UNIVERSITÄT POTSDAM

WIRTSCHAFTS- UND SOZIALWISSENSCHAFTLICHE FAKULTÄT

FINANZWISSENSCHAFTLICHE DISKUSSIONSBEITRÄGE

Hans-Georg Petersen

Economic Aspects of Agricultural Areas Mangement and Land/Water Ecotones Conservation

Diskussionsbeitrag Nr. 1

Potsdam 1995

Herausgeber:
Prof. Dr. Hans-Georg Petersen
Universität Potsdam
Wirtschafts- und Sozialwissenschaftliche Fakultät
Lehrstuhl für Finanzwissenschaft
Postfach 900327
D - 14439 Potsdam
Tel.: (+49) 0331 977-3394
Fax: (+49) 0331 977-3392

Invited lecture at the UNESCO MAB International Symposium
"Fish and Land/Water Ecotones",
jointly organized by UNESCO MAB (MAN AND THE BIOSPHERE),
Polish MAB National Commitee (Section 5: Aquatic Ecosystems), University of Lodz,
May 22 - 24, 1995, Zakopane, Poland.

ISSN 0948 - 7549

Economic Aspects of Agricultural Areas Management and Land/Water Ecotones Conservation[1]

by

Hans-Georg Petersen

I. Introduction

The task of writing a reliable and convincing paper on this topic is a very uneasy one because it is threefold: one has to know at least a bit about the agricultural sector, biology (or more precisely ecology), and about the sometimes beneficial but often distorting consequences of human activities. And all that has to be judged from the perspective of an economist who is aware of the steadily increasing uncertainties which are closely connected with post-modern sciences. Especially with regard to global, but also regional environmental issues, neither the conventional applied sciences nor the traditional professional consultancy deliver promising results. Today scientists have to tackle problems which are created by political necessities overwhelmingly caused by short-term human behavior, due in part to a serious lack of information on the long-term behavioral consequences. In these issues, typically, information stacks are high, scientific facts uncertain, individual as well as collective values disputed, and political decisions very urgent. „In general, the post-normal situation is one where the traditional opposition of 'hard'

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[1] Invited lecture at the UNESCO MAB International Symposium „Fish and Land/Water Ecotones", May 22 - 24, Zakopane, Poland. Jointly organized by UNESCO MAB (MAN AND THE BIOSPHERE), Polish MAB National Committee (Section 5: „Aquatic Ecosystems"), University of Lodz.

facts and 'soft' values is inverted. Here we find decisions that are 'hard' in every sense, for which the scientific inputs are irremediably 'soft'" (FUNTOWICZ/RAVETZ, 1991, p. 138).

This is the typical situation in which traditional experts and specialists have lost confidence in the sciences as well as in the public because the best politicians do not have expertise in choosing experts. The only precautionary measure at the current level of knowledge is to broaden the information by adding generalists into decision process and to work on an interdisciplinary level. On the one hand, we are suffering from irremediable uncertainties in knowledge and moral uncertainties which often are much more difficult to deal with. On the other hand, ecologists and economists are confronted with the challenge of formulating conditions for a sustainable development to secure the survival of our „spaceship earth" (BOULDING 1973). Scarcity in knowledge and moral values are often connected with confrontation and hard social discourse; in workable democracies such discourses are basically necessary, but sooner or later they have to lead to cooperative solutions. Only open and cooperative societies, in which moral values are always in dispute and not bound by ideology, will be able to meet the call of realizing sustainability.[1]

The following explanations are divided into four parts; in chapter II. the problems of mainstream economics, the current land use system - especially with regard to our industrialized agricultural sector - as well as the natural resource scarcity are discussed and put into the broader perspective of a regional sustainable development which is one main topic of ecological economics.[2] In the next step (chapter III.) land and water ecotones conservation[3] is described as a substantial part of the idea of an integrated agro-industrial ecosystem which is able to reduce energy input and pollution (by avoidance of non-recycled residues), and to prevent the depletion of exhaustible resources. Chapter IV. deals with concrete strategies for an agricultural policy which is much more in accordance with today's economical and ecological goals while in chapter V. the consequences for the Polish economy are discussed. Chapter VI. presents a short summary and some political conclusions of our „soft" analysis.

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[1] For a detailed discussion of the value system of the open society see PETERSEN (1993).

[2] A comprehensive definition of ecological economics is given by ZUCHETTO (1991, p. 417): „the careful and deliberate understanding of activity on the earth and its consequences, with the ultimate goal being that humans will somehow manage this activity for the long-term survival of itself and other life on earth." For a detailed comparison of ecological economics with conventional economics and conventional ecology see COSTANZA/DALY/BARTHOLOMEW (1991).

[3] Ecotones are buffering strips in between different landscapes or habitats (e.g., edge of the forest, hedges, shores, banks) where the species richness is often much higher than in the surrounding landscapes (see SCHAEFER 1992, p. 232). For a detailed analysis of land/water ecotones see SCHIEMER/ZALEWSKI (1992) and ZALEWSKI et. al. (1994).

II. Some Theoretical Presuppositions for a Regional Sustainable Development

In classical economics - especially in the writings of Ricardo and Malthus - arable land and natural resources were regarded as scarce inputs into the agricultural and industrial production processes, so that nature itself was a primary constraint to economic expansion. Therefore, economics earned the title of the „dismal science". Perhaps because in industrial countries Malthus law[1] seemed to be falsified by technical progress and strong economic growth, in neoclassical economics the influence of decreasing soil quality as a consequence of expanded agricultural production and the depletion of non-renewable resources have played only a minor role or were often totally neglected.[2] Most of the neoclassical models are merely arguing with two primary inputs: labor and capital. Both are often put in simple Cobb/Douglas-production-functions which mathematically are easy to handle. Therefore it is not surprising that for many economists the driving forces of economic growth and the connected societal welfare are a highly qualified human capital and a sufficient capital formation. Thus economic growth is caused exclusively by increases in labor and capital productivity, whereas technical progress plays a role as an exogenous factor which cannot be explained but „falls like manna from heaven". The only constraints for economic growth are capital and/or labor shortages. Hence, the economy is a closed and self-perpetuating system which is totally independent from nature.

With regard to the theory and history of economic thought it is obvious that this position is an extreme one and - hopefully - only shared by a minority of existing economists. However, this extreme position has determined the regrettably bad reputation of economics and economists with the colleagues from the „other sciences".[3] With the fundamentals of classical economists in mind the vast majority of economists should easily agree that not labor and capital, but low entropy energy and matter are the only primary factors of production. From a biophysical view both „... cannot be physically produced inside the economic system" (CLEVELAND 1991, p. 294). In opposition to the neoclassical view labor and capital as well as technology and technological change are internal, interdependent, and intermediate factors of production and the economic system (see COSTANZA 1980; HALL et. al. 1986). „The services of labor and capital and certain properties of land (i.e., soil fertility) are produced from low entropy energy-matter" (CLEVELAND 1991, p. 294)[4].

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[1]In short this law states that the food production is increasing in an arithmetic progression, whereas the population is increasing in a geometric progression (or exponentially); the result is an excess demand for food which leads to mass misery, epidemics, disease, and wars („repressive checks"), all causing a rise in mortality; see MALTHUS (1826/1912).

[2]This is especially true since HOTELLING (1931) had developed the theory of optimal resource depletion.

[3]Some more or less convincing arguments are even made by distinguished economists; see, e.g., AARON (1994).

