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2 Towards worldwide sustainable food security?

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2.1 Introduction

It seems so normal – every day inhabitants of the rich West eat huge amounts of many different foods. It is available almost everywhere and in numerous tastes and types. But we have been able to take these riches for granted only for the last 50 years. After the Second World War agriculture targeted productivity and efficiency. Large-scale deployment of technology led to decreasing prices and increasing surpluses that occasionally flooded the world's markets and created economic and environmental problems. The central theme of this essay on food security and food genomics is the balance between sustainability and food security.

The situation in the rich West cannot be compared to the poverty of much of the Third World, especially not with countries in Africa and Asia where many live at or below the subsistence level. Although in 2002 poverty was the major cause of hunger, harvest failure and (mis)-organisation of logistics also caused misery. For many decades people from the West have been trying, with varying degrees of success, to increase food production in developing countries by the introduction of new technology. The most important example was the 1960s Green Revolution in India and Asia. The West offered small farmers a combination of new crop types, artificial fertilisers, pesticides and credit. It is still unclear whether this was an overall success. Although richer farmers produced more food this was definitely at the cost of the environment, for example, with raised quantities of pesticides turning up. The position of the poor small farmer was often not improved as they had great difficulty obtaining credit to buy expensive artificial fertilisers or indeed new seed.

After the Green Revolution, genetic modification has been regularly presented as a solution for the world's food problem. A highpoint was 'Golden Rice' which contained vitamin A for fighting eye disease. Now it is the turn of genomics to guarantee food security in the Third World.

Although genomics is still in its infancy, analysis of its general characteristics shows something can still be said as to its chances of improving food security. One conviction is that food genomics will only extend the knowledge gap between the rich West and the poor countries of the Third World. A lot will have to happen to have the results of genomics research in the West directly improve the crops in the Third World.

This essay first examines global sustainable food security. The discussion then addresses the most important general characteristics of food genomics research. The third step is a consideration of whether the Third World can participate in food genomics research on the basis of three conditions. Finally the possibilities for the Third World to benefit from Western research are discussed.

2.2 Global sustainable food security

According to Prof. A. van Tunen, food security is especially a question of quantity and quality. The most recent figures of the Food and Agriculture Organisation (FAO) of the United Nations report that 815 million people in the world were undernourished in 2002 and this was especially a quantitative problem. If nothing is done, the number of chronically undernourished people in the world will increase drastically over the next fifteen years and there will be a shift of the problem to other regions. The sub-Saharan region is the most vulnerable to and indeed affected by starvation, because food output is not keeping pace with population growth. In order to reverse this trend a rapid and sustainable increase in production is essential, and measures will have to be taken to ensure that food is made available to those in need.

Both the countryside and city areas in these countries are affected by food shortages. It is often very difficult to transport food to and in these areas. By 2015 there will be as many as 26 cities in the Third World each with a population of more than ten million; so-called ‘mega-cities’. To provide sufficient food for each of these, six thousand tons of food will be needed daily.

Although, seen quantitatively, most people in the Third World are currently not suffering from starvation, the quality of their food is at best poor. Another problem is that people are increasingly changing to Western eating habits. Presently, inhabitants of countries such as China eat little meat. If they were to suddenly decide *en masse* to eat meat the animals required would cause a huge shortage of plant-based products because so much plant food would be required for feeding the animals. In order to assist the hungry in the future measures need to be taken. On a global scale there are six broad initiatives possible each of which has its own advantages and drawbacks:

