The European Group on Ethics in Science and New Technologies to the European Commission

Ethics of modern developments in agriculture technologies

- Opinion No 24 -

- 17 December 2008 -

OPINION OF THE EUROPEAN GROUP ON ETHICS
IN SCIENCE AND NEW TECHNOLOGIES
TO THE EUROPEAN COMMISSION

No 24 **17/12/2008**

****

ETHICS OF MODERN DEVELOPMENTS IN AGRICULTURE TECHNOLOGIES

Reference: Request from President Barroso

Rapporteurs: E. Agius, D. Banati and J. Kinderlerer

****

THE EUROPEAN GROUP ON ETHICS IN SCIENCE AND NEW TECHNOLOGIES (EGE),

Having regard to the Treaty on European Union, and in particular Article 188d[1] thereof,

Having regard to the EU common agricultural policy (CAP) and to Council Regulation (EC) No 1290/2005 of 21 June 2005 on the financing of the common agricultural policy[2],

Having regard to the Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO) Codex Alimentarius of 1963 for consumers, food producers, manufacturers and national food control agencies,

Having regard to the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) reports, agreed at an Intergovernmental Plenary Session in Johannesburg, South Africa in April 2008,

Having regard to Council Directive 76/895/EEC of 23 November 1976 (as amended by Directive 2002/79/EC) and to Directives 86/362/EEC and 86/363/EEC (as amended by Directive 2002/97/EC) relating to the fixing of maximum levels for pesticide residues in and on food[3],

[1] "Union development cooperation policy shall have as its primary objective the reduction and, in the long term, the eradication of poverty. The Union shall take account of the objectives of development cooperation in the policies that it implements which are likely to affect developing countries."
[2] OJ L 329, 16.12.2005.
[3] OJ L 340, 9.12.1976; OJ L 291, 28.10.2002; OJ L 221, 7.8.1986; OJ L 343, 18.12.2002; OJ L 350, 14.12.1990; OJ L 2, 7.1.2003.

Having regard to Council Directive 80/68/EEC of 17 December 1979 on the protection of groundwater against pollution caused by certain dangerous substances[4],

Having regard to Council Directive 85/337/EEC of 27 June 1985 on the assessment of the effects of certain public and private projects on the environment[5],

Having regard to the Treaty of Amsterdam of 17 June 1997, and in particular to the sustainable development strategy (SDS) and Article 152 thereof concerning public health,

Having regard to the Göteborg European Environment Council held in June 2001,

Having regard to Council Directive 90/219/EEC of 23 April 1990 on the contained use of genetically modified micro-organisms, as amended by Directive 98/81/EC[6],

Having regard to Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources[7] in order to reduce overall use of nitrates,

Having regard to Council Directive 91/414/EEC of 15 July 1991 concerning the placing of plant protection products on the market[8],

Having regard to Council Regulation (EEC) No 2078/92 of 30 June 1992 on agricultural production methods compatible with the requirements of the protection of the environment and the maintenance of the countryside[9],

Having regard to Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora[10],

Having regard to EGE Opinion No 1 of 12 March 1993 on the ethical implications of the use of performance-enhancers in agriculture and fisheries,

---

[4] OJ L 20, 26.1.1980.
[5] OJ L 175, 5.7.1985.
[6] OJ L 117, 8.5.1990.
[7] OJ L 375, 31.12.1991.
[8] OJ L 230, 19.8.1991.
[9] OJ L 215, 30.7.1992.
[10] OJ L 206, 22.7.1992.

Having regard to EGE Opinion No 5 of 5 May 1995 on ethical aspects of the labelling of the food derived from modern biotechnology,

Having regard to the United Nations Convention on Biological Diversity of 6 June 1992, ratified by the European Union on 25 October 1993, and to the Cartagena Protocol on Biosafety, approved by the European Community on 11 September 2003,

Having regard to Council Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control[11],

Having regard to the Kyoto Protocol, adopted on 11 December 1997 with the aim of reducing greenhouse gas emissions in order to fight global climate change (for the period 2005-2012),

Having regard to Directive 98/8/EC of the European Parliament and of the Council of 16 February 1998 concerning the placing of biocidal products on the market[12],

Having regard to the Commission communication "Directions towards sustainable agriculture"[13],

Having regard to Council Regulation (EC) No 1257/1999 of 17 May 1999 on support for rural development[14],

Having regard to the World Trade Organization (WTO) Sanitary and Phytosanitary (SPS) Agreements of 1995, in particular Article 5.1, 5.2 and 5.3 thereof on health risk assessments,

Having regard to Regulation (EC) No 258/97 of the European Parliament and of the Council of 27 January 1997 concerning novel foods and novel food ingredients[15],

Having regard to Council Directive 98/44/EC of the European Parliament and of the Council of 6 July 1998 on the legal protection of biotechnological inventions, in particular Article 6 thereof[16],

---

[11] OJ L 257, 10.10.1996.
[12] OJ L 123, 24.4.1998.
[13] COM(1999) 22, 27.1.1999.
[14] OJ L 160, 26.6.1999.
[15] OJ L 42, 14.2.1997.
[16] OJ L 213, 30.7.1998.

Having regard to the Commission communication "EU policies and measures to reduce greenhouse gas emissions: Towards a European Climate Change Programme (ECCP)"[17],

Having regard to Directive 2000/13/EC of the European Parliament and of the Council of 20 March 2000 on the approximation of the laws of the Member States relating to the labelling, presentation and advertising of foodstuffs[18],

Having regard to Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy[19],

Having regard to Directive 2001/42/EC of the European Parliament and of the Council of 27 June 2001 on the assessment of the effects of certain plans and programmes on the environment[20],

Having regard to Directive 2001/18/EC of the European Parliament and of the Council of 12 March 2001 on the deliberate release into the environment of genetically modified organisms and repealing Council Directive 90/220/EEC[21],

Having regard to the Sixth Community Environment Action Programme, as laid down by Decision No 1600/2002/EC of the European Parliament and of the Council of 22 July 2002[22],

Having regard to the Commission communication "Pricing policies for enhancing the sustainability of water resources"[23],

Having regard to Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety[24], with a view to protection of human life and health, taking account of, where appropriate, protection of animal health and welfare, plant health and the environment,

---

[17] COM(2000) 88, 8.3.2000.
[18] OJ L 109, 6.5.2000.
[19] OJ L 327, 22.12.2000.
[20] OJ L 197, 21.7.2001.
[21] OJ L 106, 17.4.2001.
[22] OJ L 242, 10.9.2002.
[23] COM(2000) 477, 26.7.2000.
[24] OJ L 31, 1.2.2002.

Having regard to the Commission communication "Towards a thematic strategy for soil protection"[25],

Having regard to the Commission communication "Towards a thematic strategy on the sustainable use of pesticides"[26],

Having regard to Regulation (EC) No 1829/2003 of the European Parliament and of the Council of 22 September 2003 on genetically modified food and feed[27],

Having regard to Regulation (EC) No 1830/2003 of the European Parliament and of the Council of 22 September 2003 concerning the traceability and labelling of genetically modified organisms and the traceability of food and feed products produced from genetically modified organisms and amending Directive 2001/18/EC[28],

Having regard to Regulation (EC) No 1946/2003 of the European Parliament and of the Council of 15 July 2003 on transboundary movements of genetically modified organisms[29],

Having regard to Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC[30],

Having regard to the Commission communication "Halting the loss of biodiversity by 2010 – and beyond: Sustaining ecosystem services for human well–being"[31],

Having regard to the Commission communication "A thematic strategy on the sustainable use of pesticides"[32],

Having regard to Council Regulation (EC) No 172/2007 of 16 February 2007 on persistent organic pollutants[33], which introduced maximum concentration limits,

---

[25] COM(2002) 179, 16.4.2002.
[26] COM(2002) 349, 1.7.2002.
[27] OJ L 268, 18.10.2003.
[28] OJ L 268, 18.10.2003.
[29] OJ L 287, 5.11.2003.
[30] OJ L 275, 25.10.2003.
[31] COM(2006) 216, 22.5.2006.
[32] COM(2006) 372, 17.12.2006.
[33] OJ L 55, 23.2.2007.

Having regard to Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an infrastructure for spatial information in the European Community[34] in order to support environmental protection by requiring Member States to make geographical information available in a coordinated manner,

Having regard to Regulation (EC) No 614/2007 of the European Parliament and of the Council of 23 May 2007 concerning the Financial Instrument for the Environment (LIFE)[35], which aimed at merging existing environmental programmes into a single mechanism,

Having regard to the Commission communication "Limiting global climate change to 2 degrees Celsius – the way ahead for 2020 and beyond"[36],

Having regard to the Commission communication on "Implementation of Council Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources"[37],

Having regard to the Commission communication "Towards sustainable water management in the European Union – First stage in the implementation of the Water Framework Directive 2000/60/EC"[38],

Having regard to the Commission communication on a "Proposal for a Council Regulation on information provision and promotion measures for agricultural products on the internal market and in third countries"[39],

Having regard to Council Regulation (EC) No 1107/2007 of 26 September 2007 derogating from Regulation (EC) No 1782/2003 establishing common rules for direct support schemes under the common agricultural policy and establishing certain support schemes for farmers, as regards set-aside for the year[40], with the aim of reducing the set-aside rate from 10% to 0% of agricultural land for sowing in autumn 2007 and spring 2008,

---

[34] OJ L 108, 24.4.2007.
[35] OJ L 149, 9.6.2007.
[36] COM(2007) 2, 10.1.2007; OJ C 138, 22.6.2007.
[37] COM(2007) 120, 19.3.2007; OJ C 181, 3.8.2007.
[38] COM(2007) 128, 22.3.2007.
[39] COM(2007) 268, 23.5.2007; OJ C 191, 17.8.2007.
[40] OJ L 253, 28.9.2007.

Having regard to Regulations (EC) No 1180/2007 and (EC) No 1182/2007 amending existing legislation in the fruit and vegetable sector to make it more competitive and market-oriented[41],

Having regard to Council Regulation (EC) No 1234/2007 of 22 October 2007 establishing a common organisation of agricultural markets and on specific provisions for certain agricultural products (single CMO regulation)[42], creating a horizontal legal framework for the agricultural markets,

Having regard to the Commission communication "2006 environment policy review" describing the action taken by the EU on the environment[43],

Having regard to the Commission communication "Mid-term review of the Sixth Community Environment Action Programme" with reference to protection of the environment, biodiversity and natural resources[44],

Having regard to the Commission communication on "Implementation of the Community strategy for dioxins, furans and polychlorinated biphenyls"[45],

Having regard to the Commission communication "Addressing the challenge of water scarcity and droughts in the European Union"[46],

Having regard to Council Regulations (EC) No 1290/2005 and No 3730/87 laying down general rules for the supply of food from intervention stocks to designated organisations for distribution to the most deprived persons in the European Union[47],

Having regard to the Commission communication "Preparing for the 'health check' of the CAP reform" on the overview of the adjustments needed in the CAP[48],

---

[41] OJ L 273, 17.10.2007; OJ L 350, 31.12.2007.
[42] OJ L 299, 16.11.2007.
[43] COM(2007) 195, 30.4.2007; OJ C 181, 3.10.2007.
[44] COM(2007) 225, 30.4.2007; OJ C 181, 3.10.2007.
[45] COM(2007) 396, 10.7.2007; OJ C 191, 17.8.2007.
[46] COM(2007) 414, 18.7.2007; OJ C 246, 20.10.2007.
[47] OJ L 209, 11.8.2005; OJ L 352, 15.12.1987.
[48] COM(2007) 722, 20.11.2007.

Having regard to the "Bali Roadmap" agreed between 3 and 14 December 2007 by 180 countries and opening the formal negotiations for a system to combat climate change after 2012,

Having regard to the Treaty of Lisbon, signed on 13 December 2007 and currently open for ratification,

Having regard to Article 6 of the Seventh Framework Programme of the European Community for research, technological development and demonstration activities (2007-2013), which states that "All the research activities carried out under the Seventh Framework Programme shall be carried out in compliance with fundamental ethical principles",

Having regard to the Commission communication "Supporting early demonstration of sustainable power generation from fossil fuels"[49],

Having regard to the Commission communication on a "Proposal for a Directive on the promotion of the use of energy from renewable sources"[50],

Having regard to the report by the WHO Commission on Social Determinants of Health "Closing the gap in a generation – health equity through action on the social determinants of health", published on 28 August 2008,

Having heard the rapporteurs E. Agius, D. Banati and J. Kinderlerer,

Hereby adopts the following Opinion:

****

[49] COM(2008) 13, 23.1.2008.
[50] COM(2008) 19, 23.1.2008.

TABLE OF CONTENTS

1. Scope of the Opinion 12

2. State of the Art in Agriculture 14

2.1 Introduction 14

2.2 Historical developments in agriculture 15

2.3 A paradigm shift: from food security to food safety 17

2.4 Modern agriculture: security and sustainability 18

3. Agricultural methods and technologies 20

3.1 Sustainable agricultural technologies 20

3.2 Agricultural technologies and methods 26

3.3 Biofuels production: between the first and second generations 31

3.4 Organic farming 33

4. Agriculture in the 21ST Century 35

4.1 World population growth 35

4.2 Climate change 36

4.3 Arable land capability 37

4.4 Water protection 39

4.5 Biodiversity loss 39

4.6 Depopulation of rural areas 40

4.7 Food transport and distribution: the ecological impact 41

4.8 Food waste 42

5. MODERN AGRICULTURE: MOVING TOWARDS FOOD SECURITY AND SUSTAINABILITY 45

5.1 Food security 45

5.2 Sustainability 49
6. Trends in International and European Policies 51
6.1 Globalisation and agriculture 51
6.2 The global strategy: the UN Millennium Development Goals 52
6.3 The Millennium Development Goals and the EU 53
6.4 Global trade 54
6.5 European Union common agricultural policy 56
6.6 European Union agricultural market 58
6.7 Price trends 59
6.8 Speculation and its economic impact on the food market 63
7. Intellectual Property Rights (IPR) in Agriculture 65
8. Ethics in agriculture 69
8.1 Ethical principles and values for responsible action 69
8.2 Anthropocentric and ecocentric ethics 71
8.3 Rights and responsibilities 73
8.4 Justice 76
9. ETHICAL CONCERNS 78
9.1 Food security at global, national and individual levels 79
9.2 Food insecurity 80
9.3 Sustainability of both resources and technologies 80
9.4 Food safety 81
9.5 Loss of biodiversity 82
9.6 Soil and water protection 83

9.7 GM crops in the EU 83

9.8 Biofuels 86

9.9 Food waste 86

9.10 Research funding and the brain drain in agro-food sciences 88

9.11 Dietary habits and lifestyles 88

9.12 Equal opportunities and global trade 89

9.13 Stakeholder participation and the importance of local culture and knowledge 89

9.14 IPR system 90

9.15 Fair competition 91

9.16 Food prices 92

10. Recommendations 93

10.2 The EGE's ethical approach to agriculture 94

10.3 Recommendations on introduction and promotion of agriculture technologies 96

10.4 Responsible policy-making in arable agriculture 102

10.5 Societal aspects 105

11 Concluding remarks 108

ANNEX I: 2008 FAO World Food Security Summit Declaration 109

ANNEX II: History of WTO negotiations on agricultural commodities 113

ANNEX III: Most common GMOs 114

ANNEX IV: The causes of food price increases 115

1. SCOPE OF THE OPINION

Food security, energy security, sustainability and globalisation have become core issues in the current political debate worldwide. This debate is enriched by other issues, including climate change, global trade, fluctuations in food and energy prices and the future need for additional energy sources, the revision of the EU common agricultural policy (CAP) and the link between the CAP and the EU economic strategy (the "Lisbon Agenda").

In order to address the new challenges and opportunities which lie ahead for EU agriculture, President Barroso asked the EGE to prepare an Opinion on the ethical implications of modern developments in agricultural technologies. These should include primary agricultural production, bearing in mind the relationship between agriculture and the natural environment, the UN Millennium Development Goals, such as the fight against world hunger, and the impact of changing agricultural methods on rural and urban communities[51].

The EGE accepted this complex task, aware that any such Opinion, while addressing agricultural technologies, cannot avoid referring to a plethora of interrelated issues, such as the competition for arable land between food, feed, fibres, feedstock or fuel. Because of these considerations, and out of pragmatism, the EGE therefore decided to address the technologies that could be conducive to the priorities supported by the Group, namely:

1. food security;
2. sustainable use of resources and fair trade at world level in agricultural products; and
3. ethically sound design of sustainable EU agricultural policies.

Food security and sustainability are therefore the main subjects of this Opinion, which will refer mainly to primary production of food of plant origin, and not to other areas of the EU agricultural policy such as fisheries, livestock farming, food processing and green biotechnology for pharmaceutical uses. These, together with other issues that play a role in the global discussion on the CAP (such as fisheries, forestry, climate change and energy), will not be covered "specifically" in this Opinion, although they are all recognised by the Group as being of fundamental importance in a global discussion on ethics in EU agriculture. However, the Group also intends to formulate, in this Opinion, an ethical frame for

[51] Adapted from "Frontiers in Agricultural Research: Food, Health, Environment and Communities" (2002), published by the National Academy of Sciences (New York).

agriculture within which further EGE Opinions addressing some of the above-mentioned issues may be conceived in the future, respecting the Group's remit[52].

This EGE Opinion is also conceived as a contribution to a global ethical debate on sustainable agriculture, in which international organisations[53] and European institutions[54] will work closely together to implement the UN Millennium Development Goals and design sustainable and responsible agricultural policies.

[52] The EGE advises the European Commission on ethical aspects of science and new technologies in connection with preparation and implementation of Community legislation or policies.
[53] *Inter alia*, the Food and Agriculture Organization of the United Nations (FAO), United Nations Educational, Scientific and Cultural Organization (UNESCO), World Health Organization (WHO), World Intellectual Property Organization (WIPO), International Centre for Genetic Engineering and Biotechnology (ICGEB) and World Trade Organization (WTO).
[54] *Inter alia*, the European Environment Agency, European Food Safety Agency and departments of the European Commission.

2. STATE OF THE ART IN AGRICULTURE

2.1 Introduction

> "None of us can avoid being interested in food. Our very existence depends on the supply of safe, nutritious foods. It is then hardly surprising that food has become the focus of a wide range of ethical concerns[55]."

The majority of people in developed countries not only have enough to eat, but also have a vast choice and probably eat too much. Others, particularly in the developing world, remain unable to choose, at the very least, or do not have enough to eat.

The ecosystems surrounding us are the lifeblood of the planet, providing us with everything from the water we drink to the food we eat and the fibre we use for clothing, paper or lumber[56]. Historically, agricultural production was stepped up by increasing land use and employing the best technologies available. Densely populated parts of the world, such as in China, India, Egypt and some regions of Europe, reached the limits of arable land expansion many years ago[57]. Intensification of production has therefore become a key strategy – obtaining more from the same amount of land. Until recently, food output kept up with global population growth: in 1997 agriculture provided (on average) 24% more food per person than in 1961, despite the population growing by 89%.

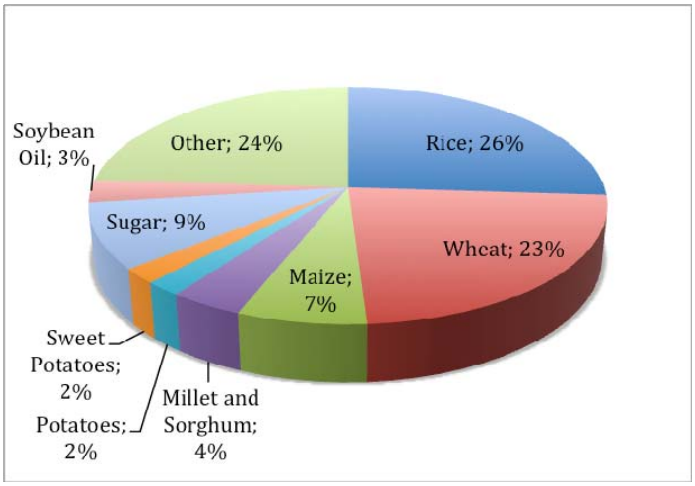
The FAO estimated that at the end of the last century there were between 300 000 and 500 000 species of higher plants (i.e. flowering and cone-bearing plants), of which about half have been identified or described. About 30 000 are edible and about 7 000 have been cultivated or collected by humans for food at one time or another. Of these, approximately 120 species are important on a national scale, and 30 species provide 90% of the world's calorie intake[58]. At the time of the FAO survey, wheat covered 23% of the world's calorie needs, rice 26% and maize 7%[59]. During 2004 and 2006 wheat and maize production in the

---

[55] Frans W.A. Brom and Bart Gremmen, "Food Ethics and Consumer Concerns", Journal of Agricultural and Environmental Ethics 12: 111–112 (2000).
[56] Stanley Wood, Kate Sebastian and Sara J. Scherr, "Pilot Analysis of Global Ecosystems: Agroecosystems", A joint study by International Food Policy Research Institute and World Resources Institute. Washington D.C. ISBN: 1-56973-457-7 (2000).
[57] Stanley Wood, Kate Sebastian and Sara J. Scherr, "Pilot Analysis of Global Ecosystems: Agroecosystems", A joint study by International Food Policy Research Institute and World Resources Institute. Washington D.C. ISBN: 1-56973-457-7 (2000).
[58] FAO, "The state of the world's plant genetic resources" (1998).
[59] FAO, "Food Balance Sheets 1984-1986", Rome (1991).

EU and the United States fell by between 12% and 16% and in 2006 global cereal stocks (especially wheat) were at their lowest level since the early 1980s[60].

Percentage of calorific intake by food group[58]



Cropland and managed pasture cover some 28% of the world's land surface; 31% of this area is occupied by crops and the remaining 69% is under pasture. Annual cropland is relatively stable at about 1.38 billion hectares. 91% of cropland is under annual crops such as wheat, while perennial crops, such as fruit trees and tea, occupy the remainder. Irrigated areas make up about 5.4% of the world's agricultural land and 17.5% of cropland[61].

2.2 Historical developments in agriculture

Between 1900 and 1940 farmers began using powered machinery (tractors, drainage pumps, electric poultry equipment, etc.), new chemical applications (synthetic nitrogen fertilisers) and new applications of biological science for both crop and livestock production (hybrid corn, artificial insemination, etc.).

By the 1930s, farmers had started to make proper use of technological innovations seeking to optimise production and increase the economic return from farming. Since the 1950s extensive use of tractors in West European countries has been helping to optimise agricultural production but has also been instrumental in (1) reducing job availability in rural areas – accompanied by migration of workers to urban areas – and (2) increasing the

[60] Joachim von Braun, "The World Food Situation: New Driving Forces and Required Actions", International Food Policy Research Institute, Washington D.C. (2007).

dependence of agriculture on energy sources (mainly fossil fuels). Provision of "fuel" for the transport system (horses, for example) became redundant in the developed world, as farmers grew produce for food or for feed for food animals.

Agriculture changed very significantly in the second half of the twentieth century. The first revolution, called the "green revolution"[62], involved using an understanding of the biology of plants and of organic chemistry to provide tools to produce a massive increase in the yields of many major crop plants. Farmers were able to provide products for a much greater market than had hitherto been possible. The development of hybrids of some of the major crops also changed the manner in which seed is used. For most of history farmers had kept seed from one harvest for use in following years. Hybrids and the ready availability of good quality seed from seed merchants changed practice in many developed countries for some of the major commodity crops. Modern arable agriculture, involving searching for and finding new varieties best suited to particular conditions, has been practised for centuries.

The green revolution started in the 1960s when varieties of wheat were improved by selection and produced dramatically increased yields. These varieties were particularly responsive to irrigation and fertilisers.

Historical milestones in agriculture	
10 000–2 000 BC	Start of cultivation by mankind
1800s	Selective cross-breeding of plants
Early 1900s	Wide-cross hybridisation
Mid–1900s	Plant mutagenesis and selection
1930s–1950s	Cell culture and somaclonal variation
	Embryo rescue
	Poly-embryogenesis
	Anther culture
1960–1970	Green revolution
1970s–1980s	Recombinant DNA technologies (GMOs, etc.)
	Marker-assisted selection (MAS)
1990s	Genomics
	Bioinformatics
	Nanotechnology

A significant advance in agriculture in the 20th century came with the understanding and use of genetic tools to produce appropriate seeds effectively. An understanding of the morphology, physiology, genetics and methods for handling seed transformed agriculture

[61] Stanley Wood, Kate Sebastian and Sara J. Scherr, "Pilot Analysis of Global Ecosystems: Agroecosystems", A joint study by International Food Policy Research Institute and World Resources Institute. Washington D.C. ISBN: 1-56973-457-7. Executive summary, page 3 (2000).
[62] Term coined by William Gaud, Director of the US Agency for International Development, in March 1968.

during the second half of the century[63]. Chemical and radiation mutagenesis, tissue culture, embryo rescue and many other techniques have been used in plant breeding to alter the genetic characteristics of the seeds that are only one of the many factors that determine the viability of and yield from the resulting plants. The percentage that germinate and the vigour of the seedlings are important in enabling the yield to fulfil its potential. In developing countries, provision of virus-free seed to farmers has possibly had more of an impact on yield than almost any other technology. Indeed, seed "is a key tool for technology transfer and technology-driven development strategies and is widely considered a focal point in agricultural progress[64]." This genetic value identified in seeds has raised concern about the availability of genetic diversity for the future. There are initiatives to conserve genetic resources on farms, in gene-banks and *in situ*[65].

2.3 A paradigm shift: from food security to food safety

At the end of the Second World War, there was an enormous need to increase food production both in Europe and in the United States for export to Europe. The goal was, therefore, to supply abundant food at the lowest possible cost to consumers. EU farmers accordingly adopted new technologies to enhance production and, at the same time, fiscal policies to externalise the environmental costs of food production were promoted[66].

Subsequently, steps were taken to optimise production. Farmers moved towards full electrification and mechanisation, wider use of chemicals to control weeds and pests, applications of information and computer sciences to improve management and marketing efficiency, use of knowledge of genetics to select appropriate varieties and modify desired characteristics and, finally, new sensor systems such as lasers for precise levelling of fields and global positioning system (GPS) technologies with satellite tracking and onboard computer monitoring to assist with more precise application of chemicals.

In the 1990s crops with enhanced traits were introduced, partially with the aid of genetic engineering. The productivity gains made possible by these science-based enhancements were dramatic. For example, the index of total output in American farming relative to total input increased by roughly 300% between 1910 and 1990. The green revolution also led to

---

[63] Ibid.
[64] McMullen, "Seeds and world agricultural progress", Washington D.C., National Planning Association Report No 227. ISBN 978-0890680889 (1987).
[65] Maxted *et al.,* "Plant genetic conservation: the *in situ* approach", London, Chapman Hall (1997).

the creation of new varieties of wheat (*Triticum aestivum*) and rice (*Oryza sativa*), which increased food production in Asia and Latin America and provided food for hundreds of millions. Over the last 50 years, therefore, improvements in knowledge of plant genetics, physiology and agronomy have underpinned large increases in crop productivity.

Some farmers, however, felt that the introduction of new technologies did not necessarily lead to economic returns, as grain prices had been falling continuously. Farmers started to question industrialised intensive agriculture policies[67] (cf. the debate about organic farming and conventional and traditional agriculture for food production). On the other hand, emerging pathogens (e.g. prions causing bovine spongiform encephalopathy (BSE, more commonly known as "mad cow disease") or the highly pathogenic H5N1 virus) grabbed the attention of consumers throughout Europe. Worldwide outbreaks of food-borne illnesses have occurred in the past. Nevertheless, recent cases have made consumers increasingly aware of the naturally occurring threats and production-induced risks to food safety all over Europe. It must be borne in mind that food is not only an agricultural or trade commodity but also an essential emotional, political and public health issue. The demand for healthy and safe food increased throughout the EU. Health-related concerns about food products generated a need for reassurance about the presence of pesticide residues, heavy metals, hormones, antibiotics and additives used in the food system or large-scale livestock farming. Food safety issues and consumers' rights became key components of EU policies on agriculture. Farmers and consumers have begun questioning some technologies, especially pest control practices and genetic engineering of crops, and want to know if they are consistent with human health, stewardship of the land and the sustainability of the Earth's ecosystems.