[4] The approach of „evolutionary economics" which has been developed in the last two decades supports such views; here the close connection between biology and economics are to be mentioned, demonstrated by the corresponding terms mutation and innovation, heredity and imitation, genes and

Technological change is also in large part dependent on energy-input, though a tight positive correlation between energy flow, technical progress, production, and economic growth does not exist. If we take the development within the industrialized countries since the late 1960's into account, it becomes obvious that the close correlation of increasing energy input and real economic growth has been reversed. As a result of a progress in energy saving technology real growth has taken place even at decreasing energy input - a fact which is often neglected by colleagues from the natural sciences. However, in looking at the long-term trends in the development of the energy cost of extractive output for natural resources, a biophysical approach clearly supports the fact that increasing scarcities especially for metals and fossil fuel (coal and petroleum) are to be observed. Additionally, the enormous rise of capital and labor productivity in this century is very closely connected with an increase of fossil energy input which is especially true with regard to the agricultural sector. Briefly expressed, the use of more energy has directly and indirectly subsidized the efforts of labor. „As a result, labor costs declined while energy costs increased sharply" (CLEVELAND, 1991, p. 314).

Declining quality of non-fuel resources leads to a higher input of fuel-resources, so that the depletion of the latter is even accelerated, thus itself leading to a further increase of the energy costs of fossil fuels. Therefore our first and basic hypothesis for the further argumentation is that fossil fuels will become scarce which in turn induces increasing energy prices and consequently gives strong economical incentives to reduce the energy input of the production processes. The shortage in energy supply may partly be mitigated by the use of fusion reactors, but at the current pace of development this technology will not reach practical maturity before the end of the next century. Our hypothesis is also supported by the external effects which are technically connected with fossil energy use. All of the new global environmental issues are more or less due to fossil energy input: global warming, acid rain, ozone layer reduction, climate changes, etc. Although the current state of knowledge is - as already mentioned above - highly uncertain and many computer simulation models are following the GIGO-principle,[1] ethical thinking and our responsibility towards future generations obliges us to follow the precautionary principle which is fundamental for a sustainable development.[2]

It is self-evident that these basic global issues are enormously important for a regional sustainability, especially in developing a sustainable regional policy perspective. Fortunately, on the one hand, regional environmental problems are gradually easier to define and to manage; this is especially true in the cases of soil and water pollution, whereas the third environmental media,

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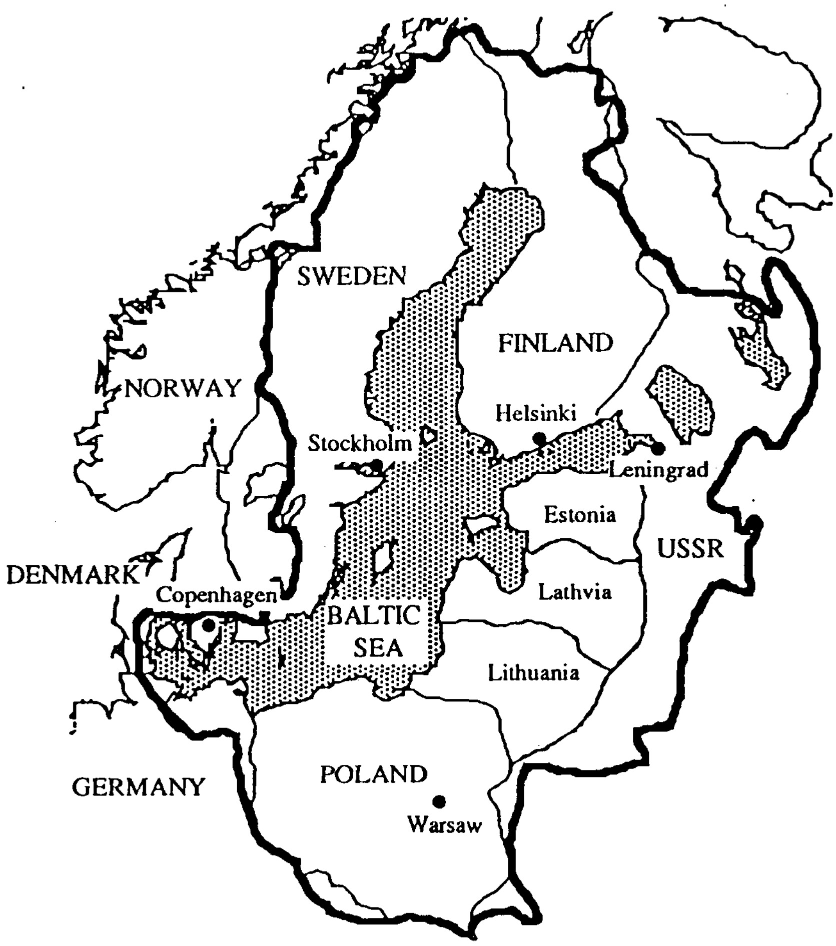
routines, selection and competition; see for more details NELSON/WINTER (1982), DOSI (1988), PETERSEN (1993, pp. 16).

[1]"Garbage In, Garbage Out"; see FUNTOWICZ/RAVETZ (1991, p. 140).

[2]This principle is described in detail in PERRINGS (1991). The following quotation gives a short summary: „A common thread in the various interpretations of sustainable development in the wake of the Brundtland report is the necessity to preserve the options available for future generations. Intergenerational equity, in this view, will be satisfied if the activities of the present generation do not impose irreversible costs on future generations" (p. 165).

the air, is partly regionally, and partly globally polluted. In the following we will lay stress upon soil and water, therefore neglecting the problem of air pollution (including acid rain). On the other hand, the boundaries of the polluted regions are normally not in accordance with those of the regional and local governmental jurisdictions; hence, political and legal boundaries only seldom coincide with the natural ones. If we take the Baltic Sea as an example, the catchment area - its „ecological boundary" - represents 15 percent of the European area which is about four times larger than the sea itself (see JANSSON 1991, pp. 450). This area covers parts of 9 Northern European countries (excluding Norway), and in the federal states even the regional or local governments have much political influence (see figure 1). Especially the boundary zones between the ecosystems (the ecotones) have attracted human beings because they have forever provided natural resources and services. This is true for the sea shores and the river banks which have always been the channels along which the human production processes took place. Nearly all capitals of the Baltic states are closely situated on the seaside. More than 70 mio. people live in the drainage basin of the Baltic Sea which „ ... provides the ultimate sink for the by-products of human activities in this land area" (JANSSON 1991, p. 452).

Figure 1: The Baltic Drainage Basin



Source: JANSSON (1991, p. 451).

All this points to the necessity of international and interregional cooperation, burden sharing, and fiscal equalization. The prerequisites are clearly formulated international and interregional environmental (or pollution) standards and a diagnosis of the polluting sources within the regions. This is - as long experiences have shown - even in a national perspective politically very hard work because of unhomogenous preference systems and different collective as well as individual interests. Whereas the general reduction of fossil energy inputs into the human production process will conserve resources and remedy global issues, regional and local responsibilities have to be directed to the task of securing environmental quality and species diversity.[1] Industrialization and the change from an almost closed farm economy in the agricultural sector to what is called bio-industry have been connected with tremendous negative external effects. „The population growth and economic expansion involved a major change in land use, resulting in the nearly complete disappearance of wild lands and natural forests“ (BRAAT/STEETSKAMP 1991, p. 285). The major regional environmental risks turned out to be: soil erosion and pollution, nitrate and pesticide pollution of groundwater aquifers, surfacewater pollution by industrial and agricultural production as well as waste water from households and rubbish dumps, depletion of groundwater reserves, and loss of forest and wild land as productive and recreational subsystems.

