

Global Food Security and the Possible Contribution of Agricultural Biotechnologies

Keynote address for REDBIO 2010, by Dr Andrea Sonnino, Chief, Research and Extension Branch, Food and Agriculture Organization of the United Nations (FAO), Rome, Italy. 1 November 2010.

EXECUTIVE SUMMARY

Latest FAO figures indicate that an estimated 925 million people are undernourished in 2010, representing almost 16 percent of the population in developing countries. The fact that nearly a billion people remain hungry even after the recent food and financial crises have largely passed indicates a deep structural problem that gravely threatens the ability to achieve internationally agreed goals on hunger reduction. If we look to the future, there are, in addition, major challenges ahead. The first is the rapidly changing socio-economic environment, where it is predicted that the world's population will increase from about 7 to 9 billion people by 2050; the share living in urban areas will increase from about 50 to 70 percent by 2050; and people's diets will change, shifting to increased proportions of vegetables, fruits and livestock products. The second is climate change, which is expected to have an increasingly negative impact on agriculture and food security.

Promoting agriculture in developing countries is the key to achieving food security, and it is necessary to act to increase investment in agriculture; broaden access to food; improve governance of global trade; and increase productivity while conserving natural resources. For the latter, it will be necessary to substantially increase investments in public agricultural research and development. Technologies to increase productivity and conserve natural resources should be accessible, appropriate and adapted to the needs of smallholders, and functional demand-driven extension systems are essential for making this happen.

The suite of technological options for farmers should be as broad as possible and should also include agricultural biotechnology. The term agricultural biotechnology (or agricultural biotechnologies) covers a broad range of technologies used in food and agriculture for a range of purposes, such as the genetic improvement of plant varieties and animal populations; characterization and conservation of genetic resources; and diagnosis of plant or animal diseases. Discussions about agricultural biotechnology have been dominated by the continuing controversy surrounding genetic modification and its resulting products, genetically modified organisms (GMOs).

In the past, and still today, there has been too much emphasis on GMOs and too little focus on the potential merits and benefits of the many non-GMO biotechnologies that are available and the positive role that they can play for food security and sustainable development in developing countries. The polarized debate has led to non-GMO biotechnologies being overshadowed and it has often hindered their development and application. The extensive documentation from the FAO international technical conference on Agricultural Biotechnologies in Developing Countries (ABDC-10), that took place in Guadalajara on 1-4 March 2010, gives a very good overview of the many ways that different agricultural biotechnologies are being used to increase productivity and conserve natural resources in the crop, livestock, fishery, forestry and agro-industry sectors in developing countries.

ABDC-10 brought together about 300 policy-makers, scientists and representatives of intergovernmental and international non-governmental organizations, including delegations from 42 FAO Member States. At the end of the four days, the Member States reached a number of key conclusions, i.e. they acknowledged that agricultural biotechnologies can help to alleviate hunger and poverty, assist in adaptation to climate change and maintain the natural resource base; that agricultural biotechnologies have not been widely used in many developing countries, and have not sufficiently benefited smallholder farmers and producers and consumers; and that more R&D should be focused on the needs of smallholder farmers and producers. They also acknowledged that governments need to develop their own national vision and policy for the role of biotechnologies; that effective communication and participation strategies with the public are necessary; and that stronger partnerships among and within countries will facilitate the development and use of biotechnologies.

The Member States also agreed that effective and enabling national biotechnology policies and regulatory frameworks can facilitate the development and use of appropriate biotechnologies in developing countries and that developing countries should significantly increase investments in capacity building and the development and use of biotechnologies to support, in particular, smallholders, producers and small biotechnology based enterprises.

Finally, the countries also agreed that FAO and other relevant international organizations and donors should significantly increase their efforts to support the strengthening of national capacities in the development and appropriate use of pro-poor agricultural biotechnologies. FAO already collaborates with a range of partners in this area and, following ABDC-10, FAO stands ready to work with its UN and non-UN partners to greatly step up these efforts to assist its Member States.

Ladies and gentlemen, it is a great pleasure and privilege to be here in Guadalajara for the ‘VII Encuentro Latinoamericano y del Caribe sobre Biotecnología Agropecuaria’ (REDBIO 2010) and to present this keynote address. I am particularly happy that this important meeting takes place in the beautiful city of Guadalajara, as it was the successful venue in March this year of the FAO international technical conference on Agricultural Biotechnologies in Developing Countries (ABDC-10), and I will come back to this conference later on in my talk.

In this keynote address, I am going to talk about one of the most important issues for humankind - global food security – as well as the increasing challenges that the world is facing to achieve food security. I will also consider the possible contribution that agricultural biotechnologies can make in helping us to face these challenges.

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I will begin by defining what we mean by food security. For FAO, food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life¹. There are four dimensions of food security: the availability of food; access to food; utilization of food; and food system stability. For food security objectives to be realized, all four dimensions must be fulfilled simultaneously.