2.4 Modern agriculture: security and sustainability

The growth rate for global demand for agricultural commodities has increased from 1.5% per year in the mid-'70s to '80s to 1.9% per annum from the mid-'90s to the present (USDA, Goldman Sachs Commodities Research, 2008[68]). Although production is an excellent goal, the challenge that lies ahead in the 21st century is to make the transition from production

---

[66] Maarten and Mandoli, "Agricultural Ethics", Plant Physiology, Vol. 132, pp. 4-9 (2003).
[67] Brouwer, "Main trends in agriculture", Policy Brief 1. EU FP6 SSA. "Agriculture for sustainable development: A dialogue on societal demand, pressures and options for policy", p. 3 (2006).
[68] Quoted by Colin Ruscoe, British Crop Protection Council (April 2008).

agriculture to agricultural sustainability. This transition will require substantial institutional innovation[69].

[69] Ruttan (1999).

3. AGRICULTURAL METHODS AND TECHNOLOGIES

The rapid growth in world population (13%), global income (36%) and meat consumption (beef 14%, pork 11% and chicken 45%) in the last decade[70] are major drivers behind increased demand for raw materials. There are essentially two options available to meet this challenge:

1. increase the area cultivated, thus putting further pressure on the remaining land, including marginal ground and forests;
2. increase the productivity of the land currently cultivated, which is a more sustainable option.
3. Improve distribution of agricultural products to ensure they are in the right place at the right time
4. Modify the consumption habits of those enjoying excess and redistribute

These challenges can be met by modern technologies, which therefore play a considerable role in sustainable agriculture.

Agricultural technologies by category

Technologies and methods to ensure sustainability	**Technologies and methods to ensure food security**	**Other technologies not directly linked to agri-food**
Sustainable land use, production and distribution	Improved production efficiency	Biofuel production
Non-tillage practices	Food stocks storage	R&D
ICT-based agriculture	Grain improvement	
Indicators for monitoring	Marker-assisted selection	
Technologies to counteract climate change	Genetically modified plants	

3.1 Sustainable agricultural technologies

Sustainable agricultural technologies aim to reduce input and increase output without depleting resources, such as soil-derived nutrients and water. Among them, biotechnologies have assumed an increasingly important role in boosting productivity while reducing manpower and production costs. As a result, over the last 50 years the cost of food has been decreasing steadily by between 10% and 50% compared with the average family's income (but see section 3.2 for a description of the latest trend). In order to achieve this, food production and distribution processes have been evolving, from optimisation of use of arable

land to new methods to turn areas not accessible at present, due to adverse environmental conditions, into arable land.

3.1.1 Soil conservation: non-tillage practices to limit soil erosion

Erosion is a natural process heightened by human land use, particularly if the land is used for growing agricultural crops. Tillage used to be (and still is) a common practice that reduces surface vegetation and disrupts both the soil architecture and the root systems present in the soil that would offer a natural defence against soil erosion. As a consequence, valuable nutrients and biomass are continuously lost from arable fields and need to be replaced for each harvest, at farmers' expense, by spreading added fertiliser. Non-tillage options have been developed over the last few decades in order to implement better preservation practices in agriculture.

Non-tillage techniques against erosion can take the form of contour farming (on gentle slopes), terrace-building and strip-crop farming, but each of these requires significant changes in crop management, including use of herbicides and, probably, herbicide-tolerant crops. Non-tillage practice is becoming important as industrial demand for what used to be waste material increases. Leaves and stalks (e.g. corn stover or straw[71]) have traditionally been left on fields after harvest, but biorefineries are set to use such waste material as cellulosic biomass for ethanol production. Conventional tillage practice involves intensive tilling of soils to control weeds and aid irrigation. This disturbs more than 70% of the soil. Residues should be left on the land in order to prevent soil erosion. Use of herbicides and herbicide-tolerant plants reduces the need to till and makes residue removal less critical – allowing the residue to be taken for refining[72].

Contour farming consists of ploughing the land following its natural contours and planting across its slope, so that water can be retained when it rains and the soil is not washed off the fields. Terraces also reduce erosion by counteracting surface run-off and are built with

---

[70] Data from EuropaBio: www.europabio.org. Source: USDA/Pioneer Market Economics.
[71] Corn stover consists of the leaves and stalks of maize plants left in the field after harvest. It makes up about half of the yield of a crop and is similar to straw, the residue left in the field after harvesting of any cereal grain. Stover can be grazed as forage or collected for use as fodder but is commonly left unused. It is used for cattle feed in Europe.
[72] BIO (Biotechnology Industry Organisation), "Achieving Sustainable Production of Agricultural Biomass of Biorefinery Feedstock" (2006).

supporting down-slope borders across the slope. A series of terraces can effectively break up long slopes, which are more susceptible to soil erosion, into short sections, each of which collects some of the excess water from a smaller partitioned area.

Strip-crop farming consists of planting alternating rows (or strips) of a closely sown crop (e.g. wheat) plus a cereal crop (known as "row crops", e.g. corn). This helps to prevent soil erosion because it preserves moisture better, as the different layers of plant roots will adsorb water differentially, helping to keep up the soil's strength. It resembles simultaneous in-field rotation, providing a means of keeping the land fertile for longer than in standard farming. Good **drainage** is also necessary in all farming practices and is an important conservation practice. It can reduce surface water dispersion in the rainy season by letting water soak deeper into the soil and can lead to increased crop production by guaranteeing optimum soil humidity.

3.1.2 Pesticides, herbicides and fertilisers

Pesticides are chemicals used (usually sprayed) on crops to kill pests harmful to plants, usually insects. Theoretically, they are targeted in order not to affect other insects or animals. They are designed to eliminate pests; however, they could also harm other species, either by direct contact or by accumulation in the food chain. Repeated use of pesticides creates the selection pressure required for disease-resistant species to evolve. **Herbicides** (and fungicides) are chemicals used to eliminate unwanted weeds from plantations. Some of them are less of a problem to animals because their mode of action is based on metabolic pathways present only in plants, but others have been shown to cause various negative health effects (such as skin irritation or even carcinogenic effects) attributable to improper use/dosage and unwanted contact with animal species and humans. **Fertilisers** are chemicals that are applied to soil to provide crops with nutrients. Nitrogen available in the form of nitrates is one example of a nutrient essential for plants that can be provided by fertilisers. Their composition and mode of action are therefore totally different from pesticides, but, like pesticides, they pose an environmental hazard when over-accumulated in the soil. As a source of nutrients, they normally have no direct negative effects on plants and animals; however, some plants can utilise the extra nutrients more effectively than others and therefore outcompete others. In this way, fertilisers can be responsible for a reduction in species diversity.

Use of chemicals has had a deep influence on agriculture in general, by avoiding crop losses due to pests and increasing production, but has also had a number of disadvantages, such as chemical intake – bioaccumulation – carcinogenic and other effects and related consumer concerns. An increasing number of farmers have started to use organic fertilisers and pesticides to avoid chemicals which could have polluting and ill effects on crops or those eating them. Another approach that has been used is **integrated pest management** where different crops are cultivated that promote the presence of animal species that compete with, or are predators on, harmful insects. The population of predators or competitors against harmful species may also be increased by cultivating them and spreading in fields.

3.1.3 Information and communication technologies (ICT) in agriculture: precision farming as a method to reduce chemicals input and maximise land use

In the era of computer technology, an increasing number of agricultural practices may be remotely controlled and monitored by computer-assisted methods. Precision farming, also called "site-specific farming", is the newest method in the most developed countries, in which advanced information technology tools are employed to ensure better land management and use of resources. With the aid of a global positioning system (GPS) and a geographical information system (GIS), nowadays it is possible to map precisely the area of farmed land and to monitor physical soil characteristics such as topography, salinity, etc. All the data can be stored and analysed at any time. Major advantages of such technology include improved crop yields, more efficient (lower) application of chemicals and, therefore, a reduction in the pollution caused by releases of chemicals into the environment.

The decrease in chemical input applies both to use of fertilisers, due to "variable-rate" fertilisation (applying discrete quantities exactly when they are needed), and to variable spraying of pesticides and herbicides, based on precise topographical maps which make restricted use possible. Precision farming is still at an experimental phase in some countries (e.g. USA), but could spread quickly once its advantages over conventional farming are established and commonly accepted.

3.1.4 Double-crop systems

The ability to thrive through stress is a genetically complex trait, but involves a relatively

small number of genes that have a significant effect on stress tolerance. Thanks to this genetic information, new crop varieties have been selected that can withstand and grow through environmental stresses such as frost, heat and drought. Some crops, for example rice and cotton, do not tolerate environmental stresses well and require large amounts of water. Sorghum, on the other hand, is a crop that tolerates drought well. By harnessing these different properties and the increasing knowledge about how crops and other plants withstand environmental stresses, new agricultural systems such as "double cropping" have been developed[73]. As a result, now it is possible to plant two crops per season every year, for example by planting crops in the spring to be harvested in the summer (e.g. early maturing soybean) and autumn, taking advantage of the different maturation times[74] in double crops such as soybean/winter barley and wheat/maize. This system could significantly reduce the amount of cropland needed for current food production and is becoming an option for increasing food production to feed the ever-increasing world population.

3.1.5 Intercropping systems

Many farmers have adopted intercropping techniques, where two crops are grown at the same time. This has been found to be beneficial in suppressing weeds, increasing crop competition and providing allelopathic effects. Two crops could use light, water and nutrients more effectively than one, leaving fewer resources available for weeds[75].

"Intercropping is most successful when the two crops have complementary growth patterns and resource needs. For example, an intercrop of peas and oats controls weeds in several ways: the oats provide early competition with weeds while the peas are becoming established; the peas then climb on the oats, blocking out light to the soil; the rooting patterns of the two crops also differ; the oats compete more with grassy weeds for nutrients and the peas compete with the broadleaf weeds; the oats also take up excess nitrogen that would otherwise stimulate weed growth.

Other successful intercrops include: oats and pulses (such as lentils or beans), flax and wheat, flax and medic, wheat and lentils, flax and lentils, barley and peas.

[73] See, for example, http://extension.missouri.edu/xplor/agguides/crops/g04090.htm.
[74] See, for example, http://www.plantmanagementnetwork.org/.
[75] http://www.gov.mb.ca/agriculture/crops/weeds/fba09s00.html#Intercropping.

Seeding rates need to be adjusted so that the two crops compete with the weeds, but not with each other. Seeding each crop at two thirds of its normal rate has produced good results[76].”

3.1.6 Climate-change-related sustainable technologies

As global warming is changing the climate worldwide and is aggravating, for instance, the process of desertification, there is a pressing need to adapt agricultural technologies in order to make greater use of land in increasingly difficult regions, such as land with a higher salt content, arid land, etc. Varieties that exhibit stress tolerance are being actively sought and then crossed with local varieties[77]. In order to achieve results with greater precision and faster, genetically modified plants are being developed (see also section 3.2.3).

It is becoming increasingly important to apply agricultural production methods that use less water and to develop technologies to maximise nitrate use (for increased retention of nitrogen) and CO_2 sequestration[78].

Lastly, sugars are essential raw materials for a range of products, including ethanol and bioplastics. Leaves, straw and wood are made up of about 70% sugar (often in the form of cellulose or starch). This waste material could therefore be fermented into ethanol for use as a fuel or feedstock for chemical synthesis. Natural cellulases, enzymes that break down cellulose into usable glucose, are not very efficient and break down plant material slowly. Biotechnology-based methods (e.g. using micro-organisms as “biofactories”) to break down cellulose enzymatically to free sugars will therefore assume increasing relevance in future. Such biorefineries would require significant amounts of material. Current yields of ethanol from agricultural residues are about 250 litres per tonne[79]. Assuming that a biorefinery would produce 250 megalitres per year, it would need approximately 1 million tonnes of feedstock or 200 000 hectares of cropland[80].

---

[76] Ibid.
[77] CGIAR (2007), “Adapting Agricultural Systems to Climate Change”: http://www.cgiar.org/pdf/cc_adapting_agr_systems.pdf.
[78] D.R. Sauerbeck, “CO_2 emissions and C sequestration by agriculture – perspectives and limitations”, Springerlink (2004).
[79] US Department of Energy, “Breaking the Biological Barriers to Cellulosic Ethanol: A Joint Research Agenda”, DOE/SC-0095: http://doegenomestolife.org/biofuels/b2bworkshop.shtml (2006).
[80] BIO (Biotechnology Industry Organisation), “Achieving Sustainable Production of Agricultural Biomass for Biorefinery Feedstock”: www.bio.org/ind/biofuel/SustainableBiomassReport.pdf (2006).

3.2 Agricultural technologies and methods

Agricultural technologies offer farmers new and better crops which will allow them to increase harvest yield and minimise losses. These goals are achieved first by certain desirable output traits, such as improved crop quality which increases yield and leads to better nutritional composition (e.g. starch, proteins and oils), and selection for better appearance and better taste. Secondly, crops can display certain input traits, such as disease resistance (to virus, bacteria, fungi, etc.), pest (insect) resistance, herbicide tolerance and resilience to abiotic stresses (tolerance to cold, heat and drought). Although, on the one hand, the advantages of such technologies for farmers are evident, on the other there is a need to make them and improved crops accessible to all farmers, including those in the poorest countries, and for a system to counter-balance the corporate agricultural industry, which often wields monopolistic control over commodity prices.

3.2.1 Grain improvement

One of the most important tasks carried out by agronomists is selective **plant breeding** in order to develop increasingly better quality crops. Over the last few decades, significant improvements have been attained for most commonly used grains, such as wheat, corn and soybean. Creation of hybrids (not only for grains, but also for fruit and vegetables) with improved nutritional value has been another significant development. Selection in multiple generations allows segregation of traits and, therefore, selection of desirable and deletion of unwanted traits[81]. Selection of desirable traits can be improved by means of markers (see section 3.2.2) or genetic manipulation (see section 3.2.3), but traditional back-crossing is always required.

Development of applications of molecular genetics for plant breeding has created new opportunities for breeding cultivated species. These technologies include:

- ***Marker-assisted selection*** (MAS) (see section 3.2.2 for further details) which can speed up studies, leading to better crops by directing selection more efficiently.

[81] Bernardo, R., "Breeding for Quantitative Traits in Plants", Stemma Press, Woodbury, United States (2002).

Coupling of selection with massive analysis of existing germplasm or with mutagenesis could allow breeding for new characteristics of interest to farmers.

- ***Genomic approaches*** to analyse complex characteristics. These technologies make it possible to study characteristics inaccessible with previous technologies and allow breeding of species with difficult genetic features. In this way, new crops could become accessible for plant breeding.

- ***Genetic modification*** (see section 3.2.3 for further details) of plants where genes of any origin can be introduced into plants in the laboratory. GMO plants normally include a small number of new genes leading to new properties such as insect resistance or herbicide tolerance.

Other plant technologies that have had an impact on improving agronomic properties and sustainability are:

Plant tissue culture: This technique allows whole plants to be produced from minute amounts of parts like the roots, leaves or stems or even just a single plant cell under laboratory conditions. One advantage of tissue culture is rapid production of clean planting materials. Examples of tissue culture products in Kenya include banana, cassava, Irish potato, pyrethrum and citrus.

Hybridisation: Increasingly, plant scientists are harnessing the characteristic feature of better yielding hybrids in plants. Hybrid vigour, or heterosis[82] as it is scientifically known, exploits the fact that some offspring from the progeny of a cross between two known parents would be better than the parents themselves. Many hybrid varieties of several crop species are being grown all over the world today. One example of this are the hybrid tomatoes commonly eaten.

Additional technologies which lead to optimisation of food production from arable land without using genetic engineering are indicated in the table:

[82] Heterosis: increase in growth, size, fecundity, function, yield or other characters in hybrids over those of the parents. Retrieved on 5 October 2008 from Dictionary.com (Unabridged (v. 1.1)) website: http://dictionary.reference.com/browse/HETeROSIS).

Some tools of biotechnology (apart from genetic engineering)[83]

• Marker-assisted breeding uses conventional breeding techniques informed by specific genetic sequences, or "markers," that segregate on the basis of particular traits. Markers speed up breeding programmes by allowing researchers to determine, early in the life of a progeny, whether the traits they hoped to combine from two organisms are present simply by checking for the presence of the markers.

• Tissue culture is used in clonal propagation of plants for which sexual breeding has proved inefficient. It has been important for reproducing crops used across the African continent, including oil palm, plantain, banana, date, eggplant, pineapple, rubber tree, cassava, maize, sweet potato, yam and tomato.

• Cloning and *in vitro* fertilisation allow the manipulation of germ cells for animal-breeding programmes, genetic-resource conservation and germplasm enhancement.

• Gene profiling or association mapping tracks the patterns of heritability of variations (alleles) of many genes. The quantitative trait loci (QTLs) collectively contribute to complex plant traits, such as drought tolerance and robust seed production, and understanding of the groupings of QTLs provides insights into how genes work in concert to produce a particular characteristic.

• Metabolomics provides a snapshot of all the metabolites being produced in a plant cell at any given time under different environmental conditions.

3.2.2 Marker-assisted selection (MAS)

Among recent biotechnologies applied to plant breeding, MAS has seen considerable developments over the last few decades[84]. MAS seeks to replace the traditional phenotype-dependent selection of breeds with a type of selection based on a marker associated with the trait of interest. A molecular marker is a short sequence of DNA that is so tightly linked to the desirable trait (such as disease resistance) that selection for its presence ends up selecting for the desirable trait, e.g. maize that is tolerant to drought and maize streak virus. The marker can be morphological, biological, biochemical, cytological or molecular (e.g. DNA-based). The theory behind MAS is that once the desirable trait to be selected has been

[83] "Global Challenges and Directions for Agricultural Biotechnology: Workshop Report", Steering Committee on Global Challenges and Directions for Agricultural Biotechnology: Mapping the Course, National Research Council, ISBN: 0-309-12078-0: http://www.nap.edu/catalog/12216.html.

[84] Collard, B.C. and Mackill, D.J., "Marker-assisted selection: an approach for precision plant breeding in the twenty-first century", Philos Trans R Soc Lond B Biol Sci. Feb 12; 363(1491): 557-72 (2008); and Frisch, M. and Melechinger, A.E., "Selection Theory for Marker-Assisted Backcrossing". Genetics 170, 909-917 (June 2005).

mapped and is linked with an easily recognisable and easily measurable marker, the marker can be used to select desired breeds instead of the plant phenotype as a whole. The ideal marker needs to be not too far away from the desirable genetic trait in order to avoid too many false positives due to spontaneous recombination or segregation. Marker-assisted backcrossing is now routinely applied in breeding programmes for gene introgression.

Examples of selection markers used in MAS

Marker category	Example
Morphological	Height, leaf coloration or grain colour
Biological	Pathogen or insect resistance
Biochemical	A specific protein produced, e.g. an isozyme
Cytological	A marker that is revealed after histochemical staining only, e.g. for chromosomes
Molecular	For example, DNA-based, which can be detected by sequencing or microsatellite analysis

3.2.3 Genetically modified (GM) plants

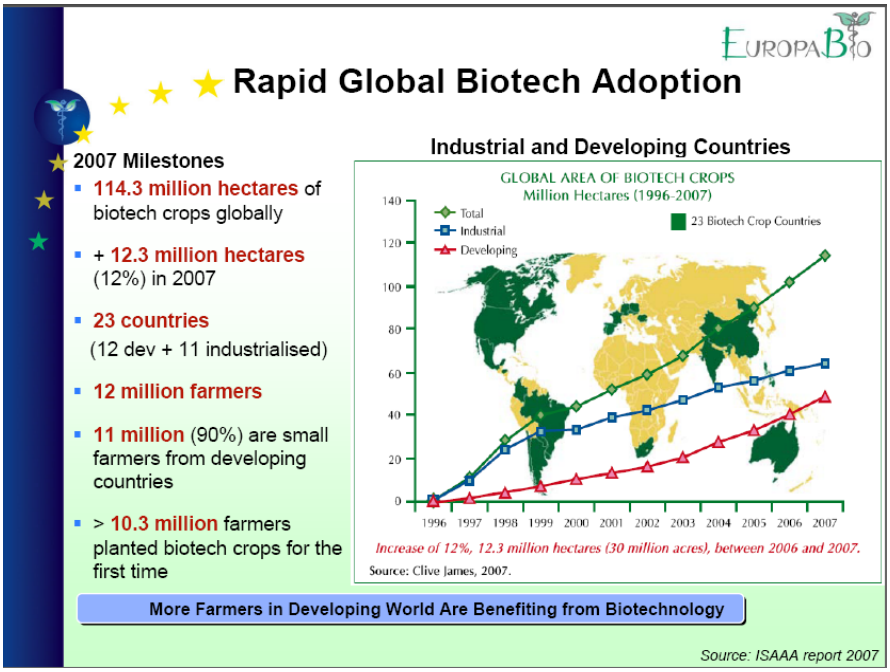
Plant genetic engineering means selective and deliberate transfer of beneficial gene(s) from one organism to another to create new improved crops, animals or materials. Examples of genetically engineered crops currently marketed around the world include cotton, maize, sweet potato, soybean, etc. Living modified organisms (effectively the same as genetically modified organisms) are defined in the Cartagena Protocol as organisms that have been produced by:

> (a) application of *in vitro* nucleic acid techniques, including recombinant deoxyribonucleic acid (DNA) and direct injection of nucleic acid into cells or organelles, or
>
> (b) fusion of cells beyond the taxonomic family that overcome natural, physiological, reproductive or recombination barriers and that are not techniques used in traditional breeding and selection.

During the 1980s the new scientific tools offered by molecular biology began to be used for introducing new characteristics into plants (and animals) for use in commercial agriculture. Many scientists saw little difference between the new technology, where genes were isolated

from unrelated organisms (often micro-organisms) and introduced into crop varieties, and traditional methods of plant breeding (natural selection, cross-breeding, conjugation, chemical or radiation-induced mutation and transformation). The first genetically modified plants were then introduced in the mid-1990s, with the goal of creating new plant species with desirable traits such as resistance to pests, herbicides or harsh environmental conditions (e.g. drought). Subsequently, other desirable traits were introduced, such as higher yield and lower perishability. The technology consists of inserting novel genetic sequences into the plant in order to confer the qualities sought. Because of this genetic manipulation, this technology has met with mixed feelings on the part of the general public in several countries and raised concerns about cross-pollination with wild species, cross-contamination of standard crop fields around GMO fields and increased resistance in pests and weeds.

Adoption of crop biotechnology between 1996 and 2007



Herbicide tolerance remains the most common transgenic trait[85]. Insect resistance is the second most common genetically modified trait. Herbicide tolerance and insect resistance are often introduced simultaneously. The third most commonly grown transgenic crop is one

[85] Herbicide tolerance is available for all the major GM crops, including soybean, maize, rapeseed and cotton. In 2005, the first herbicide-tolerant sugar beets were approved in the USA, Australia, Canada and the Philippines. Herbicide-tolerant rice and wheat have been developed, but are not currently in use. In 2006, herbicide-tolerant alfalfa was widely cultivated for the first time in the USA (80 000 hectares). In 2006, such crops made up 70% of the 102 million hectares of GM crops worldwide.

containing both traits – insect-resistant and herbicide-tolerant maize. Most of the modified crops used today are derived from insertion of a single new gene into the parent plant. Many new traits are being introduced, including those for coping with abiotic stress such as drought or salt tolerance that will markedly increase the area on which the crops concerned can be grown.

Combined herbicide and insect resistance was the fastest growing GM trait from 2004 to 2005, grown on over 6.5 million hectares in the USA and Canada and covering 7% of the global biotech area. The recent expansion of biotech crops is mainly down to the increase in Bt maize and Bt cotton production in China, India and Australia. GM varieties of soybean and maize have been widely accepted in the Americas[86]. Globally, 64% of soybean, 43% of cotton, 24% of maize and 20% of canola are now GM varieties[87].

USA: Cultivation of GM plants, 2007

	Area in million ha	Percentage share
GM soybean	23.6	91
GM maize	27.4	73
GM cotton	3.9	87
GM plants total	54.9	

3.3 Biofuels production: between the first and second generations

First-generation biofuels – At present, the main raw materials for biofuels and biodiesel production are several kinds of crop, which are cultivated in various countries. Biofuels production and the subsequent transformation chain can differ widely from several points of view, for example in terms of greenhouse gas savings over their life cycle, the cost of the greenhouse gas savings achieved, their requirements as regards arable land and quality, water and fertilisers, the impact on biodiversity, direct competition against food products, impact on fixed carbon in soils, etc. Some of the issues related to cultivation of first-generation biofuels are discussed below.

Biofuels and land use – The impact of biofuels production on land use can be direct, where land is converted directly from another use to agriculture to grow biofuels feedstocks, or

[86] http://www.gmo-compass.org/eng/agri_biotechnology/gmo_planting/283.usa_cultivations_2007.html accessed on 7 October 2008.
[87] Clive James, 2008, International Service for the Acquisition of Agri-biotech Applications (ISAAA).

indirect, in cases where biofuels production displaces other land uses (e.g. agriculture or cattle ranching), and can cause conversion of natural vegetation in other areas. Both could have a negative impact on natural resources (biodiversity, for example) and would reverse any positive benefits of biofuels production. Not only must the availability of enough land to accommodate the expansion of biofuels envisaged in many countries' strategies be taken into account, but also steps must be taken to ensure that in practice this expansion of biofuels production will lead to no significant risks of biodiversity loss and carbon dioxide emissions. Both direct land use for future sugarcane expansion and any other indirect impact should be further investigated by *ad hoc* research. The same applies to countries where not sugarcane but other raw materials are used for biofuels production, for example soybean expansion.

Biofuels and food security – The impact on food security of using crops for the production of first-generation biofuels can vary greatly between different countries (see table below[88]).

Crop use and impact on food security

CROP	FOOD SECURITY VULNERABILITY[89]
Corn	High vulnerability: principal source of protein and eatable fat for the poorest countries (e.g. Central America), which are also net importers. Price increase = reduced availability
Soy	Average vulnerability: important source of eatable fat in most countries, which are also net importers. Price increase = reduced availability
Sugarcane	Low vulnerability: principal source of food energy but nearly all countries are net exporters
Palm oil	Very low vulnerability: no significant source of eatable fat or food energy for most countries; affected countries are net exporters

Impact on food security, depending on the type of biofuel

BIOFUEL	FOOD SECURITY VULNERABILITY
Ethanol	High impact on food security if ethanol expansion is based on corn/wheat (e.g. Argentina) Low impact on food security if ethanol expansion is based on sugarcane
Biodiesel	High impact on food security if biodiesel expansion is based on soy (e.g. Argentina or Bolivia) Low impact on food security if ethanol expansion is based on palm oil

Second-generation biofuels – Some years from now (a reasonable estimate is probably ten years), second-generation biofuels will be becoming available at competitive prices. These will be based mostly on turning residues and wastes into biofuels (biomass to liquid [BtL] biofuel), by processes that are being studied and developed at the moment. They will benefit

[88] D. Rutz and R. Janssen, "Biofuels SWOT analysis", WIP renewable energies (2007).

from the infrastructure now being developed for the first-generation biofuels and they will signal the end of use of food crops for biofuels production. They might offer a better option for future fuel needs, but no conclusions could be drawn until after additional studies on costs, greenhouse gas emissions and energy balances. Second-generation biofuels can be made from almost any form of biomass. If made from forest or crop residues, they do not compete with food for feedstock. However, if made from dedicated energy crops, they compete for land and water resources[90]. Current research is focusing on producing biofuels that can be grown on non-arable land or by other kinds of cultivation. For example, in 2008 research has been focusing on algae for biofuels (design of new photobioreactors for biomass and bioenergy) that have the advantage of making no impact on food security or use of arable land and inducing positive consequences for the environment.