The present and future quality of life heavily depends on a healthy environment and a sufficient biodiversity. Today's existing environment is much more determined by culture than by nature with enormous consequences for the composition and diversity of species. The everlasting evolutionary process has always been connected with natural or genetic selection. Under anthropological influences the process of natural selection has then been accompanied by a process of „cultural selection“ (PETERSEN 1993, p. 188). As a result plants and animals are driven to extinction. During the last hundred years their rate of extinction has increased to be nearly that of the rate of human population growth (see MARKL 1991, p. 321). Because of a rising consciousness among a large part of the population in the industrialized countries, the costs of economic expansion are now newly evaluated. Therefore our second basic hypothesis for our further argumentation is that environmental quality and biodiversity of regions be evaluated as superior goods, which means that both are much more in demand the higher the income is within that region. Only environmentally healthy regions will attract innovative people and successfully survive international and interregional competition.

If our basic diagnosis of regional ecological problems is shared, then a frequent but very general therapy can also be delivered: „A growing group of thinkers from various disciplines is converging on the same overall vision: a globe with thousands of locally managed, self-reliant economies, based on ecologically meaningful boundaries and comprising culturally and

[1] The World Commissions on Environment and Development (WCED) defines the process of sustainable economic development as conservation of resources, environmental quality and species diversity; see WCED (1987).

historically integrated communities. The goal is to strengthen meaningful participation in a shared community while creating identification with the communally managed local resource base. Reestablishing and expanding traditional communal systems could help them regain community bonding while ensuring sustainable development" (CLARK 1991, p. 413). „Small is beautiful" is a formula which is not only beloved by economists; if one takes both of our basic hypotheses seriously, natural and social sciences have to develop technological strategies which are based on a „partnership with nature" (ODUM 1971). Such ecological engineering is the core of evolutionary multidisciplinary research and education (see ZUCHETTO 1991). „It is the prescriptive rather than descriptive discipline of ecology in that it utilizes ecological principles, the self-design or self-organizational capabilities of natural ecosystems, and the sustainability of solar based ecosystems rather than fossil fuel based technologies to achieve environmental quality" (MITSCH 1991, p. 428). In the following chapter we try to give a more concrete elucidation for the agricultural sector.

III. Towards an Integrated Agro-industrial Ecosystem[1]

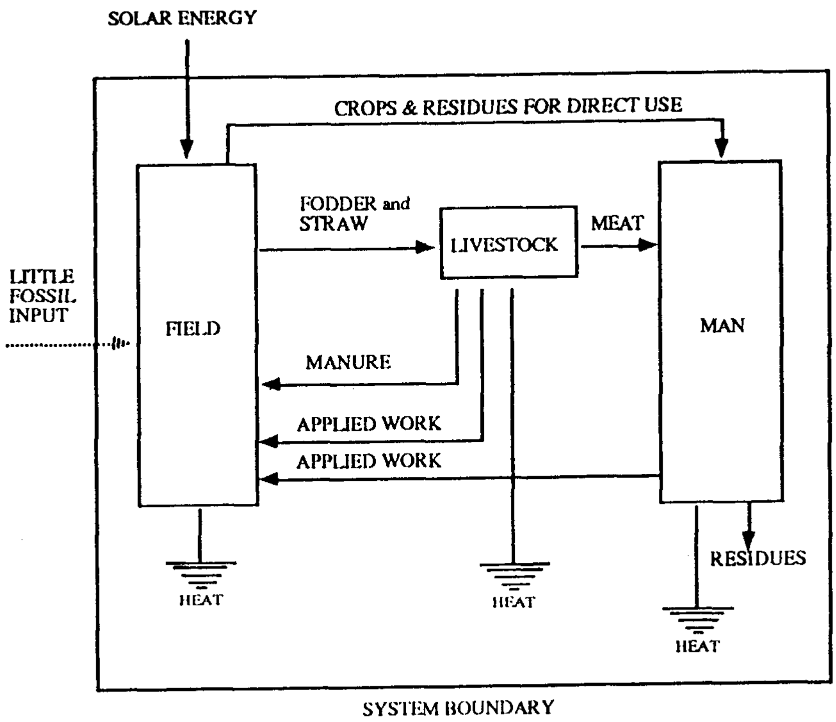
Historical perspectives are especially helpful for the understanding of ecological problems. If we consider, for example, the production method of a non-industrialized agricultural system we will find it very close to a natural ecosystem which is itself integrated and in a steady state (in German a bit more precisely: Fließgleichgewicht). „The system remains constant in its composition, in spite of continuous irreversible processes, import and export, building up and breaking down, taking place" (BERTALANFFY 1968, p. 142). Such a semi-natural ecosystem is based on networks of links so that the residues of some living species are the substrates for the others. „This gives a triple result: 1. Each species finds its primary material and the energy necessary for its development. 2. The residues produced by a species do not accumulate. 3. A continuous cycle of primary elements (carbon, nitrogen, oxygen, etc.) and trace elements is created so that they do not become immobilized in stable structures" (TIEZZI/MARCHETTINI/ULGIATI 1991, S. 461). The authors point out the fact that such natural ecosystems extend the cogeneration, which for instance exists for electricity and heat to all elements within the system, with the result that solar energy conversion is maximized.

Therefore the production process in subsistence agriculture, as shown in a system-theoretical approach in figure 2, overwhelmingly uses inputs of human and animal muscular energy, apart from the solar energy input. The input of fossil fuel is negligibly low, while the system is characterized by a process of natural recycling of nearly all residues. As a consequence the environmental pollution is also minimized. Such a system relies upon a high diversification of

[1] An excellent and detailed description is given in TIEZZI/MARCHETTINI/ULGIATI (1991).

agrarian products because of the necessity of crop rotation as well as the cogeneration of crop and livestock production, then the former is heavily dependent on manure production within the latter. Unfortunately, the labor productivity as well as the capital input is extremely low, so that the method of traditional agricultural production was and is not able to provide enough food for the use of an exponentially growing world population.

Figure 2: Traditional Farming

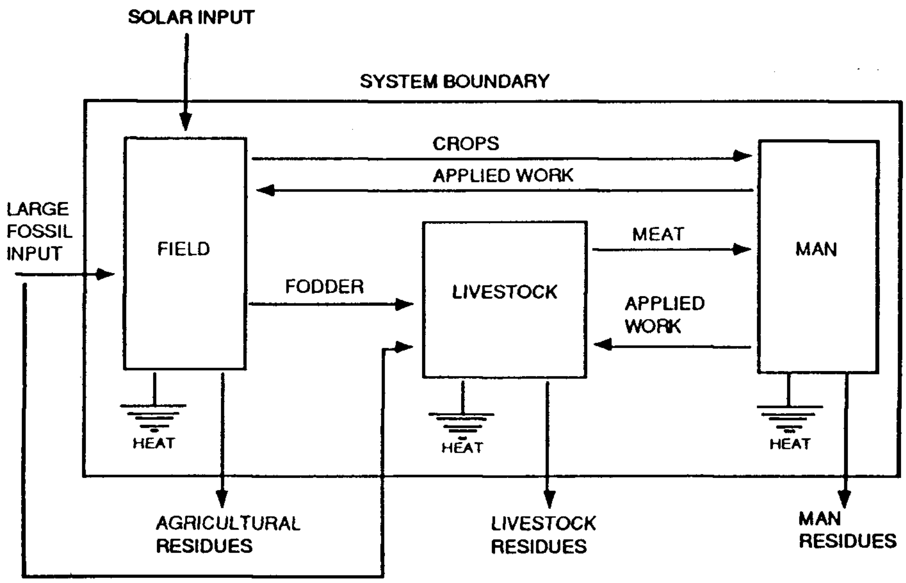


Source: TIEZZI/MARCHETTINI/ULGIATI (1991, p. 463).