The first dimension covers the availability of good quality and nutritious food from local, regional and international sources. It therefore includes the issues of food production and processing; trade imports and exports; availability of food stocks and food aid. For example, the countries of Latin America and the Caribbean possess large capacity for the production, export and import of food, so availability of food is not the main problem for food security in the region.²

The second dimension covers physical and economic access to food for an active, healthy life. This includes marketing and transport infrastructure, food distribution systems and markets; purchasing power or having the money to buy the right food; social programmes to ensure access to nutritious food; and school meals which are nutritious and appealing to children. If food is available but people do not have the money to access it, they are food insecure. This dimension is considered to be the most sensitive one for countries in Latin America and the Caribbean.

The third dimension covers the safe and healthy utilization of the food. This includes good health status, since healthy individuals can make proper use of food; having nutritious food choices for all age groups; food safety and quality; and access to clean water and sanitation.

The fourth dimension covers the fact that to be food secure, a population, household or individual should have access to adequate food at all times and should not risk losing access to food as a consequence of sudden shocks (e.g. an economic or climatic crisis) or cyclical events³. This dimension is increasing in importance with the economic and climate change related challenges facing the world, especially developing countries.

Having talked about the four dimensions of food security, the other side of the coin is food insecurity, a situation that exists when people lack secure access to sufficient amounts of safe and nutritious food for normal growth and development and an active and healthy life. It may be caused by the unavailability of food, insufficient purchasing power, inappropriate distribution, or inadequate use of food at the household level. Each year, FAO publishes a flagship report entitled “The State of Food Insecurity in the World” (SOFI) and figures from the 2010 report, jointly published with the UN’s

¹ FAO, 1996. World Food Summit Plan of Action www.fao.org/docrep/003/w3613e/w3613e00.HTM

² FAO, 2008. Opportunities and challenges of biofuel production for food security and the environment in Latin America and the Caribbean. Document prepared for the 30th Session of the FAO Regional Conference for Latin America and the Caribbean, held in Brasilia, Brazil, 14-18 April 2008. www.fao.org/Unfao/Bodies/RegConferences/Larc30/Index_en.htm

³ FAO, 2006. Food Security. *Policy Brief*. June 2006, Issue 2. [ftp://ftp.fao.org/es/ESA/policybriefs/pb_02.pdf](http://ftp.fao.org/es/ESA/policybriefs/pb_02.pdf)

World Food Programme, estimate that a total of 925 million people are undernourished in the world in 2010⁴. These figures mark an improvement compared to 1,023 million people of the previous year. The decline, which was expected, is primarily a result of better access to food as the global economy recovers and food prices remain below their peak levels of mid 2008. However, there is no cause for complacency whatsoever. There are close to 1 billion people who live in hunger and we cannot accept this terrible situation.

These new figures were released in advance of the UN Summit in New York on 20-22 September 2010, that was called to accelerate progress towards achievement of the eight Millennium Development Goals, the first of which is to eradicate extreme poverty and hunger. The 2010 SOFI figures estimate that developing countries account for 98 percent of the world's undernourished people; that two-thirds live in seven countries (Bangladesh, China, the Democratic Republic of the Congo, Ethiopia, India, Indonesia and Pakistan); and that over 40 percent live in China and India. The region with the highest number of undernourished people is Asia and the Pacific, where 62% of the world's hungry live. The region with the highest proportion of undernourished people is sub-Saharan Africa, at 30 percent.

A target of the first Millennium Development Goal is to halve, between 1990 and 2015, the proportion of people who suffer from hunger. The SOFI figures indicate that some progress has been made towards achieving this target, as the prevalence of hunger in developing countries has declined from 20 percent undernourished in 1990–92 to 16 percent in 2010. However, with the world population still increasing, a declining proportion of hunger people conceals an actual increase in numbers. In fact, the number of hungry people in developing countries has risen from 827 million in 1990–92 to 906 million in 2010.

Using 2005-2007 data, the SOFI figures also show that, in sub-Saharan Africa, the Congo, Ghana, Mali and Nigeria had reached the hunger target of the first Millennium Development Goal, and Ethiopia and others were close to doing so. In Asia, Armenia, Myanmar and Viet Nam had achieved the target reduction and others were coming close, including China. In Latin America and the Caribbean, Guyana, Jamaica and Nicaragua had reached the target while Brazil, among others, was approaching this objective.

Ladies and gentlemen, today, in the year 2010, we produce more than enough food to feed the world's population of nearly 7 billion (i.e. 7,000 million) inhabitants. However, still about one in six people in developing countries suffer from chronic hunger. If we look to the future, there are, in addition, some major challenges ahead that can drastically worsen this already unacceptable situation.

