Introduction to the Project – The Impact of Urbanization, Industrial and Agricultural Technologies on the Natural Environment

Miklós NEMÉNYI[a*]

[a]University of West Hungary, Faculty of Agricultural and Food Sciences, Institute of Biosystems Engineering
Correspondent Member of the Hungarian (National) Academy of Sciences
Vice Rector for Scientific and International Affairs

Abstract – The essential objective of the project is to analyse the impact of agriculture, forestry, industry and urbanization on the natural environment. The steady state means, that the diversity (entropy) gradient is keeping constant for a long time in order to utilize the agro-ecological potential and our life conditions in the cities. Our environment adapts continuously to the changing conditions: micro-evolutionary processes occur, and therefore resistant ecotypes and species are created. The models of knowledge evolution take entropy of the knowledge also into consideration. The presentations based on the research activities of the project should contribute to the increase of the accuracy of footprint calculation methods in the Carpathian basin and to the quality improvement of dynamic modelling of ecological systems that involve also agro-ecology, urbanization and industry.

Keywords: energy input-output models / biomass / sustainability / thermodynamic approach of agro-ecology / entropy of knowledge

The TÁMOP 4.2.1.B-09/1/KONV-2010-0006 is an EU project having the title and aiming at "The improvement of the quality of higher education through the development of research-development-innovation-education…" At the same time this is also a "Research University Proposal".

When we were developing the conception during the project preparation period, we had the following starting points:

1. What are the scientific and technological research areas in which more faculties of the University of West Hungary could take part in?
2. Whether we had significant research results in the chosen research topics?

We have got faculties in five cities of the Western Transdanubia region. Not to the same extent, but faculties in all the five towns are participating in the program.

Looking at the conference programme, everyone can see that we have chosen areas of environmental protection and ecology. Even so, since five of the six doctoral schools of our university indirectly but very intensively and one of them – namely the Kitaibel Pál Doctoral School of Environmental Science – directly deal with these areas and topics of science.

On the other hand, we have previously had several projects related to climate change, change of ecological conditions etc.

The basic aim of the project is to analyse the impact of urbanization, agricultural technologies, forest management technologies and industrial activity on the natural environment.

* Corresponding author: nemenyi@mtk.nyme.hu, H-9200 Mosonmagyaróvár Vár 2., Hungary

The programme has five sub-programmes:

- Preservation and sustainable utilization of our natural heritage;
- Complex study of urban eco-environment in the Western Transdanubia Region;
- From field to fork (Agricultural sub-programm);
- Investigation and research methodology of biotic and abiotic environments;
- Technical innovations for regional economic development (Industrial sub-program).

The first topic relates to the other four, or more precisely, the other four relate to the first one.

The main objective of sub-programmes one and four is to analyse the condition changes in living habitats and environments, a large number of research activities in sub-programme four analyses the modifications in abiotic environments, while sub-programme two analyses the negative effects of urbanization on our living environment. All listed sub-programmes deal with unfavourable changes, but they implement an approach that provides a basis for solutions. Sub-programme three analyses the impact of agricultural technologies on nature. The most modern scientific analysis and high-standard innovation processes are realised in programme five. It is important to emphasize that this sub-programme concerns the social context of the problem area, too. At the same time, the sub-programme deals with reduction of energy input and the large-scale analysis of recycling possibilities in industrial processes.

Regarding relations between the topics from scientific and practical points of views, industry shows the clearest answer, because the up-to-date industrial processes are closed: pollutants can not escape into the environment. Here the basic problem is that the large factories of multinational companies occupy arable lands and in some cases even nature protected areas. Rehabilitation of these areas takes long time. Consequently, the long-term goal of scientific activity should be to provide the scientific condition of (the scientific basis for investigating) closed systems in the urbanization process, in agricultural and forest management technologies. Regarding the transport sector, it means that fuel should be originated from renewable sources. To fulfil this expectation, the CO_2-neutral bio-fuel production should be realised. Nowadays, propellants and nitrogen fertilizers used in the crop production are produced from fossil based energy sources.

