LORÁND EÖTVÖS SCIENTIFIC UNIVERSITY

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THE LACK OF QUANTIFICATION OF NATURAL CAPITAL AS THE INHERENT LIMIT OF THE IMPLEMENTATION OF SUSTAINABLE DEVELOPMENT

PhD thesis extract

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I. Choice of topic and structure

Without phosphorus there is no thought, that is, without the energy source of the ATP molecule, which contains phosphorus, the human activitites come to an end. In a similar fashion natural resources are indispensable preconditions of all human activities. The paradigm of sustainable development protects and activates the reserves of the natural resources of the Earth with a preventive approach in order to secure a similar welfare level for the future generations. The objective of the thesis is to provide an overall picture of the theoretical and practical issues of sustainable development. There are a number of arguments for choosing this topic: it is about a present shift of paradigm, it searches for the practical solutions of sustainable development, and with the novel results of a case study it shows the way towards a sustainable form of living.

The thesis is divided into three thematic units. The first section is based upon the definition of the paradigm of sustainable development, the review of its main components and its practical outcomes. The second section discusses the value of natural capital, the importance of the valuing process and the evalutaing methods appearing in the cost-benefit analysises, that is, it emphasises that the inherent limit of the implementation of sustainable development is the lack of quantification of natural capital with the help of an overview of the monetary evaluating possibilities.

The third section provides an example for the biophysical quantification of natural capital by a methodological overview of the energy-area based ecological footprint analysis. The detailed case study of the planned Tiszaroff Water Reserve underlined the efficiency of the ecological footprint analysis in environmental decision making. The case study is in line with the criteria of the the flood control and regional development plan of river Tisza, the National Vásárhelyi Plan, and it was made to justify the need for the zonal packages prepared for the deep catchment areas of the river valley to meet the agroecological standards in its crop structure and land use pattern.

The Hungarian application of the method requires the introduction of further environmental policy measures, as only a properly interpreted sustainable vision, which is translated into the language of practice, can serve as a bulwark of societies against the adverse effects of short-sighted decisions.

II. Applied sources and methods

The descriptive part of the thesis is a synthetising work based upon an investigation of the relevant literature sources. The conceptual overview and interpretation of the paradigm of sustainable development, the examination of its basic pillars, the mapping out of the evaluating methods of natural capital were based upon the international and Hungarian scientific and legal sources. The Hungarian literature sources discussing the paradigm of sustainable development are not as abundant as it would be required by the importance of the topic *(Bora, Gy., Kerekes, S. and Szlávik, J., Korompai, A., Martinás, K. and Nánási, I.)*. The international and primarily Anglo-Saxon thematic literature researches the proper interpretation, the ecological context of the concept and the way towards sustainability in greater detail *(Beckerman, W., Boulding, K., Commoner, B., Constanza, R., Daly, H. E., De la Court, T., DeWitt, C. B., Georgescu-Roegen, N., Golding, M., Hanemann, W. M., Hardin, G., Hayward, T., Heilbroner, R., Kafka, G., Kane, M., Korten, D. C., Kothari, R., Meadows, J., Naess, A., O'Neill, J., Pallemaerts, M., Panayotou, T., Pearce, D. W. és Warford, J. J., Porras, I. M., Prough, T., Redclift, M., Schumacher, E. F., Smith, A., Soddy, F., Sterling, S. R., WCED, Weeramantry, C. G.)*.

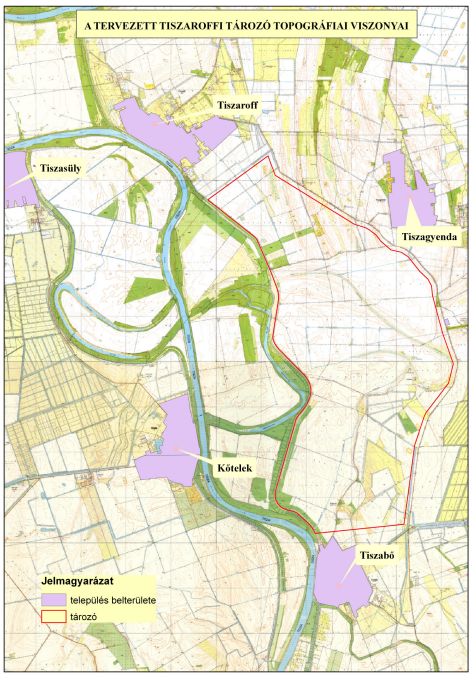
The problem of the inherent limit of sustainable development, the lack of quantification of natural capital, and the integration of the evaluation methods in the different regulating measures is emphasised by a number of Hungarian *(Bora, Gy., Forman, B., Kerekes, S. and Szlávik, J., Korompai, A., Martinás, K. and Nánási, I.*) and international authors *(Clawson, M. and Knetsch, J. L., Daly, H. E., Davis, R., Funtowitz, S . O. and Ravetz, J. R., Hamond, M. J., Hanley, N. and Spash, C. L., Hardin, G., Lancaster, K. J., Panayotou, T., Prough, T., Randall, A., Schumacher, E. F., Smith, A.)*. It was their theoretical contribution that served as a basis for the second, methodological section.