Consequently, the methods developed for industrialized production - division of labor and specialization, capital formation, and high fossil energy input - were extended to the agricultural sector with a certain time lag. But the „... transition from preindustrial cogeneration to specialization was short and fast" (TIEZZI/MARCHETTINI/ULGIATI 1991, p. 459). Human and animal muscle power were substituted by agrarian high technology connected with enormous increases in fossil fuel inputs; the process of specialization has replaced crop rotation and also promoted the formation of pure crop and livestock producers - the already mentioned monocultural bio-industry. Returning to our system-theoretical approach, the conditions of a steady state are fundamentally changed or nearly destroyed. For the system tends towards a new steady state or towards the death of the system. A steady state as well as a stable equilibrium work as systemic attractors;[1] weak disturbances can be compensated within the system, strong disturbances might cause catastrophes.[2] To prevent such developments a large number of counter-measures were necessary, all more or less connected with overwhelmingly unintended by-products.

In addition to the enormous increase of fossil fuel inputs, and because of the absence of internal stabilizing factors, many external systemic stabilizers - themselves heavily dependent on large fossil fuel inputs (e.g., large parts of the chemical industry) - became necessary such as artificial fertilizers, herbicides, pesticides, fungicides, artificial irrigation systems, etc. And monocultural production, especially the division of crop and livestock production, has often destroyed the process of residues recycling, so that greatly increasing amounts of agricultural, livestock and human residues have to be managed, which again is connected with increasing fossil fuel input (see figure 3).

Figure 3: Industrialized Agriculture



Source: TIEZZI/MARCHETTINI/ULGIATI (1991, p. 465).

The method of bio-industrialized production is therefore closely connected with the pollution of soil and water. The monocultures on the fields and the lack of soil covering during the vegetation-free periods as well as the deep-ploughing methods lead to soil erosion, while the excess input of artificial fertilizer and pesticides impair the soil, surface-, and groundwater

[1]For different kinds of attractors see, e.g., FEIGENBAUM (1980), RUELLE (1980), SCHAFFER/KOT (1985).

[2]For examples of possible catastrophes see, e.g., ODUM (1991), WALTER/BRECKLE (1991).

quality. Modern stable technology leads to much more liquid manure than in the traditional litter stables, thus producing a serious lack of organic dung and compost which again is compensated for by the input of artificial fertilizers. Liquid manure has mostly a waste water quality and in livestock production the connected land is often exclusively used as a manure dump, where the manure is directly or indirectly (by rainfall) transported to the groundwater or by ditches and creeks to the next drinking-water reservoir. Especially in rural areas with high livestock production the agricultural sector has become the main source of water pollution, whereas for example in Germany this sector contributes on average only about 25 per cent to water pollution.[1] And - last but not least - the current methods of mass livestock production are closely connected with the ethical questions concerning a species oriented livestocking, which is also important if one follows an anthropological and not purely biocentric world view.[2] Livestocking on a massive scale in inappropriate stables and cages (e.g., in the hen-houses, but also in pigsties and other cattle stables) creates not only ethical problems, but also lays serious social stress on the animals, with consequences for the quality of the product and the potential for dangerous developments with regard to new cattle-plagues, epidemics, and diseases which also might endanger human health (as in the case of the rinderpest).

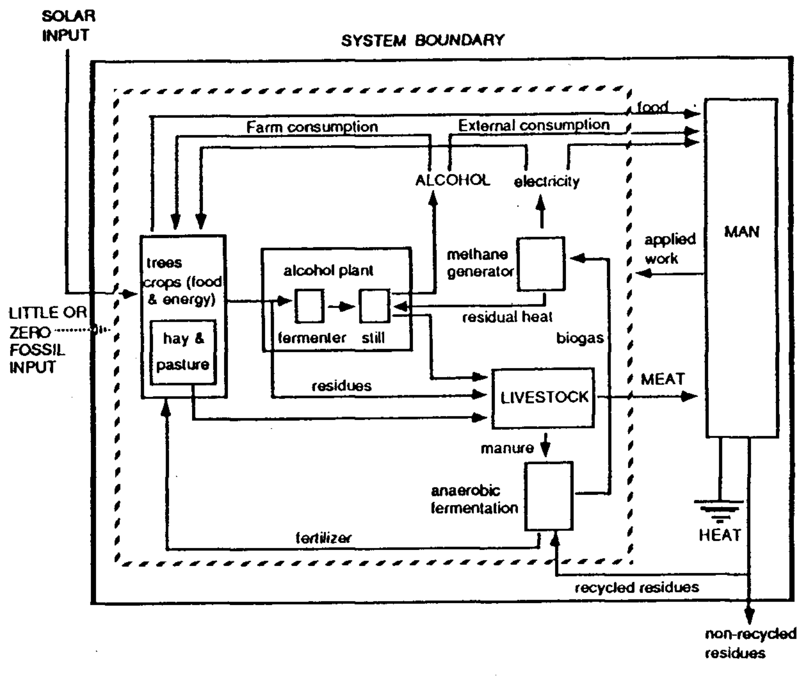
Besides an increasing scarcity in fossil fuels, the sufficient production of clean drinking water will be another dominant problem of the next century in securing the survival of mankind on earth. And here again mankind is in a vicious circle: less and less clean water reserves are available as more energy input is needed to produce drinking water, which then in turn accelerates the depletion of fossil fuel resources. All this is reason enough to reformulate the role of the agrarian sector and the current land use concept: Away from monoculture, which is more or less exclusively bound to food production, to an approach which uses the cogenerative powers of the traditional production forms. Such a strategy does not mean the pure return to pre-industrial production forms because its low productivity would lead to shortfalls in food provision, especially in a global perspective. As is true in other areas of urgency, only strategies which are oriented to the future might help; new challenges can only be met by self-responsible adaptation of behavior and thinking, that is to say by reacting with scientific and technological change. „Who wishes our species well, is not able to avoid such conclusions. Who is of the opinion that a secured future is possible without permanent changes in our living conditions, without the uninterrupted pressure to new solutions, has not realized the rules of life" (MARKL 1991, p. 218). In other words, mankind does not need less, but more and accelerated technical progress to overcome the current malaise.

[1]The industrial sector is the main polluter with about 30 to 40 per cent, while the remainder is contributed by the household sector; see KLÖTZLI (1993, pp. 200).

[2]For more details see, e.g., WEIKARD (1992).