The first is the rapidly changing socio-economic environment. The world's population is projected to increase to about 9 billion people by the year 2050. Nearly all of this increase will occur in developing countries⁵. In addition, the ongoing migration from rural to urban areas is expected to continue, so that by 2050 about 70 percent of the world's population will be urban (compared to 50 percent today). Incomes are also expected to rise in the future in developing countries, resulting in dietary changes where the proportion of grains and other staple crops in diets will decline, while the proportion of vegetables, fruits, edible oil, meat, dairy and fish will increase. With this larger, more urban and, on average, richer population, it is estimated that the global demand for food in 2050 may be 70 percent higher than today⁶.

⁴ FAO and WFP. 2010. The State of Food Insecurity in the World 2010. Rome. www.fao.org/publications/sofi/en/

⁵ World Population Prospects: The 2008 Revision. UN Department of Economic and Social Affairs, Population Division. http://esa.un.org/unpd/wpp2008/pdf/WPP2008_Highlights.pdf

⁶ FAO, 2009. WSFS background paper - Feeding the world, eradicating hunger. World Summit on Food Security, Rome, 16–18 November 2009. Document WSFS 2009/INF/2 www.fao.org/wsfs/wsfs-list-documents/en/

The second major challenge is climate change, which affects the frequency of extreme weather events, alters agricultural growing patterns as well as the distribution patterns of pests, weeds and diseases that threaten crops and livestock. The overall impacts of climate change on agriculture and food security are expected to be increasingly negative, especially in areas already vulnerable to climate-related disasters and food insecurity.

As the UN organization with the global mandate of ensuring that all people everywhere have enough to eat, FAO is aware that the war against hunger is far from being won. This is in spite of its ongoing and concerted efforts to create a broad united front against hunger by working with its Member States and the international community in support of policies and programmes that promote food security. Because of the major challenges of the future, these efforts will have to be greatly intensified.

Ladies and gentlemen, the challenges are great. However, there are solutions and agriculture is the key.

- Agriculture accounts on average for about 30% of the GDP in agriculture-based countries, and for 50% of employment in the developing world.
- Developing countries, which represent over 80% of the world's population, are home to about 500 million small farms, supporting around two billion people.
- Three out of every four poor people live in rural areas, and most depend on agriculture for their daily livelihoods.

Promoting agriculture in developing countries is therefore the key to achieving food security, and four areas can be prioritized for action⁷:

The first is to **increase investment in agriculture**. FAO continues to underline that the root cause of hunger and malnutrition is underinvestment in agriculture in developing countries. The part of total official development assistance going to agriculture, including forestry and fisheries, has decreased from 19 percent in 1980 to around 5 percent presently. In developing countries, the share of total government expenditure on agriculture has also fallen. For example, for the period 1980-2002, it fell from 14.8 to 8.6 percent in Asia; from 8.0 to 2.5 percent in Latin America and the Caribbean; and from 6.4 to 4.5 percent in Africa⁸. In Maputo in 2003, African leaders committed themselves to raising the share of agriculture and rural development in their budget expenditures to at least 10 percent. By 2008, eight countries had succeeded, nine devoted 8 to 10 percent while the majority of African countries devoted just 3 to 6 percent⁹. So, much more can be done.

The second is to **broaden access to food**. An important option for ensuring that everyone can enjoy adequate access to food is to create targeted social protection or safety net programmes, which target resources to the poor and vulnerable. The most important safety net policies include cash-transfers, in-kind transfers (such as school meals, take home rations), food price subsidies, public works programmes, fee waivers (for healthcare, schooling or transport) and food stamps. This option was used successfully by a number of developing countries during the 2007-2008 food crisis, including Brazil¹⁰.

The third is to **improve governance of global trade**. The 2007-2008 food crisis provided a clear reminder that the global food and agricultural system, including agricultural trade, is highly vulnerable. Price volatility is a key concern for policy-makers and the needs of low-income import-

⁷ Following FAO, 2009. WSFS background paper - Feeding the world, eradicating hunger. World Summit on Food Security, Rome, 16–18 November 2009. Document WSFS 2009/INF/2 www.fao.org/wsfs/wsfs-list-documents/en/

⁸ Akroyd, S. and Smith, L. (2007) Review of public spending to agriculture, a joint DFID/World Bank study, Oxford Policy Management. <http://siteresources.worldbank.org/EXTRESPUBEXPANAAGR/Resources/opm2.pdf>

⁹ FAO, 2009. Rapid assessment of aid flows for agricultural development in Sub-Saharan Africa. Investment Centre Division Discussion Paper, September 2009. www.fao.org/fileadmin/templates/tci/pdf/SSAAid09.pdf

¹⁰ FAO, 2009. Achieving food security in times of crisis. Brochure for 16 October 2009, World Food Day. www.fao.org/fileadmin/templates/getinvolved/pdf/WFD_2009_leaflet-en_web.pdf

dependent countries have to be addressed. For example, new and innovative arrangements are needed to ensure that levels of worldwide food stocks are adequate and that poor and import-dependent countries have access to them, especially at times of extraordinary scarcity. The recent rapid increase in cereal prices has again brought the issue of food price volatility into the limelight and experts from 75 FAO Member States met in Rome at the end of September to discuss the issue. In their report they recognized that unexpected price hikes and volatility are among the major threats to food security and that their root causes needed to be addressed¹¹.