The theoretical overview of the method of the ecological footprint analysis was mainly based upon the study of the foreign literature of the topic *(Barrett, J. et al., Best Foot Forward, Bicknell, K. B. et al.., Catton, W. R., Lenzen, M. and Murray, S. A., Luck, M. et al., Monfreda, C. et al., Redefining Progress, Rees, W. E., Sanderson, E. et al., Simmons, C. et al., Van Vuuren, D. P. et al., Viebahn, P., Wackernagel, M. and Rees, W. E., Wackernagel, M. et al., WWF)*. Following the overview of the theoretical background of the method a detailed case study demonstrates the applicability of it in outlining a sustainable land use practice in Hungary. The Tiszaroff study was made to justify the need for the zonal packages prepared

for the deep catchment areas of the river valley of Tisza to meet the agroecological standards in its land use pattern.

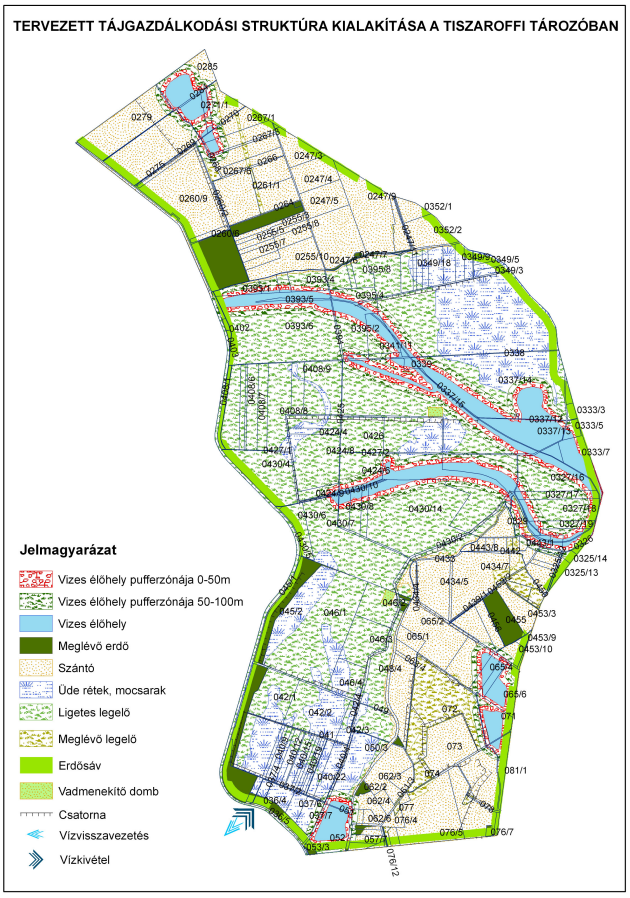
The GPS sources used in the case study *(Légiprojekt [Air Project] 2000 (1:10000); Corine Land Cover (1:50000); Digital Kreybig Soil Informational System (DKTIR) (1:25000); Topographical Maps (1:10000); Land Registry Cadastral Maps (1:4000); DTA-50 (1:50000); I., II., III. military surways)* were provided by VÁTI Kht. The processing of the land use data and information base for the footprint analysis was carried out by the Land Use and Regional Development Research Team of MTA-DE.

The researched area is within the mesoregion of Közép-Tiszavidék, the small region group of Nagykunság and the small region of Tiszafüred-Kunhegyesi-sík. It belongs to the fringes of three settlements (Tiszabő, Tiszaroff, Tiszagyenda) which form part of two small regions (Tiszafüredi and Törökszentmiklósi) (See Map 1). The total territory of the area examined is 2310 hectares. The land use pattern of the region on both small regional and settlement level is rather monotonous and homogenious in spite of its diverse natural attributes. The determining land use form is arable land cultivation with intensive agricultural practice which requires enormous energy inputs but produces a relatively abundant crop yield.



