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The role of aquaculture for assuring the sustainable development of our society

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Abstract. Economic activities, industrial and agricultural ones, have the direct goal to help increasing the quality of life of our society. Beside positive direct and desired effects of the economic activities, these have also negative, undesired and sometimes unthinkable effects on the environment and society. After the Conference for Environment in Stockholm in 1972 and the first report to the Club of Rome, "Limits to Growth", was understood that besides wanted effects of technological progress, undesired negative effects can appear. In this context the concept of sustainable development has been for the first time defined 1987 in the Brundtland-Report and is nowadays very much discussed on different levels. Considering the sustainability of our society it is necessary to evaluate all economic activities, aquaculture as well, not only from economic and technical points of view, but from environmental and social ones as well. The concept of sustainable aquaculture has been developed and tries to take into consideration all the aspects related to assuring the sustainability of our society on a global level.
Key Words: aquaculture, sustainable development, global problems, sustainable aquaculture, environmental impacts.

Rezumat. Activitățile economice, cele industriale, cât și cele agricole, au scopul direct de a conduce la creșterea nivelului de trai al oamenilor. Însă, pe lângă efectele pozitive și dorite ale diverselor activități economice, acestea pot avea și impact negativ, nedorit și uneori de neimaginat asupra mediului și societății. În special după Conferința pentru Mediu care a avut loc în Stockholm în anul 1972 și după apariția primului raport al Clubului de la Roma, "Limitele creșterii", s-a înțeles că progresul tehnologic, pe lângă efectele dorite, poate avea și impact negativ și nedorit, chiar de neimaginat până atunci. În acest context al discuțiilor la nivel global, conceptul Dezvoltării Durabile a fost definit pentru prima data în 1987 în Raportul Brundtland și în prezent este dezbătut la diferite nivele cu ocazia diverselor evenimente științifice și politice. Luând în considerare asigurarea dezvoltării durabile a societății noastre, evaluarea tuturor activităților economice umane este necesară, inclusiv activitățile legate de acvacultură, nu numai considerând aspectele economice și tehnice, ci mai ales aspectele ecologice și sociale. Conceptul acvaculturii durabile a fost dezvoltat în ultimul timp și încearcă să considere toate aspectele legate de asigurarea dezvoltării durabile a societății noastre la nivel global.
Cuvinte cheie: acvacultură, dezvoltare durabilă, probleme globale, acvacultură durabilă, impact asupra mediului.

Introduction. The Concept of Sustainable Development. After the Conference for Environment in Stockholm in 1972 and the first report of the Club of Rome "The Limits of the Growth" 1972 (Meadows et al 1972) it was understood that besides wanted effects of technological progress, undesired and negative effects can appear. Nowadays we confront us with a series of global problems, which can be grouped in three categories: world population growth, growth of the energy and natural resources consumption and environmental pollution (Meadows et al 1972; Jischa 2005).

They can be called "old" problems: growth of world population, increase of energy consumption and environmental pollution. Other issues have arisen in the last years and they can be called "new" global problems. For instance issues related to the use of ICTs can be mentioned in this category (Tulbure 2003; Jischa 2005).

In the Brundtland Report for the first time the concept of *sustainable development* has been defined and accepted as a possible solution for the global complex ecological, economical and social problems (Hauff 1987). This concept was very large discussed on

the Conference for Environment and Development in Rio de Janeiro 1992 as well as approached in the closing document „Agenda 21" (Engelhardt & Weinzierl 1993) and during the Johannesburg Conference in 2002. Many actions after this time emphasise that the evolution of technical, social and ecological systems has to be analysed in synergetic relation (Tulbure 2003). The general Brundtland definition was worldwide accepted, but alone does not deliver a concept, that can be applied to the real concrete situations.

The operationalisation of the concept of sustainable development means the transformation or translation of its goals in political measures and controlling instruments. A general methodology in order to operationalise sustainable development can be materialized in following steps (Tulbure 2003; Jischa 2005):

- defining the sustainability problem;
- establishing the space and time scales;
- systemic approach of the region by modelling the interactions;
- establishing concrete aims for the studied case;
- developing concepts and measures by establishing priorities;
- developing evaluation and control instruments, indicators;
- verifying the possible results, which could be obtained after introducing the proposed measures, comparing different scenarios;
- applying in the practice the developed concept.

