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Prospects of Agrifood Green Power in 2050 and Forecasting for 2100 with Sustenable Solutions Based on Ecobioeconomics new Paradigm

Alexandru T. BOGDAN[1)], Vioara MIRESAN[2)], Alexandru MIRONOV[1)], S. CHELMU[1)],Viorica BOBOC[1)], I. SURDU[3)], R. BURLACU[4)], Denis DIACONESCU[5)], Amalia STRATEANU[1)]

[1)]Romanian Academy, National Institute for Economical Research (INCE)-Center for Agroforestry Biodiversity Study and Research (CSCBA)- Postdoctoral School for Livesstock Biodiversity and Food Biotechnology, Bucharest, Romania; cscbas@yahoo.com
[2)]University of Agricultural Sciences and Veterinary Medicine, Faculty of Animal Science and Biotechnologies, 3-5 Manastur Street, 400372 Cluj-Napoca, Romania
[3)]Informatical System for Automation (SIAT S.A.) Bucharest, Romania
[4)]University of Agricultural Sciences and Veterinary Medicine, Bucharest, Romania
[5)]GNIR Holding S.A., Bucharest, Romania

Abstract. In developing countries, 80 percent of the necessary production increase would come from increases in yields and cropping intensity and only 20 percent from expansion of arable land. But the fact is that globally the rate of growth in yields of the major cereal crops has been steadily declining, it dropped from 3.2 percent per year in 1960 to 1.5 percent in 2000.

Many countries will continue depending on international trade to ensure their food security. It is estimated that by 2050 developing countries' net imports of cereals will more than double from 135 million metric tonnes in 2008/09 to 300 million in 2050. That is why there is a need to move towards a global trading system that is fair and competitive and that contributes to a dependable market for food. Reform of farm support policies in OECD countries is a welcome step which has led to a decline in the aggregate trade distortion coefficient from 0.96 in 1986 to 0.74 in 2007.

Climate change and increased biofuel production represent major risks for long-term food security. Although countries in the Southern hemisphere are not the main originators of climate change, they may suffer the greatest share of damage in the form of declining yields and greater frequency of extreme weather events. Studies estimate that the aggregate negative impact of climate change on African agricultural output up to 2080-2100 could be between 15 and 30 percent.

Keywords: prospects and forecasting 2050 and 2100**,** Agrifood Green Power in 2050 dynamics food and consumption, Sustenable Solutions for agrifood in 2050 and 2100, New Paradigm for 2050 and 2100: Ecobioeconomics**,** bioeconomy, ecoeconomy, food security, social economy.

INTRODUCTION

This perspective for 2050 raises a number of important questions. Are current public and private investments sufficient to ensure adequate agricultural production potential, sustainable use of natural resources, infrastructure for markets, information and communication and research for technological breakthroughs for the future? Will resources, new technologies and supporting services be available to the people who will need them most - the poor? What needs to be undertaken to help agriculture meet the challenges of climate change and growing energy scarcity?

To consider these and associated questions, FAO convened a three-day Meeting of Experts in Rome in June 2009. The Declaration of the World Summit on Food Security

(Rome, November 2009) highlights the promotion of "new investment to increase sustainable agricultural production and productivity, support increased production and productivity of agriculture", and implementation of "sustainable practices improved resource use, protection of the environment, conservation of the natural resource base and enhanced use of ecosystem services". The Declaration further commits to address the sustainable use of land and water maintaining the health and productivity of all ecosystems and better management of the biodiversity associated with food and agriculture.

The ecosystem approach is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. Application of the ecosystem approach focuses on essential processes and functions, and the interactions among organisms and their environment. It recognizes that humans, with their cultural diversity, are an integral component of ecosystems.

The 36th FAO Conference (2009) adopted a new strategic framework: sustainable intensification of crop production, through the ecosystem approach and identifying the characteristics of an appropriate enabling environment to support and reinforce initiatives taken, such as adequate policies, legislation, institutional support, economic development, availability of best knowledge and identifies some of the opportunities to improve efficiency in resource use through managing biological processes.

The estimated necessary amount of protein feed for alimentation is approximately 500 million tons per year while global production of feed protein of vegetal origin is situated under 75 million tons per year. A solution for balancing this deficit between demand and availability is resorting to semi-conventional and non-conventional sources of protein such as soya extracts, fish flour, bacteria proteins, yeast and mould (A.T. Bogdan, Gh. Mencinicopschi, Simona Ivana Gh. Campeanu). The free circulation of safe and healthy alimentary products constitutes an essential aspect of the UE common market, contributing considerably to the health and welfare of citizen as well as serving their economic and social interests (A.T. Bogdan, Gh. Mencinicopschi, Simona Ivana Gh. Campeanu). On both global and national levels, there are ongoing biotechnological research programs aimed towards obtaining nitrogen plants, other than leguminous plants and biocide producing crop plants as well as forest species capable of offering rapid production of quality wooden mass, highly regenerative or capable of forestation of extreme alpine or highly damaged areas (A.T. Bogdan, Gh. Mencinicopschi, Simona Ivana Gh. Campeanu).

DOCUMENTATION SOURCES AND INNOVATIVE CONCEPTS

Food Security towards 2050 and Forecasting for 2100

In the following, the key elements of current expert thinking regarding the outlook for food security towards 2050 will be summarized. The key message from this assessment is that it will be possible to achieve food security for a world population of 9.1 billion people projected for that time, provided a number of well specified conditions are met through appropriate policies. The main socio-economic factors that drive increasing food demand are population growth, increasing urbanization and rising incomes. As regards the first two, population growth and urbanization, there is little uncertainty about the magnitude, nature and regional pattern of their future development.

According to the latest revision, the world population is projected to grow by 34% from 6.8 billion today to 9.1 billion in 2050. Compared to the preceding 50 years, population growth rates will slow down considerably. The AT2010 study is based on the UN (1990) population projections for individual countries. In this study the updated population projection

from FAO is used, which is slightly adapted from the UN (1994) population projection for 1990-2050 (Appendix 2). For the period 2050-2100 the growth rates used by Alcamo *et al.* (1994), which were originally produced for the IPCC IS92 scenarios by Pepper *et al.* (1992), were taken. Nearly all of this increase in population will take place in the part of the world comprising today's developing countries. The greatest relative increase, 120%, is expected in today's least developed countries (Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, 2007).

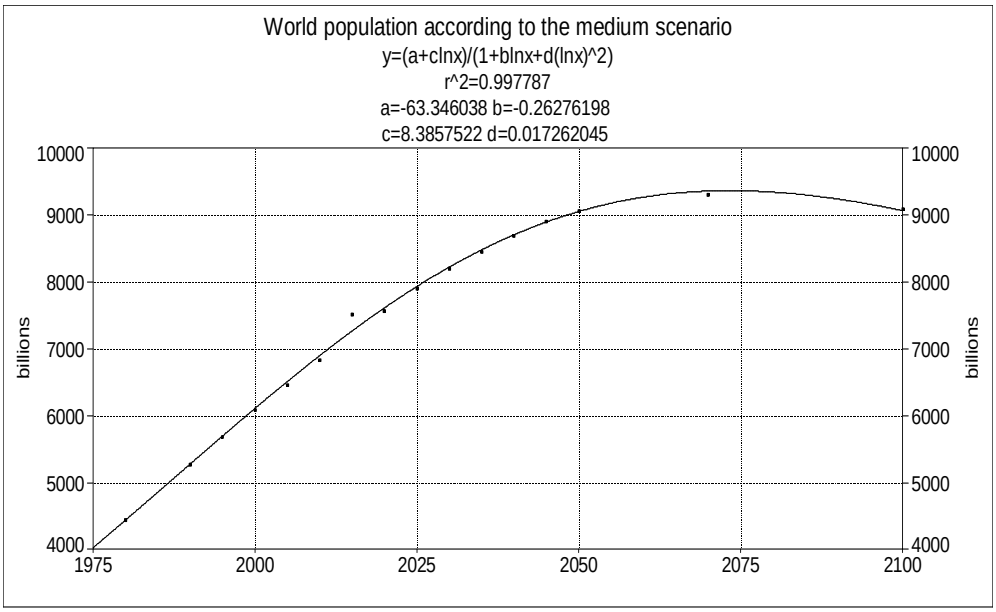


Fig. 1. Population development between 1975 and 2100
(correlation calculate by our working group, using data base on UN, 2007. World Population Prospects)