A future-oriented perspective for the agricultural sector is what Tiezzi, Marchinetti, and Ulgiati have named the integrated agro-industrial system, which uses the new scientific perceptions of ecology and economics and has been led by an interdisciplinary interchange to the „genesis of ecological economics“ (CLEVELAND 1991, p. 291) in combination with the traditional cogeneration of food and work sustained by solar energy flows. The modern cogenerative approach is a method of production in which not only food, but also energy and chemical products are manufactured. Hence, the spectrum of agricultural products is therefore expanded to products which are currently produced in the primary or industrial sector. Figure 4 shows such an integrated agro-industrial system where fossil fuel input is drastically decreased. As one important consequence, the contribution to atmospheric carbon dioxide is greatly reduced, therefore at least mitigating the greenhouse effect. This is especially true if the right scale has been chosen, so that the carrying capacity - which secures the ecological equilibrium within a region - is just reached.

Figure 4: Integrated Agro-industrial Ecosystem



Source: TIEZZI/MARCHETTINI/ULGIATI (1991, p. 467)

The basis of the agro-industrial approach is the method of biological or ecological farming (see, e.g., KLÖTZLI 1993, pp. 331) with crop rotation and species oriented livestock management; a certain specialization is still possible if the residues are overwhelmingly recycled. A change in the stable technology would produce much more solid manure which is compostable and a good, if perhaps not total, substitute for artificial fertilizers. This reduces not only the fossil energy input, but also the eutrophication of all kinds of water. Excess manure connected with livestock production can be used in regional plants via anaerobic fermentation to produce biogas, and crop can be transformed by alcohol plants to ethanol. Both sources can be used as energy inputs for the farms, and it is very likely that the agricultural sector will be transformed from a net-energy consumer into a net-energy producer. A species oriented livestock management in which the number of animals per hectare is limited in a way that the risk of cattle-plagues are reduced and the product quality is increased would also decrease the infection risks to human society and therefore again lower the external costs.

From a microeconomic perspective it is obvious that ecological farming is more labor-intensive and at current prices more costly; but the stress has to be put on „current prices“ which do not represent the social costs because the external costs which are connected with the current production methods are neglected (in energy as well as agricultural production).[1] From a macroeconomic point of view this outcome can vary greatly for the whole society or even mankind as a whole, dependent on the different normative evaluations made by the majorities in our democracies. The question as to whether ecological farming is profitable or not does not only depend on economic considerations, but is much more an ethical question which has to be discussed in the societal discourse.

In view of the future risks for the global system only a revolutionary change within our current land use systems will secure the survival of mankind on our spaceship earth. The integrated agro-industrial system is one positive contribution to regional and global solutions for a sound environment. Non-recycled residues especially would drastically be reduced. But even such a system which might not be much less productive than our current one will produce a certain excess of residues; unintended excess fertilization also seems to be unavoidable if only because of a lack of information and education. Therefore, the ecological land use system should be accompanied by a strategy of ecotones planning especially in countries where the population density allows a large-scale land use concept. Broad buffering strips along the sea shores and river banks would reduce the pollutant inflows and create a much more scenic landscape and the (re)construction of hedges and small forest would create habitats for beneficial animals, increase the species diversity and reduce the pesticides input.[2] A scenic landscape and a high biodiversity are facts which are tremendously important for the quality of human life. Especially a high biodiversity within the rivers can be supported by riparian ecotones and biomanipulation within

[1]Naturally the profitability of bio-products (as mentioned in the next chapter) is heavily dependent on the more or less administered prices of fossil fuel energy. The price for fuel oil for the purpose of energy production and house heating is, for instance, in Germany with 0.40 DM per liter much less than in Denmark (with 1.00 DM per liter). Therefore, in Denmark many more incentives are in place to substitute fossil fuels by renewable fuels.

[2]Convincing results have already been obtained in the change of management of the small stripes along the German road system which are also functioning like small ecotones.

lakes, rivers, and water reservoirs is a ingenious method to reduce the remaining pollutants to levels which are below strict environmental standards (see, e.g., ZALEWSKI et al. 1994).

As has been demonstrated, many new scientific ideas exist which foster an optimistic view that the current environmental problems will be overcome and future development secured. Today's real problem is to translate these ideas into political action. Therefore the following chapter is directed towards a strategy of agricultural policy which is - because of the need of integrated views - naturally very closely connected with some general political implications.

IV. A Workable Strategy for Agricultural Policy

An efficient agricultural policy is naturally part of an integrated ecological and economical policy program in which the polluters-pay-principle (or causative principle) and the precautionary principle already mentioned above are two cornerstones; the core of such an eco-economic program is the internalization of external burdens into the market price system (via eco-taxes, eco-subsidies, and eco-licenses) as well as the expansion of property rights especially with regard to important common property resources.[1] But as already has been mentioned, the role of the agricultural sector must also be substantially changed. If the numerous negative and few positive external effects are internalized, the relative prices will have been changed dramatically. Production technologies and many presently unprofitable or not sufficiently demanded products will therefore become of interest to producers and consumers.

The agricultural sector will gain in importance then not only as net-energy producer, but also as a sector which secures the clean drinking water supply and contributes to a highly habitable environment for everyone. Of significance is the fact that farmers could work for water protection and as landscape gardeners; both jobs would even justify a certain subsidization of the sector by the public budget. But the agricultural sector would become much more independent from the current flow of public subsidies because new goods would be produced which would also create a good chance for an increase in the number of the sectoral jobs.[2] The farm residues which under the monocultural regime were overwhelmingly turned into polluting wastes under the integrated regime now find their place as substrates for the production of ethanol, biogas, and

[1] Such measures are extensively discussed in nearly all modern textbooks of public economics and environmental economics; see, e.g., PETERSEN (1993a). For a detailed analysis of the eco-taxes see NAGEL (1993).

[2] It is obvious that some jobs in the energy sector and especially the chemical industry will become obsolete. The difficult question not easily answered is: does the total number of regional jobs increase or not. The answer is more heavily dependent on personal belief than on scientific knowledge.

other fuels produced out of renewable plant production.[1] „After the production of ethanol, it is possible to recover high protein feedstocks, and after the production of biogas there are residues with high fertilizer value. Thus, biomass processing plants, on an appropriate scale, are the core of the I.S. (integrated system, HGP); they introduce new 'trophic levels' and new feedback for the maximum exploitation of solar energy. Here, scale is key to reducing energy costs within the system" (TIEZZI/MARCHETTINI/ULGIATI 1991, p. 472). Even the combustion of biomass seems to be promising because the carbon dioxide balance is nearly neutral compared to fossil fuels, especially if the problems of smoke filtering and cleaning can be solved by newly developed „end of the pipe" technologies.

In addition to traditional food, new bio-energy, fertilizer and clean water production, agro-industrial plants will process fibers, chemicals and basic manufacturing materials. Linen and hemp production[2] could be intensified; hemp fibers especially are an excellent substitute for cellulose in paper production. Therefore, such a substitution strategy would simultaneously reduce the world-wide cellulose demand and the harvesting of rain forests of the equator and in the Northern hemisphere.[3] That would at least retard if not entirely stop the harvesting process and so decrease world-wide climate changes, and hence protect the existing species in those areas and secure a high biodiversity for the future. Assuming innovative thinking, openness towards new solutions, and individual as well as collective flexibility, many other positive examples for successful future-oriented strategies can be found in today's world, and a courageous eco-economical reform policy improving the framework of economic and societal order would set new positive signals.