The operationalisation of sustainable development is only possible, when for an individual problem-case concrete aims are established and from these aims concepts to achieve them are developed. Sustainability is to be for each different case newly defined. The space and time scales are to be established for each case.

There are several levels to apply the concept of sustainable development. On a global level this means to define general goals for the whole world, things which happened more or less with the Rio-Conference. On a national level this means to define goals paying attention to the specific conditions of a country. On regional or local level concrete measures represent the content of the Local Agendas 21. But what about applying sustainable development on the level of companies, of industrial processes or of products? In this field the operationalisation of sustainable development means to use instruments or tools of the pretty new discipline called Technology Assessment (TA) (Tulbure 2010).

Part of what engineers and professionals do is to evaluate developments in technology and other economic fields. Their evaluation has up to now almost without exception been focused on technical aspects and on economic aspects following legal and financial boundary conditions. With respect to sustainability more criteria have to be considered like: environmental quality, social and human values, quality of life. This means, the activities of engineers and other professionals when evaluating different economic activities, technologies and agricultural ones basing on certain technical applications, can be sustained by Technology Assessment (TA) (Grunwald 2002; Jischa 2005; Tulbure 2010). Although in the last 20 years it was a lot of progress in the field of technology assessment especially due to several studies which have been carried out in USA, Japan, Germany and other European countries, there is still need in developing integrative methods for Technology Assessment (Ludwig 1995; Tulbure 2010) and applying these in other economic fields, especially in aquaculture related activities.

Sustainable Aquaculture. On a global level about 520 million people depend on fisheries and aquaculture as an important source of protein and income. For 400 million of the poorest of these, fish provides half or more of their animal protein and dietary minerals. This means that the impacts that climate change will have on world fisheries and aquatic ecosystems have to be carefully analysed and understood (Bardach 1997).
Regarding the wish to increase the global fish production and to meet rising demand for fishery products, aquaculture is currently playing, and will continue to play, an important role. The Food and Agriculture Organization FAO, especially the specific Committee on Fisheries (COFI) pointed out several times the increasingly important and complementary

role of aquaculture and inland capture fisheries in fish production for human nutrition and poverty alleviation in many rural areas on a global level (Bardach 1997).

Aquaculture, in common with all other food production practices, is facing challenges for sustainable development (Bardach 1997). Most aqua-farmers, like their terrestrial counterparts, are continuously pursuing ways and means of improving their production practices, to make them more efficient and cost-effective. But in the same time, the awareness of potential environmental problems has increased significantly. Efforts are under way to further improve the resource use and environmental management in aquaculture. It was emphasized enhancement of inland fish production through integrated aquaculture-agriculture farming systems and integrated utilization of small and medium-size water bodies. The effects of these newer tendencies have to be carefully analysed and understood.

The traditional, extensive aquaculture does not per-se assure the sustainable development of our society, because there are some impacts, that have been until now not carefully enough analysed and considered. So, the classic aquaculture means that fish can be bred in open waters such as lakes, estuaries or coastal bays, where they feed on naturally available nutrients, or in farm ponds, where they can be fed with by-products from the farm. For example, traditionally in China, more than five species of carp are bred together to make the best use of feeds and ponds.

The promotion of sustainable aquaculture development requires that "enabling environments", in particular those aimed at ensuring continuing human resource development and capacity building, are created and maintained (Bardach 1997). The FAO did show interest for solving this aspect and developed a Code of Conduct for Responsible Fisheries, which contains principles and provisions in support of sustainable aquaculture development (Bardach 1997). The Code recognizes the Special Requirements of Developing Countries, and addresses in particular these needs, especially in the areas of financial and technical assistance, technology assessment and transfer, training and scientific cooperation.