1. *Better distribution of existing food resources.* Efficient logistics ensures food is in the right place at the right time and thus tends to avoid it being wasted or thrown away. Discussions on new technological developments often introduces the fact that there is no actual food shortage, but the food is not available at the right place or indeed at the right price. This can give rise to strange situations. India, for example, exports food although many of its population are hungry. Logistics measures have environmental drawbacks. They require more roads to be built, more energy to be generated and products often have a short shelf-life.
2. *Stimulating new eating habits.* If the inhabitants of the Western world were to switch to a low meat diet there would be more plant-based food available for people in the Third World. Preventing countries in the Second World from switching to more Western food habits could also have a positive effect on available quantities.
At the same time the quality of vegetable food products in the Second World should be increased because their low quality is the most important reason when prosperity is rising, to switch to meat products.
3. *Put more land into use.* There are many places in the world where land is not being used for agriculture. These are principally nature reserves and so-called marginal areas where low yields would be expected due to poor water supplies and ground quality. Starting to use such areas carries the danger of dramatic ecological effects such as reducing biodiversity and raising environmental pollution.
4. *Use of agronomic solutions that carry with them increases in nutrients and pesticides.* By operating agriculture from current scientific insights a number of possibilities are available for increasing production, such as the use of new pesticides. This is actually a slow process and the necessary conditions (e.g., a high level of provisioning and education) are often not present in the Third World. This option also causes problems with sustainability due to pollution of the environment.
5. *Biological agriculture.* Although this type of agriculture carries with it relatively little in the way of sustainability problems, it yields on average 25% less compared to current agriculture.
6. *Biotechnology*. This includes various possibilities such as genetic modification. On the global scale large and relatively rich developing countries such as China, India and Brazil are leaders in the production of transgenic crops. (The situation is not the same for all countries in the Third World; in the following, emphasis is given to the poorest in the Third World such as sub-Saharan countries). There are heated discussions about the advantages and disadvantages of genetic modification for the environment, for nature and for health. The monopoly position of a few large multinational companies and the high costs of this technology are also disadvantages. Because the science of genomics does not (in itself) involve genetic modifi-

cation (although the two can be combined) less social resistance is to be expected.

The above measures are diverse. The first two have no relationship to increased production, but involve government policy. The past has shown these measures are difficult to realise. This is not true for the third suggestion, but this one does have enormous disadvantages. The last three measures are directed towards improvement of agriculture in which development aid often plays an important role. Each of the above measures would be insufficient on its own to fight future starvation. They all have disadvantages that become apparent in the balance between sustainability and food security. Only an integral and sustainable approach will increase the amount of food in the future.

Sustainability is a social norm that has become an important factor on the international agenda in recent years. During the debate 'Food and Genes', the NGO HIVOS (Humanist Institute for Co-operation with Developing Countries) stated that research performed on behalf of the World Bank showed that there are more than 190 definitions of sustainability. I believe that the definition adopted in the Brundtland Report gets to the central issue:

'Development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs' (WCED 1987, p. 43).

By explicit emphasis on development in this definition, sustainability becomes a dynamic issue that plays an important role in the relationships of the rich West with the Third World. The question is whether genomics can help to improve food security in a sustainable way.

2.3 Global food genomics

Genomics is a collective name for a number of multidisciplinary techniques and can be used to answer new and existing questions or solve particular problems. Without those questions or problems genomics cannot be called a science but just a collection of techniques, according to De Geus of the project bureau Biotechnology of the Netherlands Ministry of Agriculture, Nature Management and Fisheries. According to Van Tunen, University of Amsterdam researcher, plant biotechnology consists of tissue culture techniques, molecular improvement, genetic modification and genomics. His definition of genomics is 'the large scale definition and use of the function and organisation of genes, from man and other animals, micro-organisms and plants at the levels of DNA, RNA, proteins and molecular content' (Van Tunen 2002). Genomics research has been concentrated especially on the human genome and a few small organisms such as the fruit fly. For plants, the main studies are on the plant *Aribidopsis*, better known as mustard seed, a relatively small weed that also occurs in the Netherlands. In the following sections five general characteristics of the social context of genomics research are depicted. (Enriquez Cabot 2001).

International cooperation

The first characteristic is that genomics can be seen as a so-called *global* technology. It is almost impossible for individual states and countries to develop and use this technology separately themselves. International cooperatives and networks are necessary to keep genomics in operation. The costs of for example a super-computer are far above the budget of most countries and companies. Very large long-term investments are needed if a country or company wants to stay involved in genomics.