But also with regard to the traditional spectrum of agricultural goods new approaches have to be developed; it is well known in the economic literature that the greater part of agricultural products have the characteristics of inferior goods. If within societies real income is increasing, the demand for basic foodstuff is increasing at a much slower rate or sometimes even decreasing. The low income elasticity of agrarian products is the main reason why the agricultural sector has decreased in importance during the growth process in industrial countries if sectoral incomes are measured either as percentages of the GNP or as the ratio of the labor force engaged in the agricultural sector to the total labor force. If this process of a shrinking agricultural sector is to be slowed down, or even stopped, and the income disparities between the agricultural and the other

[1] The most appropriate plants for biomass production are rapidly growing tree species, rape, and China reed (miscanthus sinensis). With the latter first experiments have been made in Northern Germany on fallow land; some problems were connected with high wind velocities which had a negative impact on the crop yield, so that a new breeding of better adapted species is necessary.

[2] Hemp production is currently extremely restricted because of drug policy imperatives. New hemp species will help to solve that problem.

[3] In British Columbia especially the virgin rain forests in large areas are harvested totally with an irreversible loss of biodiversity.

branches at least be reduced, farmers have to concentrate on the production of goods which show high income elasticities.[1]

In the Western economies, therefore, many farmers have specialized in tree-nursery and plant-cultivation because of the increasing demand of private house owners; but also the production of vegetables and fruit is often profitable, especially if the products have been grown by bio- or eco-methods. Nearly all agricultural goods stemming from a biological production are characterized by high income elasticities, and a large number of German consumers, naturally out of the higher income groups, are ready to pay much higher prices than for conventional products. In consequence, the profitability of eco-farms is often considerably higher than that of conventional ones, this in spite of lower labor productivity and higher costs - not to mention the psychological effects for the farmers, who become aware of working in partnership with nature and protecting their soils for the coming generations.

It is obvious that such specialization is heavily dependent on the areas where the single farms are situated; here the Thünen circles are mentioned which are concentric and show a decreasing intensity of soil production with increasing distance to the central spot of consumption. The importance of Thünen's theory has temporarily been neglected due to the improved infrastructure and transport systems. Transportation itself is connected with an enormous energy input and tremendous negative external effects, so that a reliable regional agricultural policy is significantly constrained by transportation considerations.

Other opportunities for farmers are involved in the production of renewable resources besides the above already mentioned, namely: wind energy. Productivity and profitability again depends on the geographical location and the connecting wind velocities. Reliable studies for Germany have shown that especially in the coastal areas on the North Sea and the Baltic the use of wind energy by modern wind mills can contribute up to 2 or 3 percent of the total electrical energy production (see MÜLLER 1992). In the meantime, even in the German highlands the first wind mill parks have been constructed and are profitably running, so that an optimistic forecast would lead to a share of wind energy which could come close to 5 percent within the next decade, with regional shares which are much higher. It is quite clear that in Southern European countries solar energy production is another challenge, but realistically (and hopefully!) not for Germany and Poland.

Dependent once again on the location, tourism has become an important and additional income source for a large part of the farmers; especially the ecotone concept which preserves or even

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[1] And this rule is a general one for the total economic system which regrettably is overwhelmingly neglected as the enormous subsidies for „old" goods prove (e.g., coal mining, steel production, ship-building, agricultural production, etc., etc., etc.).

restores the virgin river near landscapes is favorable for the further development of recreational activities. The same is true for biomanipulation which increases biodiversity and makes an area much more interesting for people who like to enjoy „pure“ nature, which is, and will remain, a scarce product characterized also by high income elasticities. And all these activities are important on a national and international level. Regional and international competitiveness is dependent on the evaluation of the quality of the goods which are supplied by the national and international consumers. We are often confronted with the opinion that environmental protection is connected with additional costs and that it impairs the competitive ability of regions or - even worse - is a serious competitive disadvantage. In our normative setting this is an extremely short-sighted view: if it is correct that without adaptations a serious energy crisis is ahead and irreversible environmental damages will occur, then those countries will survive which are marching at the head of the environmental movement. If we change the structures today, we will have induced technical progress and new productive structures just in time. Energy saving and non-polluting products (including technologies and machinery) will be highly competitive and serve as the base for future economic progress without impairing the chances of future generations. However, we all know people who ask, what have the future generations done for us. But is it ethical to ask this question?

The change from conventional to ecological farming would create many ecological and economical advantages. If increasing wealth is granted, bio-products are assured a future. Because of tremendous obstacles, especially political reservations and resistance, new marketing strategies are of utmost importance. Agricultural bio-products and „soft“ tourism are promising goods which increase the ability to compete in the European and world markets. The less densely populated and low-wage countries especially have comparative advantages in such productions. What is needed is a modern organization of the agricultural sector and federations which, especially in Germany, are currently characterized by exaggerated conservatism and traditionalism - hence inflexibility and immobility regrettably do not only rule in our land! What is badly needed are not peasants who follow an ideology of „blood and soil“, but farmers who have the abilities of Schumpetarian entrepreneurs and managers. And for the management of energy and other plants new forms of voluntary cooperatives have to be developed - all only possible if sufficient qualified human capital is available. An enormous task for the transfer of scientific knowledge and education on the different levels has arisen here.

V. Consequences in the Polish Example

For a short overview we will lay stress upon the employment structure and farm size, both being the most important components for a micro- as well as macroeconomic evaluation. In 1992 about 15 mio. people were employed in the Polish economy, and more than 4.1 mio. or 27.4 percent were engaged in the agricultural sector, about 87 percent of them on privately owned land. This percentage is more than 9 times as high as in the United States, 6 times as high as in Germany, and even 2.5 as high as in Spain, the latter as an example of the less developed EU countries.[1] The contribution of the agricultural sector to GNP in Poland in the same year was 8.2 percent, which is 6.6 times as high as in Germany (old states), 2.7 times compared to France, and 2.1 times compared to Spain.[2] The average number of employees per 100 hectares is in Germany only 7.9, whereas in Poland 28 persons are employed. On highly specialized crop producing farms and under favorable natural and locational constraints, this number is in Germany often less than 2.

If one takes the German model, which has a comparatively modern conventional agricultural sector for the EU, the adaptation of the Polish sector would lead to a loss of 3.5 mio. jobs. The current number of unemployed persons would rise from about 2.5 to 6 mio. people, thus increasing the unemployment rate from 16.7 percent in 1994 (see BELKA/KRAJEWSKI 1995) to nearly 40 percent - really a catastrophic and unrealistic figure. Even the adaptation to the Spanish figures would destroy 2.5 mio. jobs. A very careful agricultural policy is necessary in order to mitigate the consequences for the employment situation. There are two reasons why a strategy to introduce ecological farming would make a lot of sense and substantially reduce the pressures of excess supply on the labor market, with all the connected individual (psychological as well as real) but also social costs of unemployment. Firstly, there are some reliable estimations which point to the fact that the labor intensity in ecological farming is between 25 to 100 percent higher than in conventional farming, dependent on farm size and type. Taking an average 50 percent and - in view of the average farm size - the more realistic adaptation to the Spanish situation, the unavoidable reduction in employment within the agricultural sector could be reduced to a loss of about 1.7 mio. jobs (or minus 11.4 percentage points). And as long as the wage costs in Poland are considerably less than in the EU, this decrease in the number of jobs could be reached in the course of a long transition period in which the generative change will substantially reduce the social costs, the pressure on the labor market, as well as serious political problems.

Secondly, one must consider the enormous differences in the technical equipment and the input of artificial fertilizers. Polish farms are much less equipped with machinery than is the case within the EU; therefore, a technological change would destroy much less investment and

[1] See SOWADA (1994, pp. 16); the numbers are for the USA 2.9 percent, Germany 4.2 percent, France 5.8 percent, and Spain 10.7 percent.