There are a number of conditions an aquaculture operation must respect in order to be sustainable. Among other things, in order to be sustainable an aquaculture operation has to respect following requirements (Bardach 1997):

- continually moving towards plant-based feeds originating from sustainable agriculture;
- not to use fishmeal or fish-oil-based feeds from unsustainable fisheries and not to represent a net loss in fish protein yield;
- not to use wild-caught juveniles;
- only cultivates species that are native in open water systems, and then only in bag nets, closed-wall sea-pens or equivalent systems (if there is cultivation of non-native species, it must be restricted to land-based tanks);
- not to have negative environmental impacts in terms of discharges and effluents to the surrounding areas;
- not to have negative effects to local wildlife (plants as well as animals) or not to represent a risk to local wild populations;
- not to use genetically engineered fish or feed;
- to use stocking densities that minimize the risk of disease outbreaks and transmission;
- to avoid depleting local resources, for example, drinking water supplies and mangrove forests;
- not to threaten human health;
- to support the long-term economic and social well-being of local communities.

Achieving sustainability in aquaculture requires adhering to a full set of measures and cannot be reached through simply implementing one or two (Bardach 1997). The operationalisation of sustainable development means concretely applying so-called integrative methods, which take simultaneously into account technical, economic, environmental and socials aspects (Tulbure 2003; Jischa 2005).

Technology Assessment (TA). TA means after (VDI-Richtilinie 2000) the methodical, systematic, organised process of:

- analysing a technology and its developmental possibilities,
- assessing the direct and indirect technical, economic, health, ecological, human, social and other impacts of this technology and possible alternatives,
- judging these impacts according to defined goals and values, or also demanding further desirable developments,
- deriving possibilities for action and design from this and elaborating these,

so that well-founded decisions are possible and can be made and implemented by suitable institutions if need be.

When going through the given methodology for sustainable development one can recognize that many steps can be also identified in the phases distinguished in technology assessment (Ludwig 1995; Tulbure 2003). Very often a concrete sustainability problem especially related to a technological issue is to be solved by doing a TA-study. Or a TA-study has as a goal to research if a technology has negative effects on different domains, this means if the effects of a technology application do not conflict with the goals of sustainable development.

Operationalisation of sustainable development with technology assessment TA means analysing the complex dynamic environmental, economic and social systems in order to try to discover developments which lead to instabilities (Ludwig & Tulbure 1996). The concept of technology assessment equally how it is named, if Technology Evaluation, Innovation Research, System Analysis or others, brings together almost all of the scientific disciplines with the question of how sustainability can be operationalised (Grunwald 2002; Jischa 2005).

Technology assessment tries to give an answer to the question: Which are the technologies that we need, how are these technologies to be developed and how do they integrate into environment and society (Grunwald 2002)? These questions are in the present conditions of the East European countries from dominant importance, in the process of modernisation of old technologies and implementation of new technologies (Banse 2007). Technology assessment is the concept, which tries to answer exactly such questions. From this reason technology assessment has to play a central role in the next technological, economic, environmental and social development of these countries (Banse 2007).

Assessments for technological decisions are usually important and far-reaching, yet only rarely applicable to methodical solutions. Thus, it is the aim of an assessment to determine a scaling value of an alternative that represents its advantages in only a single expression (Grunwald 2002; Jischa 2005). The solution of this problem of selection will be especially difficult, if the following conditions hold:

- Many objectives are to be considered,
- Different assessment scales emerge,
- Objectives are weighted differently,
- Information is uncertain and may be subject to doubt,
- Problem is time-dependent,
- Many are to participate in decision making process,
- No unique criterion exists for decision making.

Therefore, a multidimensional assessment problem can be considered as a logical measurement operation (Ludwig 1995; Tulbure 2003). Consequently, one usually has to deal with complex and nonlinear systems, where many non-measurable qualities occur and interactions are at least partially uncertain.

Tools for Environmental Impact Assessment. In order to assess the possible effects of human activities, especially industrial and agricultural activities on environment, several tools, so-called instruments of technology assessment can be applied with respect to the question which has to be answered (Figure 1).