Data linking

A second characteristic is that genomics consists for a large part of *in-silico* biology, a type of biology that has risen in the last ten years alongside *in-vivo* and *in-vitro* biology. This means that the complete genomes of many types of organisms are being converted into digital form which is then stored in large databanks. These databanks are processed using specially developed software that compares the genomes of organisms. In this way research in the field of biology can spread outside the specific location of the laboratory.

Knowledge-based economy and education

Genomics research is part of the knowledge-based economy and this has major social consequences. A knowledge-based economy needs relatively few employees compared with a production-directed economy. The education system in a knowledge-based economy is organised in a meritocratic or performance-directed way. Education in a knowledge-based economy is the key to the future and must be adjusted for this.

Public-private cooperation

The fourth characteristic is the unusual form of public-private cooperation that exists in genomics research. Considering the influence of fundamental research in genomics is large, industry cannot or does not want to carry the costs for this sort of risky research itself. Universities of international renown have taken the lead in fundamental genomics research. The founders of small genomics companies are mainly researchers in these institutions. After becoming successful such small companies often merge with large multinationals for example in the area of pharmaceuticals. The long development time between discovery and end product also requires large capital-intensive companies and a stable political climate. It sometimes takes more than ten years before a product appears on the market. Patents are the most important means for protecting these interests.

Genetic profiles

The fifth and last characteristic of genomics research is that genetic resources play a major role in research activities, for example they are the starting point for determining the genome of an organism. Conversely genomics can have consequences for genetic resources because for example changes can take place in the taxonomy (the classification of organisms) or by offering the possibilities to 'purify' genetic resources by locating particular pieces of 'foreign' DNA.

Food shortages: plant or animal?

Regarding food the specific quality of genomics lies on the one hand in nutrigenomics and on the other hand in seed improvement. Nutrigenomics is the determination of the unique nutritional requirements of a person based on their genetic background. In the future it will be possible for everyone to establish their own personal diet that is adjusted to their own genetic profile. The objective is to make the chance of contracting a particular disease as low as possible. Industry should then be able to design foodstuffs that can be linked to these diets. The shift from quantity to quality could offer a solution for certain groups in the Third World, but that goes actually a step too far as the problem of starvation is a quantitative one in the first instance. The question is whether and how far genomics can still contribute to solving this problem.

The contribution of genomics to solving the hunger problem is directed especially towards seed improvement with the aim of increasing crop output. Sufficient and regular production of agricultural crops would solve many of the problems. People could also survive by eating animals but this possibility for solving the food shortage is not (yet) part of food security and genomics. There are various reasons for this: meat is an expensive luxury product for the population of many developing countries. Secondly it is not to be expected in the short term that there will be many sorts of new applications of genomics in the area of animal production because this is controversial in many countries. In time we can think about developments in the area of *marker-assisted breeding*, which can deliver new breeds without the need for genetic modification.

Marker-assisted breeding is an option in plant seed improvement for those who do not want to use genetic modification. The question is really whether the Third World can participate in these food genomics developments.

2.4 Conditions for participating in genomics knowledge development

There are three conditions that must be fulfilled in Third World countries if they want to participate in knowledge development in the area of food genomics and seed improvement. These are: infrastructure, access to genetic resources and ownership of knowledge.

2.4.1 Infrastructure

The fact that genomics is a *global* technology offers countries in the Third World some perspective to participate, however small. Companies could benefit from low wages in the Third World but these companies must first build up an infrastructure in those countries. The chances of a Third World country becoming a fully fledged partner in the production of knowledge is small. Developing countries have only limited budgets and possibilities, and genomics is a relatively expensive and complicated technology. New investments are constantly needed when new techniques become available that replace the other then-outdated weaker links. Results will only be achieved in well-equipped laboratories with advanced analysis apparatus, computers and software. Computers that are necessary for processing the explosive growth in genomics research data are simply not present in the Third World. Technological developments are progressing so rapidly that it is easy to be left behind, and it is then not easy to catch up. The Third World cannot keep up the tempo and is shut out, just as in earlier industrial revolutions.