The fourth is to **increase productivity and conserve natural resources** and I will focus on this area in the rest of my talk.

Increasing the productivity of smallholders, fishers and foresters through appropriate application of good practices and improved technologies should be a priority for developing countries wishing to achieve food security. This was also underlined at the UN Summit in New York on 20-22 September 2010, when Heads of State and Government committed themselves to accelerating progress in order to achieve Millennium Development Goal 1 through a series of actions, including “Increasing the growth rate of agricultural productivity in developing countries through promoting the development and dissemination of appropriate, affordable and sustainable agricultural technology, as well as the transfer of such technologies on mutually agreed terms, and supporting agricultural research and innovation, extension services and agricultural education in developing countries”¹².

Increasing productivity can improve food security in two ways. First, the increasing demand for agricultural products in low- and middle-income countries provides an opportunity for the rural poor to increase their incomes and to improve their livelihoods. Second, increased productivity can also lead to reduced food prices, benefiting many poor people in both urban and rural areas (the rural landless) as poor households typically spend a large proportion of their income on food.

Increased productivity should be achieved while simultaneously conserving the natural resource base upon which future productivity increases depend. In this way, the farmer’s income growth can be combined with truly sustainable resource use. The importance of productivity increases is especially clear if we consider that increases in food production for the future may only come in part from further expansion of agricultural lands and that the majority should come from increased yields per unit of land. This challenge is made more difficult by climate change, which is expected to have significant impacts on agriculture and food production patterns, and the fact that reduced investments in agriculture have led to a slowdown in productivity growth compared to previous decades. It is therefore necessary to substantially increase investments in international and national public agricultural research and development (R&D), strengthening, in particular, the Consultative Group on International Agricultural Research (CGIAR) and the national agricultural research systems.

Technologies must be appropriate and adapted to the local needs of poor farmers and they must be accessible to them. Even at current levels of technology, large gaps between potential and realized yields remain in many places. Improved information access can help reduce these gaps and initiatives such as TECA¹³, providing access to information about proven technologies for smallholders, and CIARD¹⁴, working to ensure that public domain agricultural research outputs are truly accessible, are worth mentioning in this regard.

Extension services play an essential role in closing these gaps and ensuring that farmers have access to the benefits of R&D. Lack of information and skills are a big hurdle in smallholder farmer systems, constraining adoption of technologies and reducing their efficiency if eventually adopted. When not in place, investing in functional demand-driven pluralistic extension systems is essential. Another

¹¹ FAO press release, 24 September 2010. www.fao.org/news/story/en/item/45690/icode/

¹² Outcome document for the Millennium Development Goals Summit adopted by the UN General Assembly on 22 September 2010. It includes an action agenda for achieving the Goals by 2015. www.un.org/en/mdg/summit2010/

¹³ Technologies for Agriculture. www.fao.org/teca/

¹⁴ Coherence in Information for Agricultural Research for Development. www.ciard.net/home

important related issue is that of participation, as it is now generally recognized that the potential beneficiaries of R&D and extension services should have a say in, and be able to influence, priorities and strategies, as it ensures that these services respond to their needs and priorities.

To increase productivity, the suite of technological options for farmers should be as broad as possible, including those used to improve water management in irrigated and rainfed production systems; save labour; reduce post-harvest losses; improve natural resource management, including conservation agriculture, increasing soil fertility and integrated pest management. Preference should be given to technologies promising win-win combinations of enhancing productivity and conserving natural resources.

The suite of technological options should also include agricultural biotechnologies, and I will now focus on the use of agricultural biotechnologies to increase productivity and conserve natural resources.

Ladies and gentlemen, as most of you are aware, the subject of biotechnology is often accompanied by strong emotions and controversies. So, it is important to first clarify what we mean by biotechnology. FAO traditionally uses a broad definition, based on that contained in Article 2 of the Convention on Biological Diversity, which states that biotechnology is "any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use".

The term agricultural biotechnology (or agricultural biotechnologies) therefore covers a broad range of technologies used in food and agriculture. They are used for a number of different purposes, such as the genetic improvement of plant varieties and animal populations to increase their yields or efficiency; diagnosis of plant or animal diseases; and vaccine development. They are also used to benefit agricultural biodiversity, and this area is worth some special attention as we are in 2010, the International Year of Biodiversity.