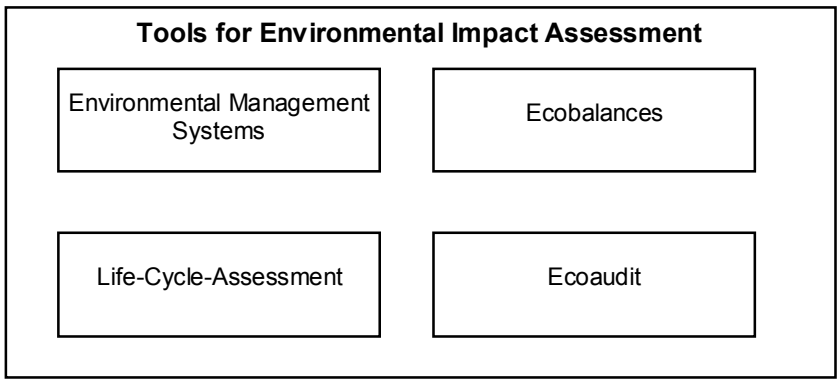

Figure 1. Tools for environmental impact assessment.

As it can be observed from the figure the most used and important tools for environmental impact assessment are the following (Ludwig 1995; Tulbure 1997; Jischa 2005):

- Environmental management systems
- Life-cycle-assessment
- Eco-Audit
- Ecobalances.

The most important one is the Life-Cycle-Assessment LCA. The other tools are also very often used depending on the concrete situation on company level, local or regional level. The legislative framework for environmental impact assessment exists from 1985 in the countries of the European Community (Banse 2007; Jischa 2005; Tulbure 2010).

In Germany for example the law concerning the examination of different public or private projects was promulgated 1990. In Romania there is a legislative regulation from 1994 through the Ordinance of the Minister for Water, Forests and Environmental Protection regarding the examination of potential impacts on the environment of economic and social activities (Ministry of Water, Forests and Environmental Protection 1994).

The analysis of the environmental effects has as a goal the assurance of activities which have as minimal impacts as possible on the environment. Going into details the followings have to be taken into account:

- possible results and consequences of a project have to be searched, described and evaluated and
- results of the analyses have to be delivered to the authorities which have to decide basing on the results.

In order to realize such an analysis the project which has to be certified must contain information about the project itself, proposed measures to diminish the negative effects, other alternatives etc. The application domain for these studies is represented by big projects or public projects. The requirements with respect to EIA of a project are the following: the assessments have to be transparent, public, the methods used are to be unified, and the results have to be comparable.

Ecoaudit. The Eco-Audit is a management tool for systematical, documented, periodic, objective evaluation of the environmental management in a company. The environmental management in a company as stated in the norms DIN-ISO 14000 represents the whole measures directed to organize and lead the activities in the company related with environmental protection including installations for environmental protection and for environmental monitoring.

The Eco-Audit is an instrument which works preventively with respect to environmental protection. By Eco-Audit the actual situation in a company is emphasized. The results state the degree with which the company respects the legislative measures and decrees in the field of environmental protection as well as the goal of the company.

Taking into account the results it improves the environmental protection program of the company.

It is remarkable that in this case it is aimed that companies take voluntarily part in with the conviction of gaining in the end economic advantages. It is to be mentioned that here also a big problem constitutes the database, that means collecting, processing and evaluating data and information from the company.

Ecobalance. The ecobalance or environmental performance evaluation represents an instrument for systematically analysis of products, processes or even companies or regions regarding environmental impacts (Beck 1993). The ecobalance can be performed as a singular study or as a comparative study. The ecobalance registers material and energetical flows when producing something, or within a process or within a company or a region.

An ecobalance is to be done in 4 steps (Beck 1993): definition of goal and scope; inventory analysis; impact assessment; and interpretation of results.

Life Cycle Assessment (LCA). The LCA is an analysis which registers all the effects on the environment of a product during its life "from the cradle to the grave", from the production to the consumption and recycling. The general life cycle of a product is considering besides production and consumption processes, also transport processes during the concrete production and during the usage phase of a product, so all transport processes within the life cycle of a product are taken into account (Grunwald 2002; Jischa 2005).