The philosophy of the project follows the opinion of the Hungarian scientist John von Neumann: “The sciences do not try to explain, they hardly even try to interpret, they mainly make models.” (GASTON,1955)

All oral and poster presentations of the conference will contribute to this principle.

The scientific antecedents go back to the 1930s. The anthropogenic effects did not appear at that time to the extent that they appear today. However, the need to describe ecological systems with a systematic approach did come up. It was based on the ”General System Theory” of Ludwig von BERTALANFFY (1969), who is considered to be one of the most significant theoretical biologists. (It should be mentioned, that the first study of BERTALANFFY et al. in this field was published in 1951.) ODUM (1983) was one of the first scientists who created the base of systems ecology and suggested using the laws of thermodynamics while describing ecological systems. (It should be noted, that FORRESTER (1961) published first the fundamentals of system dynamics related to industrial systems using the information-feedback control theory. His book served as the base of the development of systems ecology.) The publications of JØRGENSON (2001) are remarkable in this area. JØRGENSON and SVIREZHEV (2004) defined the thermodynamic characteristics of agro-ecology, too. The most unambiguous advantage of thermodynamic modelling is that both micro- and macro-level phenomena can be described as a uniform approach.

Thanks to the anthropogenic impacts, the diversity (entropy) of the global and local ecological systems has been reduced, and at the same time gradients between diversity of the biological environment and the diversity of the cultivated and urban area have increased. The

2nd law of thermodynamics is that systems aim at the greatest entropy, at the cessation of the gradient of intensive state variable. I must add that the economic systems have this characteristic, too (RUTH, 1993). Urbanisation, embedding in natural environment, forest management, agricultural and industrial technologies result in constant increase of the above-mentioned gradient.

The results of this are as follows: “The list of threats to the life support system in which we are embedded is overwhelming: deserts are encroaching on ecologically productive areas at the rate of 6 million hectares per year; deforestation claims over 17 million hectares per year, soil oxidation and erosion exceeds soil formation by 26 billion tonnes per year; fisheries are collapsing; the draw-down and pollution of ground water accelerates in many places of the world; as many as 17,000 species disappear every year; despite corrective action, stratospheric ozone continues to erode; industrial society has increased atmospheric carbon dioxide by 28 percent. All these trends are the result of either over-exploitation (excessive consumption) or excessive waste generation.” (WACKERNAGEL and REES, 1996)

Although I do not agree with every detail of the book, the above-mentioned thoughts and data speak for themselves. Unfortunately, since the formation of the Roman Club in 1968, (although the problems have been defined earlier, e.g. in Rachel Carson’s Silent Spring (1962), the initiatives of the governments to solve global problems have not turned out to be efficient: regional, mainly high-power interests have overcome global “common sense”.

MOROWITZ (1968) citing BRIDGEMAN wrote: “It springs to eye that the tendency of living organisms is to organize their surroundings, that is, to produce ‘order’ where formerly there was disorder.” Consequently, the following question comes up: if all species in the nature have the right to make order in their surroundings in order to get more energy or to increase their living conditions, then why can not humans do it, too.

The answer is given by MARGULIS (1998) citing LOVELOCK: “No organism feeds on its own waste … One organism’s waste is another’s food. Failing to distinguish anyone’s food from someone else’s waste, the Gaian system recycles matter on the global level…The sum of planetary life, Gaia, displays a physiology that we recognize as environmental regulation.”

To summarise, the fundamental question is: Who eats whom? In the anthropogenic system such regulation does not work. The most difficult challenge for scientists is to find a regulation system that contributes to the steady state conditions and sustainability, respectively.

Let me highlight the biological systems in which the energy output is larger than the technological energy input: crop production and forest management, including energy crop plantation. The question is how the technological energy input – taking also the ecological aspect into account – can be optimized: where is the limit of “order” making. It is very important for the purposes of “self-regulation” models. („Till now man has been up against Nature, from now on he will be up against his own nature.” Dennis GABOR, Hungarian Nobel Laureate in Physics in 1971.)