Map 1: The topographical features of the planned Tiszaroffi Water Reserve
Source: Topographical maps (1:10000)

The environmental impacts of the three scenarios are examined in the case study. We have not accounted for a significant change of the land use pattern in the case of the first scenario (original land use, intensive agricultural practice) and the second scenario (original land use, extensive agricultural practice) only the area of the forest zone planned in the water reserve according to the regulations was substracted from arable land. We isolated the areas belonging to the different relief levels, the areas of different land use and their buffer zones to prepare the third scenario (modified land use, sustainable agricultural practice). We planned the conditions and possibilities of a primarily environmental-friendly agricultural practice on the higher levels, where the periodic water covers would positively influence the water management of the soil (See Map 2).



Map 2: The plan of sustainable land use pattern of the Tiszaroff Water reserve
Edited: Land Use and Regional Development Research Team of MTA-DE, Debrecen

The first step of the case study was the GPS research of the Tiszaroff Water Reserve. The land use pattern of the area was mapped out according to the Corine Land Cover database, the pictures of Air Project 2000 and the land registry data. It was according to the built-up digital land model (DTM) of the water reserve that the relief model of the area was prepared. The soil structure of the area was determined by the analysis of the Digital Kreybig Soil Informational System (DKTIR) and the DTM. The exploration of the soil attributes of the Tiszarof Water Reserve was made according to the available soil maps and the examinations made on the sample areas, which provided useful information on the physical, chemical attributes and the productivity of the soil for arable land. In 2004 the current nutrient-level of some typical sample areas of arable land were examined.

The crop structure of the water reserve was determined according to small regional data and field surways. The categories of the sustainable land use pattern were determined according to the DTM, the DKTIR, the land registry data and the central regulations. The sustainable land use and crop structures were determined according to statistical data, the reccomendations of agricultural literature and the present agricultural practices.

From among the agricultural technological elements the NPK values of manuring were calculated from the data of soil examinations. The technological lines and the necessary agricultural machines of the three scenarios were determined according to the local agricultural practices and technology. The energy inputs of the agricultural machine works were calculated according to the average performance of the machines. The crop yield data (yield/hectare) of the given agricultural practices of the different soil categories originated from the relevant literature sources on agriculture and plant cultivation.

There have been a number of Hungarian (Bocz, E., Dobos, A., Gockler, L., KSH, Nagy, J., Nagy J. et al., Nyíri, L., Pásztor et al., Pepó, P. and Nagy, J., Rada, A., Szabó et al., Tóth, Vinczeffy, I.) and foreign (DEFRA, Dovring, F. and McDowell, D. R., Heichel, G., Pimentel, D., Pimentel, D. and Dazhong, W.) authors whose works provided a valuable source of data. The elaboration of the regional, land-specific version of ecological footprint analysis happenned only after a long preliminary consultation period with the co-authors (Wackernagel 2004, pers. comm., Rees 2004, pers. comm.), other users (Lewis 2004, pers. comm.) and the developers of the method (Lenzen 2004, pers. comm.). The specific local features do not get lost in the final conclusions as it is the regional data that appear on the

input side instead of the national average productivity data with regard to land used for fossile energy use.

Following the determination of the energy inputs of all the machines used, the overall energy consumption per hectare was calculated, then the data of the overall energy consumption per hectare was multiplied by the total area in the given soil category. This value was multipled by the carbon-intensity of the fuel (gasoline) consumed by the agricultural machines, which produced the carbon-intensity value of the fuel-based overall energy consumption. In the next step this value was multiplied by the carbon-assimilative capacity of global energy land which produced the energy land equivalent of the carbon-intensity of the fuel-based overall energy consumption. If this value is multiplied by the equivalency factor of energy land, the value of global energy land is produced for fuel consumption in global hectares.

The next step was the calculation of those technological steps that required natural gas as a fuel. The natural gas-based overall energy consumption of seeds, drying and fertilisers was calculated for the whole area by multiplying the natural gas consumption of drying per hectare and the embodied energy content (based upon life-cycle analysis) of seeds and fertilisers per hectare by the carbon-intensity of natural gas. Finally this value was multiplied by the carbon-assimilative capacity of global energy land and the equivalency factor of energy land and thus the value of global energy land was produced for natural gas consumption in global hectares.