As might be expected, given the range of projections in drivers to 2050, there are several sets of projections of future livestock product demand in response to increases in population, urbanization and income. In terms of fertility, the *medium scenario* assumes that the total fertility of each country will reach below replacement levels and remain at those levels for about 100 years, after which it will return to replacement level and remain there until 2300. The main findings yielded by a *medium scenario* are summarized below:

World population rises from 6.1 billion persons in 2000 to a maximum of 9.2 billion persons in 2075 and declines thereafter to reach 8.3 billion in 2175. The return to replacement level fertility coupled with increasing longevity in the medium scenario produces a steadily increasing population after 2175 that reaches 9 billion by 2300. If the effects of increasing longevity are counterbalanced by fertility, population size remains constant at 8.3 billion from 2175 to 2300 as in the zero-growth scenario. Most of the expected population increase between 2000 and 2300 occurs in the less developed regions, whose population rises form 4.9 billion in 2000 to 7.7 billion in 2300. Although the population of more developed regions also increases, the change is considerably less (from 1.2 billion in 2000 to 1.3 billion in 2300). China, India and the United States are and will continue to be the most populous countries of the world until 2300. By 2050, India is expected to have surpassed China in population size and will remain as the most populous country in the world thereafter. However, between 2000 and 2100, the three most populous countries are expected to account for a declining share of the world population, passing from 43% in 2000 to 34% in 2100. Their share is then expected

to rise slightly and remain at about 35% until 2300. The number of countries accounting for 75% of the world population is expected to increase from 24 in 2000 to 29 in 2100 and to remain unchanged thereafter. This relative stability in terms of total population belies the major changes projected in terms of the contribution of different countries to population increase or decrease. In the medium scenario, the annual change of world population is projected to decrease steadily from 77 million in 2003 to -14 million in 2010-2015 and then to rise steadily until it becomes positive again in 2175-2180. Consequently, whereas in 2000 the majority of the countries of the world have an increasing population, by 2100 the majority will have a decreasing population according to the medium scenario. Concomitantly, China and India alone are projected to account for nearly 48% of the population losses projected to occur in 2100. Net population losses are still projected to occur in some countries around 2200 but by 2300, all countries will be experiencing population increases in the medium scenario.

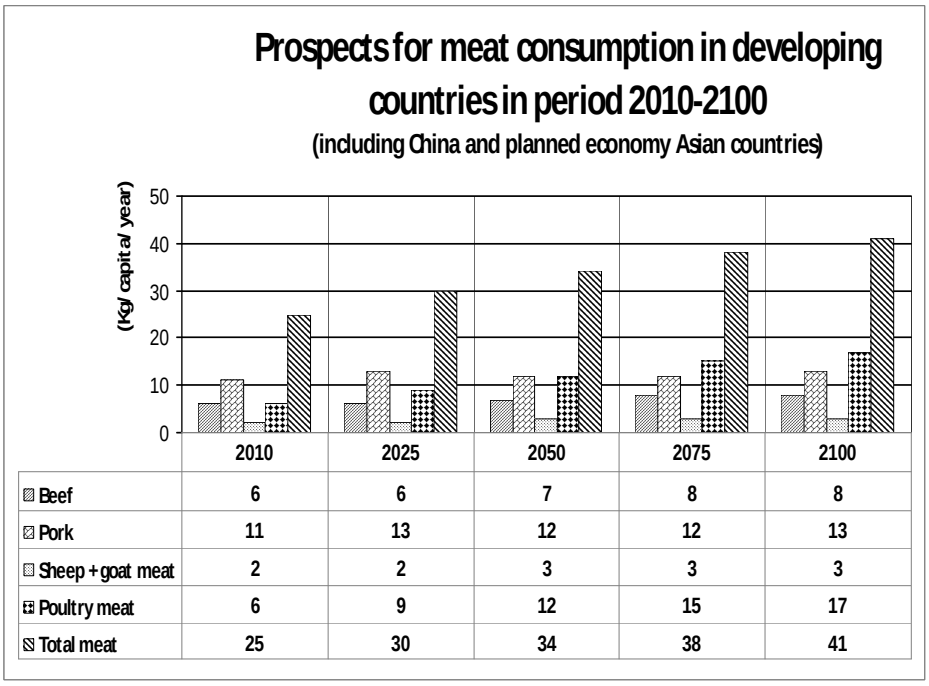
So far, analysts believe that the ***longer-term effects*** of the financial and economic crisis on economic growth will be relatively small. Most projections of demand and supply towards 2050 use the World Bank's baseline projections of economic growth. The latest version (submitted to the FAO Expert Meeting in June 2009) implies an average annual rate of GDP growth of 2.9% during the period between 2005 and 2050, breaking out into 1.6% for high-income countries and 5.2% for the developing countries. Over the 45 year period, the rates are expected to decline everywhere to half their initial levels. A key consequence of this differential growth would be a major increase in developing countries'share in global output from 20 to 55%. As a result, the relative income gap (ratio of per capita GDP) between the two country groups will be narrowing, although absolute differences would remain pronounced and even increase further, given the current very large gap in absolute per capita incomes. Moreover, inter-country and interregional inequalities within the present-day developing world would tend to become more pronounced (Mensbrugghe *et al.*, 2009).

In comparison to the past 50 years, the rate at which pressures are building up on natural resources – land, water, biodiversity – will be somewhat tempered during the coming 50 years due to the slowdown of demand growth for food and feed. However, an expanded use of agricultural feedstock for biofuels and ongoing environment degradation would work in the opposite direction. Even if total demand for food and feed may indeed grow more slowly, just satisfying the expected food and feed demand will ***require a substantial increase of global food production*** of 70 percent by 2050, involving an additional quantity of nearly 1 billion tones of cereals and 200 million tons of meat.

Increased investment, ***effective regulation and incentives are needed with regard to all three natural resources*** required for sustainable and stable production growth: land, water, biodiversity. The aim should be to stop over-exploitation, degradation and pollution, promote efficiency gains and expand overall capacities as appropriate. Adequate regulation and incentives are also needed to provide the rural population engaging in ecosystem services with win-win solutions to improve the sustainability of ecosystems, mitigate climate change and improve rural incomes. Based on the projected growth of population and incomes and expected changes in consumption patterns, the FAO estimates future consumption levels for various commodities country by country.

According to ***FAO's baseline projections***, it should be possible to meet the future food and feed demand of the projected world population in 2050 within realistic rates for land and water use expansion and yield development. However, achieving this will not at all be automatic and several significant challenges will have to be met.

The ***global average daily calorie availability*** would rise to 3050 kcal per person, a 10 percent increase over its level in 2003/05. To achieve this, global cereal production would need to increase by 40% overall, or by some 900 million tons between the 2006/08 average and 2050. The advent of biofuels has the potential of changing all that and causing world demand to be higher, depending on the energy prices and government policies. Without biofuels, much of the increase in cereals demand will be for animal feed to support the growing consumption of livestock products. Meat consumption per capita for example would rise from 41 kg at present to 52 kg in 2050 (from 30 to 44 kg in the developing countries).



	2010	2025	2050	2075	2100
Beef	6	6	7	8	8
Pork	11	13	12	12	13
Sheep + goat meat	2	2	3	3	3
Poultry meat	6	9	12	15	17
Total meat	25	30	34	38	41

Fig. 2. Prospects for meat consumption (kg/capita/year) in developing countries in period 2010–2100 (correlation calculate by our working group, using data base on *The State of Food Insecurity in the World 2004*)

Should this perspective be realized by 2050, the level of per-capita ***food availability will still vary widely between countries,*** although at higher levels. Industrial countries will have average availability levels of nearly 3600 kcal/person/day; the developing countries as a group may reach almost 3000 kcal.

