food could temporarily increase sharply if the level of long-term investments in agriculture, education and infrastructure are not increased in time. The uncertainty is amplified because biotechnology and ICT can strengthen the power positions of large companies while simultaneously raising the threshold for small farmers. Other developments may lead to even more insecurity. Climate change can expand the possibilities for agricultural production in Arctic and temperate zones, but simultaneously aggravate the problems in the tropics.[18] Large-scale migration flows may reduce the population pressure in marginal areas, but can also increase the political instability in the receiving areas. It is nearly impossible to predict how the world food situation will appear over the next quarter of a century.

1.4 Complexity leads to dilemma

The complex dynamics of the food problem confront scientists and policy makers with all kinds of dilemmas and paradoxes. For example, increasing agricultural production is necessary for the food supply, but the same production increase can threaten the basis of the existence (and therefore the food security) of small farmers, something that actually happened during the green revolution. Industrial and other non-agricultural employment is desirable in order to break through agricultural stagnation, but it is hampered because the same stagnation, in turn, limits the demand for industry and services. Social networks of the poor can improve their food security, but can also lead to network conflicts that obstruct more far-reaching improvements.

Diagnosing this complex set of problems unavoidably implies reductionism. Without reduction, it is impossible to understand the main ideas and to formulate effective policy approaches. But reduction also creates space in which ideological and interpretations driven by self-interest can hide. If one looks at the history of the international discussion on food security and development, one sees a continuous succession of dominant concepts: land reform in the 1950s, the green revolution in the 1960s, strengthening entitlements and participation in the 1970s, structural adjustment in the 1980s, public investment and good government in the 1990s, and today poverty alleviation, empowerment and institutional ownership. This succession of ideas originates partly from the continuing development of new insights, but it also reflects the political-ideological cycle. In any case, the need for cognitive simplification can lead to simple diagnoses and straightforward policy approaches. Sometimes these appear to work. Under certain conditions, vicious downward spirals can be easily broken by local initiatives or external interventions. This leads to success stories that become widely known, such as the stories of resource regeneration in the Machakos District of Kenya,[19] the formation of social capital in the Gal Oya irrigation system in Sri Lanka,[20] and so forth. Such stories have a great deal of influence on international discussions, but attempts to generalise the successes frequently lead to disappointments. In many situations, people and communities are caught into robust lock-in mechanisms that cannot easily be broken unless certain conditions are changed that depend on mechanisms at higher levels of scale.

The lack of food security is therefore a complex, dynamic problem, with social dilemmas, nested feedback effects and endogenous system fluctuations Perfect knowledge of, and perfect solutions for, such a problem are unattainable. Nevertheless, better approaches are possible than those that have been

18 Rosenzweig and Hillel (1998).
19 Tiffen *et al.* (1994).
20 Uphoff (2000).

used until now. This involves neither a technocratic approach that attempts to direct everything centrally, nor a laissez faire approach that assumes improvements will take place automatically if only governments ensure adequate property rights and properly functioning markets. Instead, better focused and more well-considered approaches are required. This necessitates diagnoses that provide improved understanding of the relevant complexity of the problem, and technologies and socio-political changes that link up with this understanding. In the next chapter, we try to contribute to such improved understanding by reconsidering the role of agriculture in the world food problems.

2. Agriculture must be put back on the agenda

At the present time there is more than enough food in the world. Malnutrition must therefore be counteracted by improving access to food. But this does not mean that the development of agriculture can be neglected. We believe that agricultural development must become a major focus in the battle against hunger and malnutrition; this is because agriculture can contribute to poverty alleviation, because it can play a role as a starting motor for economic development and because this reduces the risk of an absolute shortage of food in 25 years.

2.1 Reconsidering the world food problem

In the 1950s and 1960s hunger and malnutrition were frequently viewed as resulting from a shortage of food: there was simply too little food available. The solution was sought in increasing the food production in developing countries. An important breakthrough was the green revolution, based on new, high yielding grain varieties. Especially in Asia, this led to a major increase in food supply. Without the green revolution, population growth and rising incomes of middle income groups would have caused an increasing scarcity of food, higher food prices and consequently more hunger and malnutrition among the lower income groups.

But the green revolution has not led to the *disappearance* of hunger and malnutrition. Even in many countries with sufficient food, such as India, many people are still unable to buy food or acquire it some other way. This concerns the urban poor, people in less prosperous rural areas who were missed by the green revolution, and poor farmers and landless workers in areas in which the green revolution was introduced. Paradoxically, the problem was sometimes aggravated by the green revolution itself. In order to be able to introduce new, highly productive varieties, a complete package of inputs was required – pesticides, mineral fertilisers, irrigation and new management techniques. This was unattainable for small farmers, the more so when the general increase in supply reduced the prices of their products. These farmers could no longer compete, their incomes declined and some no longer had any income at all.

The continued existence of hunger and malnutrition despite the green revolution has led to a reconsideration of the world food problem. Economists such as Amartya Sen emphasised that hunger and malnutrition were not primarily an availability problem, but a problem involving the lack of *entitlements* to food.[21] As there is an abundant food supply globally, acute shortages can only occur temporarily and locally. After all, the food can be imported. Hunger and nutrition problems are therefore caused by the fact that people cannot acquire food, not because the availability of food itself is inadequate. In this regard, it makes no difference whether one's lack of access to food is the result of too little money, too few social relationships or insufficient land to grow food oneself.

Raising agricultural production therefore does not lead automatically to improved access to food for vulnerable groups. This became the basic principle after the 1970s. Access to food is not guaranteed even if people live in the countryside. It is crucial that the entitlements of these groups be strengthened. This does not always have to take place through agriculture. It can also take place through the development of rural crafts and services, or through migration to rural or urban areas where the demand for labour is developing more quickly. Income earned in this way can, as supplementary income or remittances, benefit households that have remained in agriculture and help them to strengthen their position.

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21 Drèze and Sen (1989; 1991).

2.2 Poverty alleviation is a prerequisite

The idea that it is especially entitlements to food that must be improved has stimulated many projects such as employment programmes, credit for income-generating activities and gardens for poor urban and rural residents. However, it is becoming increasingly clear that these only have a limited effect as long as the social and economic position of these groups is not improved in a structural manner. To achieve this improvement, a first prerequisite is adequate economic growth in the region. If this growth is lacking, it is more difficult to strengthen the position of vulnerable groups, partly because population growth dilutes any gains that are made. Adequate growth requires good macroeconomic policy: a development-oriented sector policy with sufficient competition incentives, and public investment in infrastructure, education and health care. Markets, informal institutions (such as mutual credit groups) and small companies are important to start a growth dynamic. Larger businesses (including foreign companies) can also participate, which may amplify growth. It is important that the growth be sufficiently sustainable, that it does not come to a halt due to exhaustion of resources or declines in production or health. Cleaner technologies, sustainable management of resources and timely development of alternatives for diminishing resources are required.

Box 2.1 Access to food is not enough

Besides sufficient availability of food and access to food, a third factor is important for a healthy nutritional situation: optimal utilisation of food. Sufficient access to food (at the household level) is in itself no guarantee for actual sufficient food consumption. People's nutritional behaviour can be inadequate due to, for example, limited or incorrect nutritional knowledge, insufficient motivation or by traditions that give certain family members (often women and children) lower priorities when food is being distributed. Incorrect nutritional behaviour can lead to unbalanced diets with little variety, causing people to become deficient in certain micronutrients. In addition, there may be too little time for preparing meals or for caring for members of the household. And there may be a lack of facilities required for preparing meals, such as fuel.

But even if people are aware of what constitutes a balanced diet and sufficient facilities are available for meal preparation, the nutritional situation can still be threatened. In fact, consumption of a sufficiently broad diet does not assure proper physiological utilisation of nutrients. The food may contain toxins, harmful micro-organisms and 'anti nutritional factors', substances that reduce the utilisation of micro-nutrients. Sometimes the environment is also important: food grown on soil that is poor in iodine and zinc is generally also deficient in these minerals. In addition, certain types of food processing (such as polishing rice, which causes a loss of B vitamins) or the replacement of locally processed products by industrially processed ones (such as refined palm oil, which no longer contains pro-vitamin A) play a role. Parasites can reduce the utilisation of nutrients, or cause an increased need for such nutrients. Moreover, the physiological state of the individual always plays a role. Infants, pregnant women, nursing women, the chronically ill and the elderly are in general even more vulnerable to nutrient deficiencies. This is why health care and hygiene in the household also have an effect on the nutritional status. More fundamental causes of poor nutrition include poverty, unequal gender relationships and a low education level.[22]

However, sufficient economic growth that is also sufficiently sustainable is not always enough to strengthen the entitlements of the vulnerable groups.[23] When the distribution of assets and income is excessively unequal, serious poverty can continue to exist despite economic growth. Severe economic inequality can even hamper growth. This is because poor individuals tend to develop inadequate skills,

22 Smith and Haddad (2000).
23 World Bank (2000).

because the demand for simple products increases too slowly and because serious inequality leads to criminality and excessive political instability. Some economic reforms that are intended to amplify growth can even increase poverty.

It is therefore essential that the previously described vicious downward spirals that lead to poverty and nutritional problems be broken.[24] To begin with, individual or collective disasters should no longer be allowed to push vulnerable people definitively into the maelstrom of poverty and food insecurity. To accomplish this, the risk of such disasters must be reduced, and social safety nets (such as health insurance, pensions and emergency assistance) are required to alleviate the consequences of such disasters.