Then by adding up the overall global energy land for fuel consumption and the overall global energy land for natural gas consumption the partial sums of global energy land were produced for the given soil categories. In the last step the adding up of the partial sums of global energy land resulted in the overall value of ecological footprint for energy land for the given land use categories. This way the ecological footprints of the three land use scenarios were reduced to a common denominator and became comparable, and contrasted the ecological footprints of the scenarios with the land actually available.

III. Main points of the thesis, new results

* The theoretical base of all the sections of the thesis is that natural capital is such a resource that cannot be supplemented by any other forms of capital, which was not produced

but found by humanity in a ready-made form, and which is indispensable for its existance. It is important to realise that the full world of the global ecosystem limits the human economy and keeping of the stock of natural capital on a constant level is vital for the survival of mankind to implement a more environment-friendly sustainable strategy. Sustainable development can only become a functioning social practice if it can be translated to the language of the most important environmental demands and problems of humanity, if it becomes a main directive to reach an optimal economical development path, and serves as a guideline for long-term measures that please future generations as well.

* Natural capital is an indispensable precondition of all human activities. The lack of its quantification leads to a failure of sustainability. It is the duty of the government to take the preferences into consideration so that the question of resource and sink capacities would be solved, that is, the allocation of natural capital would be achieved in a prolonged period on a Pareto level. If natural capital and the interests of future generations would be integrated in the economic analysises, it would soon be realised that the operations of the present global economic system are not only unsustainable in the long run but are uneconomic as well.

* The operation of the decentralised, self-regulating bioregions leads economic decision-making into such directions where natural capital appears in its total economic value, as it is the same person who enjoys the benefits and carries the burden of externalities of a given economic activity. With the help of the social, economic and structural system built upon small bioregions, where the inter- and intragenerational allocation of natural capital maximalises the welfare level of both present and future generations, a welfare society can be optimalised which is sustainable in the long run.

* In order to accomplish sustainable development there is a need for such monetary or biophysical quantificating methods that internalise the externalities that affect society, and there is also a strong need for the introduction of economic incentives, with the help of which the value of the intertemporal social welfare level is the greatest and the sum of the net present value of the welfare of the different generations is the highest.

* It is the smallest possible ecological footprint (EF) that is the criterion of sustainability, that is, an economic activity that does not overburden the material and energy flows of natural capital. A smaller EF than the available biocapacity is a precondition of strong sustainability. The EF method is a development model, the inner logic of which is compatible with the

behaviour of the biophysical world and mirrors the self-organising and complex structure, balance of the natural systems. According to the results of the ecological footprint analysis of the planned Tiszaroff Water Reserve it turns out that without the application of the method the difference between the apparent economic and the real ecological efficiency cannot be easily demonstrated, and the unsustainable economic activities might remain economically rational and accomplishable alternatives in the short run.

* The results obtained underline the need for the introduction of the sustainable, modified land use pattern with lower energy input, which is in line with the agroecological conditions, with an effective framework of state subventions. The overall values of ecological footprint for energy land for the different scenarios show spectacular differences for the examined Tiszaroff Water Reserve (See Chart 1). According to the overall and partial EF data the following conclusion can be drawn: among the three land use scenarios it is the present intensive agricultural practice that produces the greatest environmental load, that is, ecological footprint.

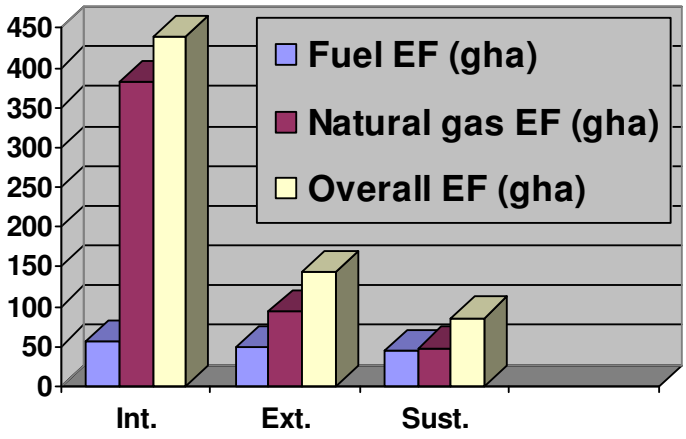


Chart 1.: The fuel, the natural gas and the overall values of ecological footprint of the intensive, the extensive and the sustainable land use practices of the Tiszaroff Water Reserve. Edited.: Botos, B.