Promoting technology change and productivity growth

World agriculture has been able to meet the rapidly growing global demand for food, feed and fibre over the last half century at real agricultural prices that were falling for much of the time, at least until the mid-80s. This was only possible due to sizeable ***agricultural productivity growth***. However, in recent years, yield growth rates have slowed down notably in many countries and for major commodities. In particular, the growth rates of cereal yields have been falling since the Green Revolution years. It dropped from 3.2% per year in 1960 to 1.5% in 2000.

Numerous studies have shown that investment in ***agricultural research and development (R&D) can generate extraordinary high rates of return***. Nevertheless, under-investment in agricultural R&D in many developing countries has continued. Total global investment in agricultural R&D totaled USD 41 billion in the year 2000. The public sector

accounted for 59% and the private sector 41%. Most private sector research was carried out in developed countries and tended to be focused on the requirements of commercial farmers in well-developed regions. Public sector R&D still dominates in developing countries and is more focused on basic research and the improvement of staple food and minor crops. Public investments in agricultural R&D worldwide grew from USD 16 billion in 1981 to USD 23 billion in 2000. There were large differences between and within regions: While public investments in the Asia-Pacific (driven by China and India) region more than doubled over this period, investments sub-Saharan Africa only grew at an annual average of 0.6% from 1981 to 2000 and actually fell during the 1990s. Agricultural R&D investments are increasingly concentrated in a few leading countries in each region.

Crop yields and animal production

The regional production can be achieved in different ways. For the crop groups temperate cereals, rice, maize, sorghum/millet, pulses, sugar, and starchy foods three scenarios were developed for both irrigated and rainfed production. These scenarios consist of different projections of irrigated areas, and irrigated and rainfed yields. For the oil crops and other crop groups scenarios were made, reflecting the mean change in yields assumed for the other crop commodity groups. Similarly, three production scenarios were develoed for beef, pork, mutton, poultry and meat from goats, as well as for milk and eggs. For meat production the scenarios consist of projections for the offtake rates and carcass weights. For milk and egg production scenarios were made for the yearly yield per animal.

In general, the medium scenario forms a continuation after 2010 of the AT2010 trend. In the low or pessimistic variant of the medium scenario the expected research breakthroughs will not occur and even the current maximum levels may not be reached as a consequence of, for instance, increased incidence of pests and diseases.

Cropping intensity and arable land

In the periods after 2010 the intensity was assumed to decrease by a factor of 2 in every consecutive period. Hence in 2010-2025 the annual increase is half that in the period 1990-2010, and in 2025-2050 it is half that in the years 2010-2025. The medium scenario is a continuation of AT2010, and the increase rate of the high scenario is 1.25 x that of the medium scenario, while in the low scenario the annual increase is only 0.75 x that in the medium scenario.

The regional total harvested area and the cropping intensity determine the arable land area. The maximum arable area is given in the land balances (Alexandratos, 1995).

Projections of global temperature rise

The two variants considered in the ADAM Project lead to global warming of 2° and 4°C in 2100, compared to the pre-industrial levels (i.e., 1.5° and 3.5°C warming relative to 1980-1999 mean, respectively) .

According to the IPCC (2007a), the likely range of global mean temperature for 2100 without climate policy is from 1.1 to 6.4°C . The IPCC range reflects uncertainty in both climate sensivity and emission trends. If climate sensitivity were not accounted for, the range would be far more confined (around 2.5-4.5^{o}C). This implies that the ADAM baseline is consistent with the IPCC range for non intervention scenarios. Best values of warming for 2090-2099 (relative to 1980-1999) for all SRES marker scenarios span the range from 1.8 to 4.0°C. This implies that the ADAM baseline (of no mitigation) is close to the best-guess value for A1FI (4°C) and somewhat above A2 (3.4°C). It should be noted that for A1FI there is a

chance of 5 to 17% that temperatures will go up by more than 6.4°C by 2100. Some analysts argue that it is important to examine such (high-impact low-probability) extremes better even if the likelihood of their occurrence is not high (Schneider, 2009).

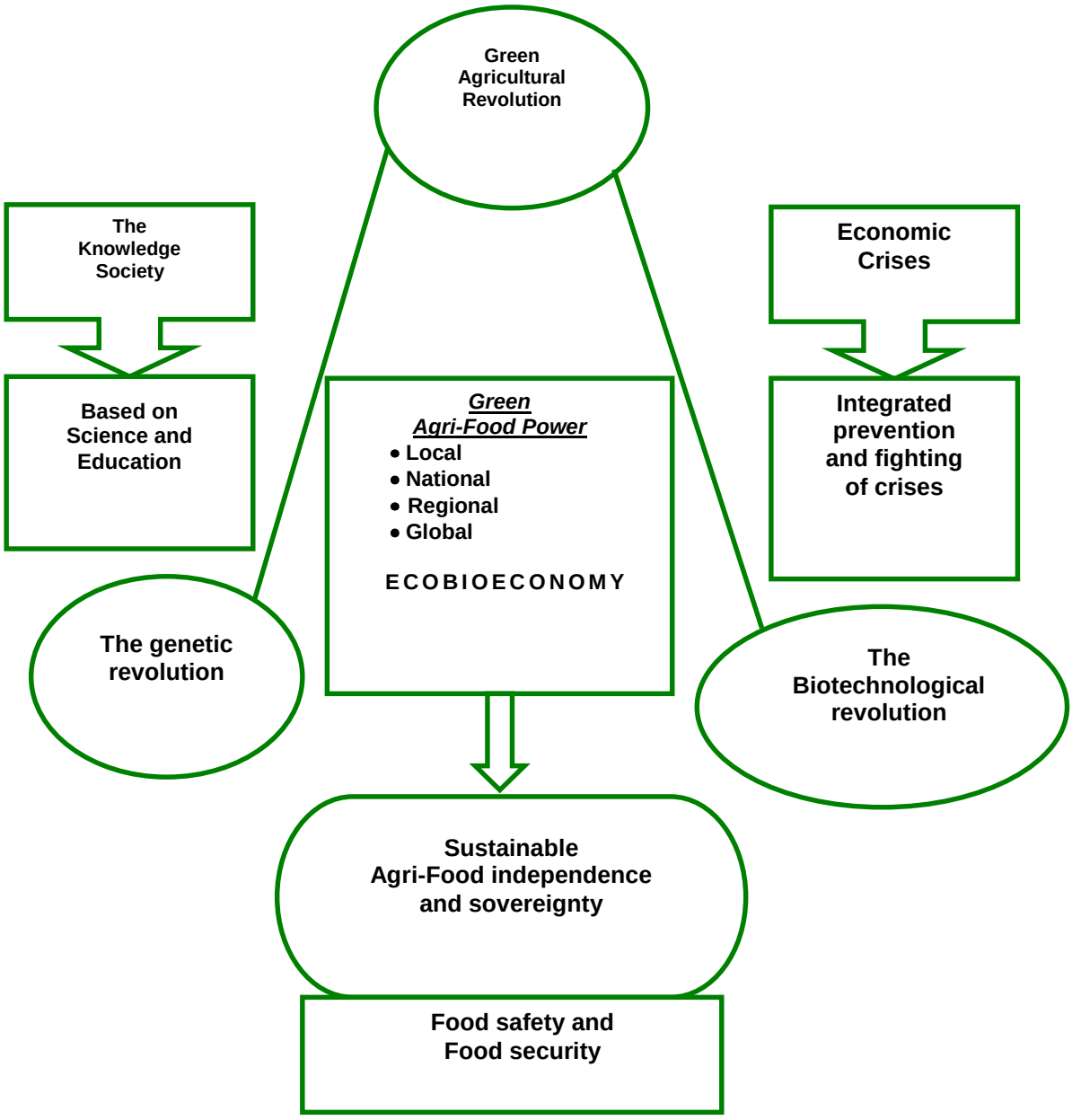


Fig. 3. Complex relations between Green Agriculture revolution, The Knowledge Society, and Economic Crises and: *Green Agri-Food Power; Sustainable Agri-Food independence and sovereignty; Food safety and Food security*, based on ECOBIOECONOMY (orig.)