In addition, specific measures are required to provide vulnerable groups with access to education, health care, credit, and to other important markets. Redistribution of property rights for land, water and the like may be necessary to enable people to break out of the vicious circles of poverty and food insecurity. Due to the low status of women in many areas, their important role in production and food security *within* households and the vulnerability of households that are run without adult male input, special attention to the position of women is essential. This is why aspects such as civil rights and non-governmental organisations are also important to strengthening the position of vulnerable groups. Among other things, this requires social organisations that can force governments to be transparent and responsible, and that can negotiate with other market actors (see Chapter 3).

As a result of the above, the emphasis in the international discussion about food security has shifted from food production to access to food. Some organisations have drawn the conclusion that agriculture is therefore not very important. Nothing could be farther from the truth. Without the green revolution, the rapid decrease of malnutrition in Asia would have been impeded by growing food scarcity. Moreover, agricultural development is important to give vulnerable groups more access to the available food. It is precisely in the area of strengthening entitlements that agriculture has three crucial tasks to perform:

1) in the least developed countries, agriculture remains important as the starting motor of general development,
2) in other developing countries, agriculture remains important for alleviating poverty,
3) a sustainable increase of agricultural production remains important to prevent access to food from becoming restricted in the long term due to increasing food prices.

2.3 Agriculture as the starting motor for development

In the least developed countries, including many countries in sub-Saharan Africa, agriculture remains important as a starting motor for general economic development. In virtually all developed countries, modern economic growth began with agricultural development.[25] The Industrial Revolution in England began with an agricultural revolution. More recently, the same phenomenon has been apparent in the newly developed industrial countries of Asia.[26] Agricultural growth actually creates a number of important pre-conditions for the development of non-agricultural sectors. Many industrial and service activities are directly related to agriculture and can only develop if agriculture itself develops.[27] In more general terms, agricultural development is necessary to create domestic markets and provide savings to use for investment in non-agricultural sectors.[28]

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24 World Bank (2000).
Drèze, J., and A. Sen, Oxford 1989; 1991.
25 Kuznets (1966).
26 Timmer (1988).
27 Janvry and Sadoulet (2000).
28 Johnston and Mellor (1961).

In recent years, many economists have postulated that these national-economic *linkage* effects of agricultural development have now become less important. As a result of globalisation, export oriented industries or services can also serve as a starting motor for economic development.[29] However, this idea finds little empirical confirmation. Where agriculture stagnates, other industries and services are also sluggish. A possible explanation is the fact that the modern industrial and service sectors are strongly dependent on properly functioning governments and institutions, as well as sufficiently developed *social capital*[30] (the willingness of people to cooperate and trust each other, which keeps down the cost of business transactions). Where social capital, institutions and governments are lacking, the development of export-oriented industries and services is hampered. During the initial phase of modernisation, agriculture is less dependent on these factors.

Agriculture even leads to a growth in social capital. After all, for a sustainable intensification of agriculture, it is necessary to solve the 'prisoners' dilemma problems that prevent people from co-operating with and trusting each other. Successful agricultural development promotes solutions to these problems; because the dependence on business transactions increases more gradually during the modernisation of agriculture than during industrialisation, the growth of social capital can keep pace with the growing need for it. In this way, perhaps, successful agricultural development may function as a nursery for the social capital that is required for the development of industry and services. Moreover, a sustainable intensification of agriculture can change the labour culture and lead to socio-economic differentiation (a middle class) which can then form the basis for increased political pluriformity.[31]

2.4 Agriculture and poverty alleviation

Even in countries where some modern development is taking place, such as India, Brazil and China, large parts of the population remain trapped in poverty and inadequate food security. Relatively speaking, the poverty is worst in vulnerable rural areas, where biophysical and social conditions make agricultural development more difficult. In these areas, migration and the development of local crafts and services must generate supplementary incomes and reduce risks. However, the problem is that such non-agricultural activities are often inadequate. Local crafts and services often remain limited to coping strategies, with which people can survive in the short term. They remain marginal activities that do not lead to any structural improvements. In many cities as well, the industrial and service sectors are not developing quickly enough to offer a living to all migrants coming from rural areas.

As long as this is the case, agriculture must continue to provide a living for many people. Moreover, agricultural development is required to make further development of local crafts and services possible. The *linkage* effects of agricultural growth, which are initially important for the national economic development, also remain important during the later phases of the development of vulnerable areas. Without agricultural development, the development of local crafts and services is hampered by the lack of local markets. Vice versa, agricultural growth appears to greatly stimulate the development of these non-farm activities.[32]

However, agricultural development may not lead to balanced development when land ownership is excessively unequal. The social capital that is created then develops primarily on a class basis, which leads to class conflicts and instability.[33] Agricultural development in such a situation creates less employment for the rural poor and fewer incentives for the development of local crafts and services. In this way, a combination of low agricultural prices and unequal land ownership in parts of Latin America have forced large numbers of small farmers from the land. They migrated in huge numbers to the cities

29 See Timmer (1988) and the literature cited therein.
30 Coleman (1990). Dasgupta and Serageldin (2000).
31 Boserup (1990).
32 For an example in sub-Saharan Africa, see Delgado *et al.* (1998).
33 Birdsall and Lodoño (1997).

or to marginal agricultural areas such as the higher slopes of the Andes or the Amazon forest, often resulting in vicious downward spirals of soil degradation and poverty. Due to the lack of purchasing power in a large proportion of the rural population and the extensive modernisation of large farms, national economic development took on a one-sided orientation towards exports of raw materials and imports of capital goods and luxury consumer goods. This resulted in an insufficient demand for labour. Consequently there were problems of insufficient entitlements in both urban and rural areas, in combination with severe social inequality.[34] Although the far-reaching urbanisation in these areas has become irreversible, a redistribution of property rights and development possibilities in agriculture is still important to combat rural poverty and to prevent the urban problems from becoming even worse.

2.5 Agriculture remains important for global food production

During the next 25 years, global demand for food will increase greatly. The world population will grow from 6 to approximately 8 billion. Moreover, the rise in incomes will lead to more demand for animal products and therefore to an increased demand for animal feed. Sufficient growth of the world food supply is therefore required to prevent major increases in the international food prices. In parts of Asia, the biophysical potential is not sufficient to satisfy the expected demand. In this region, increased imports appear to be virtually unavoidable. At the global level, however, the biophysical potential is great enough to feed the world population, even when it attains its maximum around the middle of the 21st century.[35] This is true even if the population grows according to the highest demographic projections, and if everyone in the world follows a western food consumption pattern.[36] But the biophysical potential is actually no more than a theoretical upper limit for production based on our current knowledge. There are all kinds of factors that restrict the exploitation of this potential. The actual potential is limited by environmental pollution, irreversible soil degradation, increasing demands on land and water for non-agricultural uses, and possibly by climate change.[37] In addition, the utilisation of the potential is hampered by institutional factors. For example, three-fifths of the biophysical reserve capacity is located in Latin America, sub-Saharan Africa and the countries of the former Soviet Union,[38] where improvements in food production are obstructed by large scale land ownership,[39] the lack of social capital or poor government.[40] Finally, the exploitation of the potential is limited by the infrastructure in place, the state of technology and the price of labour and other inputs. After all, these determine which exploitation possibilities are economically feasible.

The way in which the global food supply develops within the biophysical limits is therefore strongly dependent on economic, technological and institutional factors. Various international institutions have conducted model studies that estimate the development of the world food supply over the long term.[41] These studies arrive at relatively optimistic conclusions: supply should be able to keep up with demand, although according to an IFPRI study, this is true only if public investment in agricultural research is maintained at the necessary level. But the complex dynamic of the global food economy is difficult to represent by means of the econometric extrapolations and experts' estimates on which these studies are based. In the past, agronomic breakthroughs have occurred by means of irregular leaps. In the Middle Ages, the natural capacity of the soils in Western Europe permitted a level of production that fluctuated around 800 kg of grain per hectare. It is only since the 'agricultural revolution' of the 18th century that organic fertilisation, the cultivation of legumes and a better integration of arable agriculture and animal

34 Johnston and Kilby (1975). Janvry (1981).
35 Penning de Vries *et al.* (1995).
36 However, there is discussion about a number of aspects, such as the agricultural suitability of soils in tropical rainforests (for an example, see Weischet and Caviedes 1993).
37 Rosenzweig and Hillel (1998). Kempenaar *et al.* (1999). Oldeman (1999). Stoorvogel and Smaling (1990).
38 Penning de Vries *et al.* (1995).
39 Cf. Eswaran and Kotwal (1986).
40 Dasgupta and Serageldin (2000). For sub-Saharan Africa, see Bayart *et al.* (1999).
41 FAO (2000a). Mitchell *et al.* (1997). Rosegrant *et al.* (1995).

husbandry have made it possible to increase production to about 2000 kg per hectare.[42] The introduction of the potato as a crop in Europe led to an additional production increase because a larger portion of the plant is edible than is the case with grain. A further increase had to await the introduction of mineral fertilisers, beginning at the end of the 19th century. The real breakthrough of this technology occurred following the Second World War, when the development of short-straw varieties brought about a major increase in the utilisation of mineral fertilisers.

This history suggests that the evolution of agricultural production takes place in a discontinuous fashion, with sudden breakthroughs separated by long, difficult-to-predict intervals. The development of international food prices over a period of several decades is therefore very difficult to predict. For this reason it is unwise to simply wait and see and to trust the reassuring linear projections. Instead, it is better to identify worst case scenarios. When such scenarios cannot be excluded with sufficient probability, measures to prevent them occurring are required. One example of such a worst case scenario is the displacement of basic food crops for the poor by a strongly increasing demand for animal products by the wealthy. Another example is a drop in global long term investment in agriculture due to temporarily lower prices.