* The most spectacular differences amongst the partial sums of the overal EF are shown by the drastic fall in the values of the natural gas-based EF. The primary cause of it was the substitution of fertilisers with organic manure and the decrease of natural gas consumption due to the fall of need for drying caused by the decreased level of yield. It is also notable that the global energy land equivalent of only the Nitorgen fertilisers is equal in itself with the

global ernergy land equivalent of all the other energy inputs in case of the present land use form.

* The overall global energy land for fuel consumption also shows a decreasing tendency in the context of the three land use scenarios. The primary cause of it was the shift form the high fuel-consuming ploughing technology to lower fuel-consuming technologies, and the shift from the machines used for fertiliser spreading and the spraying of pesticides, insecticides and fungicides on plants to the lower fuel-consuming agricultural machines available for manure spreading and mechanical weeding.

* If the locally available supply side is accounted for, it can mean a neutralising effect after adding up the demand side. If the present intensive agricultural practice is replaced by sustainable land use, the forest area grows from 249 ha to 500 ha in the water reserve. In the case of the sustainable land use scenario with modified land structure the overall global energy land for fuel consumption is neutralised on the supply side by 2001 gha of land expressed in global hectares, which is more than 23 times more than the 86 gha of the overall EF value. These forest lands of free capacity are available as a biocapacity zone for the assimilation of the carbon-emissions of the neighbouring areas outside the examined area (they could as well be used for acquiring emission rights).

* The value of production income per global hectare of environmental load (HUF/gha) is the highest in the case of the extensive and the sustainable land use scenarios. The results received could have been even higher if in the case of the extensive scenario the decrease of environmental load and in the case of the sustainable scenario the decrease of environmental load and the ecological and esthetic value of the ecological corridors provided by the new forest zones planted (not for lumbering) would have appeared in the calculations in a quantified manner.

* The Tiszaroff area is a disadvantageous land, but with the help of compensating subventions, by extending the available agro-environmental supporting packages, and by resorting to EU funds together with national co-financial programmes even in these lands the basis for environment-conscious agricultural practices can be established, where agricultural production serves the protection of nature and it also aims at sustaining the touristic potential by the proper use of biodiversity and the recreational opportunities. The degree of agro-environmental supports should be increased for these areas.

* In the spirit of sustainable development the primary criterion for preserving natural resources in the long run is the consideration and integration of the present potential value of natural resources and the value of its potential future use. With the help of those regulating measures that internalise the externalities, where natural capital is accounted for with its total economic value, an environmental load that is within the assimilative capacity of natural environment can be optimalised in economic decision-making.

IV. Conclusions

The harmonic form of living within the closed global ecosystem should be known for a limited use of resources and waste outputs. This would assist the postponing of the exhaustion of the finite resource and sink capacities and contribute to a shift from the practice of unlimited growth to the practice of environmentally conscious qualitative and not quantitative development. However, it requires simpler and unconventional strategies: long-term preventive and precautious solutions in the interest of the common good and the unborn by fostering cradle to grave approaches. The following of a more integrated, sustainable approach is inevitable as humanitiy depends on the finite containing ecosystems for low-entropy resources and sink capacities for high entropy waste outputs. The society has to realise that natural capital is an indislensable precondition of all human activities in spite of the fact that it is rarely given a value at the market. The total value of natural capital will always be equal with all the GDP till the end of the world. The legitimacy of the economic decisions within the human, social and economic subsystem of the global ecosystem can only be strenghtened by those cost-benefit analysises which take into account the natural capital quantified with the demonstrated evaluating methods or the ecological footprint analysises which are known as an area based index of the biophysical limits of material growth.

The EF talks in graphic language about the essence of the connection between humanity and nature, it recognises the dangers of „analysis paralysis", that is, the time consumed by determining environmental impacts more than precisely can portpone effective intervention or proper decision making. The EF interprets the biophysical realities simply and quickly. It serves as an area-based index of the physical limits of material growth.

The modified version of the ecological footprint analysis applied in the area of the planned Tiszaroff Water Reserve proved to be useful because the agricultural activities in the area examined are built upon technologies of specific fuel consumption. The farmers of the

area researched can choose between two alternatives. If they stick to the original land use pattern but shift to extensive agricultural practices, they can carry on with minimal structural changes and join the National Agro-Environmental Programmes. As an other possibility they can apply for the zonal packages elaborated according to the criteria of sustainable land use practices of catchment areas, which presently wait dor EU funding. The purpose of the agro-environmental regulations determined by the packages is to establish traditional and nature-friendly sustainable agricultural practices. The nine zonal packages contain specific reccomendations for the different land use versions, and prescribe the modes and criteria of sustainable agricultural practices.