Second-generation processes are still at the pilot plant stage. They are complex and very expensive, but can use cheaper feedstock. According to a report published by the EU Joint Research Centre (Institute for Energy, 2007), second-generation biofuels are unlikely to be competitive with first-generation biofuels by 2020 and will use largely imported biomass. It should, however, be made clear that the benefits of the second-generation biofuels in terms of food security and environmental protection are controversial, both in the EU[91] and beyond.

3.4 Organic farming

According to the International Federation of Organic Farming, "Organic agriculture is a production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved ..."[92]. The Codex Alimentarius defines organic agriculture as "one

---

[89] CEPAL (2007).
[90] Some energy crops (switchgrass, poplar, etc.) can also be grown (at reduced yield) on present grassland. It is not known how much soil carbon would be released by this change in land use. Much depends on ground cover and how much soil is disturbed in planting.
[91] See the EU Institute for Prospective Technological Studies (IPTS) report on biofuels:
http://ipts.jrc.ec.europa.eu/home/report/english/articles/vol74/TRA1E746.htm
or the JRC report on biofuels in the EU:
http://www.fp7.org.tr/tubitak_content_files//306/JRC/dokumanlar/jrc_biofuels_report.pdf.
[92] International Federation of Organic Agriculture Movements (IFOAM):
http://www.ifoam.org/about_ifoam/principles/index.html.

among the broad spectrum of methodologies which are supportive of the environment. Organic production systems are based on specific and precise standards of production which aim at achieving optimal agro-ecosystems which are socially, ecologically and economically sustainable"[93]. "Organic" is a label that denotes products that have been produced in accordance with organic production standards and certified by a duly constituted certification body or authority[94]. Organic agriculture is based on minimising use of external inputs and avoiding use of synthetic fertilisers and pesticides to minimise pollution of air, soil and water.

The recent Natural Products Expo East[95] attracted more than 26 000 visitors, clearly indicating the continued success of natural and organic products on the US market. However, the organic food market is growing rapidly not only in the USA but also in most developed and developing countries. At present, 1% to 2% of total food sales worldwide are organic products. World organic food sales increased from US$ 23 billion in 2002 to US$ 40 billion in 2006[96]. In the EU, in 2006 over 6.8 million hectares of farm land were allotted to organic farming, or 4.5% of all arable land[97].

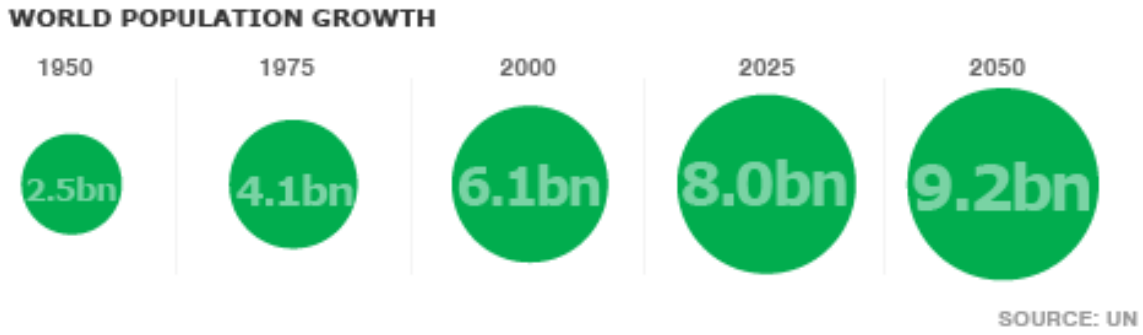
[93] ftp://ftp.fao.org/codex/Publications/Booklets/Organics/organic_2007e.pdf.
[94] To be certified as organic, food must be produced, processed, labelled and marketed in accordance with strict standards set by organic organisations in the countries where it is sold, e.g. by the US Department of Agriculture (USDA) by the Bristol-based Soil Association in the UK and under the EU policy on organic farming.
[95] The Natural Products Expo East: www.expoeast.com held in Boston (MA, USA) (15–18 October 2008).
[96] Organic Monitor: The global market for organic food and drink: http://www.organicmonitor.com/.
[97] Data from http://www.zmp.de/oekomarkt/Marktdatenbank/en/downloads.asp.

4. AGRICULTURE IN THE 21ST CENTURY

Agriculture not only requires replacing natural ecosystems with crop fields and tree farms (loss of biodiversity and carbon dioxide release) but also results in groundwater pollution, soil erosion, water depletion, soil degradation, pesticide pollution and other environmental stresses. In the second half of the 20th century a need for a different model of agriculture emerged: a sustainable and multi-functional agriculture where stewardship of the land, preservation of the resource base, the health of farm workers, preservation of the small biota that are rich in biodiversity, the value of rural communities and the value of the agricultural landscape acquired important status. One of the aims of the UN Earth Summit in Johannesburg in 2002 was to "enhance in a sustainable manner the productivity of land and the efficient use of water resources in agriculture". But how is it possible to obtain, in agricultural parlance, "more crop per drop[98]"? If greater yield is obtained, is it sustainable[99]?

4.1 World population growth

The world population is expected to top nine billion by the middle of the century. This growth will put pressure on a range of resources, including land, water and oil, and also on food supply. The extent to which this growth in demand for food on emerging markets will create additional demand for food on world markets also depends on whether the productivity growth in agriculture in the countries concerned can keep pace with the demand growth.



[98] Christian Verschueren, "Scientists Aim for More Crop Per Drop", Business Day, Johannesburg, South Africa, 30 March 2005: http://allafrica.com/stories/200503300191.html (2005).
[99] On this specific issue, Dr Christian Verschueren argues that "Stewardship, research and development, good agricultural practices and proper land management techniques are fundamental to water protection and preservation. The plant science industry is well placed to address the challenges of feeding a growing population while conserving water."

Modern agriculture currently feeds over 6 billion people. Before the dawn of agriculture the hunter-gatherer lifestyle could have supported about 4 million people worldwide[100]. Over the next 50 years food production will have to double in order to feed the world's population. Global cereal production has doubled in the last 40 years, but this has led to increased use of fertilisers, water and pesticides, of new crop strains and other technologies associated with the "green revolution" and also of fossil fuels.

4.2 Climate change

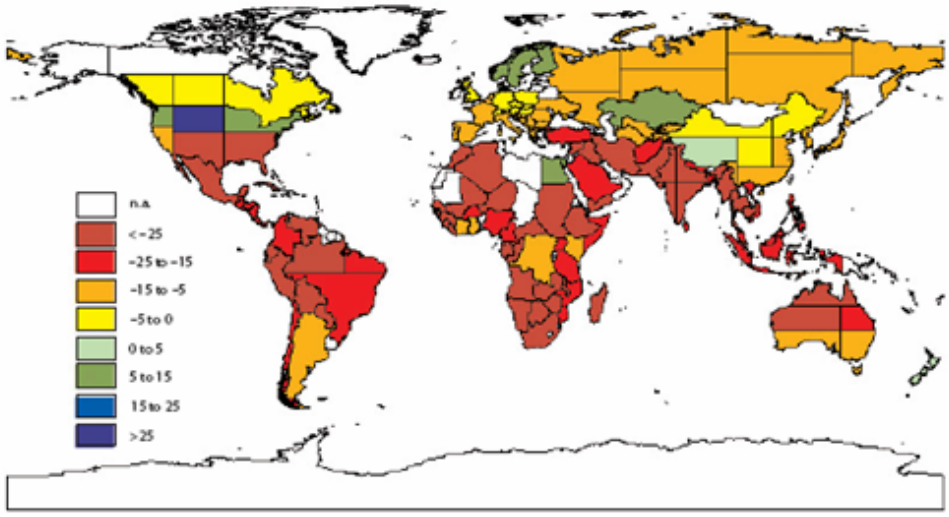
Desertification is accelerating in various regions, such as China and sub-Saharan Africa, while more frequent floods and changing patterns of rainfall are already beginning to have a significant impact on agricultural production worldwide. Poor countries are more vulnerable to adverse consequences of global warming[101]. Climate change analyses suggest that unusual weather patterns are likely to become more pronounced, with possible consequences in the form of volatility of agricultural production because of weather-related supply shortfalls. The FAO has forecast that world cereal stocks will fall to a 25-year low of 405 million tonnes in 2007/08, down by 21 million tonnes, or 5%, from the previous year's already reduced level. However, the effects of climate change are difficult to predict and, among others, include the emergence of new pests, harmful viruses and/or bacteria plus animal and plant diseases which have an influence not only on the quantity but also on the quality and, especially, safety of crop (and livestock) production. Furthermore, the higher frequency of extreme climatic events, which often disrupt agricultural production too, could potentially have an impact on food security and food prices.

Agriculture contributes to climate change in several major ways and climate change in general has adverse effects on agriculture. Climate change, at a time of increasing demand for food, feed, fibre and fuel, has the potential to damage irreversibly the natural resource base on which agriculture depends. Technological improvements, increased yields and expansion of production area may help meet the demand growth and reduce price inflation. However, even assuming constant favourable climatic conditions, a number of factors will limit the pace at which production can catch up with demand. Factors like availability of

[100] Tilman, D. et al., "Agricultural sustainability and intensive production practices", Nature 418, 671-677 (2002).

land and water, agricultural input prices, technological innovation and investment will limit the scope for increases in productivity.

Climate change will reduce production growth in many of the poorest countries and regions. This will have further price-increasing effects.
Percentage change in agricultural production due to climate change, 2080.



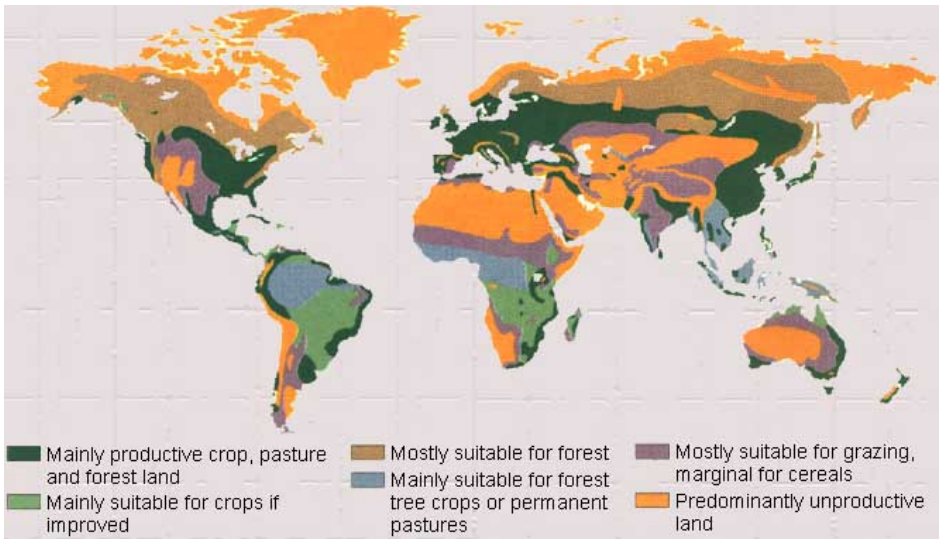
4.3 Arable land capability

In the 1970s the FAO began a decade-long study of 117 developing countries to see which of them could grow enough food for their populations on their available land. The study found that, in 1975, 54 countries could not feed their populations with traditional methods of food production and that 38% of their entire land area – home to 1 165 million people – was more populated than it could theoretically support. From population projections to 2000, it estimated that 64 countries – more than half the total – would be facing a critical situation; at low input levels 38 would then be unable to support even half their projected population. Much of the agricultural area of any country or region has limitations that could make it less suitable for arable farming. For example, there are some countries with, essentially, no arable land reserves, such as Tunisia and Burundi, and others with large amounts, for example Angola, Guyana and Brazil. Desertification and other climate change phenomena are increasing the shortage of arable land across the globe.

[101] Some of the reasons for this may be: (1) geography; (2) greater dependence on agriculture and natural resources; (3) limited infrastructure; and (4) low income, poverty and malnutrition. All these factors have contributed to lower adaptability to food crises and of complementary services, like health and education.

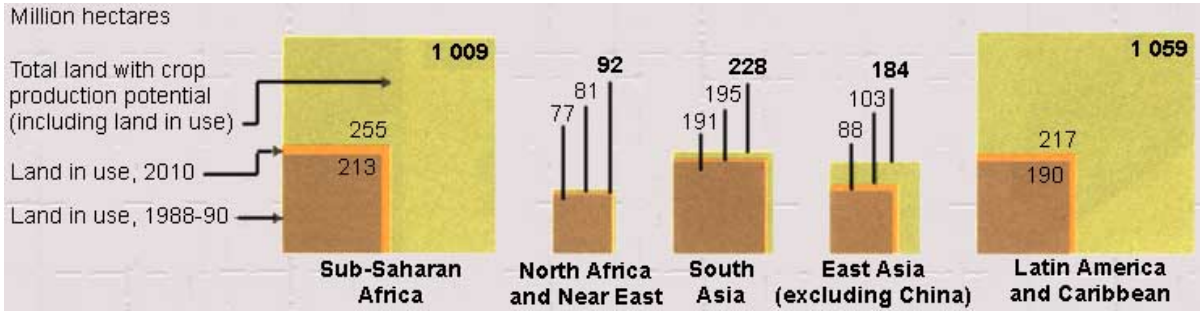
Dryland areas are home to one third of the people in the world and 90% of them are in developing countries. They are more vulnerable to environmental degradation than other areas. They are defined as land where plant production is limited by water availability and make up 40% of the total land area with 7% of all freshwater resources[102].

World potential land use capabilities



In 1995 a FAO study, *"World Agriculture: Towards 2010",* estimated that net cereal import requirements would increase from about 8 million tonnes to 19 million tonnes for sub-Saharan Africa, 38 to 71 million tonnes for the Near East and North Africa, 27 to 35 million tonnes for East Asia (excluding China) and 5 to 10 million tonnes for South Asia, primarily as a result of shortages of arable land.

Land under cultivation and land with crop production potential in developing countries

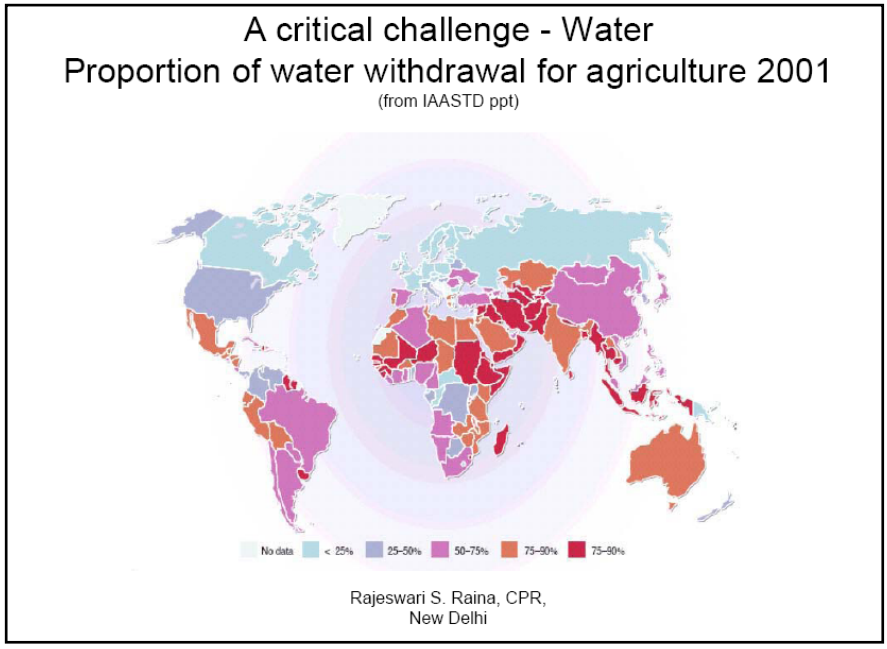


[102] Ringler, C., "The Millennium Ecosystem Assessment: Tradeoffs between Food Security and the Environment", Turk J Agric For 32 147-157 (2008).

4.4 Water protection

Population growth, lifestyle changes and economic development have been putting increasing strain on water resources that were already limited. Extreme weather conditions and other environmental problems, especially climate change which is leading to increasing floods and droughts in some regions of the world, cause loss of lives, material and economic damage and pollution and decrease food security. Since water is an essential for life, its supply and improved management are key components of any development policy, as poor water management can be a source of conflict.

In 2000, 17% of the world's population did not have access to a secure water supply and 40% lacked adequate sanitation. Most of these people lived in Africa and Asia. Modern technologies with the aim of securing water supply to communities focus on three approaches: (1) improvement of irrigation water management by optimising efficiency and farm output; (2) efficient management, treatment and re-use of wastewater by improved treatment technologies; and (3) autonomous desalination systems for sea water and other salty water in areas with scarce water resources.



4.5 Biodiversity loss

Agriculture and the natural environment are essentially in conflict, for by its very nature agriculture has an impact on the environment and is likely to reduce the diversity of plants, insects and animals that would have been found in the natural environment. Biodiversity loss

is considerable and is twofold within high-input agro-ecosystems: on the one hand, the loss of wild animal and plant species and, on the other, the loss of varieties among crop plants. Concerning wildlife, modern large-scale farming can harm biodiversity because large fields and the removal of margins (such as hedges) lead to loss of connectivity and habitat diversity[103]. Similarly, the number of varieties of major food crops fell dramatically during the twentieth century. Humans now rely on just 14 species of mammals and birds to supply 90% of all animal-derived foods (FAO). Twelve plant crops account for more than three quarters of the food consumed in the world, and just three – rice, wheat and maize – are relied on for more than half of the world's food[104, 105]. Because of modern trends towards mass production, only fifteen plant and eight animal species are now relied upon for about 90% of all human food[106].

Farmers and plant breeders tend to choose high-yield, insect-resistant varieties and this has led to the disappearance of over 90% of the varieties that were grown in the early 20th century. Crop management has changed radically with the availability of modern pesticides and herbicides, with management (including rotation, fertilisers, herbicides, ploughing, hoeing, etc.) depending on the crops actually used in the new-style rotations (the technology used will aim to protect the most susceptible crops in the rotation). A variety of herbicides are used to control weeds, ensuring that the seedbank present in the soil has as little diversity as possible. Removal of these plants has a direct effect on herbivores, seed-eaters, pollen- and nectar-feeders and an indirect effect on the whole food chain.

4.6 Depopulation of rural areas

By the end of the 20th century European farming had been transformed into a high-tech, highly specialised and highly productive modern industry. This greater use of technology has prompted a significant shift in the urban/rural population ratio. The same phenomenon can also be observed at global level.

---

[103] The disappearance of farmland margins has a negative impact on wildlife biodiversity. The same applies to increased use of pesticides, herbicides and fertilisers. In the same direction, the reduction of traditional rotation agriculture has lead to *de facto* monocultures. In addition, reduced crop and weed diversity has a negative effect on the food chain, as it results in a reduction of food available for indigenous insects, birds and other animals.

[104] FAO, "The State of the World's Plant Genetic Resources for Food and Agriculture", Rome, pp. 14-15 (1997).

[105] The International Development Research Centre (IDRC) (2006).

[106] UN Convention on Biological Diversity: http://www.cbd.int/.

Between the late 19th and late 20th century, the percentage of citizens employed in farming fell from 50% to just 3% in the United States, from 47% to just 3% in Germany and from 48% to just 6% in Denmark. This migration of labour out of farming triggered rapid growth in industry, where parallel applications of new science were boosting productivity and income to new levels. But it also unleashed a phenomenon of depopulation of rural areas, with far-reaching cultural consequences on the perception of food and its naturalness. Today, in the enlarged EU, different urban/rural ratios co-exist, with some EU regions having a strong tradition of organic or conventional farming (Poland, Bulgaria or Mediterranean countries) and others importing food products, after having chosen to switch production to other sectors of the economy (e.g. Scandinavian countries). In general, the urban population has grown more than the population in rural areas and more than 60% of the population are expected to live in cities in the near future[107].

4.7 Food transport and distribution: the ecological impact

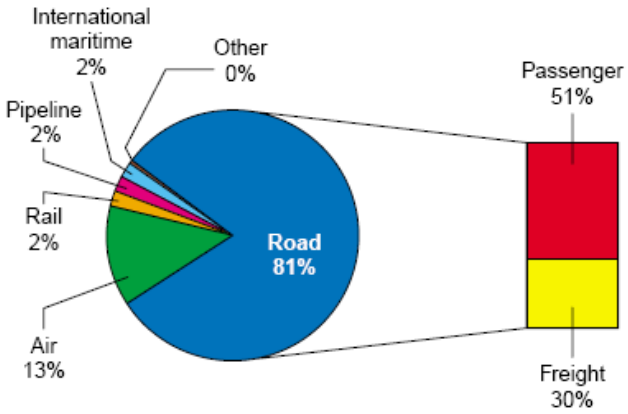
In the more developed countries, over the last few decades food production and trade have been rising steadily, with a parallel increase in transport between production and retail sites. Due to globalisation, the general trend has been towards fewer and larger suppliers rather than small, local producers. In the same way, delivery methods have shifted towards greater use of aircraft and heavy goods vehicles for carriage and local transport. Consumers have also changed their habits. In the past they used to frequent local shops, but now they tend to concentrate on bulk purchases on specific days of the week or month, usually by car and at large shopping centres not necessarily located in their neighbourhood. Factors leading to increased transport include, among others, increased global trade, the spread of big supermarket chains with centralised distribution systems, greater use of cars for shopping and increased packaging and processing.

"Food miles" – the distance travelled to market food products, also used as an indicator of sustainability (pollution) – have risen by over 15% over the last 15 years and are still rising, with an impact on traffic congestion, pollution and, ultimately, climate change[108]. The

[107] Joachim von Braun, "The World Food Situation: New Driving Forces and Required Actions", International Food Policy Research Institute, Washington D.C. (December 2007).

[108] Local sourcing helps as long as local food is transported efficiently. Organic food reduces environmental damage, but does not deliver a net environmental benefit if it has to be flown in from abroad. In energy terms, out-of-season local produce needing artificial light and heat generates more emissions than products imported by truck from abroad.

average distance driven to shop for food each year is almost 1 600 km, compared with 1 200 km fifteen years ago. Food accounts for 25% of all transport by heavy goods vehicles on roads and this figure has doubled since the 1970s[109]. This increase resulted in a rise in the amount of CO_2 emitted[110]: 19 million tonnes of carbon dioxide were emitted in 2002 (12% more than in 1992). Air freight, the most polluting form of food transport, is growing fastest. Food miles indicators take into account several factors – not just how many kilometres were travelled to deliver the product, but also the method of production and the degree to which it is sustainable, the mode and efficiency of transport and the CO_2 emitted in the process – to calculate the impact on the climate, social costs and benefits[111].



Energy consumption per transport sector (source: IEA and IFP estimates)[112]

4.8 Food waste

Food waste is a major issue in modern times from several points of view. First of all, from an ethical point of view, as better management and distribution of food resources could be beneficial to society's least privileged. Secondly, from an economic point of view, as food waste implies a considerable loss of money. And thirdly, from an environmental perspective,

[109] Data from the UK Department for Environment, Food and Rural Affairs: http://www.defra.gov.uk/corporate/deprep/2006/2006deptreport.pdf.
[110] The most fuel-efficient mode of transport is by waterway: one litre of fuel can transport one tonne of freight 222 km by river barge, 164 km by rail and only about 20 km by semi-truck. The continuous increase in fuel costs will have a more pronounced effect on the overall food-delivery system and prices.
[111] A. Smith et al., "The validity of food miles as an indicator of sustainable development", AEA Technology Environment (1994).
[112] http://www.ifp.com/content/download/57516/1274819/file/IFP-Panorama05%2009-ConsommationVA.pdf.

as decomposition of organic material is a major contributor to greenhouse gas (GHG) emissions which cause global warming[113].

Every process entails a certain margin of error, from production to distribution and consumption. There are several sources of waste all along the process, starting from harvest, where efficiency is never 100% and some of the harvest is lost because it is damaged or not ripe enough. Post-harvest losses then add up to 30% to 70%[114] during storage (where part of the harvest will be lost because of inappropriate storage conditions, e.g. due to mould, rodents, etc.) and during transport from the production, storage or processing site to retail shops, where a certain amount of production is lost because of damage. Eventually food reaches supermarket shelves where, under current marketing practice, a proportion of it is unavoidably thrown away because either it has passed its sell-by date (a problem connected to overstocking of products)[115] or it is over-ripe or spoiled. Last but not least, at the consumers' end household food stocks are not optimally managed, resulting in remarkable quantities of food waste (though very difficult to quantify).

Country	**Food waste as a percentage of food production**	**Food waste in million tonnes per year**
USA	30-50%[116]	25.9-52.9[117]
Japan	40%	20.0[118]
UK	30%	6.7[119]
NL	15%	3.0[120]

Apart from ethical and economic issues, environmental concerns about food waste are attracting increasing attention, as biodegradation of food releases methane, a greenhouse gas (GHG) 20 times more damaging to the environment than carbon dioxide (CO_2) as it adsorbs

[113] WRAP (2008), "The food we waste", ISBN: 1-84405-383-0 (version 2): http://www.wrap.org.uk/downloads/The_Food_We_Waste_v2__2_.99cb5cae.5635.pdf.
[114] According to Tessema Astatkie, Director of Canada's Post-Harvest Management to Improve Livelihoods Project, "Post-harvest crop losses can range from 30–70 per cent depending on the crop": http://www.enn.com/top_stories/article/35940.
[115] In a recent movement started in the 1990s (known as "dumpster diving") people sift through commercial trash bins looking for and retrieving products in good and edible condition discarded by supermarkets. This movement aims to prove that it is possible to make a good living out of superfluous commercial waste.
[116] Data vary, depending on the source. See http://edition.cnn.com/2007/WORLD/asiapcf/09/24/food.leftovers/index.html#cnnSTCTextt and http://uanews.org/node/10448.
[117] Ibid.
[118] 70% of which are now recycled (data from http://www.japanfs.org/. See also http://www.enn.com/agriculture/article/37737).
[119] Data from http://www.wrap.org.uk/retail/food_waste/ accessed in October 2008.
[120] 2006 data from www.minlnv.nl/consumentenvoedselplatform.