In his keynote address to ABDC-10 in March this year, Professor M.S. Swaminathan noted that biodiversity has been the feedstock for sustainable food and health security and that it can play a similar role in the development of climate resilient farming and livelihood systems, but that it is rapidly being lost. Agricultural biotechnologies, including the use of molecular markers, cryopreservation and reproductive technologies, can all play an important role in the characterization and conservation of crop, livestock, forestry and fishery genetic resources and they are currently being used in developing countries for this purpose¹⁵.

The strong controversy about the subject of agricultural biotechnology relates to one single biotechnology, genetic modification, and its resulting products, genetically modified organisms (GMOs). Indeed, the term biotechnology is often used synonymously for genetic modification (hence the need for a definition earlier). The debate about the advantages and disadvantages, real or perceived, of GMOs began over a decade ago and it still continues today without showing significant signs of abating. The positions of different parties regarding GMOs have often become firmly entrenched in what has been called a 'global war of rhetoric'¹⁶.

In the past, and still today, there has been too much emphasis on GMOs and too little focus on the potential merits and benefits of non-GMO biotechnologies and the positive role that they can play for food security and sustainable development in developing countries. The polarized debate has led to

¹⁵ For more details, see FAO, 2010. Status and trends of biotechnologies applied to the conservation and utilization of genetic resources for food and agriculture and matters relevant for their future development. Document CGRFA/WG-AnGR-6/10/5 for the 6th Session of the Intergovernmental Technical Working Group on Animal Genetic Resources for Food and Agriculture, 24-26 November 2010, Rome, Italy www.fao.org/ag/againfo/programmes/en/genetics/angrvent2010.html

¹⁶ Stone, G. 2002 Both sides now: Fallacies in the genetic-modification wars, implications for developing countries, and anthropological perspectives. *Current Anthropology*, 43:611-630. <http://artsci.wustl.edu/~anthro/research/BothSidesNow.pdf>

non-GMO biotechnologies being overshadowed and it has often hindered their development and application.

There are many non-GMO biotechnologies and they are very diverse. Some of them may be applied to all the food and agricultural sectors, such as the use of molecular markers, while others are more sector-specific, such as tissue culture (in crops and forest trees), embryo transfer (livestock) or sex-reversal (fish). They can also be roughly classified into different groups depending on whether they can be considered as 'low technology' (such as biofertilizers, biopesticides or tissue culture in crops/trees; artificial insemination in livestock; fermentation and use of bioreactors in food processing), 'medium technology' (such as use of PCR-based disease diagnostic tools or marker-assisted selection) or 'high technology' (such as genomics or *in vitro* fertilization in livestock). An important feature they have in common is that, compared to GMOs, these biotechnologies, and any eventual products arising from them, do not normally require specific regulatory approval, meaning they can be quickly adopted by farmers and that the costs of release are low.

Ladies and gentlemen, I will now provide a brief overview of the ways that agricultural biotechnologies are being used to increase productivity and conserve natural resources in the crop, livestock, fishery, forestry and agro-industry sectors in developing countries¹⁷.

In **crops**, biotechnologies have developed incrementally over the past century, but progress has accelerated greatly over the last two decades, leading to many important scientific achievements and impressive technological advances. As with other maturing technologies, there have been mixed experiences with crop biotechnologies in developing countries. Genetic modification has had limited but real success in modifying a few simple input traits in a small number of commercial commodity crops, adopted also in some developing countries.

However, the major breeding and crop management applications to date have come from non-GMO biotechnologies encompassing the full range of agronomic traits and practices relevant to developing countries' farmers. For example, mutagenesis is widely used in developing countries and more than 2,700 mutation-derived crop varieties have been obtained worldwide in the last sixty years, mainly in developing countries¹⁸. Interspecific hybridization allows the combination of favourable traits from different species and has been used successfully in, for instance, the development of New Rice for Africa (NERICA) varieties, by crossing high-yielding Asian rice with African rice which thrives in harsh environments, using embryo rescue and anther culture techniques. NERICA varieties have been cultivated on over 200,000 hectares in Africa and evaluation studies have documented their positive impacts on people's livelihoods in countries like Benin, Guinea and Mali. Interspecific hybridization programmes can, however, be slow and require a great deal of scientific expertise and skilled labour.

Marker-assisted selection is still at a relatively early stage in its application for key subsistence crops in many developing countries, although it has begun to produce some significant results, such as the development of a pearl millet hybrid with resistance to downy mildew disease in India. The costs and technical sophistication required for marker-assisted selection, however, remain major challenges for developing countries.

Micropropagation is used for the mass clonal propagation of elite lines or disease-free planting material. Many developing countries have significant crop micropropagation programmes and are using it in a wide range of subsistence crops. The socio-economic impacts of biotechnologies are seldom evaluated, but can be substantial, as shown by the study of micropropagated sweetpotato in the

¹⁷ More details can be found in the five sector-specific documents from ABDC-10 (numbered ABDC-10/3.1 to ABDC-10/7.1), at www.fao.org/biotech/abdc/

¹⁸ FAO & IAEA. 2008. Atoms for Food: a global partnership. Contributions to Global Food Security by the Joint Division of the Food and Agriculture Organization and the International Atomic Energy Agency. Report to the IAEA General Conference September 2008. www.iaea.or.at/Publications/Booklets/Fao/fao1008.pdf.