[2] The numbers are for Germany 1.25 percent, for France 3.06 percent, for Italy 3.28 percent, and for Spain 3.99 percent. The comparison of the two ratios makes it obvious that the rate of employed persons is much higher than the rate to the total GNP; this points to the above mentioned income disparity between the agricultural and the other sectors of the economies. The average income in the agricultural sector is therefore much lower, but it is also important to mention that the personal income distribution within the agricultural sector is much more uneven (or concentrated) than in the other sectors.

capital, increasing the acceptance of such a change. While in 1989/90 the input of artificial fertilizer was on an average European level, as a consequence of the „Big Bang"-crisis of 1990 to 1992 (see BELKA/PETERSEN 1995) and increasing prices (partly due to the adaptation to world market prices), this input was drastically reduced.[1] This reduction is already half the way to ecological production. A decrease in the demand for artificial fertilizer has therefore already taken place, partly connected with a corresponding loss of jobs within the chemical industry. This fact reduces the resistance of this sector and the relative prices favor the use of natural manure at least in the early transition period.

Another fact worth mentioning is the possibility that a large part of the farmers may be able to stay on their land and work at part-time jobs in the newly created agro-industrial plants and cooperatives; it is pure speculation to give a precise number, but some ten-thousand would be no exaggeration. Part-time farming is also popular in many states of Germany; and this perspective leads to the second, very serious Polish problem: the small farm size compared to the EU-average. Table 1 shows the farm size structure in different Polish regions and on the national average. Nearly 90 percent of the farms are clearly below the levels which are held as profitable within the EU.

Table 1: Farm Size Structure in the Private Agricultural Sector in Poland

		Number of farms	Farm size in hectar			
			1-5	5-10	10-15	> 15
Total	1988	4 584=100	40,8	31,1	16,9	11,2
	1992	4 333=100	42,9	29,0	16,6	12,6
Region Mid-west	1988	595=100	27,4	25,7	23,9	22,5
	1992	547=100	26,2	24,5	23,9	24,9
Region Central Pol.	1988	398=100	39,5	42,0	19,8	8,5
	1992	384=100	40,6	37,5	19,8	9,4
Region Warsaw	1988	593=100	45,4	36,9	23,4	7,8
	1992	566=100	43,4	35,3	23,0	8,0
Region Mid-east	1988	470=100	42,5	41,2	24,1	6,4
	1992	452=100	40,7	39,6	21,5	7,7
Region South-east	1988	1 139=100	66,6	29,2	4,1	0,1
	1992	1 107=100	67,4	27,8	3,7	1,1
Region South	1988	512=100	59,5	25,9	10,5	4,1
	1992	446=100	59,9	24,0	10,3	5,8
Region South-west	1988	318=100	30,2	34,5	16,7	18,6
	1992	306=100	30,4	28,4	20,3	20,9
Region North	1988	220=100	24,6	17,7	34,5	23,2
	1992	208=100	26,0	14,9	30,7	28,4
Region North-east	1988	339=100	15,6	23,3	24,5	36,6
	1992	317=100	14,5	21,5	22,4	41,6

Source: estimated from SZEMBERG (1993, p. 22). (übersetzen von Sowada AP)

[1]From 164 to 62 kilogram per hectare: phosphorous from 41 to 12, nitrogen from 69 to 34, carbonate from 54 to 16, and calcium from 182 to 117 kilogram. The influences on the crop yield are not yet very obvious (see SOWADA 1994, pp. 10).

Peasants work on 80 percent of the arable land, and 2.7 mio. farms exist. The average farm size was 6.3 hectares in 1992. Most of the farms (1.1 mio.) are less than 5 hectares and nearly all are used for full-time farming. It is not surprising that the average real income per capita is extremely low compared to EU standards. During the long-term transitional process mentioned above the farm size has to be increased substantially. This process has to be supported by agricultural policy. The conditions for land leasing have to be improved; the rational sale of land especially has to be organized because currently an enormous excess supply of arable land exists which reduces the land value. At such prices farmers feel expropriated and this impairs their readiness to sell. Therefore, arable land does not come into the most efficient and productive hands.

Another very serious obstacle exists which cannot be kept secret and could endanger the perspective given here. The EU agricultural price system should actually be in accordance with traditional, bio-industrial production methods, but has instead pressed the farmers of the member countries into a situation of ever increasing farm sizes and livestock keeping methods, and therefore to a large extend produced the polluting consequences of agricultural production. Therefore, it is questionable if our described strategy would be feasible if Poland were to join the EU very soon. European integration has had besides the indisputable positive effects of peace and wealth in Western Europe enormous negative external effects - the agricultural system is quite ridiculous and has to be totally reformed. But the resistance of all the interest groups involved has up to now always been successful. In view of these costs of integration, Poland and other countries of Mid and Eastern Europe should make some rational estimations as to whether this price is not too high.

VI. Summary and Some Political Conclusions

The last problem directly leads us to the question of why rational perspectives exist but are not transformed into practical political measures or reforms. It could be possible that our above stated normative positions are not shared by the majorities in our existing democracies, but it is my impression that that is not very likely. People with conservative values, those who are closely bound to distributive justice, intergenerational equity, or to biocentric world views together are in a majority position. If this is the case, then imperfect information and individual or collective illusions might be the reason, which can only be remedied by information policy and education. So-called personal or group interests are the main obstacles; because older generations are not informed about what today is called Modern Political Economy or public choice theory, they follow a romantic state theory approach in which the state and its institutions are always considered benevolent and much more efficient than other societal instruments (see PETERSEN 1995). In former times we have complained about market and even moral failures and increased state interventions.[1] Nowadays governmental, political, bureaucratical, and even democratical failures are gradually surfacing in the consciousness of many individuals. The peaceful revolution in the former countries of realized socialism has contributed towards enlightenment even in the West. The spreading liberal ideas (in the sense of the European continental view) will help to overcome these political obstacles.

We are still confronted with ideological positions and even today a large number of colleagues from the natural sciences, philosophy, and especially Christian theology are of the opinion that economic science is a theory of greed, egocentricity, spite, evil and envy. Because economists deal with the problem of scarcity, which is a problem on earth and not in paradise, economists are far form heaven and bound to hell. Fortunately, an increasing number of scientists are once again working on a multidisciplinary level and have overcome old prejudices and the limits of their subject areas. The open minded have found a lot of interesting and helpful information on ecology and economics. Both present a large amount of possible counter-measures able to solve global as well as regional environmental problems. As an economist I want to point out the fact that markets, political-economic considerations, institutional economics, evolutionary economics - closely bound to biology[2] -, and last but not least ecological economics will contribute much. The very popular trade-off between economics and ecology has been falsified and will be falsified even more in the future.

Scientists must realize that specialization in science has also had negative external effects; the famous German expression „Fachidiot“ has its validity. The solution of the pressing problems of the future requires that scientists free themselves from the „envy trap“ in which they were caught. Natural sciences and social sciences without any philosophical basis can only be bad sciences. I would like to close this very general overview and guideline with the hope that a bit more universal orientation in the direction of Aristotle's view of the Unity of Sciences will gain in influence at our universities; the risks and uncertainties which are always involved in considerations of the future are much easier to be dealt with if we have an ethical foundation of scientific responsibility. Without the revival of many traditional values and the formulation of some new ones, that is to say a clear moral foundation, even the best diagnoses, therapies, biological and technical devices, and cost-benefit-analyses will fail.