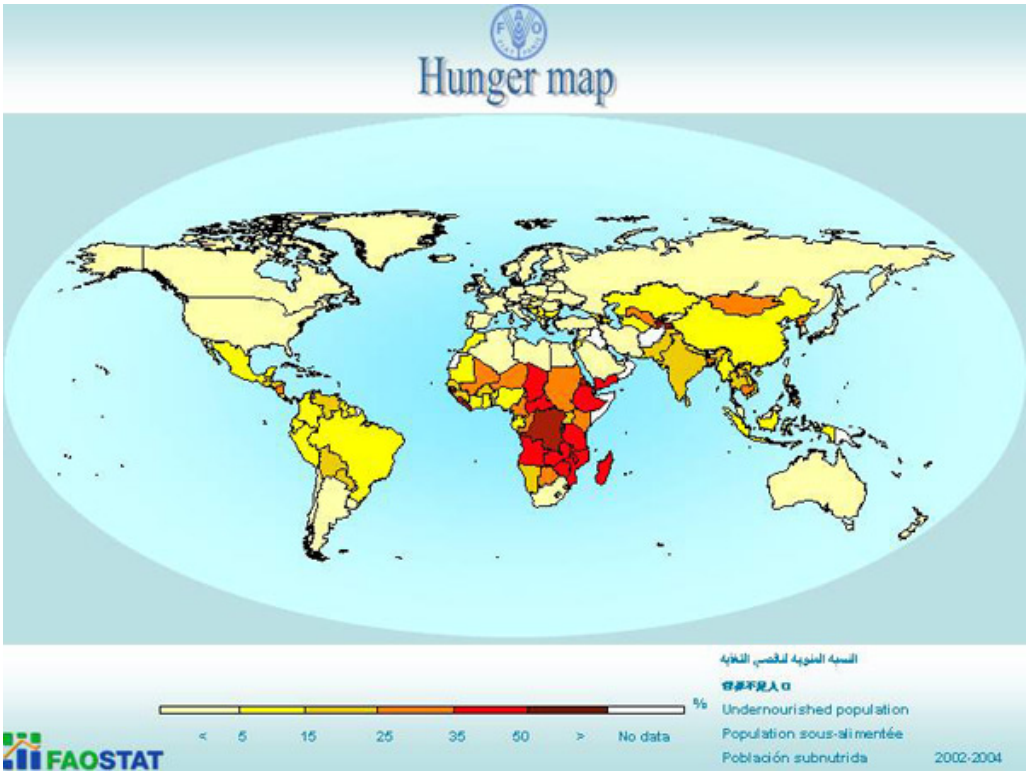
23 times as much heat as CO_2[121]. Biodegradation in low-oxygen conditions ("anaerobic digestion") produces biogas, a natural gas which is made up of 60% methane and 40% CO_2. If this process takes place in an open landfill[122], the biogas released makes an extremely negative contribution as a GHG emission, but if it occurs in a controlled manner (such as in a biogas power plant), this form of biogas conversion offers a renewable source of fuel. In this way, organic matter such as food waste could be used to generate energy in an environmentally friendly manner and as an alternative to using fossil fuels for the same purpose.

[121] According to the US Environmental Protection Agency (EPA).
[122] Council Directive 99/31/EC of 26 April 1999: to reduce GHG emissions stemming from biodegradable waste in landfills, the European Landfill Directive set the target that the amount of biodegradable waste sent to landfills in Member States must be reduced to 35% of the 1995 levels by 2020.

5. MODERN AGRICULTURE: MOVING TOWARDS FOOD SECURITY AND SUSTAINABILITY

Global income has increased seven-fold over the last 50 years while income per person has more than tripled, but this wealth is unevenly distributed. By the early 1990s, about 20% of the world's population, most of it in the developed world, received over 80% of the world's income, while the poorest 20% received only 1.4%[123]. The developed countries consume 70% of the world's energy, 75% of its metals, 85% of its wood and 60% of its food. Food security and sustainability are therefore specific needs to be met by agriculture in the 21st century.

FAO "Hunger map" (FAOSTAT data)[124]



5.1 Food security

According to the Nuffield Council report[125] on the use of genetically modified crops in developing countries, 70% of the world's poor live in rural areas and depend mainly upon agriculture for their livelihood and this situation seems unlikely to change in the next few

[123] CIA World Factbook, ISSN 1553-8133 (July 2008).
[124] http://www.fao.org/es/ess/faostat/foodsecurity/FSMap/map14.htm.
[125] http://www.nuffieldbioethics.org/go/ourwork/gmcrops/publication_301.html.

decades. Agriculture's role of providing adequate food to all and the need to guarantee fair access to food resources are therefore central.

The term "food security" originated in the mid-1970s, when the World Food Conference (1974) defined food security in terms of supply. In 1983, FAO analyses focused on access to food, leading to a definition based on the balance between the demand and supply sides of the food security equation. In 1986, the World Bank Report on Poverty and Hunger introduced the distinction between chronic food insecurity, associated with continuing or structural poverty and low incomes, and transitory food insecurity, which was the result of periods of intensified pressure caused by natural disasters, economic collapse or conflict (FAO[126], 2006).

"Halve, between 1990 and 2015, the proportion of people who suffer from hunger"[127]

Population below minimum level of dietary energy consumption

(No new global or regional data are available. Data presented are from 2006 report)

Percentage of undernourished in total population		
	1990-92	2001-2003
Developing Regions	20	17
Northern Africa	4	4
Sub-Saharan Africa	33	31
Latin America and the Caribbean	13	10
Eastern Asia	16	12
Southern Asia	25	21
South-Eastern Asia	18	12
Western Asia	6	9
Oceania	15	12
Commonwealth of Independent States	7[1/]	7
Commonwealth of Independent States, Asia	16[1/]	20
Commonwealth of Independent States, Europe	4[1/]	3
Developed Regions	<2.5[1/]	<2.5
Least Developed Countries (LDCs)	22	19
Landlocked Developing Countries (LLDCs)	38	36
Small Island Developing States (SIDS)	23	19

[1/] Data refer to the period 1993-1995.

[126] ftp://ftp.fao.org/es/ESA/policybriefs/pb_02.pdf.
[127] http://mdgs.un.org/unsd/mdg/Resources/Static/Data/Stat%20Annex.pdf.

Recently, the ethical and human rights dimensions of food security have come into the spotlight. According to a FAO policy brief on food security (2006), the main concepts that currently characterise food security are:

> ***Food availability***: The availability of sufficient quantities of food of appropriate quality, supplied by domestic production or imports (including food aid).
>
> ***Food access***: Access by individuals to adequate resources (entitlements) for acquiring appropriate foods for a nutritious diet.
>
> ***Utilisation***: Utilisation of food with the aid of adequate diet, clean water, sanitation and healthcare to achieve a state of nutritional well-being where all physiological needs are met.
>
> ***Stability***: To be food-secure, a population, household or individual must have access to adequate food at all times. They should not be at risk of losing access to food as a consequence of sudden shocks (e.g. an economic or climatic crisis) or cyclical events (e.g. seasonal food insecurity).

Food security therefore exists when all people, at all times, have (physical, social and economic) access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life[128]. Food security incorporates the concepts of availability, accessibility, acceptability and adequacy[129] and is inextricably linked with issues related to ethics, trade, humanitarian aid, etc.

5.1.1 Subsistence agriculture

The majority of the world's poor, food-insecure and malnourished live in rural areas that have agricultural potential but limited and unreliable rainfall and fragile soils[130]. Many in developed and developing countries alike have an image of agriculture very different from the truth: the myth depicts farmers "romantically but demeaningly[131]." This idealisation of farming has a strong impact on views on globalisation and on the impact of multinationals that appear to industrialise agriculture and to destroy taste and texture in the quest for yield, particularly in countries where choice is possible.

---

[128] FAO, "The State of Food Insecurity" (2001).
[129] "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 life" (UN, World Food Summit, 1996).
[130] Per Pinstrup Andersen, Presentation at the Annual John Pesek Colloquium on Sustainable Agriculture, Iowa State University (March 2002).
[131] Omvedt, Gail, "Terminating Choice", *The Hindu*, page 12 (1998) quoted in Thomas R. DeGregori, "Green Myth vs. the Green Revolution": http://www.butterfliesandwheels.com/articleprint.php?num=50.

In many countries food grown for local people may be very different from that grown for export. If the best land and facilities are given over to exports, local markets may not have the food which has been traditional for rural populations in developing countries. Many of the rural poor have been forced off the land and have migrated into the cities[132].

Comparison between family farms and commercial agriculture[133]		
Characteristics	**Family farms**	**Commercial agriculture**
Role of household labour	Major	Little or none
Community linkages	Strong – based on solidarity and mutual help between household and broader group	Weak – often based on social connection between entrepreneur and local community
Priority objectives	Consume	Sell
	Stock	Buy
	Sell	Consume
Diversification	High, to reduce exposure to risk	Low, specialisation in very few crops and activities
Flexibility	High	Low
Size of holding	Small, average 5–10 ha	Large, may exceed 100 ha
Links to market	Weak, but becoming stronger	Strong
Access to land	Inheritance and social arrangements	Purchase

In many cases arable agriculture systems are grouped to distinguish between large industrialised farming, small commercial farming and subsistence farms. "Resource-poor farmers constitute over half of the world's farmers and produce 15-20% of the world's food[134]. It is estimated that some 1 400 million people, approximately 100 million in Latin America, 300 million in Africa and 1 000 million in Asia, are now dependent on resource-poor farming systems in marginal environments[135]."

5.1.2 Quality and healthy food and public health

In the EU, food quality has played an important role in agricultural production since the 1960s. Quantity is the main issue in other regions of the world, where malnutrition is still a major global public health problem, causing over 15% of the global disease burden. Protein, energy and micronutrient malnutrition remain challenges, with high variability between and within countries. Lower dietary quality and diversity and inexpensive foods with low

[132] Sidney Mintz, "Food and Eating: Some Persisting Questions" in "Food Nations: Selling Taste in Consumer Societies", eds. Warren Belasco and Philip Scranton, New York, Routledge, pp. 25-26 (2002).
[133] Toulmin, C. and Gueye, B., "Is there a future for family farming in West Africa?" IDS Bulletin 36(2): 23–29 (2005) quoted in Xinshen Diao et al., "The role of agriculture in development: implications for Sub-Saharan Africa", International Food Policy Research Institute, ISBN 978-0-89629-161-4 (2007).
[134] Francis, C.A., "Multiple cropping systems", Macmillan, New York, 383 pp. (1986).

nutrient density have been associated with rising worldwide obesity and chronic disease rates. Poor diet throughout life is, however, a major risk factor for chronic diseases, which are the leading cause of death worldwide. Public health considerations are the reason why it is important to make dietary quality a key driver of production, rather than follow production strategies based mainly on quantity or low price.

5.2 Sustainability

A good definition of sustainable development is given in the Brundtland report[136], namely "development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs"[137].

In the context of agriculture, the way in which land is used determines the level of food production and, effectively, the state of the environment. Currently about half of global usable land is in use for arable (intensive) or pastoral agriculture[138]. The impact of agriculture on the natural environment is therefore extensive. Agriculture adds significant and environmentally detrimental amounts of nitrogen and phosphorus to ecosystems[139]. In addition, most of the best land is already in use for agriculture; any increase in land use will have to be on marginal land that is unlikely to sustain high yields and is vulnerable to degradation[140]. Immense efforts are being made to use genetic techniques to improve varieties grown on marginal land, including their drought and salt tolerance.

Proponents of biotechnology and many agro-food policy-makers around the world predict an optimistic future in which technology will overcome food shortages, improve the environment, heal or eradicate disease and lead to a prosperous and healthy society. For example, in 2007 Colin Ruscoe (British Crop Production Council) stated that "European farmers need to produce food, feed, biofuel and fibre, whilst protecting the environment and human health, in an increasingly global, competitive market. This has to be achieved within the framework of EU common agricultural policy, WTO agreements and extensive

---

[135] Food and Agriculture Organization of the United Nations, "The State of the World's Plant Genetic Resources for Food and Agriculture", Rome, page 25 (1997).
[136] Available at http://www.worldinbalance.net/pdf/1987-brundtland.pdf.
[137] World Commission for Environment and Development (1987), "Our Common Future", Oxford University Press, Oxford, UK, ISBN 0-19-282080-X.
[138] "Usable" land is all land that is not desert, tundra, rock or boreal. Hence it includes urban areas.
[139] Tilman, D. et al., "Agricultural sustainability and intensive production practices." The authors define sustainable agriculture as practices that meet current and future societal needs for food and fibre, for ecosystem services and for healthy lives by maximising the net benefit to society when all costs and benefits of the practices are considered. Nature 418, 671-677 (2002).

regulation. Supermarkets exert huge influence on farmers, in terms of production standards, traceability and prices, in this US$3 trillion business."

[140] Ruttan, V.W., "The transition to agricultural sustainability". Proc Natl Acad Sci 96 5690-5607: http://dx.doi.org/10.1073/pnas.96.11.5960 (1999).

6. TRENDS IN INTERNATIONAL AND EUROPEAN POLICIES

Globalisation in the literal sense means the process of transforming local or regional issues or phenomena into global ones[141]. It can also be used to describe a process which unifies the world population into a single society continuously interacting together. This process is the result of a combination of economic, technological, socio-cultural and political forces[142]. Globalisation is often used to refer to economic globalisation, that is integration of national economies into the international economy by means of trade, foreign direct investment, capital flows, migration and the spread of technology[143].

The economic impact of globalisation, particularly on poverty and developments on agro-food and energy markets, has received much attention in recent years[144]. Due to the global dimension of agricultural products, in terms not only of trade but also of use of land, water and other natural resources, and of the possible implications for the environment and climate (food production or energy policies), the debate on agriculture cannot deny the interconnection between the above-mentioned forces at global level.

6.1 Globalisation and agriculture

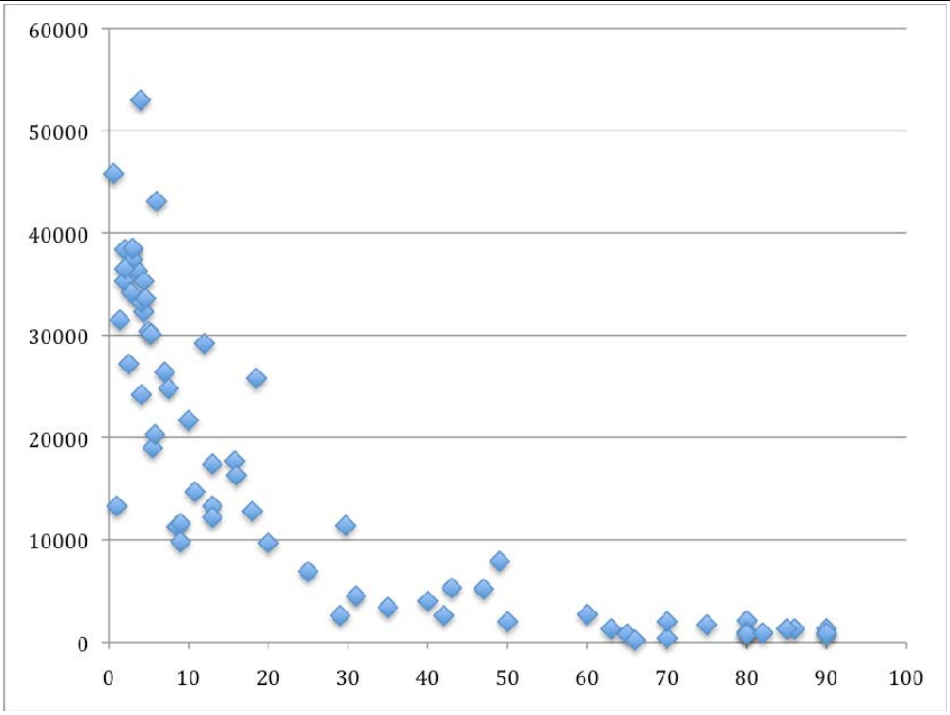
Globalisation is a complex process which involves liberalisation of trade between countries and which leads to intenser exchanges of products, culture and knowledge than in the past. In its narrowest sense, the term means the "worldwide spread of sales, production facilities and manufacturing processes, all of which reconstitute the international division of labour[145]." This is particularly true of agricultural markets, since many agricultural products are sold worldwide, as is the case with cotton, soybean (particularly for feed production), palm oil for biofuels production, etc. Globalisation is having an impact on the availability of food and on changes to the lifestyles of many in countries which critically depend on their agricultural base.

---

[141] http://en.wikipedia.org/wiki/Globalization.
[142] Sheila L. Croucher, "Globalization and Belonging: The Politics of Identity in a Changing World", Rowman & Littlefield, p. 10 (2004).
[143] Bhagwati, Jagdish, "In Defense of Globalization", Oxford, New York: Oxford University Press (2004).
[144] See Joachim von Braun and Eugenio Diaz-Bonilla, "Globalization of Food and Agriculture and the Poor", Oxford University Press, ISBN 9780195695281 (2007): www.ifpri.org/PUBS/otherpubs/globalpoor.asp.
[145] Anthony McGrew, "A Global Society" in Stuart Hall, David Held and Anthony McGrew, "Modernity and its Futures", Cambridge, Polity Press (1990) quoted by Simon Reich (1998) in "What is Globalization? Four Possible Answers", Working Paper 261, December 1998, Kellog Foundation: http://www.nd.edu/~kellogg/WPS/261.pdf.

6.2 The global strategy: the UN Millennium Development Goals

According to UN data (UNIDO, 2008), today 475 million people are living on less than €0.75 per day, 325 million on less than €0.50 and 162 million on less than €0.25. The sharp increase in prices for some of the most basic foodstuffs traded on international commodity markets will be affecting everyone who has to buy food, but the poor will be the hardest hit. The price of wheat has doubled in less than a year, while other staples, such as corn, maize and soya, are trading at well above their 1990s averages. Rice and coffee prices are running at 10-year highs, and in some countries prices for milk and meat have more than doubled. This trend seems unlikely to be reversed and prices of different food crops will grow by from 30% to 130%, according to a 2007 FAO report.



Plot of GDP per capita against proportion of the population involved in agriculture. The graph demonstrates that the proportion of people involved in agriculture is much greater in poorer countries than in the richer countries. Data derived from the CIA World Factbook (July 2008), ISSN 1553-8133.

The consequences for society are therefore severe, both for the least developed countries (LDC) and for EU citizens from countries with less favourable economies.

In 2002, UN countries and the world's leading development institutions agreed on a global strategy to eradicate major calamities. The agreement is based on a joint effort to achieve eight main goals (Millennium Development Goals – MDGs) by 2015: (1) eradicate extreme poverty and hunger; (2) achieve universal primary education; (3) ensure gender equality;

(4) reduce child mortality; (5) improve maternal health; (6) combat HIV/AIDS; (7) ensure environmental sustainability; and (8) develop a global partnership for development.

Agriculture has a major role to play in achieving the UN Millennium Development Goals. The data published on implementation of the MDGs in April 2008 show that hunger is still a major issue at world level and that the target is still far from met[146].

GOAL 1: Eradicate extreme poverty and hunger[147]

Goals	Africa		Asia			
	Northern	Sub-Saharan	Eastern	South-Eastern	Southern	Western
Reduce extreme poverty by half	Low poverty	Very high poverty	Moderate poverty	Moderate poverty	Very high poverty	Low poverty
Reduce hunger by half	Very low hunger	Very high hunger	Moderate hunger	Moderate hunger	High hunger	Moderate hunger
	Oceania	Latin America and Caribbean		Commonwealth of Independent States		
				Europe	Asia	
Reduce extreme poverty by half	---	Moderate poverty		Low poverty	Low poverty	
Reduce hunger by half	Moderate hunger	Moderate hunger		Very low hunger	High hunger	

On 5 June 2008 delegates at the Rome Food Security Summit announced their increased commitment to the fight against hunger and to agricultural development. The financial support will benefit countries hard hit by the current world food crisis, allowing them to grow enough food for themselves in future planting seasons and helping them to achieve continuing food security as a result of investment in agriculture and research. Financing totalling US$ 8 billion was announced during the Summit, which was attended by 181 nations and more than 40 Heads of State and Government.

6.3 The Millennium Development Goals and the EU

To achieve the Millennium Development Goals, on 24 May 2005 the EU Foreign and Development Ministers agreed to spend at least 0.51% of gross national income (GNI) on aid by 2010 and at least 0.7% by 2015[148]. The EU-10 promised to work towards allocating at least 0.17% of GNI to aid by 2010. The aim is to reach a target of 0.33% in 2015. These new targets will bring the EU-25 average as a whole up to 0.56% by 2010 (as proposed by the European Commission). If successful, the new plans would increase EU development aid by

[146] http://www.un.org/ga/president/62/letters/bckgpoverty.pdf.
[147] http://www.un.org/millenniumgoals/docs/MDGProgressChart2006.pdf.
[148] http://www.eu2005.lu/en/actualites/conseil/2005/05/23cagre/milldego.pdf.

€20 billion a year by 2010 and thus double the total amount of aid by 2015 (from the current €60 billion to €120 billion a year). Half of the aid will go to Africa.

In addition, the EU has responded to the price surge on agricultural markets by adjusting market management under the common agricultural policy (CAP): intervention stocks have been sold and export subsidies reduced – for example, to zero for dairy products. In addition, the EU Council of Ministers of Agriculture and Fisheries agreed to suspend, for the current marketing year, the obligation for farmers to set aside 10% of their arable land, along with the import duties on cereals. Furthermore, the general move towards more market-oriented agriculture, with less market support but also less restrictive supply control mechanisms, will allow farmers to respond quicker to price signals.

In 2007, the EU adopted specific short-term measures to reduce prices of agricultural products, including increasing the volume of arable land by abolishing mandatory set-aside, increasing milk production quotas for 2008, reducing buffer stocks and export refunds and suspending import duties on most cereals.

On 29 July 2008, the European Commission proposed establishing a special "facility for rapid response to soaring food prices in developing countries". The fund would operate for two years, 2008 and 2009[149], in addition to existing development funds and would total €1 billion, drawn from unused money from the European Union's agricultural budget.

6.4 Global trade

Trade in agricultural commodities and products is important for industrialised and non-industrialised countries alike. The volume of goods traded is increasing every year and affecting the global economy. A number of recent phenomena, from oil prices to climate change and from energy policies to population growth, are shaping the ongoing food security crisis at global level. The incidence of these phenomena in different regions of the world varies, depending on socioeconomic and geopolitical factors.

Although agriculture makes up only 8% of world trade, it is the main source of income for about 2.5 billion people, mainly in developing countries. However, farmers from poor

[149] It would be provided to developing countries which are most in need, based on a set of objective criteria. The facility would give priority to supply-side measures, improving access to farm inputs such as fertilisers and seed, possibly via credit, and to safety-net measures with the aim of improving productive capacity in agriculture. The support would be paid via international organisations, including regional organisations.

countries are unable to compete against heavily subsidised exports from the EU, USA and Japan.

	Main world agricultural products	
Wheat	**Rice**	**Jute**
Wheat is the most important cereal traded on international markets. Total world trade in wheat and wheat flour (in grain equivalent) is close to 95 million tonnes, with the developing countries accounting for some 80% of imports. The United States ranks as the world's leading wheat exporter, normally contributing around one third of world export volume.	Developing countries account for about 95% of production and about 80% of trade in rice. Most rice, a staple food for almost half the people in the world, is consumed in the countries where it is produced. Only about 3% to 5% of all rice produced is traded on the world market. Rice is one of the most difficult food commodities for trade because of consumer preferences, the small quantities involved and the dependence of production on local climatic conditions.	Jute is a fibre crop which is used mainly for sacking, although efforts are being made to diversify into other end-uses. In recent years, world production of jute has been about 3 million tonnes per year, of which 300 000 tonnes are traded internationally in the form of raw fibre and 900 000 tonnes in the form of products. World trade in jute products is dominated by (in order of importance) sacking, yarn, hessian and carpet backing.

Global trade in agriculture is a major area of activity of the World Trade Organization (WTO). In 1986 negotiations seeking to liberalise agricultural trade began. They eventually led to new treaties under the General Agreement on Tariffs and Trade[150] and to the founding of the WTO in 1995 (WTO GATT Uruguay Round). Several meetings with the aim of negotiating global trade provisions for agricultural commodities have taken place since 2000. The negotiations were launched by ministers of WTO member countries in November 2001 in the Qatari capital, Doha (Declaration of the Fourth WTO Ministerial Conference – Trade Negotiations Committee[151]). Further meetings followed (see Annex II). The main goal of the Doha Round negotiations was "to establish a fair and market-oriented trading system through a programme of fundamental reform encompassing strengthened rules and specific commitments on support and protection in order to correct and prevent restrictions and distortions in world agricultural markets." In practice, this involves efforts on substantially improving market access, reducing, with the aim of phasing out, all forms of export subsidies and substantially reducing domestic support distorting trade. In order to achieve these goals, WTO Member States' ministers[152] agreed to launch tariff-cutting negotiations on all non-agricultural products. The aim was "to reduce or, as appropriate, eliminate tariffs, including

[150] GATT began in 1948. The original agreement covered trade in goods. Later, the Uruguay Round and the WTO extended the remit to trade in services and traded inventions.
[151] http://www.wto.org/english/news_e/news02_e/tnc_01feb02_e.htm#principles.

the reduction or elimination of tariff peaks, high tariffs and tariff escalation, as well as non-tariff barriers, in particular on products of export interest to developing countries." The major difficulties concerned (1) access to agricultural markets, (2) agricultural subsidies, (3) access to industrial markets and (4) services.

On 21 July 2008, Ministers of Trade met in Geneva in an attempt to agree a basic framework for a final deal in the Doha Round of WTO world trade talks. They hoped to agree on parameters to generate new trade in agriculture, industrial goods and services. The agricultural negotiations were the most advanced chapter of the Doha Round, but they failed on 29 July 2008 and the future looked uncertain. However, the latest G20 meeting, which took place in Washington in November 2008, signalled a strong attempt to start a new session of the Doha Round of trade negotiations in the WTO. In addition, the EC indicated that it was committed to bringing the Doha Round to a successful, rapid and pro-development conclusion and to improving both the quality and the volume of the EU aid for trade for developing countries, an important supplement to trade agreements to ensure that the benefits of trade are more widely shared.

6.5 European Union common agricultural policy

The common agricultural policy (CAP) has been a key policy pillar of the European Union since its origins. It was originally conceived to expand production and provide secure food supplies to Europeans, following the food crisis after the Second World War. The CAP was therefore a key objective of the Treaty of Rome in 1957.

The most important step allowed by the CAP in Europe was establishment of free trade in agricultural products between European Member States, in response to the need to allow a controlled market with a system of annual guaranteed prices and a compensation system to maintain fixed prices regardless of market fluctuations. The CAP also established (1) a mechanism of high tariffs to prevent imports of products from non-EU countries at prices cheaper than those agreed in the EU and (2) subsidies for EU agricultural exports at a reduced price to help them to penetrate non-European markets. This system, typical of the 1960s and 1970s, led to overproduction of food supplies. In the 1990s it was criticised for

[152] The key players in the negotiations, known as the G6, were Brazil and India (representing the G20 group of developing countries), the EU, the USA, Australia (representing the Cairns group of agricultural exporters) and

lack of food security, for the environmental impact of intensive farming and for its effects on rural employment and global justice. The reform of the CAP then began.

Whereas the previous philosophy behind the CAP was mainly to preserve and boost productivity, the current version is geared to liberalisation of trade. The main trends in the above-mentioned revisions of the CAP were, therefore, cuts in the guaranteed prices and "partial" compensation of farmers with direct payments made to farmers on a yearly basis[153] (supporting the producer rather than the product). The other aspect affected by the new version of the CAP was the overproduction of agricultural products. Measures to avoid this phenomenon were introduced, such as quotas (maximum allowed quantities) and the set-aside scheme. The first were designed to control prices and avoid overproduction and the second was introduced in 1992 and required keeping a portion (10%) of arable land out of production. Incentives for environmental protection and modernisation of farming were also introduced in 1999, although they were different from CAP expenditure.

From 1992 to 2002 the CAP reform was geared to gradually reducing price support for products in the form of direct payments to producers. This trend was confirmed in 2003 when the CAP reform introduced further price cuts (for milk, rice and rye), but added a substantial change in the link ("uncoupling") between production and payments. In the new CAP, direct payments are linked only to environmental, food safety and animal welfare obligations[154]. Environmental, food safety and animal welfare standards, based on existing EU directives and "good agricultural and environmental conditions" (GAEC) were then set and made a condition for CAP subsidies[155]. Other measures supporting food quality and safety included new rural development measures to support farmers who improved food quality or animal welfare. Other reforms of given sectors of the CAP followed in 2004 (e.g. for "Mediterranean products" – olives, hops, cotton, tobacco and sugar). The European Commission is currently finalising a "health check" of the new CAP. The current CAP aims at promoting environmental sustainability, animal welfare, biodiversity protection and food safety.