Hwedza District (Zimbabwe), where the technology was adopted by 97 percent of the farmers, including both poorer and better-off farmers, and it contributed to household food security¹⁹.

Biotechnology also offers important tools for the diagnosis of plant diseases of both viral and bacterial origin, and immuno-diagnostic techniques as well as DNA-based methods are commercially applied for this purpose in many developing countries. Biofertilizers are also used in developing countries both to augment the nutritional status of crops and as alternatives to chemical supplements. Additionally, biotechnologies such as molecular markers, cryopreservation and *in vitro* slow growth storage are extensively used for the characterization and conservation of plant genetic resources in developing countries.

Livestock contribute directly to livelihoods worldwide, providing not only food, but also non-food products, draught power and financial security. They contribute 40 percent of the global value of agricultural output²⁰, and this proportion is expected to increase. The rapidly increasing demand for livestock products, known as the “Livestock Revolution”, has created opportunities for improving the welfare of at least some of the nearly one billion poor people who depend on livestock for their livelihoods. However, land degradation, environmental pollution, global warming, the erosion of animal genetic resources, water shortages and emerging diseases are all expected to present challenges to the growing global livestock sector.

Conventional technologies and biotechnologies in livestock have contributed immensely to increasing productivity, particularly in developed countries, and can help to alleviate poverty and hunger, reduce the threats of diseases and ensure environmental sustainability in developing countries. A wide range of biotechnologies are available and have already been used in developing countries.

In animal reproduction and breeding, artificial insemination (AI) has perhaps been the most widely applied animal biotechnology, particularly in combination with cryopreservation, allowing significant genetic improvement for productivity, as well as the global dissemination of selected male germplasm. It is applied at some level in most developing countries. Its use is primarily in dairy cattle and peri-urban areas where complementary services including milk marketing are available. The high cost of liquid nitrogen for the cryopreservation of semen often restricts AI use far from cities. A case study presented at ABDC-10 described the positive impact of community-based cattle AI, combined with veterinary and milk marketing services in Bangladesh, increasing incomes and providing employment²¹.

The lack of a system for the identification of superior animals limits (along with lack of technical capacity) the use of more advanced technologies, such as embryo transfer or marker-assisted selection. Molecular biotechnologies in the area of animal reproduction and breeding in developing countries have generally been limited to genetic characterization studies, usually through international cooperation.

In animal nutrition, biotechnologies are often based on the use of micro-organisms, including those produced through genetic modification. Fermentation technologies are used to produce nutrients (such as particular essential amino acids or complete proteins) or to improve the digestibility of animal feeds. Although data are scarce, amino acids and enzymes appear to be the most prominent and widespread nutrition-related biotechnology products used in developing countries. For example, India and China have developed local industries to produce them. Various factors have limited the use of many other biotechnologies. For example, silage production is not common, thus precluding the use of microbial cultures.

¹⁹ FAO, 2009. Socio-economic impacts of non-transgenic biotechnologies in developing countries: The case of plant micropropagation in Africa. By A. Sonnino, Z. Dhlamini, F.M. Santucci & P. Warren (eds) www.fao.org/docrep/011/i0340e/i0340e00.htm

²⁰ FAO, 2009. Livestock in the balance. www.fao.org/publications/sofa/en/

²¹ Livestock sector case studies: Summary report of the ABDC-10 parallel session www.fao.org/fileadmin/templates/abdc/documents/livecase.pdf

In animal health, molecular-based serological techniques are widely used in developing countries. PCR-based diagnostics are increasingly used to allow early diagnosis of diseases, although their use is mainly restricted to the laboratories of research institutions and larger governmental diagnostic laboratories. Vaccination has been widely used as a cost-effective measure to control infectious diseases, as exemplified by the case of rinderpest, an infectious viral disease of cattle, buffalo, yak and numerous wildlife species that has caused devastating effects throughout history. For example, in the 1890s, rinderpest destroyed nearly 90 percent of all cattle in sub-Saharan Africa and millions of wild animals. The progress towards eradication, through large-scale vaccination and surveillance campaigns, has been a remarkable triumph for veterinary science. The last known outbreak was reported in Kenya in 2001 and an international statement declaring the eradication of rinderpest is expected in mid-2011. This will be the second time that a disease has been eradicated worldwide, following smallpox in humans.

In 2007, more than 113 million tonnes of food fish were supplied by **aquaculture and capture fisheries** globally, providing an estimated 17 kg per capita. Aquaculture contributed nearly half (44 percent) of this total, and is the fastest growing food-producing sector in the world²². It is expected that, in the near future, aquaculture will produce more fish for direct human consumption than capture fisheries.