On the other hand, there is another very important view-point, namely the perfect utilization of agro-ecological systems (expectation of the greatest possible biomass production).

The pioneer scientist of the energetic analysis of agricultural technologies is David PIMENTEL, professor of the Cornell University. He has colligated most important scientific studies in the field of energy utilization in agriculture, and edited a very interesting book cooperating with a lot of scientists (PIMENTEL, 1980). The Handbook of Energy Utilization in Agriculture is a basic source. Such static database can provide proper information for utilization of technological energy input models.

The diagram shows the theoretical energetic situation in the crop production.

It is obvious that the increment of the energy difference function provides the optimal energy input (direct ones: fuels and indirect ones: pesticides, insecticides, fertilizers etc.), and at the same time, also the maximum energy difference. Such diagrams can be created for fertilizing, soil tillage, or even for plant protection, weed control etc. The maximum technological input denotes simultaneously the minimum diversity (entropy), too. The natural environment provides without any energy input the maximum diversity (entropy), but at the same time it is the minimum energy (biomass) difference. The steady state means: $E_{difference}$ = constant in order to utilize the agro-ecological potential. To keep it constant in the long run, we should continuously increase the energy inlet. The reason for that is that in the surroundings of arable land micro evolutionary processes take place continuously forming new resistant micro-ecotypes or species. Using more energy inputs, first of all chemicals as indirect energy inputs, is not a sustainable way. The only way is the constant expansion of our knowledge: improving the remote sensing based monitoring systems, increasing the accuracy of detection techniques, using precision plant production technologies, developing new system models that consider the natural environment, the agro-ecology (including forestry) and the urban areas as a whole unit. The more so, because for example, the micro-evolutionary processes take also place in the vicinity of cities.

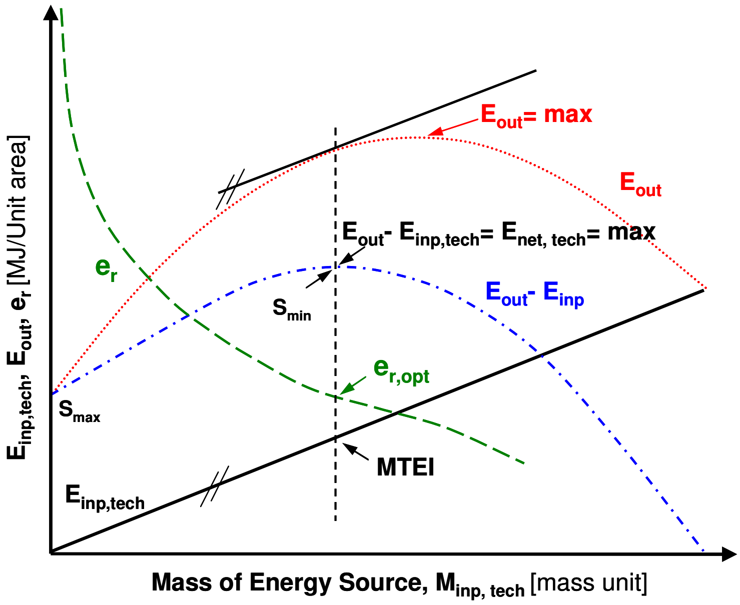

Figure 1. Theoretical demonstration of Maximal Technological Energy Input (MTEIP) (NEMÉNYI, 1983; NEMÉNYI, 2009; NEMÉNYI and MILICS, 2009; NEMÉNYI and MILICS, 2010)
Where: $E_{inp,techn}$ = technologic energy input; E_{out} = energy of produced biomass; $e_r = E_{out} / E_{inp,techn}$

The generation of knowledge, which involves entropy, is a new and advanced science. Let us consider the knowledge evolution as a function of time introduced by GOMES (2006):

$$E_t = -h_t \ln h_t,$$

where h_t is the knowledge variable, h_t produces human capital

This equation is an analogue of Boltzmann's entropy equation.