There will also be a 'brain drain' (especially to the U.S.A.) of the few people in the Third World who have followed a suitable education in the West. There is limited potential for having well-qualified researchers on hand as in the Third World there is little or no suitable education. Only cheap and simple work (e.g., data processing) can be contracted out to the Third World. The long development time between discovery and product requires a large capital-intensive company and a stable political climate that is in general not present in most developing countries. Thus genomics would not even get off the ground due to the lack of infrastructure. The most important cause is the structural lack of funds in the Third World. Therefore the Third World can only benefit from the results of genomics research in the knowledge-based economy and not in the production of the knowledge itself.

2.4.2 Access to genetic resources

There are many genetic resources, and many of these to be found in the Third World. Such countries will never become rich from them however because Western companies are often able to collect genetic resources from many different countries. Thus it is not so much about ownership or possession. Access to genetic resources plays an especially important role in genomics research by which public accessibility must be guaranteed because otherwise Western companies will gain a monopoly position. Gene banks that have collected and stored the genetic riches will fulfil a key role.

The influence of genomics on biodiversity is potentially great. Considering that from the 250,000 known plants only about 500 are used in agriculture the impact will be seen when people look at the most important crops. During the sixth conference of those involved in the Biodiversity Convention in 2002 the Dutch government made an effort to come to a reasonable arrangement for the use of genetic resources. Internationally more agreements are being reached regarding the use of the most important world food crops, such as in the Convention on Plant Genetic Resources of the FAO.

2.4.3 Ownership of knowledge

Patents in biotechnology are a more important item to keep out competitors than in other economic sectors. The most important reason for this is that there must be time available to be able to earn back the high costs of research and development. Patents are set down in national laws and are internationally recognised and they are therefore dependent on government policy. Governments or organisations that are thus empowered by governments, such as the European Patent Office, grant patent rights to public and private parties. These parties are thus able to stop other parties from making, using or selling a discovery, with exclusive rights usually being valid for 20 years. Enforcement of patent rights is usually in the hands of governments via administrative procedures and via the Law in national legal systems. Although the criteria for being granted a patent (novelty, creativity and utility) are the same throughout the world there are still some differences between national legal systems regarding the interpretation of these criteria. National courts of law need to be decisive in cases of differences in interpretation. A company must also then take out patents in a number of countries, usually first in the U.S.A. as the most lucrative international market.

The most important type of patent is a combination of protection of the composition of the substance (proteins or chemical compounds) and the method of production. Since 1980 in the U.S.A. patents have been granted for living organisms including genes, DNA fragments, methods of making useful genes and methods for making and characterising DNA. The total number of this type of patent is now in the tens of thousands. Obtaining a patent is just the first step in a long route of testing, producing, distributing and marketing.

The current system of intellectual property will change drastically as a result of developments in genomics and will play a crucial role in knowledge development. The emphasis will no longer be on patents for generally active products but on the sort of patent which is called in pharmaceuticals a *blockbuster*. These return much greater yields than they cost to develop. Genomics on the other hand offers the possibility of focusing on specific characteristics and processes. The foundation and financing from the West of so-called clearing houses (institutes that collect information about patents, process the data and make it available for countries that need the information) have been recently more often called the solution for the Third World. This cannot be actually a solution for Third World countries because they have no means to work on follow-up activities (e.g., purchasing a licence).

2.5 Perspectives of Western genomics for the Third World

What prospects does food genomics offer to Third World countries for building up a sustainable food security (Beekman 2001; Jacobs 2001) The crops that will be eligible for food genomics in the short term are especially rice and to a somewhat lesser degree maize and rape seed. The characteristics that will be central for these crops for genomics research are: food quantity (resistance to diseases and pests, and tolerance to salt and drought), food quality (nutritional value, contents of vitamin A and Fe) and medicines (vaccines and *plantibodies*). Food genomics in the West is not directed towards the local varieties in Third World countries but at crops that already play an important role in the economies of Western countries.