Food security outcomes

By 2015, and even more by 2030, the key variable we use to track developments in food security -per capita food consumption as defined above- will have grown significantly. The world average will be approaching 3000 kcal/person/day in 2015, will be just over 3000 by 2030 and higher in 2050 (6). These changes in world averages will reflect above all the rising consumption of the developing countries, whose average will have risen from the

present 2650 kcal to over 3000 kcal in 2050. More and more people will be living in countries with medium to high levels of per capita food consumption. For example, by 2050 some 90% of the increased population of the developing countries will be living in countries with values of this variable exceeding 2700 kcal/person/day, up from 51% at present and the only 4% three decades ago. Indeed, some 5 billion could be in countries exceeding 3000 kcal (6).

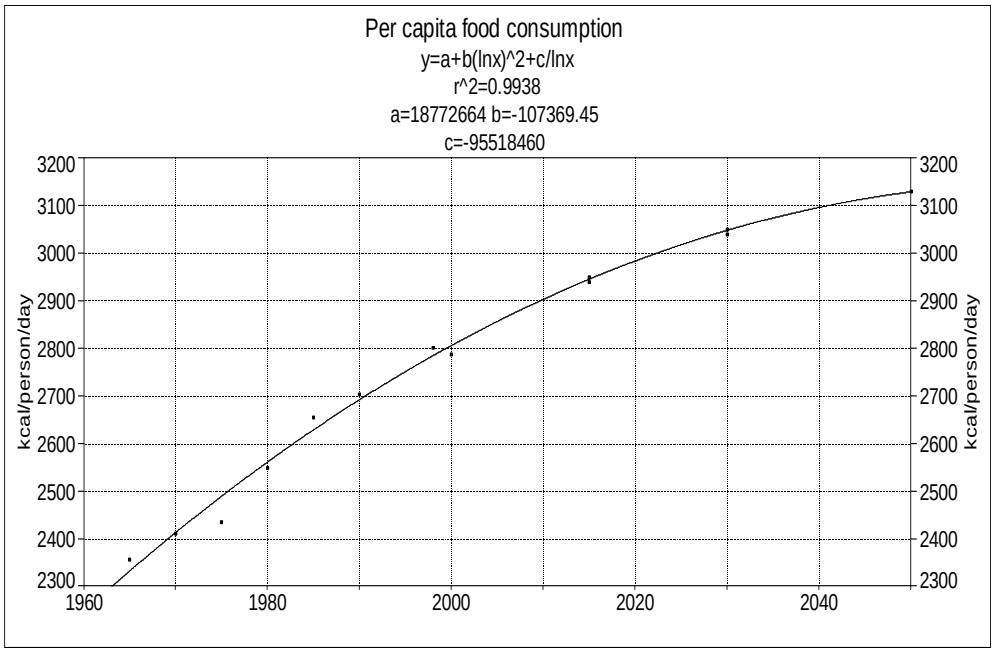


Fig. 4. Regression curve to describe the evolution of global food consumption until 2050 (correlation calculate by our working group, using data base on *Human Energy Requirements*, Report 2006)

Structural changes in the commodity composition of food consumption

The growth in per capita food consumption was accompanied by significant change in the commoditycomposition, at least in the countries that experienced such growth. Much of the structural change in the diets of the developing countries concerned the rapid increases of

livestock products (meat, milk, eggs), vegetable oils and, to a smaller extent, sugar, as sources of food calories.These three food groups together now provide 29% of total food consumption of the developing countries (in terms of calories), up from 20% three decades ago. Their share is projected to rise further to 35% in 2030 and to 37% in 2050 (in the industrial countries the share has been around 48% for several decades now) (3). However, structural change was not universal and wide inter-country diversity remains in the share of different commodity groups in total food consumption.

Cereals continue to be by far the most important source of total food consumption in the developing countries (their direct food consumption provides 54% of total calories) and the world as a whole (50%). There is, however, very wide inter-country diversity: direct food consumption of cereals provides only 15-30% of total calories in several countries ranging from those with diets based predominantly on roots and tubers to several high income countries with predominantly livestock-based diets (these latter countries consume, of course, large quantities of cereals indirectly in the form of animal feed for the production of the livestock products they consume as food). Concerning the future, the downward pressure from developments in China and India on the averages of the world and the developing countries will be attenuated and on balance the declines in these averages observed in the last few years may be halted at least in the first sub-period of the projections to 2030 before

resuming a slow pace of decline in the two subsequent decades. This likely development will be the net effect of the contrasting trends of, on the one hand, diet diversification away from the direct consumption of cereals in those countries attaining medium-high levels of food consumption, and on the other hand, increases in per capita consumption in those countries remaining at low levels of food consumption and/or diversifying towards cereals and away from other staples, e.g. roots and tubers.

The share of cereals in total calories will continue to decline, but very slowly, falling for the developing countries from 54% at present to 49% in 2030 and to 46% in 2050. Naturally, the per capita consumption of cereals for all uses (including food, feed and other nonfood uses, e.g. for seed and the production of ethanol or starch) should keep growing again after the reversal of the sharp declines of the 1990s in the feed sector of the transition economies (5).

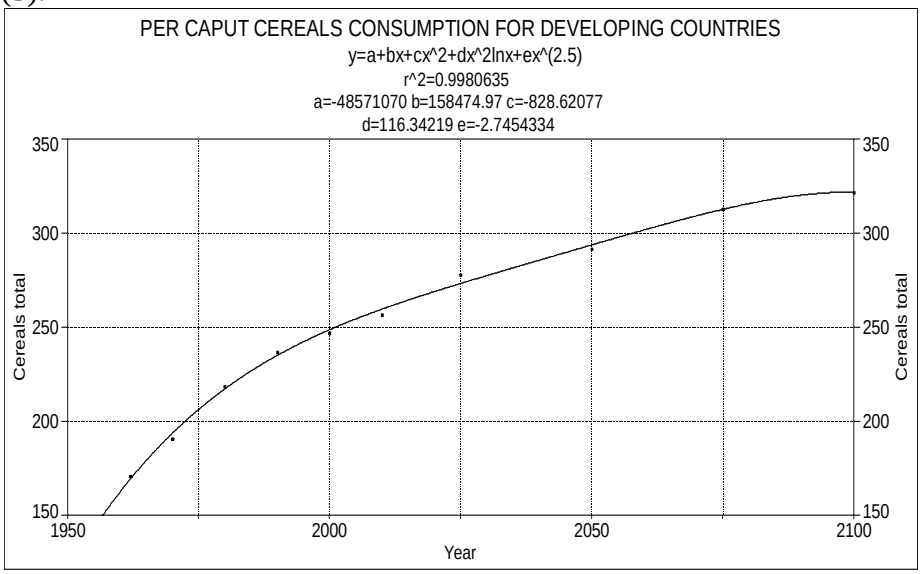
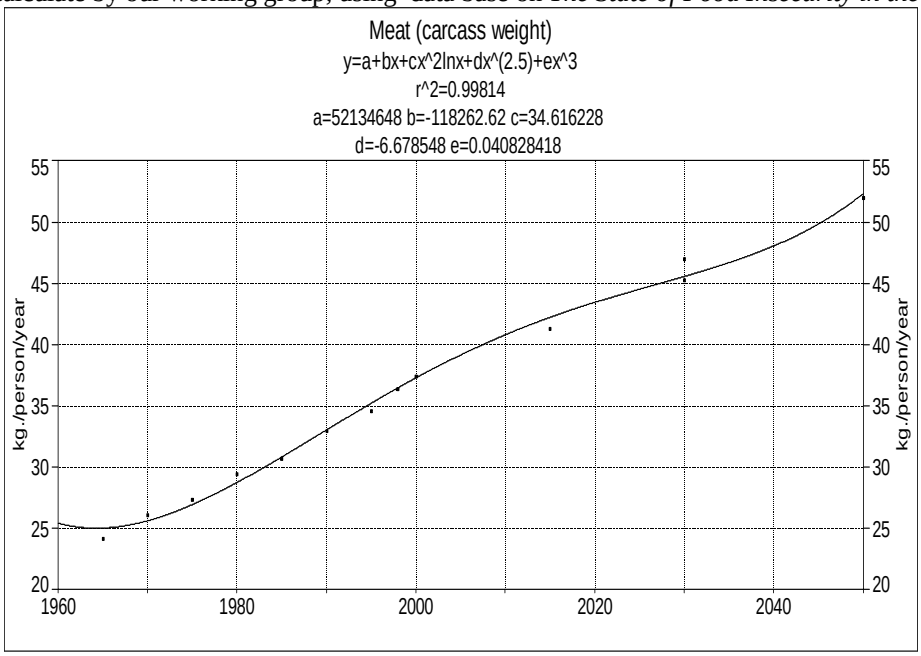