If the accumulation of knowledge through time:

$$h_{t+1} - h_t = Bh_t^{\eta} - \delta h_t \ln h_t, \qquad (1)$$

where B is constant and δ is the entropy parameter, the (1) equation should be equal with the agro-ecological entropy difference or with the micro-ecological diversity (entropy) change over time:

$$S_{maximum} - S_{minimum} = Bh_t^{\eta} - \delta h_t \ln h_t \qquad (2)$$

The solution of the equation can be found partly in GOMES (2006). The main advantage of such a model is the purposeful research activity.

Last, but not least, forty-three topics are researched in the five sub-programmes of the project, many of which have "sub-topics". After studying the presentations of the conference, the management came to the conclusion that we can provide the coherence of the research activity, aside from some topics, by analysing the way given research results contribute to the reduction of our ecological footprint.

There are a lot of dynamic-system simulation programs corresponding to the description of ecological systems (KORN, 2007). One of the possible solutions is the use of Stella and iThink (Dynamic modelling of ecological and economic systems). "Systems Thinking software like STELLA and iThink is an increasingly valuable tool for constructing understanding about all kinds of dynamic systems from natural environments to team dynamics to economic markets." (http://www.iseesystems.com/softwares/Education/StellaSoftware.aspx)

On the other hand, STELLA and iThink are not only research – but also education – oriented software packets, which is also a very important expectation placed on the project. We will report on the results of the two-year research activity in the project closing symposium.

It is my firm conviction that the project has realised its aims. (The great quantity and quality of publications back up this fact.) On the other hand, the researchers of the programme may contrast their theses in the framework of this conference and they may ask for the opinions of the scientists of international reputation in given topics. Thus final progress reports may be more mature and valuable from a scientific point of view.

References:

BERTALANFFY, L.v. – HEMPEL, C. G. – BASS, R. E. – JONAS, H. (1951): General System Theory: A new approach to unity of science. Human Biology, 23:302-361.

BERTALANFFY, L. von, (1969): General System Theory. New York: George Braziller

FORRESTER, J.W (1961): Industrial dynamics. MIT Press

GASTON, L. L. (1955): The unity of knowledge. Columbia University, Bicentennial Conference Series

GOMES, O. (2006): Entropy in the creation of knowledge. A Candidate Source of Endogenous Business Cycles.Munich Personal RePEc Archive

JØRGENSEN, S. E. (2001): Thermodynamics and Ecological Modelling. CRC Press.

JØRGENSEN, S. E. – SVIREZHEV Y. M. (2004): Towards a Thermodynamic Theory for Ecological Systems. Elsevier Ltd.

KORN, A. J. (2007): Advanced Dynamic-system Simulation. John Wiley & Sons

MOROWITZ, H. J. (1968): Energy flow in biology. Academic Press

NEMÉNYI, M. (1983): PhD Thesis, Mosonmagyaróvár, Faculty of Agricultural Sciences

NEMÉNYI, M. (2009): The maximum technological energy input principle in the plant production. Hungarian Agricultural Engineering. No. 22/2009. pp. 74-76.

NEMÉNYI, M. – MILICS, G. (2009): Thermodynamic modelling of agro-ecological systems especially regarding the cost and efficiency of the technological energy input. 10th IAEE European Conference. Energy, Policies and Technologies for Sustainable Economies, Vienna, September 9-10, 2009. pp. 37-38. Conference Proceedings

NEMÉNYI, M. – MILICS, M. (2010): Optimization of biomass production by thermodynamic approach. International Conference on Agricultural Engineering (AgEng): Towards Environmental Technologies. Clermont-Ferrand, France September 6-8, 2010. pp. 1-7. Conference Proceedings

ODUM, H. T. (1983): Systems Ecology. John Wiley & Sons

PIMENTEL, D. (1980): Handbook of Energy Utilization in Agriculture. CRC Press

WACKERNAGEL, M. – REES, W. E. (1996): Our Ecological Footprint. Reducing Human Impact on the Earth. New Society Publishers