42 Shiel (1991).

Box 2.2 Will we have enough food in 25 years? Two worst case scenarios

1. Increasing demand for animal products reduces access to agricultural crops for the poor.

When their incomes increase, people consume more meat. The feed that is required to produce a kilo of meat contains more energy than is in the meat itself. The production of a typically western diet requires at least three times as much plant-based biomass as that of a healthy diet with little or no meat. In the decades to come, rising incomes in the world will cause the demand for meat to increase. At the same time, the space for intensive animal husbandry in densely populated areas will decrease due to problems with environmental pollution and animal diseases. To still meet the demand, arable land for food crops will be replaced by grassland or arable land for animal feed. If global food and feed production grows rapidly enough to keep up with the growing demand for food and feed, that is no problem. But if this is not the case, feed prices will rise. This will encourage farmers to use more of their land to grow feed instead of food, causing the prices of food to go up as well. The result will not only be reduced access to food for the poorest groups in countries such as China (where incomes and meat consumption are expected to rise), but even more important, it will also lead to reduced food access for the poor in regions where economic growth lags behind, such as Africa.

2. Reduced investments lead to extremely high food prices

In the dynamics of agriculture and the agricultural market, a number of patterns can be discerned:

- In the first place, there is an alternation between centuries with high farm prices and those with low farm prices. In pre-industrial economies, this variation in the *secular trend* arose from interactions between the population, natural resources and technological and institutional change (see Section 1.3). The Industrial Revolution changed the character of this long-term dynamic. The phase of higher international agricultural prices that lasted from 1750 to 1875 did not end, as was normally the case before that, with a fall in the population, but with a surge in land reclamation and a breakthrough of new technologies. This caused the supply of agricultural products to increase faster than the demand. But the consequence was the same as in previous centuries following a collapse in population numbers: a century of surplus on the agricultural markets that forced prices downwards. In the meantime, however, the reserves of land and water and the potential to develop even more productive plants with simple breeding methods have decreased significantly. There are still enough opportunities to increase production by means of new technologies, but the investments that are required for this are possibly higher than we were accustomed to during the 20th century. This could lead to a new phase of higher international agricultural prices.
- On top of this variation in secular trend, there is also a variation with a shorter wavelength. This is caused by people not being able to look far enough ahead, even though many investments require a long 'ripening period'. Pessimistic expectations can temporarily cause investments to fall below the level that is in accordance with the secular trend. This causes scarcity, and prices in the following period then rise above the secular trend. As a result, pessimistic producers become optimistic, causing investments to rise above the trend, so that scarcity decreases and prices fall below the trend line, and so on. A limited and sector-specific variant of this 'cobweb' cycle is known as the pig cycle. The progression of international grain prices during the past 150 years leads one to suspect that such movements sometimes also occur in international agricultural prices. If grain prices are temporarily high (which was the case during and after the two World Wars) then investment increases, resulting in prices dropping below the trend a while later. If prices were temporarily low, then the opposite occurred. Now assume that for some reason (for example, the elimination of production restrictions in the US and the EU) profit margins in agriculture come under pressure for some time.

And assume that this occurs simultaneously with a transitional phase from a secular trend with low prices to a trend with higher agricultural prices. The low prices in the short term could then lead to a decrease in long-term investment, even though the new trend should actually bring about increased investment. As a result, international agricultural prices could rise temporarily to an extremely high level. This would have a destructive effect in net food-importing poor countries. Of course, the high prices would still lead to increased investment. But because investments in research, soil quality and human and social capital require a great deal of time before they produce their full benefits, it could be a decade or more before prices stabilise at the level of the new trend.

3. Five goals; ten strategies

Based on the analyses in the previous chapters, we have selected five goals for improving global food security. These goals are intended as interim priorities. We will then propose ten approaches or strategies that will bring us closer to achieving these goals. There is a not a one-to-one relationship between these approaches and the five goals. The same goal can be aimed for using several measures, and a single measure can serve several goals.

1st goal: Reducing risks in the food economy

Calamities such as wars, floods or droughts can lead to acute food shortages. Less dramatic fluctuations in the weather, for example, can cause crop failure or loss of food stocks. This can result in vulnerable groups permanently entering a poverty spiral and can disrupt the economy. To improve food security, it is therefore important that risks in the food economy be reduced.

2nd goal: Improving the nutritional status

Sufficient access to food is important, but does not always lead automatically to adequate consumption of a sufficiently varied diet. The actual consumption and physiological utilisation can be insufficient due to incorrect dietary habits or illnesses, for example (see Box 2.1). Every attempt to improve food security must therefore also aim to improve nutritional status. This can also be an indicator for measuring progress.

3rd goal: Sustainable intensification of agriculture in vulnerable areas

In many vulnerable, poor areas – areas that were ignored by the green revolution – there is a negative spiral of rural poverty, population growth and soil degradation. In some countries, this negative spiral hampers general economic development. To improve food security, this spiral must be transformed into a sustainable intensification of agriculture.

4th goal: Rural development with a sufficiently broad social basis

Not everyone benefits from agricultural modernisation. The green revolution frequently weakened the competitive position of smaller farmers, and recent initiatives for agricultural development within agro-industrial chains have often primarily benefited the more prosperous farmers. Some farmers are left behind even if a modified, participatory approach to agricultural development is used. Consequently, development must always pay attention to the most vulnerable groups. To protect their interests, assertive, self-aware and well-informed social organisations are required.

5th goal: Assurance of sufficient long-term investments in the global food production capacity

There is a risk that growth in production will not keep up with the growing demand for food and feed (see Box 2.2). Lagging production – and resulting in price increases – will have disastrous consequences, especially in poor, food-importing countries. Therefore, governments should make adequate, long-term investments in global food production capacity, but without this leading to the continuation of dumping practices.

3.1 A broad package of stabilising measures

Stabilising measures help to alleviate risks. There are all kinds of risks: reduced harvest caused by drought, pollution, war, illness, theft of livestock, and price fluctuations. Governments and private individuals must therefore take actions in many areas. This broad approach initially requires that traditional agricultural and food security systems be strengthened, where this is sensible. This concerns the traditional use of fields in differing agro-ecological parts of the terrain; growing multiple varieties and multicropping; maintaining grain supplies and capital reserves (animal stock); and, for example, rules of thumb for dealing with drought and other disturbances.

We believe modern technology offers many possibilities to link up with the traditional food security systems. However, it does require researchers to think differently. During the green revolution, the main objective was to increase production. To stimulate development in vulnerable areas, a shift is now required towards yield-stabilising measures (see Section 3.4). After all, these are also the kinds of measures that farmers are accustomed to taking in agriculturally marginal areas. For breeders and biotechnologists, it means that they must focus on stabilising crop characteristics such as drought tolerance and disease resistance. An interdisciplinary team of agronomists can investigate possibilities for diversification, allowing households to spread their risks. In addition, researchers can create decision support systems that help farmers when, for example, a disease begins to affect their crop. But these systems must be simple and accessible, and they should be developed in close consultation with the users.

Traditional food security systems can work quite well at the level of a household or a village, but they are usually unable to deal with more drastic changes, such as long-term drought. To reduce the risks, international and national facilities are required, along with procedures that are institutionally anchored. We can learn a great deal from experiences that have been acquired in this area. For example, following the famines in the 1970s the FAO (Food and Agriculture Organisation of the United Nations) established early warning systems to prevent famine due to crop failures. Encouraging results were attained, such as the timely observation and control of growing locust populations. But a great deal also went wrong. Partly due to the layered, top-down structure of the communication, many warnings became lost in bureaucratic organisations.[43] Recent developments in information and communication technology have made it theoretically possible to create more refined systems, where information can be sent directly to many target groups, including farmers.

To reduce the effect of large and unpredictable fluctuations in the prices of grains or export crops, a stabilising price policy is required. This should not involve setting stringent maximum prices, which lead to illegal markets, corruption and bureaucracy, as well as elimination of incentives for investing in agriculture. The result is that the poor food buyers, for whom the measures were in fact intended, are ultimately worse off. However, maximum and minimum prices determined and monitored by trade policies can be beneficial if there is a sufficient margin within which the price formation is left to market mechanisms. That limits detrimental effects, while extreme fluctuations are reduced.[44]

If things go wrong despite all the provisions that have been taken, social safety nets are required. Traditional networks that can assure mutual help during crises are still important in many places, but their capacity is limited. Here as well, governments and private parties must make extra provisions. Employment projects (food/cash for work projects) have turned out to be an efficient way to protect the entitlements of those affected by large-scale disasters.[45] Supplementary support measures are then required for the needy who are unable to work. In addition, we believe that assistance given in the form of money to a country (e.g. triangular help) is preferable to food help provided in kind. The country in

43 Devereux (2001).
44 Dawe (1998).
45 United Nations (2001).

need which receives the monetary support can then purchase food in the region. This not only causes significantly less disturbance of the regional food market; it also stimulates regional agricultural development.

3.2 Integrated nutrition policy

Many factors determine what people eat and how they utilise the food physiologically. Examples of these are: an individual's health, education levels, family incomes, a person's position in the household and soil quality in the region (see Box 2.1). All these factors make nutrition a multidimensional topic. We therefore advocate an integrated nutrition policy at the national level that acknowledges both the social and physiological aspects of food and nutrition security. Such a nutrition policy should be the collective responsibility of all relevant sectors (agriculture, economics, education, health care, water and hygiene, and social affairs).