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[1] For an efficient combination of the societal instruments (family, moral, law, and market) in Western style open societies see PETERSEN (1993).

[2] Perhaps this is one reason for Aaron's statement that the „... currently most exciting science of them all ...“ (AARON 1994, p. 11) is biology.

Literature:

Aaron, H.J.: Distinguished Lecture on Economics in Government: Public Policy, Values, and Consciousness. In: Journal of Economic Perspectives, Vol. 8, 1994, pp. 3 - 21.

Belka, M. and H.-G. Petersen (Ed.): Transformation in Poland - Reforms of Institutional Settings and Macroeconomic Performance. Campus, Frankfurt, New York 1995 (forthcoming).

Belka, M. and St. Krajewski: Polish Transformation After Five Years - Some General Remarks. In: M. Belka and H.-G. Petersen (Ed.): opt. cit., forthcoming.

Bertalanffy, L. von: General System Theory: Foundations, Development, Applications. New York, 1968.

Boulding, K.E.: The Economics of Love and Fear. Wadsworth Publishing Company, Belmond/Cal. 1973.

Braat, L.C. and I. Steetskamp: Ecological-economic Analysis for Regional Sustainable Development. In: Costanza, R. (Ed.): opt. cit., pp. 269 - 288.

Clark, M.E.: Rethinking Ecological and Economic Education: A Gestalt Shift. In: Costanza, R. (Ed.): opt. cit., pp. 400 - 415.

Cleveland, C.J.: Natural Resource Scarcity and Economic Growth Revisited: Economic and Biophysical Perspectives. In: Costanza, R. (Ed.): opt. cit., pp. 289 - 317.

Constanza, R., H.E. Daly, and J.A. Bartholomew: Goals, Agenda, and Policy Recommendations for Ecological Economics. In: Costanza, R. (Ed.): opt. cit., pp. 1 - 20.

Costanza, R. (Ed.): Ecological Economics: the Science and Management of Sustainability. Columbia University Press, New York, Oxford 1991.

Costanza, R.: Embodied Energy and Economic Valuation. In: Science, 1980, 210:1219.

Feigenbaum, M.J.: Universal Behaviour in Nonlinear Systems. In: Los Alamos Science, Vol. 1, 1980, pp. 4 - 27.

Funtowicz, S.O. and J.R. Ravetz: A New Scientific Methodology for Global Environmental Issues. In: Constanza, R. (Ed.): opt. cit., pp. 137 - 152.

Hall, C.A.S., C.J. Cleveland, and R. Kaufman: Energy and Resource Quality: The Ecology of the Economic Process. Wiley-Interscience, New York 1986.

Jansson, A.: On the Significance of Open Boundaries for an Ecologically Sustainable Development of Human Societies. In: Costanza, R. (Ed.): opt. cit., pp. 449 - 458.

Klötzli, F.A.: Ökosysteme. 3. ed., Gustav Fischer Verlag, Stuttgart et. al. 1993.

Malthus, T.R.: An Essay on the Principles of Population. London 1826. German translation by Diehl, K. and P. Mombert (Ed.): Ausgewählte Lesestücke zum Studium der politischen Ökonomie. 6. Band: Bevölkerungslehre. Verlag G. Braun, Karlsruhe i. Br. 1912, pp. 47 - 73.

Markl, H.: Natur als Kulturaufgabe. Über die Beziehung des Menschen zur lebendigen Natur. Knaur, München 1991.

Mitsch, W.J.: Ecological Engineering: Approaches to Sustainability and Biodiversity in the U.S. and China. In: Costanza, R. (Ed.): opt. cit., pp. 428 - 448.

Müller, K.: Möglichkeiten und Grenzen der Nutzung regenerativer Energien - das Beispiel Windenergie. In: Finanzwissenschaftliche Arbeitspapiere, No. 43, Gießen 1992.

Nagel, Th.: Umweltgerechte Gestaltung des deutschen Steuersystems. Theoretische und empirische Analyse der Aufkommens- und Verteilungseffekte. Campus, Frankfurt, New York 1993.

Odum, E.P.: Prinzipien der Ökologie. In. Spektrum der Wissenschaften, 1991, pp. 305.

Odum, H.T.: Environment, Power, and Society. Wiley, New York 1971.

Perrings, Ch.: Reserved Rationality and the Precautionary Principle: Technological Change, Time and Uncertainty in Environmental Decision Making. In: Costanza, R. (Ed.): opt. cit., pp. 153 - 166.

Petersen, H.-G.: Finanzwissenschaft I. 3. ed., Kohlhammer Verlag, Stuttgart et. al. 1993.

Petersen, H.-G.: Moderne Politische Ökonomie - ihr Beitrag zur Lösung der Krise der Demokratie. In: B.-O. Bryde and C. Leggewie (Ed.): Triumph und Krise der Demokratie. Verlag Ferber, Gießen 1995 (forthcoming).

Petersen, H.-G.: Ökonomik, Ethik und Demokratie. Zu einer Theorie der Effizienz und Gerechtigkeit offener Gesellschaften. Nomos, Baden-Baden 1993.

Petersen, H.-G.: Politische Ökonomie von Nationalismus und Migration. In: R. Hasse and W. Schäfer (Ed.): Die Weltwirtschaft vor neuen Herausforderungen. Vandenhoeck & Ruprecht, Göttingen 1994, pp. 229 - 258.

Ruelle D.: Strange Attractors. In: The Mathematical Intelligencer. Vol. 2., 1980, pp. 126 - 137.

Schaefer, M.: Ökologie. 3. ed., Gustav Fischer Verlag, Jena 1992.

Schaffer, W.M. and M. Kot: Do Strange Attractors Govern Ecological Systems? In: Bio-Science, Vol. 35, 1985, pp. 342 - 350.

Schiemer, F. and M. Zalewski: The Importance of Riparian Ecotones for Diversity and Productivity of Riverine Fish Communities. In: Netherlands Journal of Zoology, Vol. 42, 1992, pp. 323 - 335.

Sowada, Ch.: Landwirtschaft im Systemumbruch am Beispiel Polens. Ausgewählte Probleme aus ökonomischer Sicht. In: Finanzwissenschaftliche Arbeitspapiere, No. 46, Gießen 1994.

Szemberg, A.: W wolnym tempie. In: Zycie Gospodarcze, 05.23.1993, Nr. 21, p. 22.

Tiezzi, E., N. Marchettini, and S. Ulgiati: Integrated Agro-industrial Ecosystems: An Assessment of the Sustainability of o Cogenerative Approach to Food, Energy and Chemicals Production by Photosynthesis. In. Costanza, R. (Ed.): opt. cot., pp. 459 - 473.

Walter, H. and S.-W. Breckle: Ökologie der Erde. Bd. 1: Ökologische Grundlagen in globaler Sicht. Stuttgart, 1983.

Weikard, H.-P.: Der Beitrag der Ökonomik zur Begründung von Normen des Tier- und Artenschutzes. Eine Untersuchung zu praktischen undo methodologischen Problemen der Wirtschaftsethik. Duncker & Humblot, Berlin 1992.

World Commission on Environment and Development (WCED): Our Common Future. Oxford University Press, Oxford 1987.

Zuchetto, J.J.: Ecological Economics and Multidisciplinary Education. In: Costanza, R. (Ed.): opt. cit., pp. 416 - 427.