Fig. 5. Regression curve to describe the dynamic of cereals food consumption for developing cauntries (correlation calculate by our working group, using data base on *The State of Food Insecurity in the World 2004*)



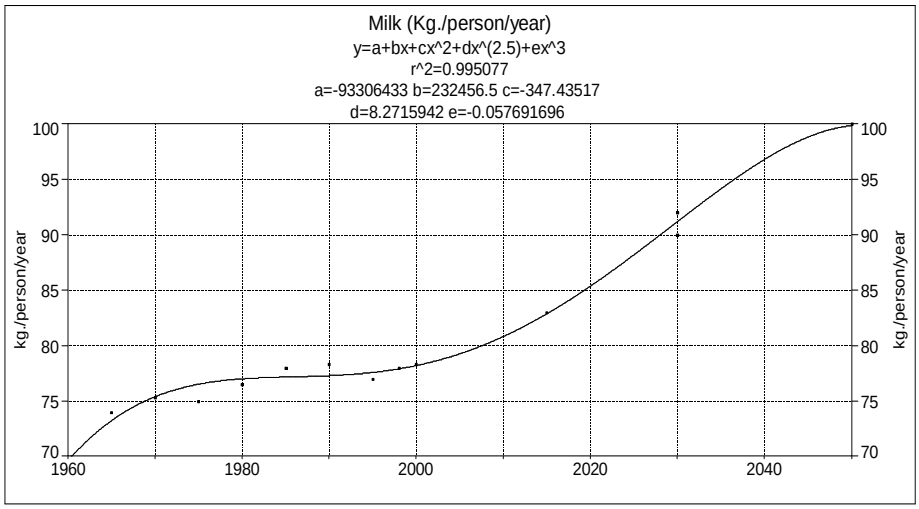


Fig. 6. Regression curve to describe the evolution of meat carcass weights and milk consumption until 2050 (correlation calculate by our working group, using data base on *Human Energy Requirements*, Report 2006)

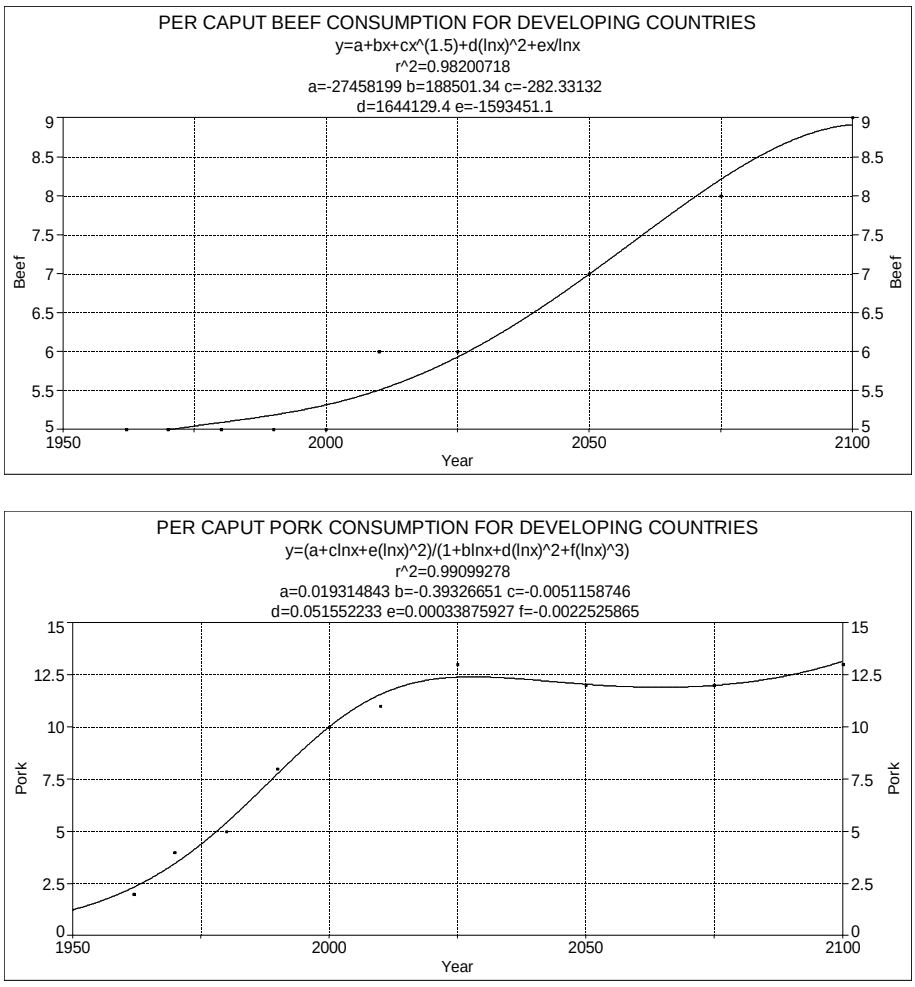


Fig. 7. Regression curve to describe the dynamic of beef and pork consumption for developing cauntries (correlation calculate by our working group, using data base on *The State of Food Insecurity in the World, 2004*)

Estimates of undernourishment in the future

The implications of the changes indicated above for undernourishment in the future are unfolded SOFI08 indicated that the numbers undernourished in the developing countries increased from 90/92-2003/05, although the percent of the population affected declined. We saw above that the same applies to changes in the period 99/01-2003/05. However, we noted that revisions in the data of kcal/person/day alone would have produced a small decline, not an increase. It is the application of the whole package of data and parameter revisions that generates a small increase. Should we take this as indicating that the problem is getting worse rather than improving towards the WFS target of halving absolute numbers by 2015 (from those in 90/92)? We can only note that the increase in the estimate of the absolute numbers is small and may well not be significant, given the data noise.

Comparing the new projected numbers of undernourished in Tab.3 with those in Tab. 2.3 of the IR, it is evident that projected undernourishment is now higher, both in absolute numbers and as percent of the population. The impact is reinforced for the absolute numbers because now the projected population of the developing countries (from UN 06, shown in Tab.5) is higher. The revised projections indicate a slow decline in undernourishment. However, in the IR the rate of decline was such that the achievement of the WFS could be within reach shortly after 2030. In the revised estimates, the achievement of the target is shifting further into the future –to just before 2050.

The present paper connects Nicolas Georgescu-Roeger's world-wide-known paradigm of improving the agricultural efficiency to Lester Brown's more recent Eco-Economy – Building an Economy fo the Earth paradigm.