There is a perspective in the Hungarian use of the method in justifying not only the industrial but also the agricultural shifts of technologies. The further possible use of the method is the analysises to be prepared soon for the other water reserves of river Tisza, which help justifying the legitimacy of the zonal packages that are in line with the priorities of the National Vásárhelyi Plan. It is a long term objective of sustainability that an agricultural practice would dominate which is based on the sustainable use of natural resources, the preservation of the integrity of nature and human environment, the protection of agricultural lands and the production of high quality products.

With the help of those economic incentives that are based on the monetary evaluation methods and the forecasts of the ecological footprint analysises and which internalise the externalities more environent-friendly aconomic activities can be prompted, where not only the direct victims bear the direct and indirect expenses of environmental degradation. By any means the economic incentives of the environmental policy decisions have to take into account the limits of the wider closed global ecosystem, the biosphere, as the system of human economy is contained by it. This way a sustainable vision that takes into consideration the marginal social costs and which supports the long term protection of natural resources could gain a wider social support. In the meantime the opening problem of the whole research that the greatest inherent limit of the implementation of sustainable development is the lack of quantification of natural capital in economic analysises would be solved.

V. Publications of the author in the field of the thesis

Studies published in referred, scientific periodicals:

Burjánné Botos, B. (2002): A fenntartható fejlődés nyomában [On the track of sustainable development] (287-300 pp). *Földrajzi Értesítő.* LI. Évf. 3-4. füzet.

Burjánné Botos, B. (2002): A fenntartható fejlődés 'jövő' alappillére, avagy a fenntartható fejlődés a 'jövő alappillére' [Sustainable development as the main pillar of 'future' or the 'future pillar' of sustainable development] (105-135 pp). *Studia Caroliensia.* III. évf. 1-2. szám.

Burjánné Botos, B. (2003): A természeti tőke számszerűsítésének elméleti és gyakorlati kérdései, megoldásai [The theoretical and practical questions and solutions of the evaluation of natural capital] (87-104 pp). *Földrajzi Közlemények.* CXXVII. (LI.) kötet, 1-4. szám.

Botos, B. és Dobos, A. (2005): A tervezett tiszaroffi tározó ökológiai lábnyom elemzése [The ecological footprint analysis of the planned Tiszaroff Water Reserve] (20-27 pp). *Tájépítészet.* VI. évf. 10. szám.

Other publications, studies:

Burjánné Botos, B. (2002): A fenntartható fejlődés által meghatározott környezetgazdasági szabályozó eszközök társadalmi, gazdasági és ökológiai elfogadhatóságának vizsgálata – különös tekintettel az EU tagállamok által nyújtott modellre épülő magyarországi megvalósítás lehetőségeire [The study of the social, economic and ecological acceptability of the environmental economic incentives determined by sustainable development – with a special regard to the Hungarian solutions built upon the EU model] (118-127 pp). In: Raicsné Dr. Horváth Anikó (ed.): *ÓTE Tükörkép.* ÓTE, Baja.

Burjánné Botos, B. (1999): *Short-sightedness versus sustainability: an environmental policy study of the dangerous waste disposal site at Garé, Hungary.* Master of Science thesis, Department of Environmental Sciences and Policy, Central European University, Budapest.

Lecture notes:

Burjánné Botos, B. (2002): *Természetismeret – Biológia (KRE-TFK)* [Environment and Nature – Biology (KRE-TFK)]. Közép-Kelet Kft. Kiadó és Nyomda, Budapest.

Publications in conference volumes:

Burjánné Botos, B. (2000): A természeti tőke számszerűsítési problémái [The problems of the evaluation of natural capital] (146-151 pp). In: Molnár J. (ed.): *Földrajz az egész világ.* Miskolci Egyetem, Miskolc.

Burjánné Botos, B. (2001): A természeti tőke szerepe a gazdasági számításokban. [The role of natural capital in economic analysises] (146-151 pp). In: Molnár J. (ed.): *Földrajz az egész világ.* Pécsi Egyetem, Pécs.

Burjánné Botos, B. (2002): A fenntartható fejlődés 'jövő' alappillére, avagy a fenntartható fejlődés a 'jövő alappillére' [Sustainable development as the main pillar of 'future' or the 'future pillar' of sustainable development] (146-151 pp). In: Molnár J. (ed.): *Földrajz az egész világ.* ELTE TTK, Budapest.