Crops are needed in agriculture worldwide that comply with the current requirements of the market and the environment. It is thought that food genomics will be able to contribute to sustainable agriculture. In the first place this will be achieved by research into crop resistance, from which the environment will benefit by a reduction in pesticide use. For this the emphasis lies on classic crops such as potatoes and tomatoes that can serve as models. There could be a reduction in energy use resulting from work in the area of cold resistance. In the future plants could be designed that take up certain dangerous materials from the soil or add certain compounds essential for other plants to the soil. Genomics research could also contribute to a reduction for example in synthetic plastic and polyester use by the development of degradable bio-plastics.

Considering the enormous increase in patent applications and the number of mergers, problems can be expected regarding the monopoly position of some companies. The products could because of this become very expensive and chances of developing crops for increasing sustainability and food security could be missed. The periodical *Intermediair* (2002) has reported that ActionAid, an English development charity for the Third World, submitted a patent application for its 'specially developed' pre-salted French fries. The organisation hopes that it will even go so far that all snack-bar owners who sprinkle their own salt on their French fries will then have to pay money to ActionAid. It is intended to be a demonstration of the fact that biotechnology companies have submitted patent applications on primary foodstuffs to which they have made only very small changes. In this way, proposes ActionAid, all the food in the Third World will eventually be patented. The Texan company Rice Tech for example has been granted patents on hybrids of basmati rice. The Indian government had to go on their knees to the US government to prevent the US patent office from awarding a patent to Rice Tech regarding *all* types of basmati rice. Rice is one of the five crops, alongside wheat, maize, soya and sorghum, that constitutes three-quarters of food in Third World countries. Almost 70% of all patents for modification of these crops are in the hands of just five biotechnology companies, including Dow and Monsanto. The authorities should move towards compulsory licences (a country then compels a licensee with threats that otherwise, thus without a licence, they could make an already patented product), such as happened recently in the U.S.A. with a vaccine against the anthrax bacterium. Companies should also actually be able to maintain their own lower prices for a number of countries.

2.6 Conclusion

Biotechnology and more recently genomics have been regularly presented as the solution to world demand for food. Some find this argument 'pure product promotion', such as the HIVOS during the debate *Food and Genes (Eten en Genen)* of the Terlouw Commission. They believe that food supply over the next 35 years will be actually greater than the demand and that genomics will lead to a decrease in the income of small farmers because new seed will become more expensive. In addition, food prices will decrease further due to increased production.

Third World countries will not benefit from the creation of knowledge in the area of food genomics. They are mainly directed towards the production of raw materials and only a little towards the production of goods. They have not for a long time been part of the knowledge-based economy. Food genomics puts high demands on the knowledge infrastructure of countries and Third World countries do not have this infrastructure and thus also will not be able to catch up. So the knowledge gap between the West and the Third World can only expand. The so-called strategy of *empowerment* (providing countries or groups with knowledge and materials) will not work because the developments follow each other too rapidly. The potential of countries to participate in developments is not available in Third World countries. It is thus not necessary in the framework of development cooperation to set up aid programmes that are aimed at developing food genomics in Third World countries.

It is desirable that genomics research makes an important contribution to feeding the growing world population. Countries in the Third World must be able to benefit from the new possibilities that exist due to the knowledge developed in the West from food genomics research. That can only happen if genomics research in Western countries is directed towards the local crops of the Third World countries. As is the case with some medicines, local crops or 'orphan' crops are not seen as commercially interesting. Western governments must stimulate international research into these crops. This can be for example via tax measures and also by financing specific programmes at universities and by stimulating private-public cooperation. Farmers in Third World countries could eventually get crops that have been adjusted to local conditions and that give a greater yield. The consumers in these countries could then be able to buy food that is safer and healthier. Third World countries could put more emphasis via food on prevention in health care that would eventually be cheaper and simpler. Future foodstuffs with a health-improving effect will actually be too expensive for the Third World. They must be custom-made for individuals or small groups and that is very expensive.

The way towards global sustainable food security must therefore proceed through the local varieties from the Third World, otherwise the Third World countries will only get on their plates the 'crumbs' from production in the West.

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