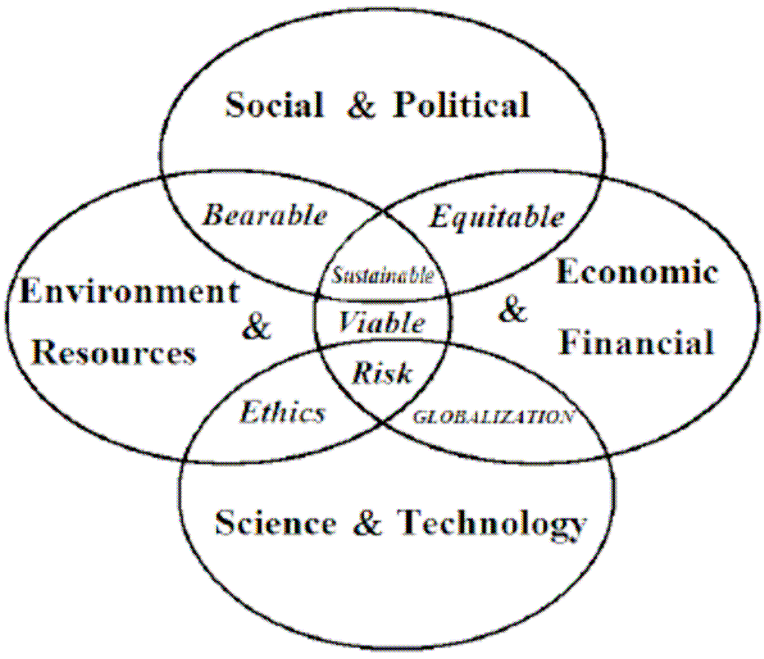


Fig. 8. Modification of Lester Brown`s diagram for eco-economics paradigm, considering globalization and economic-financial crisis,
with Sustenable Solutions Based on Ecobioeconomics new Paradigm
(modification by our working group)

The relations between humans and the animals they use as food have changed in time. At first, man was a hunter. Now hunting is a sport. Afterwards, he became a preserver, keeping only the wounded or young animals for food. Now keeping is a matter for the Zoogardens. Later on, humans started to reproduce animals and became breeders. Now they are breeders of many animal species. Today some breeders, especially as far as poultry and pigs are concerned, have become producers. Now people speak about poultry and pig industries. This development has been determined by the increase in the human population in one part of the globe or another. Over the last century a human demographic explosion has taken place. So, the requirements for food, for commodities and for other goods have increased tremendously. Industries have grown very much and along the way so has the needs for transports and energy. The frames and trends of economy have to be changed. Agrifood must solve the problems of food security and of the safety food, in point of the quantity and the balance of nutrients needed by the humans. There are less fossil fuels and they have became very expensive.

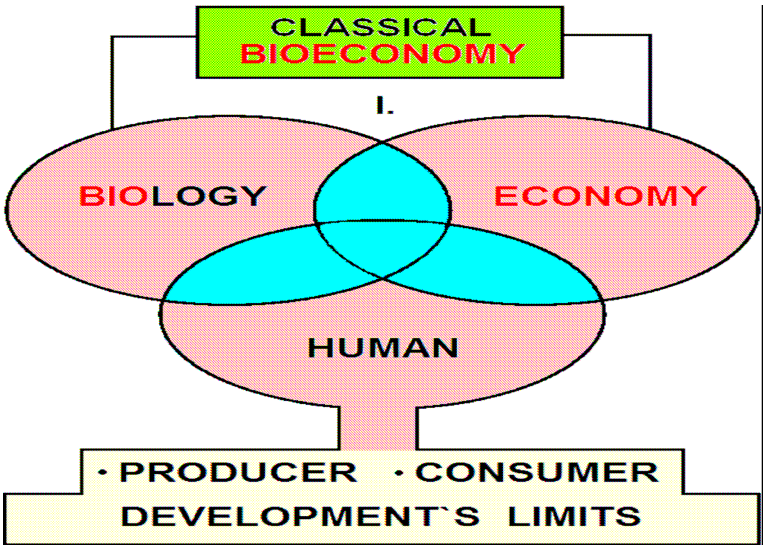


Fig. 9. Remarks for **classical bioeconomy** based on prioritary terminology using the term "bioeconomy" from Grigore ANTIPA (1906–1916) and Nicolas Georgescu ROEGEN (1960-1975), with human significations of economy (orig.)

They should be substituted by bio gas and bio fuel or by non conventional sources of energy (such as the sun, the wind and the waves). It is obvious that all the organic synthesis solutions are connected to the prefixes "bio", „eco", „natural", this rightly entitleing them to the name of "Green power".

Bioeconomy, an elaborated and promoted concept by ***Nicholas Georgescu-Roegen*** (1906-1994) was making up in one theory which presents a revolutionary way on economy concept. Contrary of before thinking bioeconomy theory, which placed the industrial revolution and technically progress by one side and live world evolution and ecology on the other side, the economist with Romanian origins named N. Georgescu-Roegen get with a decisive clarification which has clear connotations from contemporarily political economy.

N. Georgescu-Roegen demonstrated that "on one side, the solving of decisive environment problems are as thick as thieves on scientific, technological and informatics progress of the human society, but, in the same time, only the existence of the human progress

alone, cannot solve automatically the ecologically problems which humans and accelerate human developing made at the industrially revolution beginning. The decisive factor is represented by the human society will to solve the existent problems, overall…" ("The Entropy Law and the Economic Process").

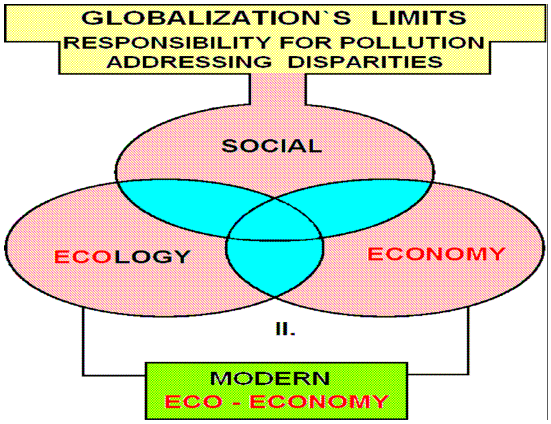


Fig.10. Remarks for **modern eco-economy** based on prioritary terminology using the term "**ecoeconomy**" from Lester Brown (1996–2010), with social significations of economy (orig.)

This is the effect of the chlorophyll (the pigment of green plants, all the way from mere algae up to the big trees) capability to deposit sun energy into molecules of organic substances synthesized from CO_2 and H_2O adding in some cases N, P or even other chemical elements. The Green power is amplified by biodiversity. It is obvious that a sustainable economy of the future has to become a bio-economy, adapted to the rural area and based on a large biodiversity that will create first of all an opportunity for more producers of primary organic synthesis and further on for a longer line of consumers up to the final state of dead organic matter that must be mineralized. In this context, Nicolas Georgescu-Roeger's world-wide-known Bioeconomics paradigm of improving the agricultural efficiency becomes most topical, particularly as mankind's limited natural resources are being depleted.

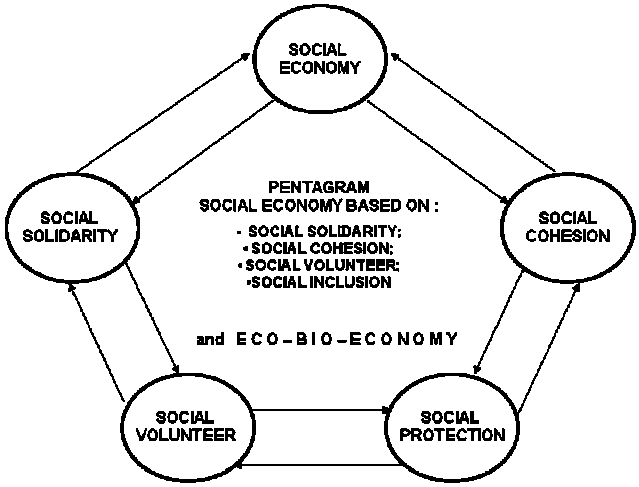


Fig. 11. Remarks for **eco-bio-economy** based on prioritary terminology using the term "**ecobioeconomy**" from A.T. and our working group (2009–2010), with social significations (orig.)

These aspects have been emphasized even more by the current global economic and financial crisis. On the basis of the more recent Green Power paradigm, the paper also presents a new point of view about a possible new paradigm of sustainable rural bioeconomics.

Nowadays a sustainable economy must become rural, based on Agrifood Biodiversity. Bioeconomy and Eco-Economy scientifically applied to the rural economy, in the context of a sustainable rural development, the possibility exists to issue the following tentative terms for consideration in the future: a. Bioeconomic sustainable development of the rural areas; b. Eco-Economic sustainable development of the agrifood production; c. Eco-Bioeconomic sustainable development of the agrifood green power.