Japan (representing the G10 group of net agricultural importers).

[153] This shift has helped to bring the EU into line with the logics of GATT/WTO rules and global agricultural trade in general. Cuts in tariffs and reductions in export subsidies were then instrumental in promoting competitive agriculture in the EU and beyond.

[154] Farmers will receive a single farm payment (neither crop- nor product-specific) unconnected to the quantity of the product produced, in order to avoid overproduction.

[155] The 18 directives on cross-compliance include five environmental directives, three on animal welfare, four on food safety and animal health and six on registration of livestock and notification of animal diseases.

The options considered in the current "health check" of the EU common agricultural policy[156] include abolishing the set-aside requirement, gradually abolishing milk quotas by 2015, adjusting market price aid in the cereals sector and making the transition from support for energy plants to more effective solutions to bolster the bio-energy sector – without, however, having an adverse impact on production of food and feedstuffs – including production of second-generation biofuels. In addition, the European Commission recently adopted Communications on food prices, energy and oil prices.

EU CAP
1. Moving away from payments based on historical receipts to a "flatter rate" system. 2. Increasing the rate of decoupling in countries which opted to maintain the link between subsidy and production in a number of agricultural sectors, although coupled support may still play a role in regions where production is small-scale but of particular economic or environmental importance. 3. Gradually reducing the support level as total payments to big farmers increase, starting from a level of, for example, €100 000 per year. 4. Increasing the amount of land a farmer has to own before qualifying for EU support from the current level of 0.3 hectares. 5. Reviewing the cross-compliance standards which farmers are required to meet in order to receive support from Brussels.

6.6 European Union agricultural market

The agro-food sector accounts for around 7% of the total EU economy, distributed mainly between the retail and primary sectors and manufacturing or processing of food products. Particularly in the primary sector, biotechnologies play a key role and account for 13% to 23% of turnover. The main applications include breeding and propagation of crops, production of food additives, diagnostics for screening and enzymes for food production.

Agriculture involves around 5% of the EU population and accounts for 20% of average EU household consumer expenditure and a large proportion of the EU's internal and export trade. It generates less than 1% of GDP in Germany and the United Kingdom and about 8% in Portugal and Romania (the figure for the European Union as a whole is about 2% of GDP). The proportion of the European population directly involved in agriculture is about 4.4%, ranging from only about 1.4% in the United Kingdom to nearly 30% in Romania.

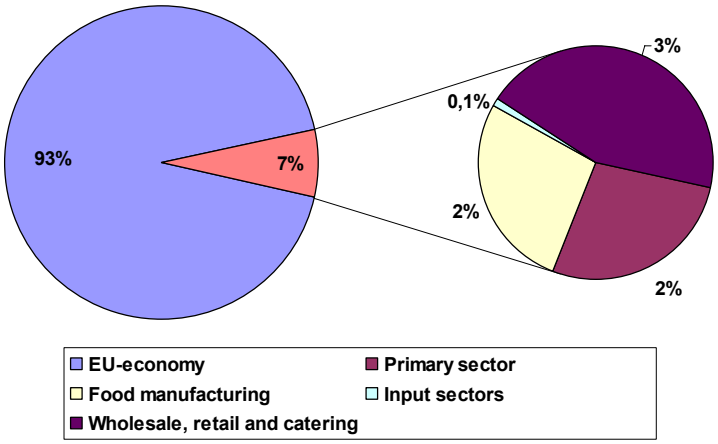
The economic value of agriculture in local economies in the EU increases in rural areas to 5% of their gross value-added (GVA[157]). In the 10 Member States that joined the EU in 2004

[156] http://ec.europa.eu/agriculture/healthcheck/index_en.htm.
[157] European Commission, Directorate-General for Agriculture and Rural Development (2006), "Rural Development in the European Union – Statistical and Economic Information Report 2006": http://ec.europa.eu/agriculture/agrista/rurdev2006/RD_Report_2006_Foreword_Content.pdf.

the contribution in rural areas is as high as 7% of GVA. Within the primary sector, agriculture is the most important contributor to the EU economy with 1.8% of the EU's GVA (87% of the primary sector's GVA), while the remaining 0.2% of the primary sector's contribution to the EU's GVA comes from forestry and fisheries. The input sectors account for a much smaller share of the EU economy, generating only 0.1% of the EU's GVA. In all, the sectors covered by this analysis contribute 4.22% of the EU's GVA. By comparison, with 3.36% of the EU's total GVA, the food and beverage wholesale and retail sectors are almost as important to the EU economy as the primary sector.

Agriculture is therefore not only a key economic sector in the EU of high social and political importance, but also the sector where the process of European integration is furthest advanced. The revised CAP is an integral component of the EU's economic strategy (the renewed Lisbon Agenda) and of the role played by the EU in global trade.

Economic significance of the agro-food and food services sectors to the EU economy (overall GVA)



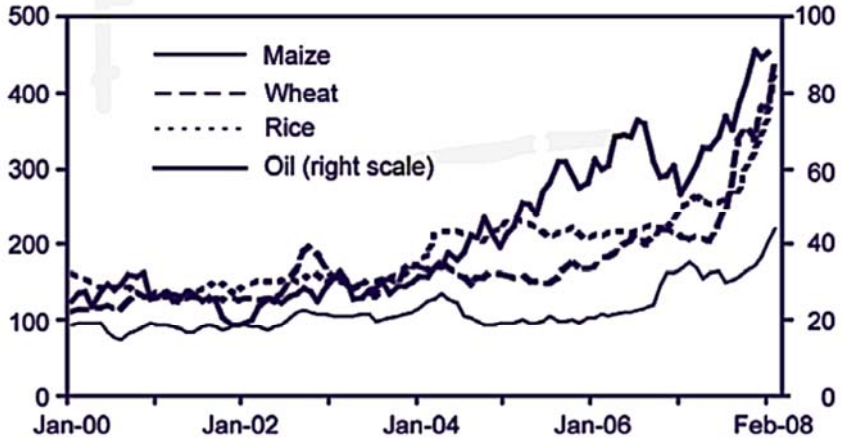
The impact of food and energy price shocks on this sector is severe and affects EU trade, employment and social welfare. In that sense, concerns about food security and the sustainability of agriculture are of primary importance for any discussion on a policy design for the CAP which is responsive to climate change, world population growth, energy and food crises and global trade rules.

6.7 Price trends

For thirty years, food prices, both in Europe and globally, have been falling in real terms. This trend has been reversed over the last few months by sudden, steep increases in world agricultural commodity prices. Between September 2006 and February 2008, world

agricultural commodity prices rose by 70% in dollar terms. Particularly sharp increases were recorded in wheat, maize and rice prices and for dairy products. Reference prices for world markets in early February 2008 compared with the same month in 2007 were of the following orders of magnitude: +113% for US wheat versus +93% for EU wheat, +83% for US soybean, +52% for Thai rice and +24% for US maize. Since February 2008, the reference price for rice (Thailand's export price) has doubled, as it soared beyond US$ 1 000 a tonne at the end of April. Meat, such as poultry, and vegetable oils also showed hefty price increases. In Europe, prices for wheat and dairy products increased by 96% and 30% respectively between September 2006 and February 2008. Some exporting countries have responded to rising prices with restrictive export policies[158].

World commodity prices (January 2000–February 2008)



Sources: FAO international commodity prices database 2008, and IMF world economic outlook database 2007.

The price surge affected several commodities at the same time: cereals, meat and dairy products all posted two-digit or even three-digit increases in less than a year. The scale and abruptness of the price surge have generated macroeconomic imbalances across the world. Developing countries and the most vulnerable populations have been hit disproportionately. Millions living on the edge of poverty face hunger and malnutrition.

There are many reasons for the increases, including a large increase in energy prices. This has an indirect impact on food prices, as costs of chemicals, mechanical cultivation, transport

[158] India has introduced export bans, Vietnam and Thailand export limits on rice, Indonesia export taxes on palm oil and Kazakhstan a ban on wheat exports. Such taxes and export bans are designed to protect domestic markets from short-term supply shortfalls and price shocks. However, they further tighten international agricultural markets for food-importing developing countries. In the medium term, such restrictions reduce the incentives for farmers to invest and increase production and contribute to imbalances on regional markets.

and distribution increase dramatically, but has also triggered a shift away from production of food crops towards crops for energy. About 30% of US maize production will be used for bioethanol production during 2008[159].

In addition, an increase in prosperity in emerging countries has generated demand for more and different kinds of food to those traditionally eaten[160]. The growth of emerging economies, such as China, Brazil and India, is radically changing food requirements and having an impact on sustainable agriculture, as consumers demand more meat and processed food.

1990/2005 ratios of per capita consumption (FAO)	**India**	**China**	**Brazil**	**Nigeria**
Cereals	1.0	0.8	1.2	1.0
Meat	1.2	2.4	1.7	1.0
Milk	1.2	3.0	1.2	1.3
Fish	1.2	2.3	0.9	0.8
Fruit	1.3	3.5	0.8	1.1
Vegetables	1.3	2.9	1.3	1.3

The most populous country in the world, China, exemplifies this. Chinese consumers now eat 50 kg of meat per year, compared with just 20 kg in 1985. Developing countries that are net importers of food, such as in Africa but also the Philippines, Indonesia, China and Moldova, are the hardest hit by the crisis. Countries dependent on food aid and which are also energy importers are the most vulnerable. According to the FAO[161], the cereal import bill of the world's poorest countries is forecast to rise by 56% in 2007/2008. This follows a hefty increase of 37% in 2006/2007. For low-income food-deficit countries in Africa, the cereal bill is projected to increase by 74%. As food takes the largest share in these countries' consumer price basket, fully passing on higher food prices means higher inflation, with possible adverse macroeconomic effects on stability and/or growth due to tighter monetary policies.

According to Eurostat data, prices of all categories of food grew substantially in the EU from February 2007 to February 2008. While food price increases in EU-15 were around 5% to 7%, they were much higher in the new Member States (21.8% in Bulgaria and 17% in

[159] Ibid.

[160] Growth brought annual increases of 9% in Asia, 6% in Africa and 2% in industrialised countries in the time frame 2004-2006. If these trends were to continue, this would produce an increase in food consumption proportional to the growth of the emerging economies. For example, it has been calculated that in India (2000–2025) this would lead to per capita growth in annual consumption of 176% for meat, 70% for milk and vegetables and 27% for grain.

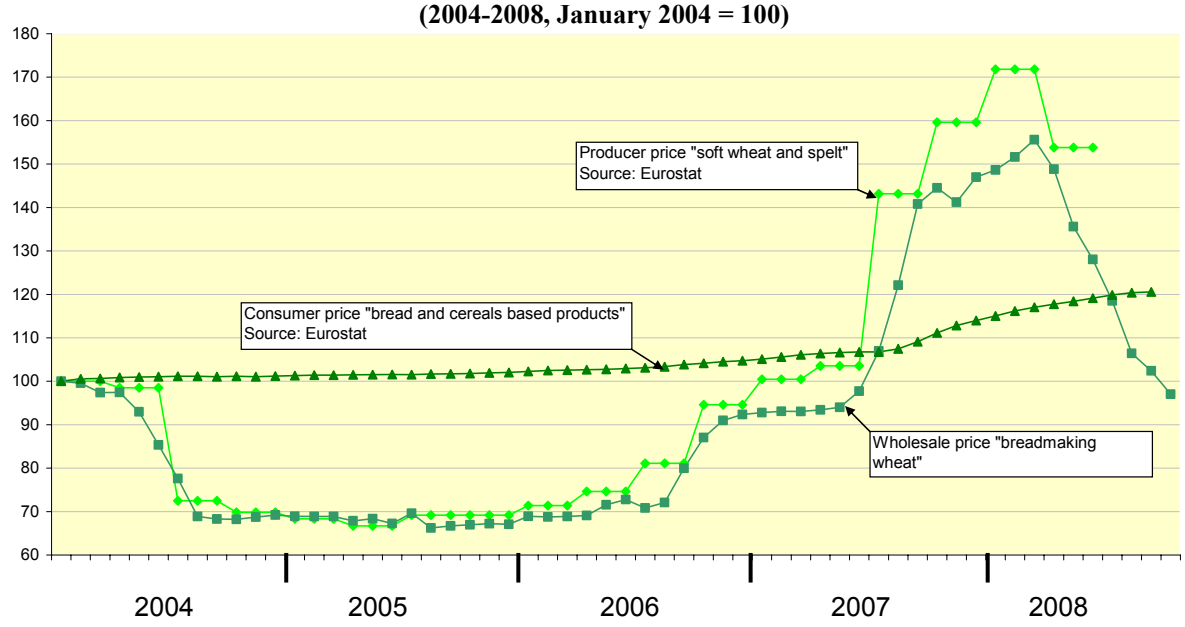
Estonia). This coincides with a higher proportion of expenditure on food in household budgets. The percentage of household expenditure ranges from 9.06% in the UK to 41.87% in Romania. In addition, the poorest 20% of households spend a much higher proportion of their income on food – e.g. 30.7% in Slovakia and 27.2% in Hungary. Also, in some countries with higher income levels the proportion spent on food by the poorest households is substantially higher than for an average household (27% in Italy, 23.8% in Spain, 19.9% in Slovenia, 20.2% in Greece, 22.6% in Cyprus, 16.2% in Ireland and 14% in Germany)[162]. In the European Union, food price inflation rose to 7% in March 2008. Households' purchasing power has fallen and the 16% of Europeans living below the poverty threshold are the most exposed[163].

Additional information on food price increases can be found in the Annex to this Opinion. It should, however, be added that commodities prices are continuously changing and that this report could only be updated to November/December 2008. Recent developments seem to point to a reversal of the trend seen in 2007 and up to March/April 2008, in that producers' and wholesale prices started falling during the final months of 2008. Consumer prices continued to rise, but at a slower pace than during previous months and in line with the standard inflation rate. At the moment, it is difficult to predict future developments.

---

[161] FAO, "Crop prospects and food situation", No 2, April 2008.
[162] According to Eurostat data for the year from February 2007 to February 2008.
[163] In 1987 the EU established the "most deprived" scheme for distribution of free food to people in need in the European Union. Before the reform of the CAP, such food stocks were stored in warehouses around Europe, but nowadays large surplus stocks are non-existent. Since 1995 the food aid scheme has therefore allowed the surplus stocks to be topped up by a financial contribution, when necessary. In 2008, 19 of the 27 EU Member States are participating in the scheme. As intervention stocks are likely to remain low in the future, the Commission is launching an impact assessment of the "most deprived" programme in 2008, with the aim of examining options for the future.

Monthly producers', wholesale and consumer prices in the EU cereals sector (2004-2008, January 2004 = 100)



6.8 Speculation and its economic impact on the food market

The general price increase is a phenomenon accompanying the current financial crisis. The loss of confidence in the financial markets has encouraged many investors to abandon equity investments (i.e. shares) and turn to raw materials, such as gold, oil, wheat or dairy products. Increases in the raw materials price have had only a small impact on the final price of food, as the raw materials cost accounts for only 10% of the total cost of the product. The rise in energy and fuel prices has had the biggest impact, as it affects the cost of many components, from fertilisers to transport, food processing and then, of course, final distribution. Crude oil prices have been rising since 2004 and reached well over US$ 130 per barrel, before slipping back to US$ 70 in November 2008[164]. Some argue[165] that there has been increased activity by speculative investors in commodity-related financial markets to hedge price risks or use excess liquidity in the wake of the financial market crisis, and that such activities lead to increased price movements and volatility on futures and spot commodity markets and have amplified the underlying price movements. However, in 2008 the US Commodity Futures

[164] The average price in 2007 was US$ 73 compared with US$ 25 in 2002. The price rise has mainly been due to increased demand by emerging economies, as supply has struggled to keep up with demand, resulting in a very tight market. High oil prices can also be attributed to the weakening dollar, as oil has been used by the market as a safer investment and as a hedge against inflation.

[165] See the testimony of Michael W. Masters, Managing Member/Portfolio Manager of Masters Capital Management LLC, before the Committee on Homeland Security and Governmental Affairs of the United States Senate, 20 May 2008: hsgac.senate.gov/public/_files/052008Masters.pdf.

Trading Commission studied the role of speculators on commodity and oil markets and found no evidence of any causative role played by financial speculation in food price rises. The same was reported by other sources independently[166, 167].

The depreciation of the US dollar has also contributed to driving prices upwards. Exchange rate effects have added to the unequal impact of price increases. For countries whose currencies are tied to the euro (e.g. FCFA countries in West and Central Africa) the negative effects have been somewhat softened. Countries whose currencies are depreciating are hit particularly hard.

[166] The Wall Street Journal, editorial, "See you later speculator" (15.9.2008): http://online.wsj.com/article/SB122143397998234079.html.
[167] The Economist, "Of froth and fundaments" (9.10.2008): http://www.economist.com/research/articlesbysubject/PrinterFriendly.cfm?story_id=12373732.

7. INTELLECTUAL PROPERTY RIGHTS (IPR) IN AGRICULTURE

Intellectual property occupies a central position in the biotechnology innovation system, which is expected to provide a source of new medicines, foods and bio-energy. Intellectual property rights are a relatively new phenomenon in agriculture. The manner in which they are recognised, traded and managed – both nationally and globally – has already made an impact on the way in which agriculture provides material to growers and consumers[168]. Patents were originally a mechanism whereby a State provided an inventor with exclusive rights to deny others use of the invention in return for disclosing details so that anyone skilled in the art could reproduce the invention. Today, they are almost a currency.

The TRIPS Agreement (Agreement on Trade-Related Aspects of Intellectual Property Rights[169]) is one of the agreements that form the Uruguay Round of negotiations under the GATT Treaty which led to the founding of the World Trade Organization. It addresses most forms of intellectual property rights (IPR). Although there are many different forms of IPR, only three are significant to agriculture – appellations of origin, plant variety rights and patents. Appellations of origin are mainly used for food products[170] (including cheese and wine). There had been hopes that use thereof would be extended by the Doha Round of World Trade Organization negotiations[171].

National governments grant plant variety rights to enable plant breeders to exclude others (for a limited time) from producing or marketing material of a specific plant variety. There are international agreements relating to the granting of such rights, in particular the International Convention for the Protection of New Varieties of Plants (UPOV Convention), and there is a European Regulation on Community plant variety rights (Council Regulation (EC) No 2100/94 of 27 July 1994). The UPOV Convention originally came into force in

---

[168] Matthew Herder and E. Richard Gold, OECD International Futures Project on "The Bioeconomy to 2030: Designing a Policy Agenda", third meeting of the Steering Group, Paris, 7-8 February 2008, Intellectual Property Issues in Biotechnology: Health and Industry (2008).

[169] Article 7 of the Agreement states: "The protection and enforcement of intellectual property rights should contribute to the promotion of technological innovation and to the transfer and dissemination of technology, to the mutual advantage of producers and users of technological knowledge and in a manner conducive to social and economic welfare, and to a balance of rights and obligations."

[170] Appellations of origin are a special form of geographical indication and generally consist of a geographical name or a traditional designation used on products that have a specific quality or characteristics that are essentially due to the geographical environment in which they are produced. They are protected in accordance with international treaties, regional or bilateral agreements and national laws.

[171] Both the Paris Convention for the Protection of Industrial Property and the Madrid Agreement for the Repression of False or Deceptive Indications of Source on Goods use the term "indications of source". An indication of source refers simply to a country, or place in that country, as the place of origin of a product, the quality or characteristics of which are due exclusively or essentially to the geographical environment, including natural and human factors.

1961, followed by revisions in 1972, 1978 and 1991. Unusually for an international agreement, it is possible to remain a member of the Convention without complying with the latest version but by adhering to an earlier one instead[172].

	UPOV 1978	UPOV 1991
Protection	Plant varieties of nationally defined species	Plant varieties of all genera and species
Requirements	Distinctness; Uniformity; Stability	Novelty; Distinctness; Uniformity; Stability
Protection term	Minimum: 15 years	Minimum: 20 years
Protection scope	Commercial use of reproductive material of the variety	Commercial use of all material of the variety
Breeders' exemption	Yes	Not for essentially derived varieties
Farmers' privilege	In practice: yes	Up to national law
Double protection (PVR and patent)	Any species eligible for PVR cannot be patented	—

The differences are significant. In order to obtain the rights, a variety must be distinct, uniform and stable. Under the 1991 Act[173], it must also be novel. The 1991 revision defines a new concept – "essentially derived variety" – that attempts to protect varieties with only "cosmetic" changes from pre-existing varieties. A variety is deemed to be "essentially derived" from another (initial) variety if it is predominantly derived from the initial variety and retains the essential characteristics resulting from the genotype, or combination of genotypes, of the initial variety. Whether a new variety is essentially derived or not is a private, commercial matter which, in the event of dispute, could be for the courts to resolve. In most EU countries agricultural crops must also meet VCU criteria, i.e. they must have satisfactory value for cultivation and use compared with products already on the market.

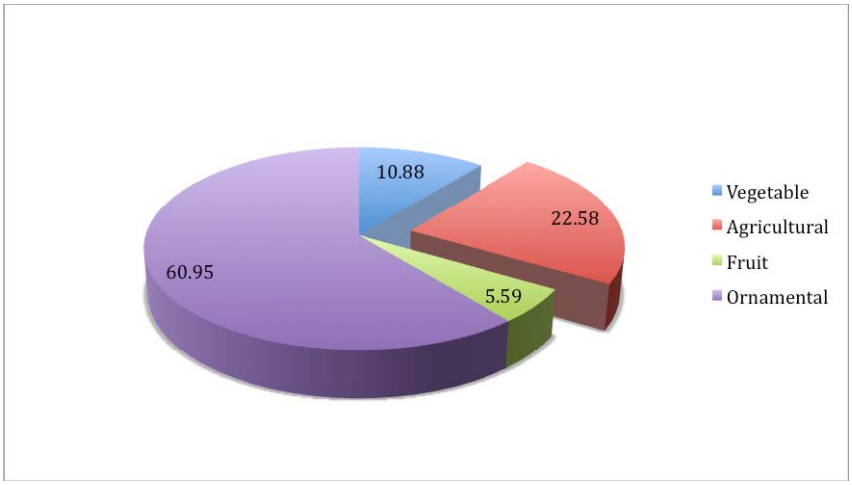
Patents are arguably the strongest form of IP protection. A patent is a right granted by a government to inventors to exclude others from imitating, manufacturing, using or selling a specific invention for commercial use for a certain period. In industrialised countries this lies between 17 and 20 years. The invention must be novel, must not be obvious to someone skilled in the art and must have utility. It is a compact between the inventor and society, in which the patent protection is "exchanged" for disclosure so that new inventions may use the

[172] Most of the members of the EU have acceded to the 1991 revision, including the European Union itself under Regulation 2100/94, but Belgium still adheres to the 1961/1972 version and France, Ireland, Italy, Portugal, Slovakia, (Norway and Switzerland) to the 1978 version.

[173] The 1991 revision curtailed the right of farmers to retain seed from one season to the next. The system is primarily directed towards providing plant breeders with the right to use material already on the market as a starting point for developing a new variety.

information published about the original invention. They are "territorial" in that they apply within the borders of the country granting them.

Average annual number of applications for Community plant variety rights by crop sector[174]



Patents could not be obtained for plant varieties within the European Union until recently. Article 53(b) of the European Patent Convention[175], to which all EU countries adhere, specifies that European patents should not be granted for "plant or animal varieties or essentially biological processes for the production of plants or animals". Article 27(3) of the TRIPS Agreement permits members to exclude from patentability "plants and animals other than micro-organisms and essentially biological processes for the production of plants or animals other than non-biological and microbiological processes. However, Members shall provide for the protection of plant varieties either by patents or by an effective *sui generis* system or by any combination thereof." Directive 98/44/EC allows patents on plants, on condition that they are not directed to a single variety. Article 4(1) prohibits patents on plant and animal varieties, but Articles 4(2)[176], 8(2)[177] and 9[178] broaden the patentability to all subsequent generations. Food was once a local commodity produced and consumed in a

[174] Statistics from the Community Plant Variety Office. The total is about 3 000 per annum (July 2008).
[175] The EPC is an international treaty on the basis of which the European Patent Office grants patents valid for the Member States which are then interpreted in the national courts.
[176] "Inventions which concern plants or animals shall be patentable if the technical feasibility of the invention is not confined to a particular plant or animal variety."
[177] "The protection conferred by a patent on a process that enables a biological material to be produced possessing specific characteristics as a result of the invention shall extend to biological material directly obtained through that process and to any other biological material derived from the directly obtained biological material through propagation or multiplication in an identical or divergent form and possessing those same characteristics."
[178] "The protection conferred by a patent on a product containing or consisting of genetic information shall extend to all material, save as provided in Article 5(1), in which the product is incorporated and in which the genetic information is contained and performs its function."

relatively small area. This has changed markedly in the last few years, and intellectual property protection of food products could have an impact on food availability and prices. Recent cases in the United Kingdom and in the Netherlands provide insight into the implications of globalisation and intellectual property in relation to food[179].

[179] See the Monsanto Technology LLC v Cargill case, heard in the High Court in London (Chancery Division, Patents Court) by Mr Justice Pumfrey (Monsanto v Cargill [2007] EWHC 2257 (Pat), 10 October 2007).

8. ETHICS IN AGRICULTURE

Production, processing, storage and distribution of food and agricultural products are generally accepted as routine parts of everyday life all around the world. Therefore, these activities have rarely been addressed within the realm of ethics. But food and agriculture, and the economic benefits derived from taking part in the associated system, are means to an inherently ethical end: feeding the world's population and preserving the Earth's food-producing capacity and natural ecosystems for future generations. The ethical dimension of agriculture is therefore inherent to discussions on modern agriculture technologies.

8.1 Ethical principles and values for responsible action

In 2007, to mark the 50th anniversary of the founding of the EU, the EU-27 Heads of State and Government unanimously adopted the "Berlin Declaration" indicating the milestones of the EU political project. The Declaration states that peace, freedom, democracy, justice and solidarity[180] are key values of the EU and that EU policies, including on agriculture, have to be conceived and implemented in accordance with them.

On 12 December 2007, the Presidents of the European Commission, the European Council and the European Parliament proclaimed the European Charter of Fundamental Rights. The Charter indicates, *inter alia*, a set of values, such as human dignity (a key value of the European Union[181]), freedom, democracy, pluralism, non-discrimination, tolerance, justice, solidarity and gender equality, as the milestones of the European Union and its policy design.

The European Charter of Fundamental Rights shows that, while Europe is multicultural, a set of shared values exists in the EU. Ethical goals for responsible action in agriculture (food security and sustainability) can be extrapolated from the Charter. Their underlying values are rooted in two fundamental ethical principles:

1. **Respect for human dignity;**

[180] "We are striving for peace and freedom, for democracy and the rule of law, for mutual respect and shared responsibility, for prosperity and security, for tolerance and participation, for justice and solidarity." Berlin Declaration, 2007.

2. Justice.

Beyond that, EU policy is also rooted in the principle of solidarity, which puts the emphasis on sharing responsibilities, benefits and burdens within the Community and, indeed, globally. Moreover, in the case of new technologies, the precautionary principle has been applied[182].