However, an inter-sectoral approach does not always enjoy broad support; such an approach is not even supported by all nutritionists. Consequently, it is rarely applied in practice. Improvements in nutritional status still have to be made with individuals trained in a mono-disciplinary fashion, with sectoral policy and with budgets that are organised in a sector-by-sector fashion. Generally speaking, the task of improving the nutritional status is assigned to a single ministry, usually the Ministry of Health. Within the health care sector, however, the emphasis lies on diseases, patients and medicine; a balanced diet as the 'best medicine' and the importance of choice behaviour at the household level are therefore given too little attention. To promote cooperation between sectors, governments should make the improvement of the nutritional status a national goal. After all, a Ministry of Agriculture that also strives for nutritional improvement has to take account not only of the productivity of crops but also of their nutritional value and their processing and preparation possibilities. In the same way, a Ministry of Economic Affairs which also strives for better nutritional status could perhaps cooperate with the Ministry of Health to strive for better working conditions, e.g. those that allow women to breast-feed their babies.

The current trend of using a sector-wide approach when organising development assistance can support a broader nutrition policy, but only within specific sectors. This is regrettable because it can obstruct a truly integrated approach. However, it is still unclear how governments can then give institutional shape to an integrated multi-sectoral nutritional policy. A national coordinating organisation, such as a National Nutrition Council, appears to be a good option if given an adequate mandate, financial means and capacity, but in practice there have been only a few successful examples of this approach. In Thailand, a multi-sectoral approach directed primarily from the health care sector appears to work. Perhaps we can learn from these experiences.

The fact that the United Nations has made 'reducing poverty and hunger' an international development objective is very promising.[46] As a result, the problem is defined also at the individual level, since an individual can have hunger in nutritional terms, but a country cannot. The application of anthropometry for measuring nutritional status as an indicator for poverty and hunger is a practical tool for evaluating the effectiveness of nutritional policy.

An integrated nutrition policy also means that interventions must be developed in a situation-specific manner in consultation with the parties concerned. After all, the causes of food insecurity and the possible solutions for this problem are different in every situation. This requires nutritionists to be open to a wide range of approaches, because an approach that is very successful in one situation can be a total failure in another. Multiple approaches must often be taken simultaneously (see Box 3.1).

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[46] United Nations (2001).

Box 3.1 The usefulness of genetically modified rice with pro-vitamin A

There has been a great deal of discussion about where governments should place their priorities when approaching deficiencies of micronutrients such as iodine, vitamin A and iron. Some nutritionists believe technical interventions are the best approach. These approaches include pills, drops or tablets, fortification of foods by the food industry, and having breeders increase micronutrient content of crops by means of genetic modification. Other nutritionists believe strongly in the food-based approach, which assumes that virtually all necessary nutrients and micronutrients can and must be acquired through proper nutrition. They believe this approach should be part of food security programmes, besides making improvements in sanitation and health care.

We believe that governments should make the choice for a specific strategy dependent on the problem and the target group. A food-based approach, including nutritional education, is a long-term solution that deserves full support. Quite often, however, a diet that is both qualitatively and quantitatively adequate cannot be achieved instantaneously, certainly not by the urban poor. In the short term, therefore, supplements or food fortification can improve the nutritional status of people, sometimes even through simple measures. But this approach is subject to a number of limitations; therefore it should not be relied on entirely. Supplements and fortification do not solve the problem of food energy shortfalls and deficiencies of macronutrients, such as proteins and specific fatty acids. In addition, if this approach is to have a chance of being successful, it must first meet a number of conditions. Repeated supplementation requires a good health care infrastructure, so that a large part of the target group can be reached. Food fortification requires that people actually consume the fortified food and that the food industries responsible for the fortification maintain a certain level of quality assurance. It has turned out to be difficult to satisfy both of these conditions, which has reduced the impact of supplementation and fortification programmes. However, some problems, such as iodine deficiency, can be solved exclusively with measures such as supplementation or fortification.

The development of crops with extra micronutrients is currently subject to a great deal of interest from scientists and the media, partly due to the recent development of genetically modified rice with beta-carotene (pro-vitamin A). We believe this approach is still premature. For large groups of consumers of certain cultivars, this approach may offer a solution, but a number of questions must still be answered, such as:

- What is the biological availability of the micronutrients in a diet that contains these crops, and how stable are the micronutrients during food processing and preparation? It is known, for example, that anti-nutritional factors hamper absorption and that a lack of fat in the diet can obstruct the absorption of carotene and its conversion into vitamin A.
- How do consumers respond to the taste, texture, appearance and processing and preparation properties that may have been altered by the genetic modification?
- A large target group must consume the genetically modified cultivar, partly to justify the development costs. But how feasible and desirable is it to apply this technology to the great diversity of cultivars that are adapted to local, marginal conditions?

Moreover, the same issues that affect the usefulness of food fortification also apply to these types of genetically modified crops: except for mother's milk during the first six months of life, no single food is complete in itself. It will always be necessary to strive for variation in the diet.

3.3 More public investments are required

Development in poor, vulnerable areas is hampered because there are few roads, no markets, and a shortage of education and expertise, not to mention major health problems. These are all areas in which governments should invest. But at the present time, public investments in infrastructural facilities are often extremely inadequate. Many developing countries invest hardly anything in their rural areas. The Structural Adjustment Programmes, which were implemented in the 1980s and 1990s under the direction of the World Bank and the IMF, have failed to improve the situation. These programmes emphasised a balanced macroeconomic policy. This was partly intended to stimulate agricultural development. But in many regions where development lagged behind, this was not successful, partly because the programmes did not foresee the required public investment in infrastructure. In fact, such programmes often led to a reduction of these investments because governments chose those regions to make the budget cutbacks that were forced on them. Agriculture was made even more difficult by lack of road maintenance, inadequate markets, insufficient good sowing seed, etc. A reversal of this trend is urgently needed.

Significant investments are therefore necessary in the building and maintenance of roads, communication systems, education, health care and agricultural research.[47] At the same time, these investments serve other aims. Good roads are necessary for transporting food in case of calamities; education and health care contribute to the nutritional status of vulnerable groups; and public works can serve as employment projects to protect the entitlements of vulnerable groups.

In addition, governments must invest in sustainable production systems. Conservation of soil fertility and biodiversity, anti-erosion measures, infrastructure for water facilities and reforestation cannot be left to private companies because such investments reduce short-term profitability. In the long term, however, they serve major common interests.

3.4 Tailor-made solutions for vulnerable areas

Sustainable intensification of agriculture in areas with difficult conditions for production (due to mountainous terrain, drought, infertile soils and/or poverty) requires a different agronomic approach than ecological intensification in areas that are more beneficial for agriculture. In the past, the emphasis for all areas was placed primarily on high yields. To grow specially bred, high-yielding crops, optimal care and mineral fertilisers, pesticides and irrigation are required. However, in vulnerable areas, high external input agriculture (HEIA) is difficult to implement due to the difficult production conditions. This has led to calls for production systems with low external inputs (low external input agriculture – LEIA).

We believe that LEIA systems can, at most, be a coping strategy. They help farmers to survive longer, but sustainable intensification on poor and degraded soils is impossible without providing external nutrients (especially mineral fertilisers). In cases where over-cropping takes place (to feed the growing population in the area), farm animals also provide inadequate amounts of manure. However, good prospects are offered by a proper integration of LEIA and HEIA approaches. In this combined approach, crops and soil management methods are developed that make higher yields possible with a moderate use of external inputs; at the same time, this approach reduces the risk of crop failure.[48] To achieve this goal, crops and technologies must be adapted as much as possible to local production conditions. This approach therefore requires that the techniques be customised to local conditions. A blanket recommendation, such as adding the macronutrients nitrogen, phosphorous and potassium (NPK) is

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47 Van Keulen and Kuyvenhoven (1997).
48 For integrated soil management, see Kauffman (1996).

inadequate for many types of soil that have a shortage of micronutrients. Adding small quantities of micronutrients in such cases enormously increases the effectiveness of the macronutrients.[49]

However, the need for locally customised techniques has far-reaching consequences for the agricultural knowledge system. The green revolution was based on central institutes that developed a limited number of high yielding varieties with accompanying input packages, which were then distributed to the farmers by extensionists. Such an approach is inadequate for locally customised operations. Instead, close cooperation is required between farmers with local expertise and experts with knowledge of advanced techniques. Information and communication technology (ICT) can benefit the communication between both parties. ICT can also support data analysis and, if a village has access to computers, make possible the local use of centralised databases. Together with biotechnology, ICT can increase the effectiveness and rate of crop improvement (see Box 3.2), making the development of local-specific varieties financially feasible.[50] Genetic modification must be used very carefully due to its potential risks, but this technology must not be excluded beforehand (see Box 3.3).

We see a role for the internationally operating research institutes in the development of the above instruments; this requires reformation of the existing international agricultural research network. And it will not be easy to reshape the expertise system in such a way that delivering customised work actually becomes common. After all, this requires farmers and experts to work together intensively over the long term. It requires long-term contractual relationships, such as those within agro-industrial chains and those between farmers, government services, non-governmental organisations and private parties. However, the trend towards complete commercialisation and privatisation of government services for agricultural research and extension does not benefit this process.[51]

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49 Voortman *et al.* (1999).
50 Bindraban (1997). Podlich and Cooper (1998). Yin *et al.* (1999a,b, 2000).
51 Cf. Leeuwis (2000).