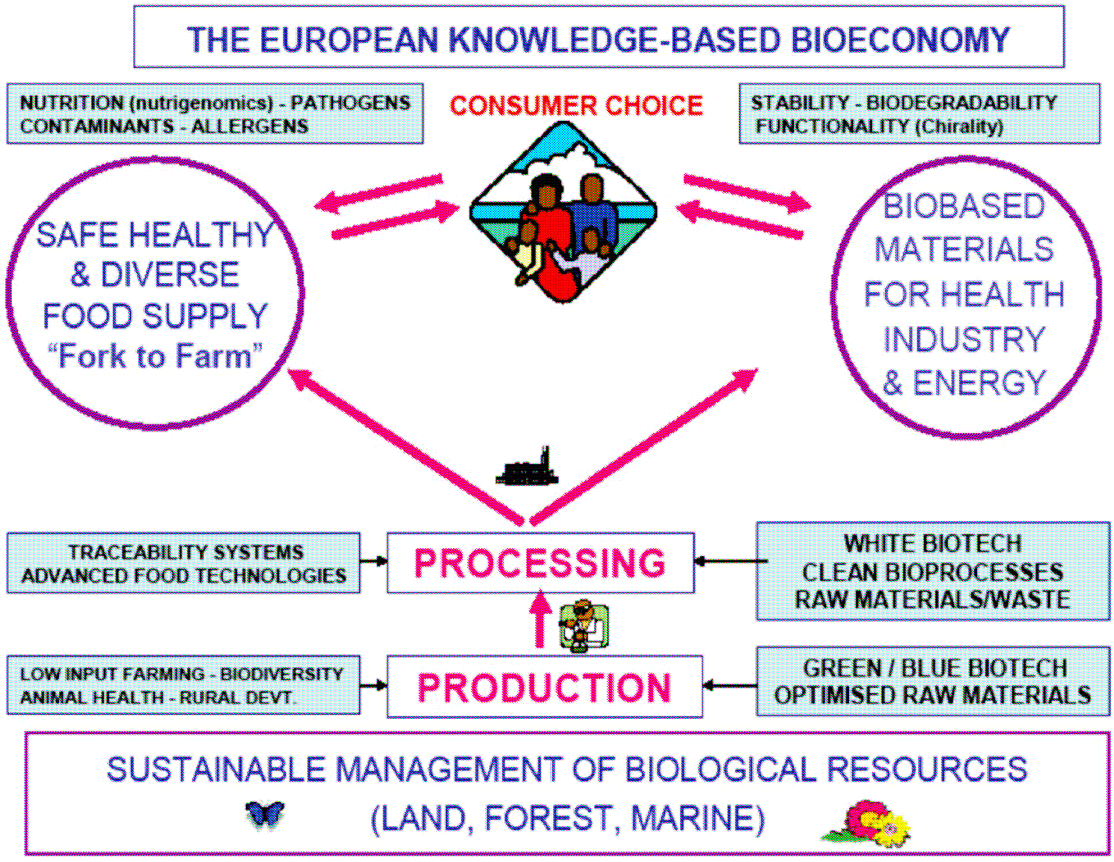


Fig. 12. The European Knowledge based on Bioeconomy (KBBE–FP 7)

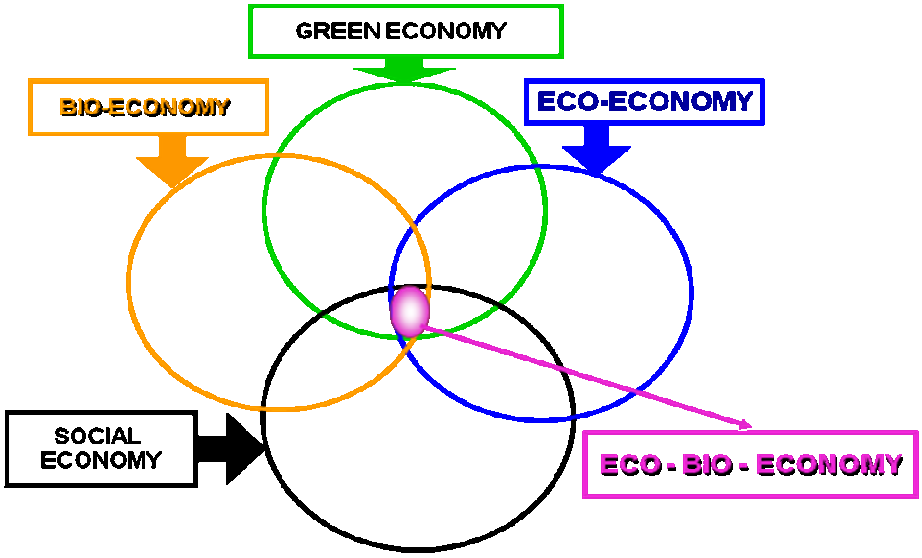


Fig. 13. Complex interrelations between the terms: green economy, ecoeconomy, bioeconomy and social economy, to define the new paradigm "**ecobioeconomy**" by A.T. BOGDAN and our working group (2009–2010), with social significations (orig.)

CONCLUSION

The livestock sector plays a crucial role in the provision of global public goods and services. There are opportunities to alleviate many of the risks associated with the expanding sector and to develop its full potential in ensuring benefits for the poor with a gender equality perspective, and to encourage a more responsible use of increasingly scarce inputs and natural resources. This will require dynamic generation and adoption of new technologies, products and services as well as networks and institutional development within an enabling policy and regulatory environment. The vigorous growth of the livestock sector, its importance for income generation, food security, human nutrition and health, and its impact on various public goods and services require careful attention by the international community.

Increased sustainable livestock production is dependent on up-to-date, relevant, comprehensive and reliable, gender-sensitive information to underpin the rural development process and to ensure that it is supported by effective policies. To support such processes, FAO has set up a web-based "Gateway to governance in the livestock sector"10. By mandate, FAO is the only international organization that has the breadth of capacity and mandate to address the livestock sector guidance in all its complexity. FAO has thus a clear comparative advantage in assisting member countries on livestock sector policies which benefit the poor, the general public and the natural resources.

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REFERENCES

1. Aiello F., (1999). "The Stabilisation of LDCs' Export Earnings. The Impact of EU STABEX Programme", *International Review of Applied Economics*, 1999, Vol. 13, n. 1, pp. 71-85.

2. Anderson, K., 2009, "Policies Affecting Agricultural Incentives in Developing Countries", paper prepared for FAO.

3. Alexandratos, N. (1996). "China's Cereals Deficits in a World Context", *Agricultural Economics*, 15-6 Alexandratos, N. (2008), "Food Price Surges: Possible Causes, Past Experience, and Longer Term Relevance", *Population and Development Review*, 34(4): 663–697 (December 2008). http://www.fao.org/es/esd/FoodPriceSurges-Alexandratos.pdf

4. Anderson K., Martin, W., and E. Valenzuela, (2006). "The Relative Importance of Global Agricultural Subsidies and Market Access", *World Trade Review*, 5(3): 357-76, November.

5. Baffes, J. and H. de Gorter, (2005). "Disciplining agricultural support through decoupling", World Bank Policy Research Working Paper 3533.

6. Berg E. and B. Schmitz, (2006). "Weather based instruments in the context of whole farm risk management", Paper presented at the 101th EAAE Seminar "Management of Climate Risk in Agriculture", Berlin.

7. Bezemer, D. And D. Headey, (2006). "Something of a Paradox: The neglect of Agriculture in Economic Development" Paper presented at the IAAE conference, Gold Coast, Australia, August 12-18, 2006.

8. Bouët, A., (2008). "The expected benefits of trade liberalization for world income and development: opening the black box*"*, IFPRI, Food Policy Review 8.

9. Bouët A., & Laborde, D., (2009). "Market Access Versus Domestic Support: Assessing the relative impacts on Developing Countries Agriculture", paper prepared for FAO.