Respect for **human dignity** is a universal and fundamental ethical principle. According to the explanations given in the Declaration relating to the Charter of Fundamental Rights, "The dignity of the human person is not only a fundamental right in itself but constitutes the real basis of fundamental rights." The 1948 Universal Declaration of Human Rights enshrined this principle in its preamble: "Whereas recognition of the inherent dignity and of the equal and inalienable rights of all members of the human family is the foundation of freedom, justice and peace in the world[183]." This fundamental principle entails fundamental human rights: in the context of this Opinion, the right to food, the need to respect individual freedom, self-determination and well-being. All these rights are to be met by specific obligations and responsibilities which are discussed below.

Justice is the principle that covers the institutional dimension of ethics. Justice is the guiding reference to guarantee equality, fairness and equity between citizens within a society and between all societies. The European Union aspires to create a democratic society based on

---

[181] Article 1 of the European Charter of Fundamental Rights states that "Human dignity is inviolable. It must be respected and protected." The concept of human dignity was addressed in EGE Opinion No 20 (see http://ec.europa.eu/european_group_ethics/docs/avis20_en.pdf).

[182] The *precautionary principle* (or approach) has been interpreted in various ways. For many it means that if relevant scientific data are not available and if there is a risk of environmental damage, we should not proceed. Others interpret this as an injunction to proceed with caution, considering each release into the environment case by case and probably also proceeding step by step. Recourse to this approach "presupposes that potentially dangerous effects deriving from a phenomenon, product or process have been identified, and that scientific evaluation does not allow the risk to be determined with sufficient certainty" (European Commission, COM(2000) 1, 2.2.2000).

[183] http://www.europarl.europa.eu/charter/pdf/04473_en.pdf.

justice in order to safeguard the rights and freedoms of all its citizens. This fundamental principle embraces the following moral values which are relevant to this Opinion:

- **distributive justice** (which guarantees the right to food on an equitable and fair basis);
- **social justice** (which protects the most disadvantaged in society) and **equal opportunities** (which guarantee fair trade at national and international levels);
- **intergenerational justice** (which safeguards the interests of future generations);

8.2 Anthropocentric and ecocentric ethics

Many traditional western ethical approaches have advocated *anthropocentric* or human-centred positions and assigned an intrinsic value to human beings or a significantly greater intrinsic value to human beings than to any non-human things. This therefore justifies protecting or promoting human interests or well-being at the expense of non-human things. Anthropocentrism is a key characteristic of much western philosophy and of monotheistic religions.

Anthropocentric theories justify making instrumental use of nature for human purposes, although some of them have underlined that there are limits to human activities affecting the environment because they could damage the well-being of human beings now and in the future, since our well-being is essentially dependent on a sustainable environment[184]. Anthropocentric ethics argue strongly that humans are at the centre of reality and that it is right for them to be so.

By contrast, since the 1960s ecocentric theories have been advocating the intrinsic value of the biosphere or the ethical dimension of nature[185]. Environmental ethics therefore emerged as a new discipline of philosophy in the early 1970s. It questioned the moral superiority of human beings over other species on Earth and advocated the need to make basic changes to

[184] See Passmore (1974), Bookchin (1990) and Norton, Hutchins, Stevens and Maple (1995).
[185] Rachel Carson, "Silent Spring" (1963), which brought together a number of essays published earlier in the New Yorker magazine giving details of how pesticides, such as DDT, aldrin and dieldrin, concentrated along the food chain.

values and goals at individual, national and world levels with a view to protecting the environment. The main tenets of ecocentric ethics can be summed up as follows:

- Ecological humanism (eco-humanism or "deep ecology" [186]) argues that all ontological entities, both animate and inanimate, can be given ethical worth purely on the ground that they exist.
- Ecological theories argue in favour of the intrinsic value inherent in collective ecological entities like ecosystems or the global environment as a whole[187].
- Conservation ethics theories argue in favour of preservation of the environment on the ground that it has extrinsic value – instrumental to the welfare of human beings. Conservation is therefore a means to an end and purely concerned with mankind and intergenerational considerations[188].

The philosophical debate on environmental ethics remains unresolved. It has focused, *inter alia*, on animals, the biosphere, environmental protection, wildness, the role of human beings in nature (erosion of natural resources), urbanisation, the built-up environment, etc. However, relatively little attention has been paid to the ethical implications of modern agriculture.
Connections between environmental destruction, unequal resource consumption, poverty and the global economic order have been discussed from an interdisciplinary point of view[189]. Many of the more recent assessments of issues concerned with biodiversity, ecosystem health, poverty, environmental justice and sustainability look at both the human and environmental sides, eschewing in the process commitment to either a purely anthropocentric or a purely ecocentric perspective[190]. The EGE recognises the relevance of both anthropocentric and ecocentric ethics theories. However, the topic covered by this Opinion (agriculture) implies *per se* instrumental use of natural resources by human beings.

---

[186] "Deep ecology" is the argument in favour of the intrinsic value or inherent worth of the environment – the view that it is valuable in itself.
[187] This category includes James Lovelock's Gaia hypothesis, i.e. the theory that the planet Earth alters its geo-physiological structure over time in order to ensure the continuation of an equilibrium of evolving organic and inorganic matter. The planet is seen as a unified, holistic entity with ethical worth, to which the human race is of no particular significance in the long run.
[188] Some have also advocated preservation of "world heritage sites", unspoilt parts of the world that acquire "scarcity value" as they diminish over time. Their preservation is a bequest for future generations, as they have been inherited from our ancestors and should be passed down to future generations, so that they can have the opportunity to decide whether to enjoy unspoilt countryside or an entirely urban landscape.
[189] Shrader-Frechette (1984), Gruen and Jamieson (eds.) (1994), Karliner (1997), Diesendorf and Hamilton (1997) and Schmidtz and Willott (2002).

Whatever philosophical position is used to assess the ethics of modern agriculture, it is important to address the complex balance of protagonists involved: human beings, the environment and future generations.

8.3 Rights and responsibilities

Agricultural ethics is about choices for people engaged in agriculture, either directly as farmers or indirectly as government regulators, extension agents, researchers, industrial workers, law-makers, technology developers, consumers or protestors[191]. This calls on decision-makers and relevant stakeholders to promote and implement responsible use of agriculture, based on respect of a number of (ethically justified) fundamental rights. In this context, decisions on ethically sound design of new technologies in modern agriculture place responsibilities on those called to take them and monitor their implementation.

8.3.1 The right to food

Sufficient food is a basic prerequisite for survival. Therefore the right to adequate food[192] is recognised as one of our most important values. The right to food is one of the principles enshrined in the 1948 Universal Declaration of Human Rights. Likewise, the Universal Declaration on the Eradication of Hunger and Malnutrition, adopted in 1974, declared that every person has the inalienable right to be free of hunger and malnutrition for their full development and to preserve their physical and mental capabilities. In 1992 the World Declaration on Nutrition recognised that access to suitable, wholesome and safe food is a universal right.

In 2002 the UN Special Rapporteur on the right to food defined the right to adequate food as a human right, inherent in all people, "to have regular, permanent and unrestricted access, either directly or by means of financial purchases, to quantitatively and qualitatively adequate and sufficient food corresponding to the cultural traditions of the people to which the consumer belongs, and which ensures a physical and mental, individual and collective

---

[190] Hayward and O'Neill (1997) and Dobson (1999).
[191] M J. Chrispeels "Agricultural ethics": http://www.plantphysiol.org/cgi/content/full/132/1/4.
[192] Article 1 of the International Covenant on Economic, Social and Cultural Rights.

fulfilling and dignified life free of fear." This definition embraces all the normative components[193] explained in detail in General Comment 12 of the International Covenant on Economic, Social and Cultural Rights (ICESCR)[194]. The United Nations Commission on Human Rights has asserted that the right to food is a human right, protected under international human rights and humanitarian law[195].

From a sustainability perspective, the human right to food and to a healthy natural environment are inextricably related, because environmental degradation jeopardises the world's capacity to meet rising food needs[196]. In addition, as the opportunities for agricultural production decline because of depletion of natural resources, communities in the developing world that depend on agriculture as their primary source of income face a loss of broader economic development opportunities. In the long term, equitable food production and ethical principles – the rights of humankind to a healthy environment, the rights of future generations to inherit natural resources and the human right to food – are therefore overlapping and complementary.

8.3.2 Responsibilities

Of necessity, agriculture is intended for the benefit of human beings, society and, if sustainable, the environment. These are not necessarily the same, since the benefits to living human beings could, in the short or long term, entail a cost to the environment. Human use of the environment over the 10 000 years we have been harnessing nature has been relatively benign. In the last 100 years, however, we have made rapid, and possibly irreversible, changes to the environment, including excessive use of fossil fuels in relation to their replacement, excessive use of water, production of greenhouse gases and a huge increase in

[193] In 2004, after two years of discussion and negotiation in a working group, the FAO Council adopted by consensus the Voluntary Guidelines to Support the Progressive Realization of the Right to Adequate Food in the Context of National Food Security. The Voluntary Guidelines are not legally binding but draw on international law and provide guidance on implementation of existing obligations. They are addressed to States Party to the International Covenant on Economic, Social and Cultural Rights and to States that still have to ratify it. But they are also intended for stakeholders working towards better implementation of the right to food at national level.

[194] "The right to adequate food is realized when every man, woman and child, alone or in community with others, has physical and economic access at all times to adequate food or means for its procurement."

[195] UN Economic and Social Council, Commission on Human Rights (2004), "Economic, Social and Cultural Rights – The Right to Food", E/Cn.4/2004/10, page 4, paragraph 3.

[196] Von Braun and Ashy Brown (2006), "Ethical questions of equitable worldwide food production systems".

the human population. In this context, the concepts of beneficence and non-maleficence acquire a relevance to support the production of safe, healthy and high-quality food in agriculture.

Individual and collective responsibilities for food security and sustainability should not be confused or overlapped when food security and sustainability are discussed. Clear separation between individual and collective responsibilities is difficult with regard to the issues addressed here (for example, food waste). As far as food security is concerned, responsibility also lies with individuals and their choices in food consumption. For example, following diets rich in meat products and purchasing non-seasonal food certainly have an impact on global warming, food scarcity and erosion of arable land. Similar considerations apply to management of food waste and global hunger. Consumers' responsibility with regard to food security and the hunger divide is lower than their responsibility for food sustainability, since food security depends mainly on the design of national or supranational agricultural policies and trade rules.

Responsibilities also lie with different players involved in the agro-food sector: food producers, food retailers, food distributors and policy-makers in the agricultural sector at regional, national or supranational levels (the EU Member States and the EU as a whole).

Food producers have direct responsibilities for food safety and quality (technologies used for production and methods) and food sustainability (methods of production and raw materials imports).

Food retailers have direct responsibilities for food security (monopolies, food price increases, non-seasonal food, etc.), food safety (food quality and public health) and food sustainability (imports of food, large-scale farm production, etc.).

Food distributors have direct responsibility for sustainability (food miles and methods of transport).

Policy-makers have responsibility for implementation of equitable and fair food systems (food security, safety and sustainability) at both national and supranational levels. They also have responsibility for monitoring that all involved in the food production, processing and distribution system act in ways consistent with the above-mentioned rights.

8.4 Justice

Theories of justice vary greatly and have formed the basis of philosophical debate in Europe for millennia. The contemporary discussions on the concept of justice emerged from the philosophical debate on the relationship between the State and citizens with the work of J. Rawls[197] and its critics[198], but also concerns the role of the State in protecting and advancing human rights as such. Today, two dimensions are of central importance in the context of modern agricultural technologies: the global justice discourse, with the priority of food security and safety, and the question of intergenerational justice, i.e. the obligation to preserve the environment and (natural) resources for future generations.

8.4.1 Distributive and social justice

Although the philosophical debate on the theory of justice continues, fairness and *distributive justice* are key principles for the modern debate on agricultural ethics. The principle of distributive justice addresses the question of which goods a society or a collective group must distribute among its individual members, and in what way, in proportion to (1) the individual's needs and (2) the resources available (which would include market and other financial considerations).

Production efficiency must be balanced by distribution efficiency reflecting ethical concerns such as fairness and justice.

Justice in the agro-food domain mainly concerns food safety considerations (nutritional features of food products), ecological considerations (intergenerational justice and use of natural resources) and economic considerations (global trade and the impact of given import/export measures on the economies of other regions of the world).

---

[197] Rawls develops what he claims are principles of justice by using an entirely and deliberately artificial device which he calls the "original position", in which everyone decides principles of justice from behind a "veil of ignorance". Rawls claims that all those in the original position would adopt a maximin strategy which would maximise the position of the least well-off. Rawls claims that parties in the original position would adopt two such principles, which would then govern the assignment of rights and duties and regulate the distribution of social and economic advantages across society (Rawls, 1971).

[198] R. Nozick (1974), M. Walzer (1995), G.A. Cohen (2000) and R.P. Wolff (1977).

8.4.2 Intergenerational justice

The concept of sustainable development enshrines the principle of *justice between generations*. Consequently, another important factor to consider in the ethics of agriculture is intergenerational justice. Based on a broad understanding of justice[199], future or past generations can be viewed as holding legitimate claims or rights against present generations, who in turn bear correlative duties to future or past generations. One of the legitimate claims of future generations vis-à-vis present generations appears to be a claim to distributive justice. Depending on the understanding of the relevant principles of distributive justice to be applied, if there is an intergenerational conflict of interests, considerations of justice could place an obligation on present generations not to pursue policies that create benefits for themselves but at the expense of those who will live in the future[200]. The philosophical debate on intergenerational justice is complex[201], but plays a key role in discussions on ethics, food security and sustainability.

[199] See Mill, Chapter 5 (1969).
[200] See Rawls (1971 and 1991), D. Parfit (1987), Partridge (1981) and Miller and Kumar (2007).
[201] See Dobson, Andrew (ed.), "Fairness and Futurity. Essays on Environmental Sustainability", Oxford: Oxford University Press (1999); E. Agius, "Towards a Relational Theory of Intergenerational Ethics", in Bijdragen 50 (1989) 293-313; Fotion, Nick and Jan C. Heller (eds.), "Contingent Future Persons. On the Ethics of Deciding Who Will Live, or Not, in the Future" (1997), Dordrecht, Boston and London: Kluwer Academic Publishers; Miller, Jon and Rahul Kumar (eds.), "Reparations. Interdisciplinary Inquiries" (2007), Oxford: Oxford University Press; Partridge, Ernest (ed.), "Responsibilities to Future Generations. Environmental Ethics", New York: Prometheus Books (1981); Ryberg, Jesper and Torbjön Tännsjö (eds.), "The Repugnant Conclusion", Essays on Population Ethics, Dordrecht, Boston and London: Kluwer Academic Publishers; Sikora, R.I. (2004) and Brian Barry (ed.), "Obligations to Future Generations", Philadelphia: Temple University Press (1978). For further information see http://plato.stanford.edu/entries/justice-intergenerational/#Bib.

9. ETHICAL CONCERNS

Agronomy policies adopted over the last few decades have been aiming to increase production by developing new technologies and have achieved considerable improvements in yields. Taking the above-mentioned principles of the EU and the UN seriously, the ecological balance could be significantly tilted as agriculture becomes more efficient. However, modern technologies can be used in agriculture to favour sustainability and food security and to bridge gaps between some parts of the world and others and between present and future generations. But the uneven development paths, unsustainable use of natural resources, worsening impact of climate change, loss of biodiversity, poverty, malnutrition and poor quality of food, in spite of modern technology, are clear indicators that economic and technological progress needs to be inextricably related to ethics and to be based on sustainability of natural resources and food security. However, the ethical dimension of agriculture is not only confined to policy design. It also deeply concerns the technological dimension of modern agriculture, at EU and global levels, and any unexpected consequences that arise from use of new technologies in agriculture[202]. When deciding whether certain developments or technologies should be accepted or promoted, we look at the outcomes, at the benefits. But how should these benefits be calculated? Benefits for whom and for how long?

The ethical concerns outlined below address issues described in the previous chapters of this Opinion, namely the present trends (methods used, costs, etc.), existing legal regulation and policies on agriculture and trade and the values and principles outlined in the previous chapter.

[202] As an example, some argue that use of the pesticide DDT has beneficial effects on populations of areas where malaria is endemic but, due to its accumulation in the food chain and consequent adverse neurological effects on both animals and humans, DDT has been banned in many countries, despite the fact that its potential use against malaria might save millions of lives in various regions of Africa. As another example, the new varieties of wheat (*Triticum aestivum*) and rice (*Oryza sativa*) produced by the green revolution increased food production in Asia and Latin America and provided food for hundreds of millions of people, but also marginalised untold millions who lost their access to land or their employment (Conway, "The Doubly Green Revolution", Comstock Publishing Associates, Ithaca, NY, pp. 78 et seq., 1997).
See also M.J. Chrispeels ,"Agricultural ethics": http://www.plantphysiol.org/cgi/content/full/132/1/4).

9.1 Food security at global, national and individual levels

Agriculture is the main provider of food and has a great impact on nutrition and health and on economic growth. There have been many arguments about the distribution of both food and farmland between the rich and poor, in developed and developing countries alike. Most of the world's poor are small tenant farmers. In order to increase their standard of living, the governments of many developing countries adopted (in the 1970s) policies for "industrialising" agriculture. The fact that today there are more than 800 million people worldwide whose food supply is uncertain, even though sufficient food is being produced[203], points to a worrying distribution problem and is a sign of inadequate structures in agriculture and in world trade in agricultural goods. Global food production has apparently "more than kept pace with population growth in recent decades and a diminishing proportion of the world's population are undernourished[204]." There is, however, a worrying distribution problem in many countries. As the population has been increasing steadily during the last century in every continent, agriculture has been facing increasing challenges to meet goals such as provision of resources and, most importantly, of food. Since one of the major causes of hunger is poverty, the fight against poverty can provide part of the solution to both world hunger and the consequent threats to political stability and peace, especially in developing countries. The questions are how to find a proper balance between access to food for all and open trade in agricultural products? Should specific measures be conceived to limit the food divide between industrialised and non-industrialised countries? To what extent should individual freedoms in connection with food affect global production and distribution of food products? Should specific measures be conceived to guarantee food security while affecting individual dietary choices (in view of the increased consumption of meat and its impact on agriculture)? To what extent can economic considerations to protect the welfare of given geopolitical realities, such as Europe, prevail over food security and hunger in global strategies?

---

[203] Jacques Diouf, Director-General of the FAO, "Enough food is produced in the world today for everyone to be adequately fed. But 800 million people in the developing world do not have enough to eat." (World Chronicle, 31 October 2003).

[204] Øystein Kravdal (2001), "Has population growth restricted improvements in food availability per head 1970-1995?", Population Studies 55, pp. 105-117.

9.2 Food insecurity

To ensure food security, first of all the sources of food insecurity must be identified and dealt with case by case. A working definition of food insecurity given by the WHO is consumption of less than 80% of what is considered the average per capita calories intake (2 850 kcal). Threats to food security can take different forms, have different dynamics[205] and be caused by several factors[206]. The practices that have evolved to support production agriculture (low commodity prices made possible by efficient, large-scale farms) are seen by many as unsustainable and contrary to stewardship of the land (Gliessman, 2000). However, abandoning production agriculture could push up food prices and then affect food security in the EU and worldwide.

Global and regional per capita food consumption (kcal)[207]

Region	1964-1966	1997-1999	Projected for 2015
World	2358	2803	2940
Developing countries	2054	2681	2850
Sub-Saharan Africa (excluding South Africa)	2058	2195	2360
Industrialised countries	2947	3380	3440

9.3 Sustainability of both resources and technologies

Sustainability requires limiting the ecological footprints of agriculture and safeguarding the environment for future generations[208]. Sustainable development is defined in the Brundtland

[205] Transitional food insecurity means a momentary food shortage, as could be the case with seasonal food insecurity, for instance during the cropping season. Chronic food insecurity means permanent reduced food availability to the population, lasting two or more seasons, rendering a region vulnerable to famine.

[206] For example, the sharp price increases for staple foods over the last few months, harvest losses due to prolonged droughts or floods (partly due to climate change in many regions of the world) or in cases where agricultural raw products are used for energy production instead of food (see the biofuels debate mentioned earlier in this Opinion).

[207] WHO Global and Regional Food Consumption Patterns and Trends.
See http://www.who.int/nutrition/topics/3_foodconsumption/en/print.html.

[208] The UN Earth Summit in Johannesburg in 2002 focused, *inter alia*, on how to "enhance in a sustainable manner the productivity of land and the efficient use of water resources in agriculture". Stewardship, research and development in good agricultural practices and proper land management techniques are fundamental, as are water protection and preservation.

report [209] as "development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs[210]." It embodies the principle of *justice between generations*: future generations are vulnerable because they are "downstream" in time from us and thus exposed to the long-term consequences of our present activities. They therefore need to be protected from natural resources misuse by the present generation who have decision-making powers over current agricultural policies.

If new technologies or new practices are involved, are they likely to widen the gap between the rich and the poor, both within countries (particularly in developing countries) and between developed and developing countries[211]? Will they generate wealth for society as a whole which can assist those who need it? If they are more efficient and will provide more food but at the expense of some traditional farmers, is this acceptable? How can a balance be struck between increased productivity and environmental sustainability[212]?

It has been argued that, as the world population along with its need for food grows, new technologies are necessary for creating and encouraging new methods of agricultural production and trade with a view to developing equitable food distribution capacity and a food-secure world. The current amount of land under cultivation cannot expand much further without detrimental environmental effects. Therefore, food production technology must create methods to improve the productivity of the land currently under cultivation and prevent harvest losses. An integrated scheme for effective use of land is crucial.

9.4 Food safety

Food safety covers the conditions and practices that preserve the quality of food to prevent contamination and food-borne illnesses. It entails protecting the food supply from microbial,

---

[209] Available at http://www.worldinbalance.net/pdf/1987-brundtland.pdf.
[210] World Commission for Environment and Development (1987), "Our Common Future", Oxford University Press, Oxford, UK, ISBN 0-19-282080-X.
[211] A small but significant array of policy-makers, citizens and consumers have argued that new technology will exacerbate food insecurity, threaten the environment, endanger human health and, ultimately, impoverish some parts of society. There seems to be a conflict between those who see technology as all good and those who see it as an example of globalisation and of the take-over of people's lives by anonymous, big multinational conglomerates.
[212] Low commodity prices are beneficial for consumers and safeguard export markets, but ecosystems and rural communities may suffer from some of the policies that encourage specific agricultural practices. For example, the current agricultural system relies heavily on irrigation, continuous monocultures and purchased inputs (fertilisers, pesticides, herbicides, farm machinery, etc.) and many such practices have a negative impact on the environment.

chemical and physical hazards or contamination that can occur at all stages of food production and handling: growing, harvesting, processing, transporting, preparing, distributing and storing. Food safety is therefore a heterogeneous and multidisciplinary issue that concerns not only the food products as such but also the production methods. In this context, considerations relating to agricultural safety (use of chemicals) for the environment, wildlife and farm workers take on key importance.

This Opinion has described the relevance of this factor in EU agriculture. Some, however, have argued that food safety standards that developed countries impose on exports from developing countries have sometimes created barriers to market access[213]. The major problem for farmers who supply supermarkets is that they cannot raise their prices to pay for the investments needed to meet the quality and safety requirements set by the supermarkets. This appears to be true throughout the world, whether in developed or developing countries. An emerging concern is, therefore, whether the EU CAP should focus on food safety and consumer protection and promote the quality and healthiness of food products. European food safety measures applied to importing countries should be proportionate.

9.5 Loss of biodiversity

For decades the development of agriculture has been leading to continuous biodiversity loss of species used in industrial farming. During the Fourth International Conference on Sustainable Agriculture for Food, Energy and Industry[214], the Executive Secretary of the Convention on Biological Diversity (CBD) addressed, *inter alia*, the risk of extinction and biodiversity loss in agriculture and how agricultural production is becoming more vulnerable to climate change and diseases that could spread more easily in monoculture systems[215]. In addition to loss of agricultural biodiversity, other serious problems can arise from the loss of

---

[213] "Higher quality and safety standards mean that consumers will ingest fewer pesticides and harmful microbes, and generally eat higher-quality fresh produce, but they also mean that agricultural development programmes must take on the responsibility and challenge of assisting small farmers in making the transition to producing safer and higher-quality produce." Julio A. Berdegué, Fernando Balsevich, Luis Flores, Denise Mainville and Thomas Reardon (2003), "Case Study: Supermarkets and Quality and Safety Standards for Produce in Latin America" in "Food safety in food security and food trade", ed. Laurian J. Unnevehr, IFPRI.

[214] The Fourth International Conference on Sustainable Agriculture for Food, Energy and Industry was held on 2-5 July 2008 in Sapporo, Japan.

[215] The Executive Secretary of the Convention on Biological Diversity (CBD), Ahmed Djoghlaf, stressed that "while not caused solely by the decreases in the number of cultivated species, the current food crisis is an example of what lies ahead if we continue to allow the loss of agricultural biodiversity, despite predicted global changes in growing conditions": http://www.cbd.int/doc/speech/2008/sp-2008-07-02-sapporo-en.pdf.

natural biodiversity and of habitat, for example due to deforestation of new areas to make room for intensive agriculture. A decrease in genetic diversity means fewer opportunities for the growth and innovation needed to boost agriculture at a time of soaring food prices. Furthermore, as biodiversity in food and agriculture declines, the food supply becomes more vulnerable and unsustainable. Agriculture becomes less able to adapt to environmental challenges, such as climate change or water scarcity.

9.6 Soil and water protection

Water availability is a crucial question when considering any requirement to increase agricultural production and product availability. Agriculture accounts for approximately 80% of the world's water consumption[216] and is the cause of much pollution of water supplies. Water availability and access are key constraints to poverty reduction and food security. "Maintaining enough water for agriculture of reasonable quality will be increasingly difficult due to climate change; competition for water with industries, urban uses and the environment; and the need to produce biofuels … [an] improved understanding of water availability is critical to integrated water resources management[217]." There is an obvious necessity to "maintain equity in water access, agricultural productivity, human health and environmental quality in the face of increasing water scarcity at local, basin and transboundary scales via development of adaptive management strategies, policy responses and trade-offs[218]."

Maintaining land and soil quality is also a major determinant of agricultural productivity, and steps must be taken to ensure that land is used in an efficient and sustainable manner.

9.7 GM crops in the EU

Genetic modification of food crops and foods has been controversial in the EU and worldwide. In the United States and Argentina, in particular, the new products have been welcomed by the farming community and have not met with significant rejection by

---

[216] Dobrowolsk et al., USDA-CSREES 2006 National Water Quality Conference, "What price water? Status of water availability for agriculture in changing economic times."
See www.usawaterquality.org/conferences/2006/Abstracts/Huffaker.pdf.
[217] Research theme of the CGIAR International Water Management Institute:
http://www.iwmi.cgiar.org/Research_Impacts/Research_Themes/Theme_1/index.aspx.
[218] Ibid.

consumers. In both these countries the introduction of new variants has proceeded apace and farmers have benefited from the agronomic traits that have been added. In Argentina, in particular, the adoption of no-till approaches when using the new variants has had a dramatic effect on conservation.

The picture in Europe has been very different. Governments reacted to this new technology in different ways. Communities in much of Europe made their feelings clear to governments, and a strong movement to reject these products began in the late 1990s and is still active. Many regions have declared themselves GM-free. In much of Europe consumers have chosen to shun products containing GMOs and retailers have chosen to use this as a marketing ploy to attract customers. In 1998 the European Union introduced a *de facto* moratorium on the introduction of GM products both into the environment and as new foods – although not restricting GM feed for animals to quite the same extent. This triggered a dispute between the EU and Argentina, Canada and the United States. Developing countries have been wary of introducing the new varieties, as the impact on their income if they fail to sell in Europe would be substantial, even though agricultural production could have improved considerably if the transgenic varieties had proved effective in their agricultural conditions.