The life-cycle-analyses is appropriate to improve the production lines of products, to compare different products and to ecologically optimize the life-cycle of products. The LCA is in fact an ecobalance which can be performed as a singular study or as a comparative study. The ecobalance registers material and energetical flows when producing something, or within a process or within a company or a region. Such an analysis needs several steps (Ludwig 1995; Tulbure 2010):

a) definition of goal and scope;
b) inventory analysis;
c) impact assessment;
d) interpretation of results.

a) Definition of goal and scope - The goal shall unambiguously state the intended application, the reasons for carrying out the study and the intended audience, i.e. to whom the results of the study are intended to be communicated. In defining the scope of an LCA study, the following items shall be considered and clearly described: the functions of the product, the functional unit, the system boundaries, methodology of impact assessment, data requirements, assumptions, limitations.

b) Inventory analysis - It involves data collection and calculation procedures to quantify relevant inputs and outputs of a product system. These inputs and outputs may include the use of resources and releases to air, water and land associated with the system.

c) Impact assessment - It is aimed at evaluating the significance of potential environmental impacts using the results of the inventory analyses. The impact assessment may include elements as: assigning of inventory data to impact categories, modelling of the inventory data within impact categories and possibly aggregating the results in very specific cases and only meaningful. It is to be mentioned that the methodological and scientific framework for impact assessment is still being developed. Very often in the step of assessment aggregated indicators are used in order to allow a transparent evaluation.

d) Interpretation of results - in this phase the findings from the inventory analysis and the impact assessment are combined together. The interpretation takes the form of conclusions and recommendations to decision-makers, consistent with the goal of the study.

Results and Discussion. With respect to technology assessment and LCA applied for different aquaculture activities it has to be mentioned that presently very few examples can be found in this area (Bardach 1997; Jischa 2005). Anyway a difficult step is

represented by getting on data and information about different aquaculture processes. On the other hand in order to compare different life cycle stations of a product from the point of view of environmental and social impacts, like for instance pollutants emissions, a method has been developed and concretely applied for different industrial processes and economic activities at the Clausthal University of Technology (Ludwig 1995; Tulbure 2003; Jischa 2005). Until now there are few tryings to concretely apply this methodology of environmental impact assessment also for different products resulting from aquaculture and aquaculture related processes, first of all because of lack of aquaculture related data. This means that in the future more attention should be given to all these aspects related to aquaculture (Bardach 1997; Jischa 2005).

From the existing experience in the field of concretely applying LCA can be concluded that the get results related to sustainable aquaculture will surely emphasize the most difficult phases in the LCA, where the environmental impact, expressed for instance by pollutants emissions, is the biggest. It is to be mentioned that transport processes have to be taken into account as well. It is interesting to calculate emissions indicators in all life cycle stations for different products resulted from aquaculture, allowing in this way comparisons and assessments of different products. In this way dangerous and unsafe points in the aquaculture production lines can be found and measures to improve aquaculture production can be established. The results may emphasize that this methodology can be successfully applied.

Conclusions. For economic activities, not only industrial ones, also agricultural ones, the operationalisation of sustainable development could mean to lead technology assessment studies especially environmental assessments. The heightened awareness of the importance of environmental protection and the possible impacts associated with products manufactured and consumed has increased the interest in the development of methods to better comprehend these impacts.

The concept of sustainable development has begun to find its important place from global to local levels. On the other side several companies in Western Europe having practiced environmental optimisation of production processes recognised that by these means also economic advantages can be achieved. This gives example also to companies activating in the field of aquaculture and arises interest for environmental assessments.

There are several tools in order to evaluate environmental impacts of industrial activities like life cycle assessments (LCA), ecoaudit, ecobalances or environmental management systems. Life cycle assessments (LCA) are presently world-wide used to assess the environmental impact of different products, but the evaluation questions are still not satisfactory clarified.

In this paper the importance of making such environmental assessments also for aquaculture related activities has been pointed out, with regard to assuring the sustainable development of our society. It has been emphasised that the evaluation question is until now not sufficiently clarified and that there is a need to develop new assessment methods based on different aggregated emission indicators. There is some experience by using such indicators for analyzing the environmental impacts of different industrial and transport related economic activities. It would be interesting to apply these methods in the future also for the field of aquaculture for assessing the environmental and social effects of aquaculture, in order to assure the sustainable development of our society, so, at the end to develop a sustainable aquaculture.

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