Box 3.2 Molecular technology and ICT can make conventional plant breeding more efficient

Crop breeding has always played a vital role in agriculture. But breeding was, and still is, a time-consuming activity where breeders should visually screen large numbers of offspring for the desired characteristics. The chance of success is remarkably low: the average breeding programme lasts 10 to 15 years. This is one of the most important reasons that efforts until now have focused primarily on a limited number of highly productive varieties, usually cereals. However, these highly productive varieties require favourable production conditions, such as sufficient water, fertilisers and crop protection. This is also a reason why they cannot be used in marginal areas, where the environment is difficult to modify to the needs of these varieties. These marginal areas have therefore hardly benefited from modern crop breeding. The slow breeding process does not lend itself to developing varieties that are adapted to specific local conditions. Indeed, modifying varieties to all the various conditions means that an equal number of different, location-specific varieties are required.

The breeding process can now be shortened by several years with the help of information technology and molecular technology. Calculation models can be used beforehand to determine the chance of obtaining offspring with the desired characteristics when starting with specific parents. This can be done by estimating the complex numerical process of inheritability in accordance with the laws of Mendel. In addition, there are molecular breeding technologies, such as marker assisted breeding. In marker technology, the genes that are involved with the desired property are given a molecular label. These labelled genes can then be tracked using molecular technology to determine whether they are present in the offspring. In this way, breeders can determine which of the offspring have the desired genes at an early stage of development, thereby saving a great deal of time.

ICT and marker technology not only accelerate the breeding process, they also increase the potential for selecting and breeding plants with properties that are based on multiple genes instead of those based on a single gene. These are in fact the properties that are the most interesting in marginal areas, such as drought resistance and partial disease resistance (which means that crops are not 100% resistant, but are resistant to a broad range of pests and diseases).

Marker technology and ICT can also support on-farm breeding, a form of participatory breeding which is outstandingly suited for marginal areas. In this system, farmers do not receive ready-to-use varieties from research institutes. Instead, breeders from the research institutes support the breeding and selection process carried out by the farmers themselves. Experiments are taking place with this type of breeding at a number of locations around the world. The advantage of on-farm breeding, supported by ICT and marker technology, is that the varieties are then location specific, and better use can be made of the locally available, farmer varieties, which leads in turn to more agro-biodiversity in the field.

Marker technology therefore does not involve the 'artificial' transmission of genes in the laboratory, which is the case in genetic modification. But at the same time, a warning is appropriate. Marker technology and ICT are expensive. Therefore, as with genetic modification, there is a danger that the applications will remain limited to products for prosperous consumers, such as *nutraceuticals* (crops with a higher nutritional value) and *pharmaceuticals* (crops from which medicines can be extracted).

Box 3.3 Genetic modification is also useful for marginal areas

Genetic modification (GM) is an advanced technology in which biotechnologists working in laboratories insert genes directly into the DNA of a plant, animal or microorganism. The GM crops that are now on the market, developed in the 1980s, contain only one or a up to a few inserted genes, often bacterial genes. In this way, simple properties of a number of important trade crops have been modified, such as resistance to a specific viral disease, a single insect, a single herbicide or a single toxic substance (such as aluminium). The advantages and disadvantages of these first generation GM crops for the environment is still under debate. However, it already appears clear that most of these varieties are not particularly interesting for small farmers in marginal areas because they do not have appropriate characteristics.

The marginal areas in developing countries actually require varieties in which genetically complex properties have been modified. An important property of this type is drought resistance, which tends to maintain production under adverse conditions, rather than increase it under beneficial conditions. Drought resistance is determined by a complex of multiple genes. The genes that are involved in the response to drought depend on location-specific conditions, such as the nature and severity of the stress and the development phase of the plant itself. For example, if grain is affected by drought during flowering, fewer seeds are produced. But this is partially compensated for by the fact that proportionally more nutrients are transported from the leaves to the seeds, so that these seeds become heavier. In nearby regions, drought may occur while the seeds are filling out. If this happens, leaves make insufficient sugars to properly fill the seeds, but the plant also has a compensation mechanism for this: it then begins to use the reserves in the stem. From the above it can be deduced that crops have various mechanisms for dealing with stress. During the various processes that take place at various times, various genes are also involved.

Laboratories throughout the world are now involved with unravelling the complex ways in which plants respond to drought. When more clarity emerges about this topic, it may indeed be possible to use genetic modification so that the plant is better able to deal with drought. A great deal of research is still required, but it may turn out that enormous improvements can be achieved in this way, improvements that may actually benefit vulnerable areas[52].

The public sector will have an important role in this process by providing access to the necessary biotechnology. In fact, the biggest risks are due to the reluctance of governments to make public investments as prompted by public opinion. The private sector will continue to invest in biotechnology. At a certain point, the public sector will fall so far behind that it will not be able to catch up. This is partly due to the fact that knowledge is protected by intellectual property rights. Even more problematic is the fact that inadequate public investment in both technological development and well-informed social debate leads to a lack of powerful, effective and adequate legislation, despite the great need for such legislation.

It is also unlikely that the private sector will make substantial investments to help solve problems in countries and regions with inadequate financial means. The fact that so many private laboratories are now focusing on nutraceuticals and pharmaceuticals confirms this scenario. In addition, this concentration of capital can lead to a concentration of power regarding the application of biotechnology within the private sector. The potential consequence could be genetic erosion (even fewer crop varieties in the world).
We believe genetic modification can contribute to food security as long as the technology is also applied to develop location- specific varieties and if it becomes part of a broader package of measures to insure food security. A watchful eye must be kept on the potential risks of this technology, many of which are still unknown, but this must not prevent the development of and investment in many promising applications.

52 De Vries, J. and G. Toeniessen, (2001).

3.5 Rural diversification

We define the term 'rural diversification' as diversification in agriculture (multiple types of animals and crops, multiple varieties) and the development of non-agricultural rural activities. This leads initially to spreading of risks: it limits the risk that calamities or other disturbances will lead to extensive destruction of the systems of entitlements of the local communities. In addition, diversification makes the local food provision system in agriculture less vulnerable to failure or crop destruction. Local food processing – also a form of diversification – is important to reduce the risk of loss due to spoilage or damage by insects. After all, preservation makes it easier to store and transport food, while maintaining its quality, especially food for supplying urban areas. In addition, diversification in the form of small-scale crafts and trade activities also results in additional income to supplement farming income. Such forms of diversification play an important role in the livelihood strategies of agricultural households and provide an opportunity to make a living for households that cannot find any employment in agriculture.[53] This broadens the foundation for rural development. Finally, rural diversification can contribute to a sustainable intensification of agriculture. It makes it easier to invest in agriculture because it provides more resilience and extra income for agricultural households. Moreover, small-scale crafts and trade activities can help create new markets and credit possibilities for local agriculture.

Many – although not all – rural crafts and trade activities can be conducted efficiently in a small-scale fashion. This is certainly true in a context where social capital is not fully developed and the quality of the government is inadequate; in such cases, large-scale implementation frequently leads to high transaction costs. Small-scale activities are therefore important to initiate a dynamic that can lead to economies of scale in a later phase. Removing obstacles to these activities and supporting them by means of credit facilities, training, etc., can contribute in an important way to the above aims.

3.6 Poverty alleviation and redistribution

Even the most vulnerable households and individuals must acquire access to public infrastructural facilities such as education, health care, roads and clean water. And governmental support must also focus on crops, technologies and facilities that link up with the needs of small farmers, landless households and women. The existing livelihood strategies of vulnerable groups must be supported with small-scale credit facilities, focused technological assistance, and so forth. Special safety nets are required for individuals in need who cannot work and are insufficiently supported by informal networks.

Land reform is frequently required to strengthen the position of small farmers. However, land reform only benefits small farmers if it is based on the negotiated and/or compensated redistribution of rights concerning the use of resources. This concerns not only property rights; other access rights such as that of gleaning fields can also be important. In addition, land reform must benefit individuals who have access to the human capital to develop their farms and not the urban poor or beneficiaries of political parties, for whom this is not the case. Moreover, land reform alone is never enough. Technical assistance, credit, supply, marketing, etc., are required to support the new farmers.[54]

If poverty alleviation policy is to succeed, then the participation of local and vulnerable groups is required. To achieve this, well-informed social organisations must be established that can critically support the poverty alleviation policy. For effective empowerment, they may require help from foreign partners. This empowerment demands a number of political and social preconditions, such as freedom of organisation and expression via the media, and investments in education for both women and men.

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53 Janvry and Sadoulet (2000).
54 Janvry and Sadoulet (2000).

3.7 Effective food chains

For capital-intensive trade, processing and credit activities, large companies are essential. In many developing countries after de-colonisation, such companies became government-owned or semi-government-owned, but often turned out to be inefficient. In recent years, governments have therefore privatised these businesses and have liberalised markets. Unfortunately, this often has not lead to the desired results. Due to thin markets (and/or political favours), privatisation has sometimes led to private monopolies and sometimes the activities disappeared entirely because they were unprofitable. In such situations, other solutions are required to achieve effective food chains. One possibility is to support food chains by means of farmer cooperatives. In many developed countries, such cooperatives have broken through monopolistic situations or developed activities that have excessively high transaction costs for private investors. Another possibility is public–private cooperation, where the government makes it more attractive for private parties to invest in vulnerable regions.

Good coordination within the food chain cannot always be achieved through unregulated market transactions. With traditional export crops such as cotton, coffee and cacao, far-reaching forms of vertical coordination have existed for years. In this type of coordination, the companies who purchase the products also supply input packages, credit and extension services to the farmers; in exchange, the farmers follow the guidelines of these companies. Recently, supermarket chains and the food industry have also begun placing special requirements on the cultivation process. This is due to the increased quality competition and the phytosanitary and food safety norms of importing countries. One advantage of this development is that the agribusinesses that buy the products develop an efficient knowledge and communication infrastructure that benefits production. One side effect is that these agribusinesses also increase their dominance over the growers. To provide sufficient counterweight, it is therefore desirable that the growers organise themselves.