The impact of rejection of the products and of the requirement for regulation that draws a distinction between transgenic products and those produced by conventional methods has been profound. There appears to be a degree of polarisation – with many countries fearful of EU rejection of their products and of accepting products that some consider harmful, but others expecting significant gains from adopting the new technology. Commercial applications have resulted in insertion of genes into a small number of crops, primarily oilseed rape (canola), soybean, cotton and maize, to provide herbicide tolerance or pest resistance. These have captured a large market share but have also come in for heavy criticism[219].

[219] Peter W.B. Phillips (2002), "Biotechnology in the global agri-food system", Trends in Biotechnology, Vol. 20, No 9, September 2002.

Positions on GMOs are sharply divided across the EU. Industrial stakeholders point to the advantages of this technology in terms of ecological sustainability [220], economic sustainability [221] and social sustainability [222] and underline both the increasing public acceptance of this technology[223] and its potential to produce enough healthy food for the population, while preserving precious resources, such as soil and water, and mitigating climate change. Consumers' organisations, environmental protection organisations and several NGOs underline the risks associated with coexistence of GM crops alongside natural species, the lack of public acceptance and the risks stemming from the monopoly which this sector of industry could induce (see also the UN International Assessment of Agricultural Knowledge, Science and Technology for Development – IAASTD[224], 2008). Others argue that "the scientific risks and socioeconomic issues associated with biotechnology need to be examined in the context of technology's role in addressing long-term goals, such as preserving biodiversity, conserving natural resources, achieving food security, improving the health of populations, cleaning up polluted lands and bodies of water, and obtaining adequate sources of energy[225]." Yet others underline that genetic technologies not only involve genetic modification. Identification of genes which confer desirable or undesirable traits (salt tolerance, disease resistance or susceptibility) make plant breeding a much more effective tool than it was in the past, without any need to insert new genes from unrelated species. Many are now arguing for mechanisms for performing an environmental impact assessment of new technologies, taking into account the risks and benefits of new technologies and the

[220] Over the ten-year period from 1996 to 2006, agricultural biotech reduced greenhouse gas emissions from agriculture by 14.8 billion kg of CO_2, which is equivalent to taking 6.6 million cars off the roads in one year (= 25% of the cars registered in the UK), and also reduced crop spraying by 286 million kg.

[221] The global net economic benefits of biotech crop cultivation at farm level totalled €4.5 billion in 2006 and €21.6 billion over the ten-year period.

[222] In 2006, 54% of farm income gain went to farmers in developing countries. In Europe, as in the rest of the world, two thirds of the benefits of growing biotech crops are shared between European farmers and consumers, while one third goes to the developers and seed suppliers.

[223] Consumers' perception of GMOs is changing, as shown by the latest Eurobarometer survey (2008), where the number of Europeans worried about biotech crops was down to 20%, from 24% in 2004.

[224] The UN International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD, 2008) notes that contained use of modern biotechnologies (enzymes, DNA diagnostics, etc.) is widely accepted, whereas uncontained application of modern biotechnology – for instance, GM crops – is contentious. The IAASTD emphasises the need for more and better targeted investment in biotechnology. For example, marker-assisted selection (MAS) in plant breeding, platform technologies – DNA diagnostics or chips for screening planting material, nanotechnology for targeted input delivery or pathogen elimination, etc. – and argues that transgenics do not contribute to addressing the IAASTD goals. See www.agassessment.org.

[225] National Academy of Sciences (2008), "Global Challenges and Directions for Agricultural Biotechnology – Workshop Report": http://www.nap.edu/catalog/12216.html ISBN 978-0-309012077-7, page vii.

risks of not implementing them – persisting with inefficient, unsustainable agriculture, for example[226].

9.8 Biofuels

Some technologies are not directly implicated in food production (and therefore in food security). However, their introduction does have implications for use of the available arable land and then has an impact on the sustainability of natural resources. In particular, one technology which has acquired specific importance and attracted special attention is production of biofuels and its impact on global hunger and agricultural policies at EU and global levels. An international debate is under way on the sustainability of biofuels production from food-related materials, as an increase in biofuels production based on these methods would possibly have a negative impact on food markets and lead to certain food price increases. One solution would be to develop new methods for production of biofuels which would use alternative raw source materials, such as biomass derived from recycling biological waste.

Bioethanol produced in Brazil from sugarcane is one example of effective use of agriculture to produce fuel. The cane grows with little water and no fertilisers and all the residues are used or recycled. This produces 45% of the fuel used in Brazil on less than 1% of its arable land. A less favourable example is the biofuel produced in the USA from corn and maize, which requires large quantities of water and fertilisers and is already taking 25% (140 million tonnes) of the current US maize production, with public support totalling US$ 6 billion. In particular, in terms of greenhouse gas savings, this route is estimated to have a negative impact or at best produce a 20% saving over its complete cycle compared with oil[227].

9.9 Food waste

Food waste is a phenomenon which concerns not only mechanisms from food production to

[226] For example, see UK Department for Environment, Food and Rural Affairs (2007), "Managing the Footprint of Agriculture: Towards a Comparative Assessment of Risks and Benefits for Novel Agricultural Systems: Report of the ACRE Sub-Group on Wider Issues raised by the Farm-Scale Evaluations of Herbicide-Tolerant GM Crops" (revised after public consultation), 3 May 2007: http://www.defra.gov.uk/environment/acre/fsewiderissues/pdf/acre-wi-final.pdf, Section 1.5.
[227] Time, pages 28 et seq. (14 April 2008).

distribution and consumption and the legal obligations set out in the EU food law but also, particularly, consumers' attitudes. A general trend, at least in the most developed countries, is to buy too much for a variety of reasons: because of miscalculation of needs (groceries shopping is often reduced to bulk purchases a long time apart from each other which therefore makes it difficult to estimate exactly how much will be needed), because portions are often bigger than consumers' appetite and because the higher standard of living means that consumers tend to pay less attention to saving. At the same time, stricter food safety standards lead, for example, to restaurants not being allowed to give away leftovers to charities and having to throw away any excess food prepared. In these ways, a considerable amount of food waste is generated, and only a small proportion of it is recycled appropriately, e.g. via organic waste disposers. A huge amount of food is thrown away every day. As an example, the bread produced during the last hour of business in Vienna's bakeries and then discarded if unsold could feed the entire population of Graz, Austria's second largest city. There are many examples like this and, apart from the underlying ethical questions, the economic side of the story is significant. Better management of food resources and distribution would lead to substantial savings that could be diverted to other purposes. For example, 5% of the USA's yearly food waste equals one day's food for 4 million people[228]. The total food surplus of the USA alone could feed Africa's undernourished, France's could feed the Democratic Republic of Congo's and Italy's could feed Ethiopia's[229]. Other potential uses of food waste concern environmental protection and energy production. To give just a few figures:

- A 50% reduction in food waste could reduce the environmental impact (in the form of greenhouse gas emissions) by 25%[230].
- Biogas cars can reduce CO_2 emissions by between 75% and 200% compared with fossil fuel cars[231].
- In Europe, biogas is available as a fuel in Austria, France, Germany, Sweden and Switzerland. Sweden is the leading user in Europe[232] and already has 7 000 biogas cars and 779 biogas buses.

---

[228] According to the US Department of Agriculture (USDA).
[229] According to the UN World Food Programme.
[230] The UK's Waste and Resources Action Programme (WRAP) calculates that the entire food supply chain in the UK contributes 20% of the UK's greenhouse gas emissions.
[231] According to a study by the National Society for Clean Air: www.nsca.org.uk.

9.10 Research funding and the brain drain in agro-food sciences

The Seventh EU Research Framework Programme (FP7) has a dedicated theme entitled "Food, Agriculture and Fisheries, and Biotechnology" covering three major activities: (1) sustainable production and management of biological resources from land, forest and aquatic environments; (2) fork to farm: food (including seafood), health and well-being; and (3) life sciences, biotechnology and biochemistry for sustainable non-food products and processes. It is important that Europe continues to have the highest standards of knowledge in these fields (including food safety and food technology) and, most importantly, that researchers in agro-food sciences are supported and motivated to stay and work in Europe. The brain drain towards non-EU countries seems to be a serious problem, as there is a risk of not fostering the next generation of researchers who will maintain high skills and knowledge in the EU.

9.11 Dietary habits and lifestyles

Systems for rapid distribution of speciality foods and efficient distribution of commodities have changed the eating habits of millions in the developed world. The availability of cold storage and effective packaging has accentuated this change. It has become possible to grow food and non-food crops throughout the world and to deliver them to consumers able to pay for them. Low costs in African, Asian and South American countries have made it possible to produce food costing less than home-grown products in many markets in Europe and North America. Even meat products are no longer necessarily produced locally and can be shipped to markets all over the world. The impact on agriculture of being able to grow more food, either for local consumption or for export in return for hard currency, is profound and leads to situations where some countries (including in the EU) are becoming increasingly dependent on massive imports of certain food (or feed), with all the potential risks this entails.

There are many ethical issues related to environmental protection and sustainability that need to be considered, as this change has consequences both for those who gain from greater

[232] Source: New Energy Finance, London.

variety and availability, e.g. farmers and exporters who are able to innovate in new locations throughout the world and to market products new to consumers in other parts of the world, and for those who are made even poorer, as productivity is geared to exports rather than to local markets.

9.12 Equal opportunities and global trade

Production efficiency in agriculture must be balanced by distribution efficiency reflecting ethical concerns such as fairness and justice. The most important prerequisite for independent, stable development in the agricultural sector is greater *justice of opportunities* in economic competition at national and international levels and better starting conditions in education, infrastructure or a fair legal framework enabling participation in market activities. Above all, greater justice demands empowerment of groups that were previously excluded, including farmers in many parts of the world. Greater justice of opportunities has both an instrumental value and a high inherent value for those concerned. The principle of justice of opportunities as "positive discrimination" demands preferential treatment, until at least approximately equal opportunities have been created. Special arrangements are needed to improve the opportunities of poor countries in competition for worldwide agricultural trade.

9.13 Stakeholder participation and the importance of local culture and knowledge

It is important to recognise that agriculture is practised at a number of levels. Industrial agriculture, whether practised in developed or developing countries, cannot be confined to the requirements set out in this Opinion, but provides currency and security to countries that can be used for the benefit of the people. It might be necessary to ensure that agriculture addresses the needs of local and/or regional markets first. This consideration makes it clear that development of the agricultural sector calls for an integrative action plan that covers, among other things, local and regional transport systems, health and education infrastructure and systems of accountability of political institutions and companies as much as rules for

regional, international and global trade. How can a balance be struck to "ensure food security, decent and dignified employment, health and respect for the environment[233]"?

The ways in which food is prepared, served and consumed differ from one culture to another. Traditional and local knowledge constitutes an extensive realm of accumulated practical knowledge and knowledge-generating capacity that is needed if sustainability and development goals are to be achieved. Many effective innovations are generated locally, based on the knowledge and expertise of indigenous and local communities rather than on formal scientific research. Traditional knowledge of indigenous and local communities is recognised by the UN Convention on Biological Diversity. Traditional farmers embody ways of life beneficial to conservation of biodiversity and to sustainable rural development. Local and traditional knowledge has been successfully built into several areas of agriculture, for example in the domestication of wild tress, in plant breeding and in soil and water management.

9.14 IPR system

The current IPR system (for plant varieties and GM crops) could pave the way for market predominance where a few companies control much of agricultural production, with an impact on innovation and the growth of local economies in developing countries. This raises concerns about how to promote IPR policies that could avoid such risks. In this context, a proper balance between WTO rules and the socioeconomic aspects of different regions of the world calls for consideration guided by concern for fair trade, justice and solidarity in global trade in agricultural products, including seed.

---

[233] "Agriculture is the main source of employment for the majority of the world's people, especially in developing countries. It cannot be held captive to the profit-making interests of a minority." "Food Sovereignty over Trade": http://www.peoplesfoodsovereignty.org/statements/new/18-b.htm.
UN Economic and Social Council, Commission on Human Rights, 2004 "Economic, Social and Cultural Rights – The Right to Food", E/Cn.4/2004/10, paragraph 26.

9.15 Fair competition

According to Food and Water Watch[234], in 2006 just two firms controlled nearly three fifths (58%) of the corn seed market. For the nearly three quarters (73%) of corn farmers that plant genetically modified varieties, the concentration is much higher. The agrochemical market is similarly concentrated, with four firms controlling 60% of global agrochemical sales in 2004. Four wet corn milling firms control more than two thirds (68.7%) of the market and the top four breakfast cereal companies control more than three quarters (78.4%) of cereal sales. Today the top 30 supermarket chains now control one third of global sales; the top 10 seed companies control one third of the global market; and two companies control 75% of the world cereal market[235].

The risk of monopolies on the food market is a cause for concern. In the same way, seeds and chemicals used in agriculture are controlled by just a few companies and intellectual property rights, cross-licensing and user licences limit use of seed for cultivation.

The current system, consisting of various State aid schemes and the resultant subsidy competition between industrialised nations, is geared almost exclusively to the fight for global market share, for instance by means of a substantial increase in export promotion. This system affects worldwide agricultural trade in favour of the industrialised nations and in many cases leaves poor countries at the mercy of highly subsidised exports from the North. Complete liberalisation of agriculture can therefore be questionable, because it could increase the concentration into just a few agro-industrial complexes and undermine small-scale farms. Poorer countries need a greater degree of flexibility to protect their still under-developed agriculture against foreign competition, for example by means of one-sided external protection or by providing scope for internal subsidies, such as for small-scale farms.

One kind of impact of globalisation has been that global commodity markets are increasingly dominated by a few companies that can set prices. Even at national level, liberalisation has

---

[234] http://www.foodandwaterwatch.org/food/agricultural-policy/us-farmbill/retail-realities/winners-and-losers-in-us-farm-policy/?searchterm=seed. See also data provided in the Food Policy Report "The world food situation", December 2007.

[235] Dr Eric Drésin, "Strengthening Consumer Health Through Sustainability" in The Ethical Aspects of Modern Developments in Agriculture Technologies, Proceedings of the round table debate, Brussels, 18 June 2008. See http://ec.europa.eu/european_group_ethics/publications/docs/agriculture_technologies_ethics.pdf.

led to only a small number of private companies – meaning that farmers are forced to accept low prices whilst consumers have often not benefited from the lower prices promised by "free trade[236]". Indeed, it is argued that "monopolistic practices by transnational agribusiness corporations increasingly in control of agricultural trade, processing and marketing" result in consumers failing to benefit from "free trade[237]".

9.16 Food prices

According to recent FAO data, the world food price index rose by nearly 40% during 2007. Most agricultural commodities have been affected, with the price of wheat tripling since 2000[238]. These developments are having an impact on the food and nutrition of poor people[239]. Moreover, the food price shocks are affecting the social stability of several less developed countries across the world. Violent protests and food riots in Latin America, Africa and Asia bear witness to the dramatic impact on the world's poorest, putting years of progress at risk. The heavy burden of food price inflation is borne by the urban poor, but also by the rural poor. According to preliminary estimates from the World Bank, the surge in food prices could push around 100 million people into deeper poverty. Europe is also affected by this phenomenon and the affordability of food is becoming a problem for some European citizens. The social implications of food price rises are therefore significant and action is both needed, to alleviate the negative consequences of food price volatility on a large portion of European society, and justified from an ethical perspective, in the name of social justice and solidarity.

---

[236] UN Economic and Social Council, Commission on Human Rights, "Economic, Social and Cultural Rights – The Right to Food", E/Cn.4/2004/10, paragraph 21 (2004).
[237] Ibid.
[238] Ibid.
[239] Joachim von Braun, "Rising Food Prices – What Should Be Done?", IFPRI Policy Brief: http://www.ifpri.org/pubs/bp/bp001.pdf (2008).

10. RECOMMENDATIONS

10.1 Introduction

Production, processing and distribution of agricultural products and food are generally accepted as routine parts of everyday life. Food and agriculture are means to an end that is not only technical, economic or political in nature but also inherently ethical, namely to feed the world's population while respecting future generations' needs and expectations in terms of food security, safety and sustainability.

The current revision of the EU common agricultural policy, food security and safety, climate change, agricultural sustainability and global trade in agricultural commodities are all issues that have grabbed the attention of media, policy-makers and civil society in the last few years. According to the latest FAO report published in early December 2008, some 963 million people were suffering hunger in the world in 2008, 40 million more than in 2007, as a consequence of higher food prices. The continuing financial and economic crisis could push even more people into hunger and poverty. There is therefore a passionate debate on how to face these challenges, with high expectations that new technologies in agriculture could contribute to solving this problem. In order to address the new challenges and opportunities which lie ahead for EU agriculture, President Barroso therefore asked the EGE to give its advice on the ethical implications of modern developments in agricultural technologies. The Group accepted this difficult task and decided to focus primarily on agricultural technologies and methods for primary production of food of plant origin.

The Group is aware of the need to promote innovation in agriculture but it is equally aware that technologies alone cannot provide final solutions to the challenges modern agriculture is facing in the EU and worldwide. However, the Group supports all technologies in agriculture, insofar as they are conducive to the goals and priorities indicated in this Opinion. The Group also emphasises the need for an integrated view and an integrated approach on agricultural technologies, so that the production, storage and distribution processes are considered together when the ethical implications of any new technology are assessed.

10.2 The EGE's ethical approach to agriculture

The Group considers the goals of (1) food security, (2) food safety and (3) sustainability as first priorities and guiding principles to which any technology in agriculture must adhere. Therefore the Group recommends an integrated approach to agriculture, based on a system where its constituent units are balanced, not just at technical level (where there is continuous assessment of the balance between the input required, e.g. resources, energy, etc., and the outcomes expected to achieve its goals) but also at ethical level (where members of society act and interact on the basis of commonly held values).

The EGE calls for explicit embedding of ethical principles in agricultural policy (whether traditional or innovative) and argues that respect for human dignity and justice, two fundamental ethical principles, have to apply to production and distribution of food products too (see section 8.1). In addition, the EGE calls for impact assessment of agricultural technologies, as described in section 10.2.4 of this Opinion.

10.2.1 The right to food

The starting point of any ethical agricultural policy must be the obligation of States and of the international community to secure all human beings' right to food. Agricultural policies at national, EU and international levels must therefore aim, first and foremost, to secure access to food at regional, national and international levels, so that everyone has sufficient access to safe and healthy food corresponding to their particular cultural background and available scientific data.

10.2.2 Sustainability of agriculture technologies

The need to maintain productive agriculture worldwide is emphasised by the fact that a large proportion of the world population lacks proper access to food and by the recurrent food crisis in 2007 and early 2008. However, the strong ecological impact of agriculture highlights the need to implement a different model of agriculture in the future: a sustainable and multi-functional agriculture where, apart from securing safe food for everybody, stewardship of the land, preservation of the resource base, the health of farm workers,

preservation of the small biota that are rich in biodiversity, the value of rural communities and the value of the agricultural landscape acquire important status.

From an ethical perspective, sustainable agricultural technologies should help to maximise use of natural resources while protecting them from exhaustion and thereby allowing natural regeneration. In order to achieve this, the Group advocates that:

1. there is a need to optimise processes involved in primary production, distribution and storage of food;
2. use of arable land needs to be optimised and methods are needed to turn areas not accessible at present, due to adverse environmental conditions, into arable land;
3. all other processes involved, "from farm to fork", need to be optimised and simplified (to reduce harvest losses and waste and, where possible, to implement waste recycling systems).

10.2.3 Food safety

The Group considers food safety a prerequisite for production and marketing of food products from arable agriculture, including imports of agricultural commodities and products from third countries, and calls on the competent authorities to monitor enforcement of food safety provisions. The Group supports the work done by the EU, Member States and relevant bodies (EFSA in particular) on enforcement of food safety standards and considers it necessary that:

- EU food safety standards have to be based on scientific data only;
- If EU food safety standards for food products from arable agriculture differ from international standards, they must be scientifically justified.

In addition, the Group urges the EU to enforce current legislation and traceability provisions in order to avoid fraud and calls for further research on new technologies for food safety.

10.2.4 Technology impact assessment

In the field of new agricultural technologies, in addition to risk assessment, there is a need for impact assessment at national and European levels[240]. Impact assessments examine the risks and benefits to human health and the environment of using a new technology and those of not using it, including the risks and benefits of retaining current technologies. They take account of the need to ensure sustainability, food and feed security and safety.

The Group proposes that such impact assessments should consider safety (agro-food and environmental) issues and also address the social implications, e.g. how agricultural technologies will affect social, economic and institutional structures, with particular concern for justice (equal access and participation in decision-making) and fair distribution of goods. Furthermore, the Group suggests that the Commission should, *inter alia*, continue to fund studies on the social effects of agricultural technologies. Such research should also focus on macroeconomic trends, trade implications and possible international problems and, in particular, examine the risk of creating a technological divide which could widen the gap between the developed and developing countries.

10.3 Recommendations on introduction and promotion of agriculture technologies

The EGE is aware of the great variety in primary production methods for agricultural products of plant origin and of the fact that several regions in the EU still use traditional methods of agricultural production. The Group recognises the need to respect the diversity of EU primary production, but is equally aware of the need to make EU primary production of food, feed and fibre of plant origin competitive on the global market and, therefore, of the need for innovation in this sector.

The Group supports the current efforts by the EU to promote innovation in agriculture but calls for specific efforts to support mainly technologies that are conducive to food security, safety and sustainability in order to ensure ecologically and socially sound agricultural production (techniques and methods), based on fair treatment both of the environment and of farmers.

[240] Details on the prospective technology assessment proposed here can be found in EGE Opinion No 22.

The EGE also recognises that agriculture brings both benefits and harm, particularly to the environment, and that all technologies could involve risks with irreversible effects. The Group therefore believes that, before a technology is considered for use in agriculture, its effects should be carefully studied and evaluated by means of an impact assessment that takes account a comparative assessment of the current and new technologies. This assessment should be guided by an integrated approach to agriculture where both environmental and social implications are taken into account. The Group urges the EU to promote food safety, health and quality as a prerequisite for (1) production and marketing of EU food products from arable agriculture and (2) imports of such products from non-EU countries and asks the EC to focus efforts on research in the sectors indicated above.

10.3.1 Agricultural biodiversity

The Group is aware that any decrease in genetic diversity means fewer opportunities for the growth and innovation needed to boost agriculture at a time of soaring food prices and possible future food shortages. The Group is equally aware that any decline of the agricultural biodiversity used in food and agriculture has an impact on the sustainability of agriculture (including its capacity to adapt to climate change or water shortages). The Group therefore supports action to protect this biodiversity, such as the International Treaty for Plant Genetics and Resources and the Global Plan of Action for the conservation and sustainable use of plant genetic resources for food and agriculture. This involves setting up systems to store genetic information and seed in order to maintain crop diversity.

10.3.2 Soil and water protection

The Group is aware that a number of products currently used in agriculture could pose a risk to human or animal health and to the environment, especially when used in high concentrations. Technologies that reduce the need for dangerous chemicals whilst maintaining yield and quality should be promoted. In particular, protection of human[241] and animal health by lower exposure to chemicals should be encouraged. As mentioned

[241] Including especially farm workers, who may be vulnerable to adverse working conditions.

previously, the Group urges that an impact assessment should be conducted for all new technologies used in agriculture in the light of the goals of this Opinion, giving priority to food security, safety and sustainability.

The Group is aware that soil erosion and water pollution are consequences of agriculture and therefore stresses the importance of the non-tillage techniques and improved water management plans developed over the last few decades in order to implement better preservation practices, in keeping with its recommendation on an integrated approach to agriculture. The Group encourages use of all technologies and methods to increase soil productivity, prevent soil erosion (deterioration of soil quality) and water pollution and promote recycling of waste material (e.g. cellulosic biomass for production of ethanol). In this context, the Group supports use of:

1. proven techniques (such as contour farming and non-tillage techniques), where appropriate for sustainable use of soil;
2. bioengineering for the sustainability purposes indicated above (e.g. reduction of spray pollution, active ingredients in herbicides and CO_2 emissions);
3. modern genetics, where appropriate and safe in order to improve and select crop varieties appropriate to specific environmental conditions (e.g. in the case of MAS (see section 3.2.2) for plant tolerance to high salinity);
4. ICT tools for optimisation of agricultural plant products (global positioning system and geographical information system or ICT tools to optimise irrigation and monitor physical characteristics of soil, such as topography, salinity, etc.);
5. all technologies and methods that could be beneficial to better water management and prevention of water pollution. The EU should allocate funding for the implementation of optimal use of water resources.

The Group encourages and calls for development and promotion of the above-mentioned technologies in the EU and worldwide. In order to narrow the technological divide, the Group encourages development of specific measures, both within Europe and on a wider global scale. Development and technology plans should, however, guarantee farmers' and

producers' free choice of methods of production[242] and promotion of new technologies for competitive local production. The Group also supports precision farming in the EU and in developing countries, where its advantages over conventional farming could be greatest.

The Group stresses the importance of the UN Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention), intended to strengthen national measures for protection and ecologically sound management of transboundary surface waters and groundwaters[243]. The Group also supports international initiatives such as UNESCO's International Hydrological Programme (IHP) for water research, water resources management, education and capacity-building, which aim, *inter alia*, to assess the sustainable development of vulnerable water resources and to serve as a platform for increasing awareness of global water issues.

10.3.3 Biofuels and agriculture

The Group is aware that positions on the impact of biofuels on use of arable land are sharply divided. The Group recognises that introduction of biofuels in Europe could reduce Europe's dependence on fuel imports and could be of interest to some farmers. The Group therefore considers that production of biofuels in Europe could be promoted, provided it does not interfere with food production, use of the fuels does not lead to any increase in greenhouse gas emissions and, worldwide, no new land is cleared for biofuel production (e.g. in the form of deforestation). The development of second-generation biofuels is important. Accordingly, the Group recommends that the infrastructure necessary for these to be produced sustainably should be set up within the European Union. The Group therefore recommends that:

1. planting of crops for biofuel production should not interfere with food production, such as in the case of set-aside or marginal land;

---

[242] One valuable regulatory tool to protect local production and safeguard local methods of production is the "Protected Designation of Origin" (PDO, *appellation d'origine contrôlée*) and "Protected Geographical Indication" (PGI), which protects a specific name and limits use thereof to certain products produced in a restricted area and by a specific method.

[243] See http://www.unece.org/env/water/.

2. steps should be taken to recycle both crops and food waste in the production chain, using the biofuel derived from crop production in order significantly to improve the energy balance of biofuel production[244];
3. research should be funded, at EU and Member State levels, in order to obtain biofuel from waste materials, from non-edible parts of plants or from plant species that do not compete with food production or for resources such as water and land used for growing food;
4. reduction of use of fossil fuels, especially in transport, should be promoted;
5. infrastructure for second-generation biofuels should be promoted, financed and advanced in the European Union.

10.3.4 GM crops

While agricultural scientists are debating the role of GM crops for food security (to increase production yields and the nutritional capacity of food products), the Group acknowledges that use of GM crops is controversial in the EU. In this debate, concerns have been expressed about possible risks of economic monopoly and to biosafety. The Group recognises that EU legislation and international treaties place an obligation on the EU to undertake a scientific risk assessment. The Group urges that the precautionary principle should be taken into account to make sure that all technologies avoid the risk of "serious or irreversible damage", as provided for in Principle 15 of the Rio Declaration on the Environment[245], and also of unwanted pleiotropic effects. The Group recommends that risk management procedures should be revised to take full account of the need for an impact assessment of all new technologies (see section 10.2.4). Food safety and environmental assessment should therefore be prerequisites for approval. In general, the Group takes the view that all agricultural technologies[246] should be sustained in the EU only if they are conducive to the goals of this Opinion and if they meet the ethical criteria indicated in it.