Aquaculture started primarily as an Asian freshwater food production system and has now spread to all continents, encompassing all aquatic environments and utilizing a range of aquatic species. From an activity that was principally small-scale, non-commercial and family-based, it now includes large-scale commercial or industrial production of high value species that are traded at the national, regional and international levels.

Compared with livestock and crop production, aquaculture is a novel production system in many developing and developed countries, and it has made less use of conventional technologies, such as traditional genetic selection programmes, and biotechnologies to increase production than these other sectors. Nevertheless, a number of biotechnologies have been used in aquaculture systems in developing countries. These include the manipulation of sex in fish using hormonal treatment to generate single sex populations, for example in tilapia. Hormonal treatment has also been used successfully to control the timing of reproduction in fish and shellfish, for example in salmon and trout farming in Chile.

Extensive research has also been carried out on other biotechnologies relevant to genetic improvement and reproduction, such as induction of triploidy to create sterile populations; use of androgenesis and gynogenesis to produce individuals with genetic material from a single parent; and use of molecular markers for parental analysis and genetic selection. However, they have had little practical application so far in developing countries.

Disease outbreaks are a serious constraint to aquaculture development. Better management of intensive systems is needed, and biotechnologies are assisting in this task. Immunoassay and DNA-based diagnostic methods are currently applied for pathogen diagnosis in developing countries (e.g. in shrimp production). Also, vaccines are used against diseases causing severe mortalities in cultured fish and shellfish. As molecular-based vaccine production procedures rely heavily on biotechnological tools, vaccines are produced mainly in developed countries.

Reducing the environmental impacts of aquaculture is a significant task. Aquaculture is often accused of being unsustainable and not environmentally friendly. Reducing the impacts of effluent discharge, improving water quality and responsible use of water are key areas to be considered in aquaculture

²² FAO, 2010. Current status and options for biotechnologies in fisheries and aquaculture in developing countries. Document ABDC-10/6.1 www.fao.org/biotech/abdc/backdocs/en/

development. Some biotechnologies are being used to address these areas, including bioremediation for the degradation of hazardous wastes and use of DNA-based methodologies for the early detection of toxin-producing algae.

In capture fisheries, the sustainable management and conservation of fisheries is a priority. Better understanding of the population structure of fisheries is therefore of paramount importance. The use of molecular markers and the principles of population genetics have proved very effective for assessing the actual levels of genetic variability within single populations and for measuring the extent of differentiation between populations. Some of the main ways in which molecular marker data have been applied for conservation decision-making in fish populations include characterizing the genetic structure of the populations being harvested; detecting changes/falls in population size; and estimating the effective population size (a key indicator for determining the degree of endangerment of a population).

Forests and other wooded areas perform key economic and ecological functions. Not only do they provide goods and livelihoods but they also protect soils, regulate water and absorb carbon. Forests also shelter much of the world's biodiversity. The world has slightly less than 4 billion hectares of forests, covering 31 percent of the world's land area²³. Thirty percent of the world's forests are primarily used for production of wood and non-wood products. Only 7 percent of forests in the world are in plantations, with the balance found in natural or semi-natural, largely unmanaged and undomesticated forest stands. Planted forests are expanding, and their contribution to global industrial wood production is approaching 50 percent of the total. Close to 1.6 billion people rely on forest resources for their livelihoods and most of them (1.2 billion) use trees on farms to generate food and cash.

For management of naturally regenerated forests, DNA-based and biochemical markers are available for a growing number of tropical species. Today, findings are available to guide operational forest management plans, including in developing countries, but only for a very limited number of the hundreds of tree species that are managed in naturally regenerated tropical forests. This area of forest biotechnology continues to expand.

For planted forests, although there is some overlap, the range of biotechnologies used is generally quite different from that used for naturally regenerated forests. Plantations can have different types of management systems (e.g. intensive, semi-intensive) and use different types of genetic material (e.g. wild material, genetically improved trees). Depending on the level of management intensity and the genetic material used in the planted forest, different groups of biotechnologies are being used, including tissue culture for micropropagation, biofertilizers, genetic fingerprinting, whole genome sequencing and genetic modification.

Agro-industries provide a means of converting raw agricultural materials into value added products while generating income and employment and contributing to overall economic development. Food processing converts relatively bulky, perishable and typically inedible raw materials into more useful, shelf-stable and palatable foods or potable beverages. Processing contributes to food security by minimizing waste and loss in the food chain and by increasing food availability and marketability. Food is also processed to improve its quality and safety.

Biotechnology as applied to food processing uses fermentation and microbial inoculants to enhance properties such as the taste, aroma, shelf-life, texture and nutritional value of foods. Traditional methods of genetic improvement such as classical mutagenesis and conjugation can be applied to improve the quality of microbial cultures. Hybridization is also used for the improvement of yeast strains. Genetic modification is widely employed in R&D for strain improvement. While these techniques are common in developed countries, they are only now beginning to be applied in developing countries for the improvement and development of starter cultures.