10. Brown, L. (1995). *Who Will Feed China, Wake-up Call for a Small Planet,* W.W.Norton, New York.

11. Bruinsma J., ed. (2003). *World Agriculture: Towards 2015/30, an FAO Perspective*, London: Earthscan and Rome: FAO. http://www.fao.org/es/esd/gstudies.htm

12. Bruinsma, J. (2009). *The resource outlook to 2050: By how much do land, water and crop yields need to increase by 2050?* (Paper for this EM)

13. Carter M. R., (2008). "Inducing Innovation: Risk Instruments for Solving the Conundrum of Rural Finance", Keynote Paper Prepared for the 6th Annual Conference of the Agence Française de Développement and The European Development Network Paris, 12 November.

14. Conforti, P., (2009). "Agricultural insurance and risk management: Developing Countries Experiences", paper prepared for FAO.

15. Corden W.M., (1977). The Theory of Protection, Paris, Economica.

16. De Gorter, H., (2009). "*Integrating Developing Country Agriculture into Global Climate Change Mitigation Efforts*", paper prepared for FAO.

17. DFID (2005). quoted In: Bezemer, D. And D. Headey, 2006, "Something of a Paradox: The neglect of Agriculture in Economic Development" Paper presented at the IAAE conference, Gold Coast, Australia, August 12-18, 2006.

18. Disdier A.C., Fontagné L., Mimouni M. (2008). The Impact of Regulations on Agricultural Trade: Evidence from SPS and TBT Agreements, American Journal of Agricultural Economics, 90(2): 336–350.

19. Dorward, A., (2009). "Rethinking agricultural input subsidy programmes in a changing world," Paper prepared for FAO.

20. Erb, K.H., Gaube, V., Krausmann, F., Plutzar, C., Bondeau, A., Haberl, H., (2007). A comprehensive global 5min resolution land-use dataset for the year 2000 consistent with national census data. Journal of Land Use Science, 2 (3), 191-224.

21. Erb, K.H., Krausmann, F., Lucht, W., Haberl, H., (2009). Embodied HANPP: Mapping the spatial disconnect between global biomass production and consumption. Ecological Economics, doi: 10.1016/j.ecolecon.2009.06.025.

22. FAO (2004). *Human energy requirements. Report of a Joint FAO/WHO/UNU Expert Consultation*, Rome, 17–24 October 2001. FAO, Food and Nutrition Technical Report Series,1, Rome.

23. FAO (2006). *World Agriculture: towards 2030/2050, Interim report*, ttp://www.fao.org/

24. es/esd/gstudies.htm

25. FAO (2008). *The State of Food Insecurity in the World 2008.*

26. FAO (2009). *Crop Prospects and Food Situation*, No2 (April 2009).

27. FAPRI (2009). *U.S. and World Agricultural Outlook*, FAPRI Staff Report 09-FSR 1.

28. Fischer, G., van Velthuizen, H., Shah, M. and F. Nachtergaele (2002). *Global Agro-ecological Assessment for Agriculture in the 21st Century: Methodology and results*, RR-02-002, IIASA, Laxenburg Fischer, G., van Velthuizen, H., and F. Nachtergaele (forthcoming), *Global Agro-ecological Assessment – the 2009 revision*, IIASA, Laxenburg.

29. Fischer, G. (2009). "How do climate change and bioenergy alter the long-term outlook for food, agriculture and resource availability?" (Paper for this EM). IEA (International Energy Agency) (2008), *World Energy Outlook 2008*. Paris: OECD/IEA.

30. Garrido, A. and M. Bielza, (2008). "Evaluating EU risk management instruments: policy lessons and prospects for the future", Chapter 4 in Meuwisen *et al* (2008).

31. Glauber, J.W. (2004). "Crop Insurance reconsidered". *American Journal of Agricultural economics*, 86: 1179- 1195.

32. 20 *Expert Meeting on How to Feed the World in 2050 24-26 June 2009*

33. Masters, W., (2009). "Trends in Agricultural Protection: How might agricultural protection evolve in the coming decades?", paper prepared for FAO

34. Lutz, W., Sanderson, W., Scherbov, S., (2001). The end of world population growth. Nature, 412, 543-545.

35. Lutz, W., Sanderson, W.C., Scherbov, S., (2004). The End of World Population Growth in the 21stCentury. New Challenges for Human Capital Formation & Sustainable Development. Earthscan, London, Sterling, VA.

36. McKinsey Global Institute (2009). *Averting the Next Energy Crisis: the Demand Challenge.*

37. OECD (2005). "The Impact on Production Incentives of Different Risk reducing Policies". *OECD Papers*, No 422. Vol. 5 No 11., OECD, Paris.

38. OECD (2008). An Assessment of Risk Exposure in Agriculture. A Literature Review. TAD/CA/APM/WP(2008)23FINAL, OECD, Paris.

39. OECD (2009a). Risk Management in Agriculture. A Holistic Conceptual Approach TAD/CA/APM/WP(2008)22/ FINAL

40. OECD (2009b). An Overview of Risk-Related policy Measures TAD/CA/APM/WP(2008)24/REV1, OECD, Paris.

41. OECD (2005). *Review of Agricultural Policies in China, Main Report*, Document AGR/CA(2005)6, OECD, Paris.

42. OECD/FAO (2009). *Agricultural Outlook, 2009-2018: Highlights*, OECD, Paris.

43. OFID (2009). *Biofuels and Food Security: Implications of an accelerated biofuels production*, An OFID study prepared by IIASA.

44. Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (2003). Long-range World Population Projections: Proceedings of the United Nations Technical Working Group on Long-Range Population Projections, 30 June 2003 (ESA/P/WP.186).

45. Rosegrant, M.W., J. Huang, A. Sinha, H. Ahammad, C. Ringler, T. Zhu, T.B. Sulser, S. Msangi, and M. Batka (2008). *Exploring Alternative Futures for Agricultural Knowledge, Science, and Technology (AKST)*. ACIAR Project Report ADP/2004/045, International Food Policy Research Institute, Washington, D.C.

46. Skees J. R., P. Hazell and M. J. Miranda (1999). "New Approaches to Crop Yield Insurance in developing Countries". EPTD Discussion Paper n. 55. Environment and Production Technology Division, IFPRI, Washington, D.C.

47. Skully, D., (2009). "OECD policy and distortionary effects: A review of the evidence", paper prepared for FAO.

48. Schmidhuber, J. (2006). *Impact of an Increased Biomass Use on Agricultural Markets, Prices and Food Security: a Longer-Term Perspective*, paper for International Symposium of Notre Europe, Paris, 27-29 November, 2006 (http://www.fao.org/es/esd/pastgstudies.html).

49. Stevens, P. (2008). *The Coming Oil Supply Crunch*, a Chatham House Report, London.

50. Vercammen, J., "Irreversible Investment under Uncertainty and the Threat of Bankruptcy", *Economics Letters*, 66 (2000): 319-25.

51. Vercammen, J., (2003). "Cooperative Investment and the Value of Contracting with Transaction Costs", *Journal of Agricultural and Food Industrial Organization* 1: article 1.

52. World Bank (2005).

53. United Nations (2003a). *World Population Prospects: The 2002 Revision*, Vol. I: *Comprehensive Tables* (United Nations publication, Sales No. E/03.XIII.6).

54. United Nations (2003b). *World Population Prospects: The 2002 Revision*, Vol. II: *Sex and Age Distribution of the World Population* (United Nations publication, Sales No. E/03.XIII.7).

55. U.N. (2007). *World Population Prospects: The 2006 Revision.*

56. USDA (2001). "China's Grain Policy at a Crossroads", *Agricultural Outlook* (September).

57. USDA (2009). *USDA Agricultural Projections to 2018*, Long-term Projections Report OCE-2009-1.

58. UN (2007). World Population Prospects: the 2006 revision. United Nations, Department of Economic and Social Affairs, Population Division, New York.

59. UN (2008). World Urbanization Prospects: The 2007 Revision. United Nations, Department of Economic and Social Affairs, Population Division, New York.

60. World food and agriculture to 2030/50: highlights and views from mid-2009 Alexandratos