---

[244] Adapted from Turley *et al.* (2008) "Liquid Biofuels – Prospects and Potential Impacts on UK Agriculture, the Farmed Environment, Landscape and Rural Economy", Report prepared for DEFRA, Organics Forestry and Industrial Crops Division.

[245] "In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."

[246] Other technologies which can improve food security include, for example, technologies aimed at improving harvest yields, such as double-crop systems, etc.

10.3.5 Research in agricultural sciences

The Group encourages the EU to increase the budget for research in agricultural sciences, green biotechnologies and all other sustainability-oriented agriculture research sectors within the Seventh EU Framework Programme for research activities (FP7) in order to achieve the goals supported by the Group in this Opinion. At the same time, the Group believes that Europe should ensure the highest standards of knowledge in these fields (including food safety, food technology, nutrition science, etc.), so that it can monitor introduction of these new products for public consumption. Research in these areas should be encouraged both at European and Member State levels for the benefit of European consumers and farmers.

Modern agricultural research should choose an integrated approach; accordingly, the overall aim of agro-system research, including the interaction between different crops and the environment (plant sociology), landscape ecology, etc., should be to achieve an optimum net harvest of solar energy in forms beneficial to mankind and the environment. Specific measures should also be implemented to counter the brain drain of European researchers in this field. The Group specifically recommends that research should be funded:

- on crops that are important for food security and for European farmers in need of public funding, such as for example wheat or Mediterranean horticultural species. The possible impact of climate change should be evaluated and priority should be given to approaches to counteract it;
- on crops that are important in parts of the world where food security has not yet been achieved and on characteristics of interest for increasing the yield of these crops in these areas. The role of local knowledge in these cases should be recognised;
- to preserve the biodiversity of plant species that are important in agriculture and to preserve the environmental equilibrium disturbed by agriculture. In particular, the European Union should support seed banks existing worldwide and in Europe to preserve existing biodiversity;
- to study new energy sources (e.g. biogas and other renewable energy sources) for machinery presently used in agriculture that depends heavily on fossil fuels, which would be more appropriate to the foreseeable scenarios of lower availability of oil.

10.4 Responsible policy-making in arable agriculture

The Group is aware that food security and sustainability are heterogeneous issues which require multiple factors to interact to promote efficient solutions. Unequivocal solutions, including technological ones, are hard to find and need to be scientifically tested, but technological methods could be conducive to sustainable improvements in food security when combined with responsible policy-making and policy implementation. The current food crisis and the delay in progress towards the UN Millennium Development Goals on global hunger highlight the need to promote different agricultural methods more efficiently for food security in the EU and beyond.

The Group recommends that the EU promotes access to appropriate infrastructure and technologies in regions where an increase in food production would contribute to solving the problems of hunger and malnutrition. This has to be done respecting local culture and knowledge. Design, implementation and promotion of an ethically sound policy on primary production of agricultural plant products is a complex process which involves many different players (from policy-makers to consumers and from international bodies to Member States), each sharing rights and responsibilities.

10.4.1 Global trade in agricultural products: fair and free trade and aid for trade

In agriculture, not only technologies have strong ethical implications but also trade and the framework for trade. The European Union accounts for 60% of official development assistance worldwide[247] and yet food security cannot be guaranteed for about one billion people. The Group supports the key role which the EU is playing in promoting global aid for food security across the EU and worldwide. The Group supports the G20 decision to find a constructive agreement to bring the WTO Doha Round to a successful, rapid and pro-development conclusion. The Group is also aware that, to date, the EU has been a world player in agricultural trade, both as an importer and exporter of agricultural products, and urges the EU to take the identified priorities of food security, safety and sustainability as ethical principles in its role in the global economy.

To achieve the goals identified, global agricultural trade needs an ethical framework. Solidarity, justice and free and fair trade in agricultural products and technologies are priorities. The Group therefore advocates that the EU promotes a market system that includes aid for trade, fair (protected) trade and free trade[248] and emphasises the importance of aid for technological development as laid down in the UN Millennium Development Goals. To try to achieve these goals, the Group advocates consideration of a new framework for trade in agricultural products and urges policy-makers, relevant stakeholders and the international community to take into account the ethical principles and human rights laid down in the EU and UN declarations, and to follow the EGE in setting the priorities of food security, safety and sustainability as ethical goals for the global agricultural market.
In accordance with the principle of justice, as indicated in section 9.12, the Group recommends that the revision of the common agricultural policy, including subsidies, should take into account the effects of European policies on (a) trade with Europe and (b) local agricultural production in countries lacking sufficient production and access to food. In this way the EU could play an important role in promoting fair trade.

The Group not only considers that sanitary and phytosanitary standards for imported agricultural products should match those required by the EU regulatory framework but also proposes that the measures provided for in the CAP, such as respect for consumers' choices, animal welfare, biodiversity and socio-environmental protection, should also be taken as the basis for imports of agricultural goods into the EU. This should be progressively implemented at multilateral or bilateral level.

10.4.2 Intellectual property rights system

The Group supports promotion of innovation in agriculture but is concerned about the impact of patents on agricultural crops. The move to control use of seed by means of licence agreements is also troubling. The EGE recommends that the EU carries out an analysis of the

---

[247] In June 2008 the European Council reaffirmed that the EU will deliver on the collective target of 0.56% of gross national income by 2010 and of 0.7% in 2015.
[248] Fair and free trade is a market-based approach in which producers from developing countries are empowered and sustainability is promoted, while movement of goods and provision of services are unhindered by government-imposed restrictions.

shifting of plant variety protection from the UPOV scheme to a patent system and whether it produces a system that effectively stifles innovation.

The Group is also aware that patents are associated (primarily) with new technologies and that their take-up may therefore be hindered by the high cost, particularly in developing countries. In accordance with Article 16 of Directive 98/44/EC of the European Parliament and of the Council, the consequences of patents in agriculture (products and technologies) for the developing countries should be taken into account. In order to disseminate useful new developments in this field, patent pools should be considered to ensure availability to farmers in developing countries.

In the short term the Group recommends that farmers' rights to keep seeds and use them in following seasons, when this is possible, should be maintained taking into account Article 9 of the International Treaty on Plant Genetics Resources[249].

10.4.3 Fair competition and "vertical monopolies"

The Group calls for examination of the European and international mechanisms on fair competition by private companies in the agricultural products sector to ensure that the impact of agreements on the sharing of patents and vertical control is properly addressed.

In particular, the Group calls for examination of the concentration of industries in the seed, grain transport and food distribution businesses on specific food products and of their prices that reach consumers. Action should be taken against *de facto* "vertical monopolies" in which a company has control over production, processing and distribution of certain products.

Furthermore, it is not clear whether free and fair competition within Europe or internationally is still guaranteed, as indicated in section 9.15. The EGE therefore calls for monitoring of the agricultural segment and encourages evaluation of the effectiveness of the current regulations with respect to the above-mentioned monopolies.

[249] http://www.planttreaty.org/ .

10.4.4 Food prices

As a result of the volatility of food prices, access to basic food products has become difficult for millions of citizens in the EU and worldwide. In fact, the volatility and the imbalance of food prices have resulted in social and political instability across the world. The Group therefore asks the Commission:

1. to collect data on determinants affecting food price fluctuations (from production to marketing and on the impact of transport and distribution costs);
2. to use transparent financial mechanisms to stabilise food prices (both increases and decreases) and conceive measures to reduce prices whenever a radical increase occurs;
3. to study the interrelation between food security and sustainability in financial market governance, particularly whether financial speculation has affected the current food price fluctuations. If so, the Commission should consider what action needs be taken to promote transparency and the stability and sustainability of the market and currencies in order to achieve the Millennium Development Goals better (e.g. a financial transaction tax).

10.5 Societal aspects

Agriculture is one of the main policy sectors in the EU and plays a strong role in terms of economics, labour and social goods[250]. The policy design for this sector needs to be consistent with societal needs, goods and expectations. Differences in food products and dietary habits typify European (and global) diversity and reflect consumer demand and different methods of production. Consumers' needs and choice are therefore of central relevance to promoting and designing agricultural technologies. Since the EU common agricultural policy (CAP) strengthened the consumer-oriented approach, the Group calls for active participation by civil society, farmers and other stakeholders in designing EU policy and decisions on trade in agricultural commodities at European and international levels. The

[250] The agro-food sector accounts for around 7% of the total EU economy, involves around 5% of the EU population and generates 20% of average EU household consumer expenditure and a large proportion of the EU's internal trade and exports.

Group also urges that public health and safety considerations (both for EU citizens, farmers and workers involved in the food production and distribution system) should be duly monitored and assessed by the relevant EU bodies, as stated in Article 152 of the Amsterdam Treaty.

The Group also considers that trade in agricultural commodities should be inclusive and transparent (active involvement of consumers), be fair (respect workers' rights and be based on the principle of justice) and respect cultural diversity. Special attention should also be paid to migrant workers' rights, child work (see the International Convention on the Protection of the Rights of All Migrant Workers and Members of Their Families[251] and the UN Convention on the Rights of the Child[252]) and other relevant documents protecting human rights.

10.5.1 Public participation

Given the seriousness of the problems of food security and scarcity of resources, the Group argues that it is ethically important that all stakeholders work together. Broad participation in policies and programmes, including promotion of democratic participation by representatives of civil society in negotiations on global trade in agricultural products (WTO) is required.

The Group calls on Member States to take specific action to increase public participation in policy design for primary production of food of plant origin. This debate should be linked to information campaigns on the consequences of dietary habits for food sustainability (consumption of meat in particular), including (1) preventing waste of food products, (2) promoting healthy lifestyle and (3) raising public awareness of agricultural methods and technologies.

The Group calls for companies involved in production, transport and distribution of food products to strengthen the values highlighted in this Opinion in corporate social responsibility (CSR) policies.

---

[251] International Convention on the Protection of the Rights of All Migrant Workers and Members of Their Families (1990), http://www.un.org/documents/ga/res/45/a45r158.htm

[252] See the UN convention on the rights of the child (1989) http://www2.ohchr.org/english/law/crc.htm

The Group sees the involvement of civil society as offering the possibility to increase consumers' sense of responsibility and, therefore, the chance of influencing the food market in the EU towards a more sustainable system. This effort could involve, for example, ethical education concerning agricultural questions, gardening and cooking in schools, internships and trips to farms along with prevention and recycling of waste.

The Group suggests that solidarity with respect to the lack of basic goods for the "bottom billion" should further guide and play an important role in policies and action. This should be promoted and honoured in public and spotlighted by the media in order to achieve the aim of a global society (see also section 9.1).

10.5.2 Responsibility of EU citizens

Dietary habits affect the sustainability of agriculture. For instance, according to a recent FAO study[253], the high consumption of meat products affects primary agricultural production, use of land, water and environmental pollution. In this context, education of consumers on public health (healthy dietary habits), food quality, agricultural sustainability (e.g. imports of non-seasonal food, food waste, etc., as described in section 4.7) would be beneficial and make a major contribution to food security and sustainability. The Group therefore underlines the specific responsibilities consumers have for orienting the market.

10.5.3 Food waste

The concept of food waste concerns different levels (production, storage, transport, distribution and consumption) and has strong ethical implications for social and distributive justice. As indicated in section 4.8 of this Opinion, it seems probable that the phenomenon of food waste has taken on very high proportions, The Group is aware that waste is a key issue in the context of food security, safety and sustainability. Appropriate technologies should be developed and applied in modern agriculture to reduce and/or recycle food waste. The EGE

[253] http://www.fao.org/newsroom/en/news/2006/1000448/index.html and ftp://ftp.fao.org/docrep/fao/010/A0701E/A0701E00.pdf.

also proposes quantitative and qualitative analysis of waste dynamics at national and supranational levels, along with research into optimisation of waste recycling.

11 Concluding remarks

In this Opinion the EGE has addressed key ethical issues regarding modern developments in agricultural technologies that are evident at present or can be foreseen at this moment in time.

In order to answer the request by President Barroso, the EGE has developed an ethical framework. The Group is aware that there are specific issues in this field that could need further and more detailed discussion.

The EGE fully supports the 2008 FAO *World Food Security Summit Declaration*[254] and calls on the EU and citizens to ensure a sound design for sustainable and responsible agricultural policies.

[254] See Annex I to this Opinion.

ANNEX I: 2008 FAO WORLD FOOD SECURITY SUMMIT DECLARATION

DECLARATION OF THE HIGH-LEVEL CONFERENCE ON WORLD FOOD SECURITY: THE CHALLENGES OF CLIMATE CHANGE AND BIOENERGY

WE, the Heads of State and Government, Ministers and Representatives of 181 countries and the European Community, have met in Rome at this High-Level Conference convened by the Food and Agriculture Organization of the United Nations, together with the United Nations World Food Programme, the International Fund for Agricultural Development and Bioversity International on behalf of the CGIAR system, to seek ways of achieving world food security and, in this context, to address challenges of higher food prices, climate change and bioenergy.

1 We reaffirm the conclusions of the World Food Summit in 1996, which adopted the Rome Declaration on World Food Security and the World Food Summit Plan of Action, and the objective, confirmed by the World Food Summit: five years later, of achieving food security for all through an ongoing effort to eradicate hunger in all countries, with an immediate view to reducing by half the number of undernourished people by no later than 2015, as well as our commitment to achieving the Millennium Development Goals (MDGs).We reiterate that food should not be used as an instrument for political and economic pressure. We also recall the Voluntary Guidelines to Support the Progressive Realization of the Right to Adequate Food in the Context of National Food Security. We reiterate that it is unacceptable that 862 million people are still undernourished in the world today.

2 We are here to address the challenges of bioenergy and climate change, and the current situation of soaring food prices that is having adverse impacts on food security, particularly in developing countries and countries in transition, all the more because the indications are that food prices will remain high in the years to come.

3 We are convinced that the international community needs to take urgent and coordinated action to combat the negative impacts of soaring food prices on the world's most vulnerable countries and populations. We are further convinced that actions by national governments, with the support of the international community, are required in the short, medium and long term, to meet global and household food security needs. There is therefore an urgent need to help developing countries and countries in transition expand agriculture and food production, and to increase investment in agriculture, agribusiness and rural development, from both public and private sources.

In adopting this Declaration, we pledge to embrace food security as a matter of permanent national policy, renew our commitment to achieving the World Food Summit objectives and the Millennium Development Goals, and commit ourselves to the following measures.

Immediate and Short-Term Measures

1 The global food situation calls for a strong commitment from governments as well as from all other stakeholders. We call upon all donors and the United Nations system to increase their assistance for developing countries, in particular least developed countries and those that are most negatively affected by high food prices. In the immediate future it is essential to proceed along two main lines.

2 The first line of action is to respond urgently to requests for assistance from affected countries.

a) The relevant United Nations agencies should be assured the resources to expand and enhance their food assistance and support safety net programmes to address hunger and malnutrition, when appropriate, through the use of local or regional purchase.

b) The appropriate regional organizations which have emergency food security arrangements should enhance their cooperation with a view to effectively cope with soaring food prices.

c) All efforts by governmental and non-governmental organizations to strengthen immediate humanitarian and development assistance should be synergized with those of the multilateral organizations, and made coherent, to deal with the continuum from urgent to longer term assistance.

d) All national and international efforts should be made to ensure that international emergency food assistance is delivered as quickly and efficiently as possible to populations in distress.

e) To facilitate adjustment to higher food prices, donors and international financial institutions, in accordance with their mandates and in consultation with recipient countries, should provide in a timely manner, balance of payments support and/or budget support to food-importing, low-income countries. Other measures should be considered as necessary to improve the financial situation of the countries in need, including reviewing debt servicing as necessary. We also call on the relevant international institutions to simplify the eligibility procedures of existing financial mechanisms to support agriculture and environment.

6. The second line of action is immediate support for agricultural production and trade.

a) All relevant organizations and cooperating countries should be prepared to assist countries, on their request, to put in place the revised policies and measures to help farmers, particularly small-scale producers, increase production and integrate with local, regional, and international markets. South-south cooperation must be encouraged.

b) Development partners are invited to participate in and contribute to international and regional initiatives on soaring food prices and, in particular, under the FAO initiative launched on 17 December 2007, in support of country-led measures to give farmers in low-income food-deficit and the most affected countries access to appropriate locally adapted seeds, fertilizers, animal feed and other inputs, as well as technical assistance, in order to increase agricultural production.

c) Development partners are called upon to undertake initiatives to moderate unusual fluctuations in the food grain prices. In particular, we call on relevant institutions to assist countries in developing their food stock capacities and consider other measures to strengthen food security risk management for affected countries.

d) Members of WTO reaffirm their commitment to the rapid and successful conclusion of the WTO Doha Development Agenda and reiterate their willingness to reach comprehensive and ambitious results that would be conducive to improving food security in developing countries. Implementing an aid for trade package should be a valuable complement to the Doha Development Agenda to build and improve the trading capacity of the developing countries.

e) We will strive to ensure that food, agricultural trade and overall trade policies are conducive to fostering food security for all. For this purpose we reaffirm the need to minimise the use of restrictive measures that could increase volatility of international prices.

Medium and Long-Term Measures

7. The current crisis has highlighted the fragility of the world's food systems and their vulnerability to shocks. While there is an urgent need to address the consequences of soaring food prices, it is also vital to combine medium- and long-term measures, such as the following:

a) We urge national governments, all financial institutions, donors and the entire international community to fully embrace a people-centred policy framework supportive of the poor in rural, peri-urban and urban areas and people's livelihoods in developing countries, and to increase investment in agriculture.

b) It is essential to address the fundamental question of how to increase the resilience of present food production systems to challenges posed by climate change. In this context, maintaining biodiversity is key to sustaining future production performance. We urge governments to assign appropriate priority to the agriculture, forestry and fisheries sectors, in order to create opportunities to enable the world's smallholder farmers and fishers, including indigenous people, in particular in vulnerable areas, to participate in, and benefit from financial mechanisms and investment flows to support climate change adaptation, mitigation and technology development, transfer and dissemination. We support the establishment of agriculture systems and the sustainable forest management practices that positively contribute to the mitigation of climate change and ecological balance.

c) In addition, we reaffirm the Mauritius Strategy for the sustainable development of small island developing states and call for its implementation in the context of the challenges of climate change and food security.

d) We urge the international community, including the private sector, to decisively step up investment in science and technology for food and agriculture. Increased efforts in international cooperation should be directed to researching, developing, applying, transferring and disseminating improved technologies and policy approaches. We urge member states to establish, in accordance with the Monterrey Consensus, governance and policy environments which will facilitate investment in improved agricultural technologies.

e) We encourage the international community to continue its efforts in liberalizing international trade in agriculture by reducing trade barriers and market distorting policies. Addressing these measures will give farmers, particularly in developing countries, new opportunities to sell their products on world markets and support their efforts to increase productivity and production.

f) It is essential to address the challenges and opportunities posed by biofuels, in view of the world's food security, energy and sustainable development needs. We are convinced that in-depth studies are necessary to ensure that production and use of biofuels is sustainable in accordance with the three pillars of sustainable development and takes into account the need to achieve and maintain global food security. We are further convinced of the desirability of exchanging experiences on biofuels technologies, norms and regulations. We call upon relevant intergovernmental organizations, including FAO, within their mandates and areas of expertise, with the involvement of national governments, partnerships, the private sector, and civil society, to foster a coherent, effective and results-oriented international dialogue on biofuels in the context of food security and sustainable development needs.

Monitoring and Review

1 We request the Food and Agriculture Organization of the United Nations, in close

partnership with WFP and IFAD and other relevant international organizations, including those participating in the High-Level Task Force on the Global Food Crisis and in collaboration with governments, civil society and the private sector, to monitor and analyse world food security in all its dimensions – including those addressed by this Conference – and to develop strategies to improve it.

2 In realizing the contents of the measures above, we stress the importance of the effective and efficient use of the resources of the United Nations system, and other relevant international organizations.

***

We firmly resolve to use all means to alleviate the suffering caused by the current crisis, to stimulate food production and to increase investment in agriculture, to address obstacles to food access and to use the planet's resources sustainably, for present and future generations.

We commit to eliminating hunger and to securing food for all today and tomorrow.

Rome, 5 June 2008

This Declaration was adopted by the High-Level Conference on World Food Security: the Challenges of Climate Change and Bioenergy, on 5 June 2008. On the adoption of the Declaration, statements were made by Argentina, Cuba and Venezuela, which will be included in the Report of the High-Level Conference.

ANNEX II: HISTORY OF WTO NEGOTIATIONS ON AGRICULTURAL COMMODITIES

Doha Round negotiations (DDA)
2003 in Cancún: Talks to forge agreement on the objectives of this round failed, due to a deep North/South divide on agricultural issues. Developing nations gained strength, forming two new negotiating groups – the G20, consisting of middle-income developing countries, and the G90 group of poorer developing countries – and finally rejecting the deal which they viewed as unfavourable.
2004 in Geneva: WTO members agreed a framework for continuing talks. The EU, USA, Japan and Brazil agreed to end all agricultural export subsidies, reduce trade-distorting subsidies and lower tariff barriers. Developing nations consented to reduce tariffs on manufactured goods, reserving the right to protect key industries.
2005 in Hong Kong: The initial objective was to conclude a final agreement at this conference, but too little progress was made by then to do so. Instead, a deal was struck in which rich nations agreed to allow quota- and tariff-free imports from all least developed countries (LDCs) and 2013 was set as the deadline for ending agricultural export subsidies.
2006 in Geneva: Last-ditch talks in July 2006 failed to produce an agreement on reducing farm subsidies and lowering tariffs, prompting WTO chief Pascal Lamy formally to suspend the Doha Round.
2007 in Davos: Trade ministers from around 30 key nations agreed, on 27 January, to restart negotiations.
2008 in Geneva: Trade ministers failed to reach agreement on global trade in agricultural products.

(http://ec.europa.eu/commission_barroso/mandelson/speeches_articles/sppm214_en.htm)

ANNEX III: MOST COMMON GMOS

GM soybean

The first genetically modified (herbicide-resistant) soybeans were planted in the United States in 1996. Ten years later, GM soybeans were planted in nine countries covering approximately 58.6 million hectares. Over half of the world's 2007 soybean crop (64%) was genetically modified, a higher percentage than for any other crop. Every year, the EU Member States import approximately 15 million tonnes of soy material, primarily for use as feed. Soybeans are also used to produce tofu, miso, soy sauce and many food additives. In 2006, 236 million tonnes of soybeans were produced worldwide. The world's leading soybean producers are the United States (37%), Brazil (25%), Argentina (20%) and China (7%). Large-scale, commercial plantations of genetically modified soybeans can also be found in India, Paraguay, Canada, Romania and South Africa.

GM maize and MON810

Bt maize is maize that has been genetically modified to produce an insecticide (the Bt toxin). The transferred gene comes from the soil bacterium *Bacillus thuringiensis* (Bt) and produces a non-toxic protein that, once ingested by certain insects, is converted into a toxic form that kills the pest. Unlike many chemical insecticides, Bt toxin is harmless to humans and is broken down fairly quickly. In organic farming Bt preparations are frequently used to protect plants by spraying them rather than introducing a genetic modification in the plants themselves.

The main Bt maize varieties used around the world are those with resistance to the corn borer. This small grey-brown moth is a major maize pest found in all maize-growing areas in southern and south-eastern European. Since the 1960s the corn borer has been spreading northwards and has now reached the Baltic coast. In regions with high levels of corn borer infestation farmers can avoid using plant protection products to combat the corn borer by introducing the appropriate GM maize variety. Another effect of Bt maize is that it has a lower contamination rate with fungal toxins. Research has shown that Bt maize plants usually contain fewer mycotoxins than conventional maize plants.

Bt maize is cultivated on a large scale mainly in the USA, where in 2007 the area under Bt maize rose to 18.4 million hectares. Bt maize is also grown on an appreciable scale in Canada, Argentina, South Africa and the Philippines. In Europe cultivation of Bt maize has increased steadily in recent years, covering 110 000 hectares in 2007, which equals around 1% of the total area under maize.

ANNEX IV: THE CAUSES OF FOOD PRICE INCREASES

Causes of price fluctuations/increases
Rapidly growing demand in developing countries and emerging market economies[255]. For example, world coarse grain production grew by an average rate of 1.24% a year from 1997 to 2006, but consumption in developing countries grew by 2.37% a year over the same period. High global GDP growth increases consumption (demand for more meat and dairy consumption, which is grain-intensive). Coarse grain consumption for livestock feed increased by 2.54% a year in the developing world, compared with just 0.43% in the developed world.
Crop shortfalls in 2005/2006 due to droughts in some major producer countries (Australia and USA) led to low stocks[256] in 2006/2007. Also, with climate change and changes in weather patterns, some researchers forecast an increase in the variability of crop output and a gradual decline in some regions.
Demand for biofuels is often perceived as a major driving force behind prices. Further substantial increases in demand are projected, however, in the next ten years or so under the existing biofuels mandates, to around 110 million tonnes of maize for US biofuels and 45 million tonnes for the EU. Other countries have also introduced, or plan to introduce, biofuels mandates.
The introduction of export taxes in major exporting countries, especially for rice and wheat, has been a major factor in the rapid escalation of prices[257].
Price volatility on food markets has attracted speculative investors, with commodity and hedge funds becoming leading players.
Agricultural prices have become more linked to energy prices. First, energy price-sensitive products such as fertilisers, pesticides and machinery are key inputs into the production process. Second, the growing importance of biofuels is tending to strengthen the correlation between energy and food prices. This structural link between food and energy markets is likely to continue and to gain strength in future.
The long-term decline of food prices relative to other products over the last couple of decades has caused a shift in investment away from agriculture and into other sectors.

[255] OECD/FAO projections forecast a slowdown in consumption growth, especially in developing countries; that remains uncertain, however.

[256] Although crop production recovered in 2007, this was barely enough to meet the increased demand and left little to replenish stocks. As a result, the stock situation remains precarious for most agricultural commodities with world corn and barley inventories at 20+-year lows and wheat inventories at 31-year lows.

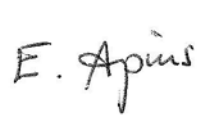
[257] If a significant exporter announces an export tax, it reduces supply on the market and makes the situation more difficult for other market operators and increases their incentive also to introduce an export tax.

17th December 2008

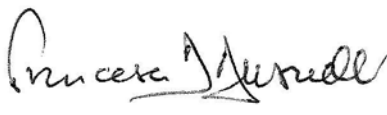
The European Group on Ethics in Science and New Technologies

The Chairperson: Göran Hermerén

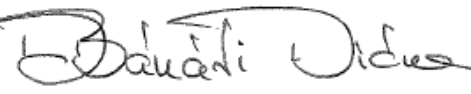
The Members:



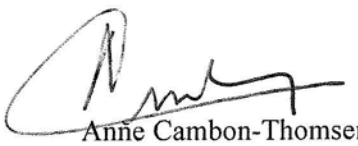
Emmanuel Agius



Francesco Busnelli

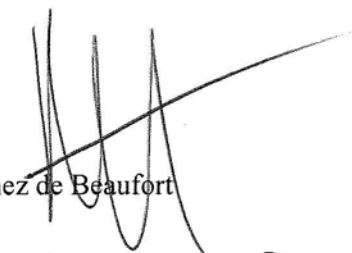


Diana Banati



Anne Cambon-Thomsen

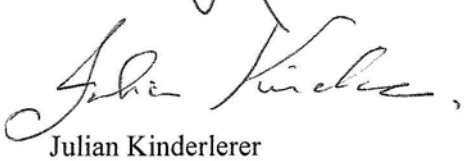
Rafael Capurro



Inez de Beaufort

Jozef Glasa

Hille Haker



Julian Kinderlerer

Krzysztof Marczewski

Paula Martinho Da Silva

Linda Nielsen

Pere Puigdomenech-Rosell

Günter Virt