An effectively organised market sector can also be developed locally on a small scale. Processing companies close to the farmers offer many advantages to the region. The fact that the raw products are processed, treated, stored, transported and marketed locally can lead to a significant reduction in postharvest losses and to a less perishable, more readily available, more diverse and safer food package during the entire year in the region itself. The added value of processed products generates extra income for processors and traders in the region, and the higher sales prices can stimulate agricultural production. Moreover, locally processed products can eliminate the need to import these products.

Box 3.4 Max Havelaar bananas and eco-products[55]

Many poor regions have an urgent need for markets for their products. The process of globalisation appears to have made it easier to sell products to foreign companies. After all, the demand of prosperous consumers for luxury goods such as exotic fruit, flowers and vegetables is still growing. Developing countries can take advantage of this trend and increase the high added value of such luxury products even more by satisfying the increasing concerns in the first world about environmental and social aspects, such as the occupational conditions of labourers. Regions can also take advantage of the demand for 'fair produced and traded products' such as *Max Havelaar* bananas. The international demands that are placed on the production and trade of such high-quality endorsed products clearly offer development possibilities in the long term. In addition, they can take advantage of the demand for products from organic agriculture. For small farmers who are already farming extensively, the shift to organic production is often easier than for farmers who produce in an intensive fashion.

But we must also sound a cautionary note. In their enthusiasm to take advantage of new opportunities, farmers in developing countries sometimes overestimate the magnitude of the two 'solidarity' markets just mentioned. These are still relatively small niche-markets that are growing quite slowly. However, we don't mean to imply that 'idealistic' products and products from organic agriculture are taking a marginal position in the market. Idealistic food chains have played an important, catalysing role. *Max Havelaar* was the first to create a demand for 'honest' products from small farmers; with increasing demand, it can be taken over by supermarket chains and multinationals in the food industry. However, this creates a new problem. Large buyers want to have guaranteed availability and quality. Small farmers find it difficult to meet these high demands due to, among other reasons, logistic problems. Therefore, the large supermarket chains frequently negotiate with wealthy, big farmers. This can increase social inequality between farmers, where a few farmers will expand and thrive while others have to look for alternative sources of income. But at the same time, this development can launch general economic development in the region.

3.8 Better prices for agricultural products

Sustainable intensification of agricultural requires price relationships that allow farmers to invest in soil and water conservation and in soil fertility. At the present time, crop prices at farm gate in developing countries are often so low in relation to the costs, that farmers are virtually unable to invest. These low prices are partly due to domestic factors such as high transport costs, taxes on export crops, and inefficient market structures. But they are also due to the excessive supply of agricultural products on the world market. Western countries respond to this oversupply by protectionism that not only supports their domestic farm incomes, but also leads to substitution of domestic products for imports and expansion of exports, causing international agricultural prices to fall even lower. In contrast, agriculture is not protected in many developing countries, so that domestic agricultural prices are under pressure from the low world market prices.

We think that Western countries should no longer distort the international agricultural markets because this prevents a sustainable agricultural intensification in developing countries. Developing countries must be given better access to Western agricultural markets. At the present time, this access is even more restricted due to increasing demands on food safety, animal welfare and the environment. It is inevitable that consumers make increasing demands as their income rises. But one must be on guard against the

[55] Bindraban, P.S. (2000).

illegitimate use of such arguments to benefit rent-seeking aims of agribusinesses in developed countries.[56]

Even though the World Trade Organisation (WTO) is striving for market liberalisation, it can sometimes be desirable for developing countries to establish protective import duties on agricultural products. Such duties are justified if they are necessary for agricultural development to benefit a large part of the poor population that would be threatened by food insecurity without this development. Regional customs unions can play a role in this process. To attain sustainable agricultural development in developing countries, protective import duties can even be more important than access to Western markets. For most developing countries, the domestic market for agricultural products is much larger than the export market. This makes domestic price relationships crucially important. Protective import duties have a positive effect on domestic agricultural prices. However, the level of protective duties must be carefully dosed. It must be high enough to encourage investment in a sustainable intensification of agriculture, but not so high that it weakens stimuli for innovation.

The above is not an argument in favour of a general attempt to attain regional self-sufficiency in food. Quite the contrary. International trade will become more and more important for global food security. In fact, the greatest increase in the demand for food will occur in regions such as eastern Asia, where the biophysical potential for increasing agricultural production is limited. Without increased food imports, it would be difficult for this region to supply the increased demand in a sustainable fashion. On the other hand, there are other regions, such as North and South America, where the potential for food production is much larger than the expected demand, so that production expansion at significantly lower costs is possible. International trade makes it possible to benefit from these cost advantages. However, 'trade' is not the same as 'free trade'. In Asian countries such as South Korea and Taiwan, agricultural development may have functioned as a starting motor for general development. To make this agricultural development possible, these countries initiated support measures, such as focused subsidies, credit possibilities, technical input packages, marketing possibilities and trade limitations. Increasing food imports are no longer a problem in these countries because industrial exports provide sufficient foreign exchange to pay for the imports. But this is an entirely different situation than that in many African countries, which do not protect their own agriculture. These countries have sufficient biophysical potential to feed their own population, but they are still becoming more and more dependent on food imports. It is increasingly difficult for them to pay for these imports because they are caught in a vicious downward spiral of poverty, soil degradation and general stagnation. In this situation it would appear to be preferable for those countries to protect their own agriculture. Such protection is even more justifiable when international markets are distorted by agricultural policies of developed countries. The reforms taking place in international trade politics must therefore allow enough space for import duties on agricultural products in developing countries, and for these duties to be applied for a longer period. Because it is only when farmers are able to maintain sustainable soil management for a number of years that the organic matter content and the productivity of the soil begin to recover.[57]

3.9 Ecological intensification in regions that are favourable to agriculture

In the decades to come, the global demand for food will continue to increase greatly. The biophysical potential of the Earth is great enough to satisfy this expected increase in demand. But this does not say very much about the production that will actually be attained. In contrast with the period before the green revolution, little suitable land is left that can still be taken into production. Moreover, the expansion of production areas is limited by the growing claims on land and water from urban construction, industry

[56] Otsuki, T., J.S. Wilson and M. Sewadeh, (2001).
[57] Breman (1997). Koning *et al.* (1997).

and nature conservation. In addition, growth in productivity in many regions is limited by poverty, infrastructure neglect or by environmental pollution and soil degradation. The essential growth of supply must therefore be attained primarily from an increased production per unit of area in regions where this is possible.

The modified approach to marginal, vulnerable regions that we have argued for above (Section 4.4) is not enough to result in the necessary increase in production. This approach serves primarily to strengthen entitlements and will provide a limited contribution to the necessary growth in volume of global agricultural production. In addition, a significant increase in production per unit of area is required in regions were production conditions are beneficial and can easily be controlled.

At the present time, various approaches are being taken to attain more sustainable agriculture in precisely those areas that are beneficial for agriculture. In developed countries, organic farming is a small, but growing, sector. Because organic farming does not use pesticides and mineral fertilisers, it does not burden the environment in this regard. However, it must be noted that the production per unit of area is usually lower in organic farming and that without adequate 'organic' fertilisation, the soil becomes exhausted. In addition to the organic approach, there is a more recent approach known as precision agriculture. This encompasses a broad range of measures and technologies with the aim of increasing the efficiency with which inputs such as fertiliser (organic or mineral), water and pesticides are used. This approach involves precision regulation applied at various levels. These range from nutrient application that is more precisely attuned to the demands of crops, to the detailed harmonisation of various farm processes.[58] These forms of ecological intensification result in a reduction of environmental load while maintaining or even substantially increasing the level of production.

Besides such precision controls, other technological leaps are also required if we are to continue to supply the growing needs of human beings in a sustainable fashion. Such technological advances include new, innovative solutions that greatly improve the conversion and utilisation efficiencies of light, CO_2, water and nutrients, or the use of entirely new crops and animals. In addition, it may be possible to exploit the ocean and to make drastic changes in traditional crop systems such as irrigated rice production (see Box 3.5). New technologies such as ICT, biotechnology, nanotechnology and molecular technologies are essential instruments for attaining such technological leaps.

A precondition for the adoption of all technologies is that they are profitable with at most a limited increase in international food prices. In view of the high or increasing cost of labour in regions that are suitable for such ecological intensification, this means that these new technologies must make thrifty use of labour. Otherwise they will only be implemented if there is a drastic increase in international food prices. Due to the problems this would cause in food-importing poor countries, such drastic price increases must be avoided.

[58] Aarts (2000).

Box 3.5 Highly productive and environmentally benign

It is often assumed that extensive cultivation is more sustainable than intensive cultivation. But intensive, highly productive cropping systems can be equally, or even more, sustainable than extensive ones. Here are two examples of such systems:

1. Conversion to an environmentally sound, highly productive dairy farming system

Dairy farms in the Netherlands are very intensive and highly productive, producing more than 8000 litres of milk per cow per year, but they are not very environmentally sound. There is a serious imbalance between the input of nutrients to the farm in the form of mineral fertilisers, roughage and concentrate, and the output of nutrients in the form of milk and meat. This surplus in nutrients is stored in the soil, leaches to groundwater and surface water or becomes airborne, which leads to a serious load on natural habitats and the environment.