²³ FAO, 2010. Global Forest Resources Assessment 2010. www.fao.org/forestry/fra/fra2010/en/

Biotechnology is widely employed as a tool in diagnostics to monitor food safety, prevent and diagnose food-borne illnesses and verify the origins of foods. Biotechnological developments have led to the widespread availability of methods of identification that are more rapid and less costly than those based on conventional techniques. PCR-based and enzyme-linked immunoabsorbent assay (ELISA) methods are now applied for the detection of major food-borne pathogens.

Ladies and gentlemen, to meet the tremendous challenge of achieving food security in the future, developing countries and the international community need to act on several fronts. One of these is to increase agricultural productivity, while conserving the natural resource base, using the tools of science and technology, including agricultural biotechnologies. To highlight this issue, FAO organized the international technical conference on Agricultural Biotechnologies in Developing Countries (ABDC-10) that took place in Guadalajara from 1 to 4 March 2010, hosted by the Government of Mexico. I would like to conclude this address by dedicating a few words to it.

A major objective of ABDC-10 was to take stock of the application of biotechnologies across the different food and agricultural sectors in developing countries, in order to learn from the past and to identify options for the future to face the challenges of food insecurity, climate change and natural resource degradation.

Partnership has always been a central component of FAO's work and both the build-up and organization of the conference were hallmarked by a highly participatory approach. A large international Steering Committee was established, chaired by Professor M.S. Swaminathan. The Committee included individuals invited in their personal capacity, selected on the basis of their scientific expertise in one or more areas of agricultural biotechnologies, as well as those representing relevant stakeholder groups, including intergovernmental organizations, civil society organizations and private sector organizations.

ABDC-10 was co-sponsored by the International Fund for Agricultural Development (IFAD), while the Consultative Group on International Agricultural Research (CGIAR), the Global Forum on Agricultural Research (GFAR), the International Centre for Genetic Engineering and Biotechnology (ICGEB) and the World Bank were all major partners. In addition to plenary sessions, the conference programme included 27 parallel sessions which were sector-specific, regional or of cross-sectoral interest, most of which were organized by different intergovernmental and non-governmental organizations and regional fora. For example, the Latin America and the Caribbean regional session was organized by the Inter-American Institute for Cooperation on Agriculture (IICA), the International REDBIO Foundation and REDBIO.

The conference brought together about 300 policy-makers, scientists and representatives of intergovernmental and international non-governmental organizations, including delegations from 42 FAO Member States. At the end of the four days, the Member States reached a number of key conclusions²⁴, i.e. they acknowledged that agricultural biotechnologies can help to alleviate hunger and poverty, assist in adaptation to climate change and maintain the natural resource base; that agricultural biotechnologies have not been widely used in many developing countries, and have not sufficiently benefited smallholder farmers and producers and consumers; and that more R&D should be focused on the needs of smallholder farmers and producers. They also acknowledged that governments need to develop their own national vision and policy for the role of biotechnologies; that effective communication and participation strategies with the public are necessary; and that stronger partnerships among and within countries will facilitate the development and use of biotechnologies.

²⁴ Paragraphs 37-38 of the ABDC-10 report, available at www.fao.org/biotech/abdc/

The Member States also agreed that effective and enabling national biotechnology policies and regulatory frameworks can facilitate the development and use of appropriate biotechnologies in developing countries and that developing countries should significantly increase investments in capacity building and the development and use of biotechnologies to support, in particular, smallholders, producers and small biotechnology based enterprises.

Finally, the countries also agreed that FAO and other relevant international organizations and donors should significantly increase their efforts to support the strengthening of national capacities in the development and appropriate use of pro-poor agricultural biotechnologies. In this area, FAO already collaborates with a range of partners for capacity development of Member States in biotechnology and related issues through technical co-operation and training. This technical assistance is provided by FAO in three ways.

The first is provision of technical assistance directly to Member countries, where one of the main instruments is the Technical Cooperation Programme (TCP), launched in 1976 to enable FAO to respond rapidly to urgent needs for technical and emergency assistance in Member countries and to contribute to their capacity development. The second is provision of support for the establishment of biotechnology networks or acting as a catalyst for their establishment in different parts of the world. I am happy to say here that one excellent example is REDBIO, which was launched twenty years ago under the sponsorship of FAO. The third is through partnerships with international agricultural research centres and other institutions, where FAO has provided extensive technical assistance in co-operation with research centres supported by the CGIAR and/or with national agricultural research systems.

Following ABDC-10, FAO stands ready to work with its UN and non-UN partners to greatly step up these efforts to assist its Member States, on their request, to ensure that they can strengthen their capacities to develop and use pro-poor agricultural biotechnologies for the benefit of the food insecure in their countries.

I thank you for your attention and I wish you all a very successful meeting.