This led Wageningen University and Research Centre to initiate a search for possibilities to make intensive animal husbandry more environmentally friendly. This process began with model analyses where a prototype of a farm was developed that satisfied the economic and ecological aims and also more stringent farming legislation. This prototype dairy farm has been implemented as an experimental farm: *De Marke*. This farm is now being used for monitoring, modifications and further development. Moreover, the experimental farm is a source of discussion for the many farmers who visit it. The basic principle is that by maintaining the best possible harmonisation of nutrient flows within the farm, the nutrient surplus can be drastically reduced. For example, fertiliser is applied on the farm at the instant the crops actually need it. This requires temporary, emission-poor manure storage. It turns out that fine-tuning requires significant modifications to the farm system, but the experimental farm does show that it is possible to develop a highly productive dairy farming system that is both economically feasible and ecologically sound. The findings from the experimental farm are currently being applied on commercial dairy farms in the Netherlands.

2. Conversion to highly productive dry rice cultivation[59]

For the past 4000-5000 years, rice has been grown under so-called inundated conditions. This means that 5 to 15 cm of water covers the field in which 3- to 4-week-old seedlings are transplanted by hand. This extensive, 'wet' rice cultivation system has a large number of agro-economic advantages. For example, weed pressure is greatly reduced because rice is capable of transporting oxygen from the air to its roots, which weeds cannot. The water layer makes it easier to work the soil and serves as temporary water storage in monsoon climates. In addition, the water saturation of the soil has a beneficial effect on the availability of soil nutrients and promotes the growth of the nitrogen-fixing *Azolla* fern. In some soils, the water layer also prevents the occurrence of excessively acid and toxic soils. With this production system, characterised by a high water requirement and high labour inputs, rice production can be maintained at a low level of 1 to 2 tonnes per hectare in a biophysically sustainable fashion. Much higher yields can be attained with external input of fertilisers, biocides etc.

In recent decades, however, developments have taken place that have made it necessary to reconsider wet rice cultivation. The increasing demand for labour outside the farm makes it necessary to sow rice directly instead of using time-consuming manual transplanting. Increasing demand also requires higher rice yields and the production of multiple, sequential crops. However, wet rice cultivation creates soil conditions that are not beneficial for the production of non-rice crops. Finally, there is an increasing demand for water from other sectors, leading to a decreasing and uncertain availability of water for rice cultivation.

[59] Hengsdijk and Bindraban (2001).

At the same time, new technologies have been developed that eliminate the agricultural arguments in favour of inundated cultivation. For example, weed and disease pressure can be controlled by means of integrated crop protection methods, the nutrient requirement can be met by using mineral fertilisers and the water supply can be adapted to the needs of the crop by using integrated and participatory irrigation management. This does not mean that we advocate the replacement of wet rice cultivation everywhere by the more productive dry rice cultivation system. Inundated rice cultivation is an integral part of societies comprising hundreds of millions of people, many of them very poor. It offers a solid and reliable source of basic food; one should therefore be very cautious about disturbing such a system. When modifying the cultivation system, one must in any case make sure that specific groups do not enter a negative downward spiral of poverty. Sometimes such groups must be supported by means of supplementary social-economic measures. However, the changing factors in the surroundings make conversion unavoidable.

3.10 International precautionary policy to assure long-term global food availability

Box 2.2 contains a worst case scenario for the global food situation in the long term: international neglect of agriculture could lead to a temporary, rapid increase in food prices. This scenario is hypothetical, but in view of the complex dynamic of the global food economy, it is not less valid than the projections of existing model studies. As long as the future is too uncertain to exclude such scenarios, a policy is required that can prevent them. Such a precautionary policy must lead to sufficient global capacity for food production to avoid potential scarcity. This does not mean that the actual production must be greater than the demand, but it does mean that it must be possible to increase the production rapidly enough if the international market requires this. A precondition for this is that governments invest in key developments with a long ripening period, and that they prevent large-scale disinvestment. In many areas, large investments in sustainable soil management are required to restore the quality of agricultural lands. A large-scale, perhaps irreversible, destruction of global soil capital through soil degradation (especially in developing countries) or conversion of farm land to other uses (particularly in developed countries) must be avoided. Sufficient human capital must remain in agriculture to increase food production if necessary, and investments are required in technologies for ecological intensification.

The problem is that the international market situation in the short term does not encourage the above measures. The current overproduction and resulting low prices promote the careless use of agricultural lands and human capital in agriculture. Priority in research funding is now being placed on high value-added products and ecological agriculture without increased production, rather than on technologies for ecological intensification. This is precisely the 'cobweb' reaction that has been described in Box 2.2. Governments must therefore be on guard that a decrease in agricultural income support does not lead to an amplification of this cobweb reaction.[60]

[60] It can no longer be assumed that the effect of a radical reduction of the agricultural income support in these developed countries will be compensated by an increase of world market prices and therefore lead to price improvements in countries that do not protect their agriculture. If a decrease in the income support in the US and the EU occurs simultaneously with a reduction of production quota, the price improvements will be limited. Moreover, a reduction of income support can have negative consequences for agricultural research in developed countries, resulting in reduced spin-off from such research to developing countries. As part of a precautionary policy, it therefore appears desirable to not reduce agricultural income support too radically.

Box 3.6 How can we secure the long-term, global availability of food while preventing overproduction and dumping?

International precautionary policy concerning the long-term global availability of food leads to a difficult trade-off. To reduce the risk of rapid price increases in the future, it is desirable to achieve sufficient reserves in agricultural lands, technological possibilities and human capital. But once these reserves are available, commercial firms will attempt to use these reserves to attain increased turnover in the short term. This would amplify global overproduction and promote overt or hidden forms of dumping. This dilemma can only be solved by linking a precautionary policy to effective control of production. In the decades before the Uruguay Round, international trade agreements aimed at a comparable goal. The idea was to make multilateral agreements on a product-by-product basis concerning production and trade volumes, and prices on the world market. However, these agreements were unable to withstand the rent-seeking behaviour of businesses who wanted to increase their turnover, the 'prisoner's dilemma' of countries who believed that other countries would use the agreements to increase their own market share, and the contrasts between old and new production countries. To solve these problems, international arrangements with a limited number of clear rules are required. The Uruguay Round Accord is an example of such a clear arrangement. But this accord must be modified to counteract export expansion, increase market access for developing countries and still be able to support agricultural production capacity where needed.
A possible arrangement is the following. All countries are given the right to support their agricultural producers. For developing countries, this right is unlimited. For developed countries, however, there are a number of limitations:

- Developed countries may no longer apply a number of trade policy instruments such as export subsidies and variable import duties because these excessively distort trade (for developing countries, export subsidies are virtually unfeasible, while variable import duties are necessary to protect access to food for the poor).
- Developed countries are required to give preferential access to agricultural imports from the least developed countries.
- Every increase in the level of self-supply regarding agricultural products from developed countries that support their agricultural sectors is taxed with an international food security duty. This duty must be paid to a global food security organisation and is used to promote agricultural development and food security in developing countries. The level of the duty is based on the volume of the extra agricultural production resulting in an increase in the degree of self-supply of a country, multiplied by the amount of the support the country gives to its agricultural sector, multiplied by a uniform duty ratio. This duty ratio is periodically modified in such a way that world market prices remain in between a desired maximum and minimum level. When determining the level of support, all forms of support are counted, including 'de-linked' income supplements, compensations for animal welfare measures, and government facilities for agro-industrial research.

By means of such an arrangement, a precautionary long-term policy, a balanced organisation of world markets and new impulses for the improvement of food security in developing countries can be simultaneously achieved without unnecessarily restricting the room of individual countries for setting policy.

4. Remarks about recent trends

Goals and strategies are not enough. It is also important to ascertain trends that make it more difficult to achieve these goals. In this chapter we will describe three trends that should be analysed regarding their consequences for food security: privatisation of agricultural research, liberalisation of the world market, and multifunctional agriculture.

4.1 Privatisation of agricultural research

The first worrisome trend is that government investment in agricultural research has been decreasing for the past years. As a result, agricultural research institutions more frequently decide to conduct research in which the private sector is interested. We are especially concerned about the reduction of international donor support in (and for) developing countries. After all, it is unlikely that private companies will invest a great deal of money in research that is relevant to food security. Indeed, the development of location-specific crops and technologies adapted to vulnerable areas is usually not very profitable. Nor does the market encourage technological leaps in the production ecology of regions that are more beneficial to agriculture. Private companies are therefore not very interested in these topics. They prefer to devote their efforts to reducing their production costs and to improve the health, safety and taste aspects of food for prosperous consumers. This means that public investments remain essential for innovations in food security.

The second worrisome trend is the expansion of patents on biological products and processes. Such private property rights may hamper public research into food security, e.g. biotechnological research for the improvement of food crops that are important in vulnerable areas. Moreover, patents can obstruct the use of new inputs, such as sowing seed, by farmers, and they can strengthen oligopolistic practices of seed companies and other suppliers. International regulation is required to prevent this.

4.2 Liberalisation of the world market

The World Trade Organisation (WTO) promotes the further liberalisation of world trade. During the Uruguay Round, some progress was indeed made in counteracting trade distortions. The limits the accord placed on the direct subsidisation of agricultural exports are especially important to global food security. However, the problem is that countries can still support their farmers with direct allowances (income supplements). But only highly developed countries, where agriculture comprises a small part of the economy of the professional population, can afford such allowances. By replacing price supports with direct allowances and at the same time reducing limits on production, the US and the EU can continue to expand their exports, even though world market prices are below their costs of production. In contrast, a number of other countries, including developing countries in Asia, have been forced by the current accord to reduce the protection of their own farmers against cheap imports.

We have argued in favour of sustainable intensification of agriculture in vulnerable areas, rural development with a sufficiently broad social basis, and policies that assure global food availability over the long term. For developing countries that are affected by vicious downward spirals of agricultural involution and general stagnation, it is important in this regard that they are allowed to establish protective import duties on agricultural products so that their farmers get possibilities for investment (see Section 3.8). However, it is unclear how much room developing countries will be given to do this. Besides, attempts to mobilise support in developing countries for reforms proposed by various groups from developed countries are questionable. This concerns the liberalisation programme of the Cairns Group (which does not acknowledge the importance of developing countries being able to provide a certain amount of protection to their own agriculture), the 'decoupled allowances supplements' that are promoted by the US (which also lead to concealed dumping), and the protection of 'multifunctional

agriculture' that is desired by the EU (see Section 5.3). Developing countries must be more assertive about moving the GATT/WTO reform process in a direction that is also desirable to them. International institutions that want to support developing countries should encourage independent reflection in these countries.

4.3 Multifunctional agriculture and land use

Various governments and organisations, including the FAO and the EU, are striving for 'multifunctional agriculture and land use'. This concerns the combination of various functions in rural areas, such as the production of high quality food, recreation and natural habitats. An important aim of multifunctional agriculture is to establish a vital countryside in areas where 'production agriculture' is decreasing[61]. In addition, this concept is taking a strategic role in the international negotiations about agricultural trade policies within GATT/WTO. The desire to promote multifunctional agriculture gives the EU (and countries such as Norway, Switzerland, Japan and South Korea) an argument to continue to support their agriculture. Besides establishing a vital countryside, this support can also lead to the export of agricultural products below the cost of production. This concept is therefore rejected by countries that aim for a far-reaching 'liberalisation' of agricultural trade policy (e.g. US, Cairns Group). Due to its political-strategic implications, multifunctional agriculture should be treated cautiously when applied to issues involving food security. Policy makers should avoid using the food problem in developing countries for furthering trade policy aims of developed countries (including the EU). Careful consideration leads to the insight that multifunctional agriculture offers both opportunities and risks for global food security.

The opportunities lie primarily in areas where multifunctionality leads to increased income possibilities for the rural population. Activities such as ecological or traditional production, rural crafts, tourism services and nature management make it possible for the rural populace (certainly for the short term) to earn an income that is not based on the production of staple foods. This can contribute to a form of rural development with a sufficiently broad basis. Developing countries can benefit from these types of land use by exploiting niche markets, by quality trademarks, by co-management of natural areas and so forth. Such activities may sometimes also play a catalysing role for further development. At the same time, the potential of these approaches must not be overestimated. The market niches for traditional, ecological or 'idealistic' products are growing, but they are still limited.

Besides providing opportunities for global food security, multifunctionality also entails a number of risks. To begin with, this concerns specific forms of multifunctional agriculture in developing countries that become established in response to demands from the West, such as wildlife parks for western tourists or nature protectionists, or joint implementation projects where Western countries can meet their Kyoto obligations by establishing CO_2 sinks in poor countries. Both developments can hamper sustainable intensification of agriculture in vulnerable, marginal areas. In areas which have virtually no agricultural potential, converting land into wildlife parks or CO_2 sinks is not a serious problem, but many wildlife parks and CO_2 sinks are being established in areas that do have some agricultural potential and where the population pressure is increasing. This can have negative effects on local food security, certainly when, as is often the case, the population is poorly paid for the services they provide. Therefore, adequate and fair compensation is required. Monetary compensation should not be paid to governments on a one-time basis, but should be continuous and should benefit the local population. Such forms of agriculture and land use require a great deal of negotiation, committed agreements, strong institutional support and a high degree of mutual trust. When agreements are not complied with, the poorest groups suffer the most. The interests of nature conservation in developing countries must therefore be carefully weighed against the importance of economic development and food security of the local population. This process must not be thrown out of balance by the dominant influence of movements and organisations in developed countries.

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[61] Potter, C. and J. Burney, (2002).

5. Bringing the problem closer to home

Attention at Wageningen UR for complex international issues, such as food security, is fading. This appears to be a logical consequence of the previously discussed national and international trends and developments, including privatisation of research. Nevertheless, it remains very important in strategic terms for Wageningen UR to continue to make structural investments in such societal issues. We also believe there are possibilities for making such investments.

5.1 Part of the globalisation process

In the Netherlands, we are confronted with international matters on a daily basis. These range from international agreements concerning free trade and immigration, to exotic Brazilian mangoes and Indonesian dishes. The globalisation process is increasingly affecting the lives of Western citizens and consumers. But our actions in the West are also having an increasingly direct effect on development possibilities in the Third World.

As an international research and education institution, Wageningen UR is part of the globalising world. This world is undergoing tempestuous changes resulting from revolutionary technological developments, an increasing interdependence among countries, and the increasing influence of civil society. To assure its continued existence, Wageningen UR must find ways to link up with these developments. During this process it cannot escape from specific international trends, trends that may indeed make it more difficult for Wageningen UR to offer solutions for the world food problem.

The shift from public research to private research is also very apparent at Wageningen UR. This is shown by the higher priority that is being given to the life sciences in the broadest sense and to the development of functional foods for wealthy consumers, while at the same time education that is relevant to development issues is being eliminated. This is understandable because Wageningen is required to orient itself more strongly than before towards parties that can offer financial support. But as we strive to build a healthy, market-oriented organisation, the short-term survival urge can weaken our focus on investments that bear fruit over the long term. This can lead to the neglect of education and research that benefit the world food problem.

This is particularly regrettable because Wageningen UR is in fact very well equipped to address the world food problem. Its mission is “to use scientific research and education to help people acquire sufficient, healthy food in a vital world. It thereby focuses on responsible production and distribution of sufficient, high quality agricultural products, the careful management of soil, water and atmosphere, and the harmonious utilisation of the various functions of the rural area. While maintaining its link with agricultural society in the Netherlands, Wageningen UR is developing into an organisation with a strong, international orientation.”

This mission statement indicates that Wageningen UR can provide a valuable contribution to solving the world food problem. However, we believe it is necessary to place more emphasis on increasing the access of poor people to food as a stimulus for economic development, and on a more humane distribution of prosperity. Wageningen UR must assume a strong and active role in international discussions to make sure these goals are made explicit on the international agenda. In this way it can influence governments, the business community and civil society, and at the same time it can also allow itself to be steered by these same institutions. To achieve this, we must use our excellent international reputation in a strategic fashion. At the same time, it is essential that this role is acknowledged and supported within Wageningen UR.

5.2 Market for complex questions

Those outside of Wageningen UR have also noticed that our organisation is moving away from the poverty issue. This movement accommodates the current, market-oriented trend, but contrasts sharply with the growing social awareness of many private businesses. Such companies invest consciously in projects that strive to reduce social disadvantage, develop ecologically sustainable forms of production and stop development in areas with valuable natural habitats. Although these actions are ultimately based on the companies' own self-interest, the tendency to transform short-term overexploitation (which threatens their own existence) into a long-term strategy is encouraging.

Despite the current trends, development-oriented research and education must still be financed primarily by public means, especially means from developed societies. The fact that public investment in this area is declining is very alarming. However, Wageningen UR does not have to submit to this trend. It can undertake activities where its potential clients – governmental agencies, international organisations or private companies – are well informed about their crucial importance. In this way, it would be simple to formulate a number of issues where Wageningen UR can provide a scientific contribution. For example, to what extent does trade liberalisation benefit the development of the poorest countries, and should these countries actually protect their economies (which are primarily based on agriculture)? Another issue concerns sustainable development. International discussions on this concept, such as those launched during Rio 92, appear to be carried out separately by environmental groups and those with a development orientation. However, the strong interdependence between environmental and economic development in Third World countries requires a collective vision. A third issue is that of multifunctional agriculture. In the Netherlands and Europe, multifunctional agriculture is associated with sustainable farming and land use, but in an international context the consequences for poor countries could be disastrous. We refer here to the risk of hidden subsidies on agricultural products in the West and claims on land in poor countries made by these prosperous regions. The search for this form of allegedly sustainable agriculture and land use (which could reduce the environmental burden in the Netherlands and Europe) stands in stark contrast to the desired developments regarding food security in the poor countries of the world.

Answers to these and many other questions that are circulating in international discussions are crucially important for the negotiating positions of countries and companies when making international agreements. The world's rising economies have a great need for a multifaceted view of such strategic topics. Wageningen UR can benefit from their well-funded need. But the need of underdeveloped nations is also great. International organisations (UN) and governments in developed countries can provide extensive financing for knowledge transfer in this area. In addition, companies in the food sector will be unable to avoid the issues of sustainable exploitation of natural resources and sustainable development. This is even more the case now that private investments in developing countries are increasing rapidly and the demand for 'responsibly' produced products (products that meet environmental and social standards) is increasing.

To exploit this potentially large but difficult market for complex social and development issues, Wageningen must use its strengths. Its great diversity of agricultural, nutritional and natural science disciplines gives Wageningen an enormous potential to formulate innovative and creative solutions. Tackling these issues requires an interdisciplinary approach. The interdisciplinary approach requires a great deal of time and effort, but is a highly promising and rewarding process in the long term. To apply these interdisciplinary qualities, Wageningen UR staff must have a strong, in-house dose of international expertise. They must also cooperate closely with parties outside Wageningen UR, including developing countries. For this purpose, long-term alliances must be established.

To accomplish the above, concrete elaboration is required. To this end, we invite interested parties, both inside and outside Wageningen UR, to make a constructive contribution to the continuing activities of the Wageningen Platform for Food Security.

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