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ECO-BALANCING AS A GUIDELINE FOR ENVIRONMENTALLY SOUND REGIONAL PLANNING SUPPORTED BY GIS APPLICATIONS

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ABSTRACT - During the last several years, environmental impact assessment, regional or spatial planning, and environmental balancing seem to develop similarities, e.g. joint basic methodological approaches such as the use of environmental indicators, the focus on same environmental goods such air, water, soil, flora/fauna, etc. (Lenz 1999). Especially GIS-based software systems show their multiple applications in these fields.
After a short introduction about the central role of indicators in transdisciplinary problem solving processes, experiences from a set of regional environmental (or eco) balances show a wide range of advantages as well as disadvantages in the context of the widespread use of GIS-based planning tools. Relying on concepts and examples for the spatial eco-balances in the district of Pfaffenhofen (Upper Bavaria, Germany; cf. Lenz 1997) and the municipality of Mulfingen (Hohenlohe, Germany) - both of them related to the concept of environmental indicators of the Advisory Board of Environmental Affairs of the Federal Republic of Germany (SRU 1994) and the Federal Environmental Agency (UBA 1995) - we can show GIS-based information systems of a high practical relevancy. On the basis of the GIS software ArcView, the data base management system Access, and html scripts, we developed environmental information systems to balance environmental effects in a map scale of 1:5,000 - 1:50,000, in order to provide the administration with tools for an environmentally sound and sustainable development of their area (Lenz 1997, 1999, Beuttler et al. 1999). The spatial distribution of land use types, solar energy potential, area consumption and drinking water consumption for the municipality of Mulfingen are highlighted in this paper. Still, the practical use of the systems seems to be limited due to the lack of computer skills among the administrators – even after programming graphical user interfaces for the indicator “drinking water consumption”-, as well as due to widely distributed and hard-to-access data and information sources.

Key words: GIS, eco-balances, environmental planning, environmental indicators, environmental information systems.

INTRODUCTION

The regional eco-balancing approach combines the classical landscape planning (predominantly for the protection of environmental compartments and recreation properties as landscape zones) with the balancing of a distinct, but - in terms of environmental protection - broad set of environmental indicators for (effect) eco-balances. Hence the latter becomes spatially related. By taking on board the district administration and establishing an information system, a high practical relevancy and acceptance of the final users can be achieved. The aim is a system to balance environmental impacts in a map scale of 1:10,000 - 1:50,000, in order to provide the district administration with tools for an environmentally sound and sustainable development of their region (see Lenz 1997).

In this context we should mention that eco-balancing had already been, for years, a classical tool of ecological planning, but the term was successfully (re) introduced by business management because of the origin of balances in economy. Hence, Life Cycle Assessments (LCA), business managers carry out the process -or business of- eco-balance much more often than ecologists. If there are classical ecological planning units and procedures (e.g. regions, landscapes, watersheds, and such related tools as land consolidation), then we should consider the already developed approaches as well as the high importance of having "state of the art" ecological indicators. These indicators (listed in fig. 2) and the further quantification of their status are the basis of the quality of every ecological balancing, besides the tools provided by environmental informatics.

Figure 1 shows the relationship of ecosystem science and (landscape) ecology to resource management, indicating the better need to couple environmental knowledge with management techniques and socio-political evaluations. The current situation is indicated where models, indicators and indices are formulated according to various issues and techniques in "problem solving" processes. Those planning processes are carried out via expert evaluation of modelling results and use of assessment models. Coupling the information is still to be accomplished and could be supported by a so-called assessment science leading also to more scientific underpinning of indicator development. (Lenz et al. 2000, 2001).

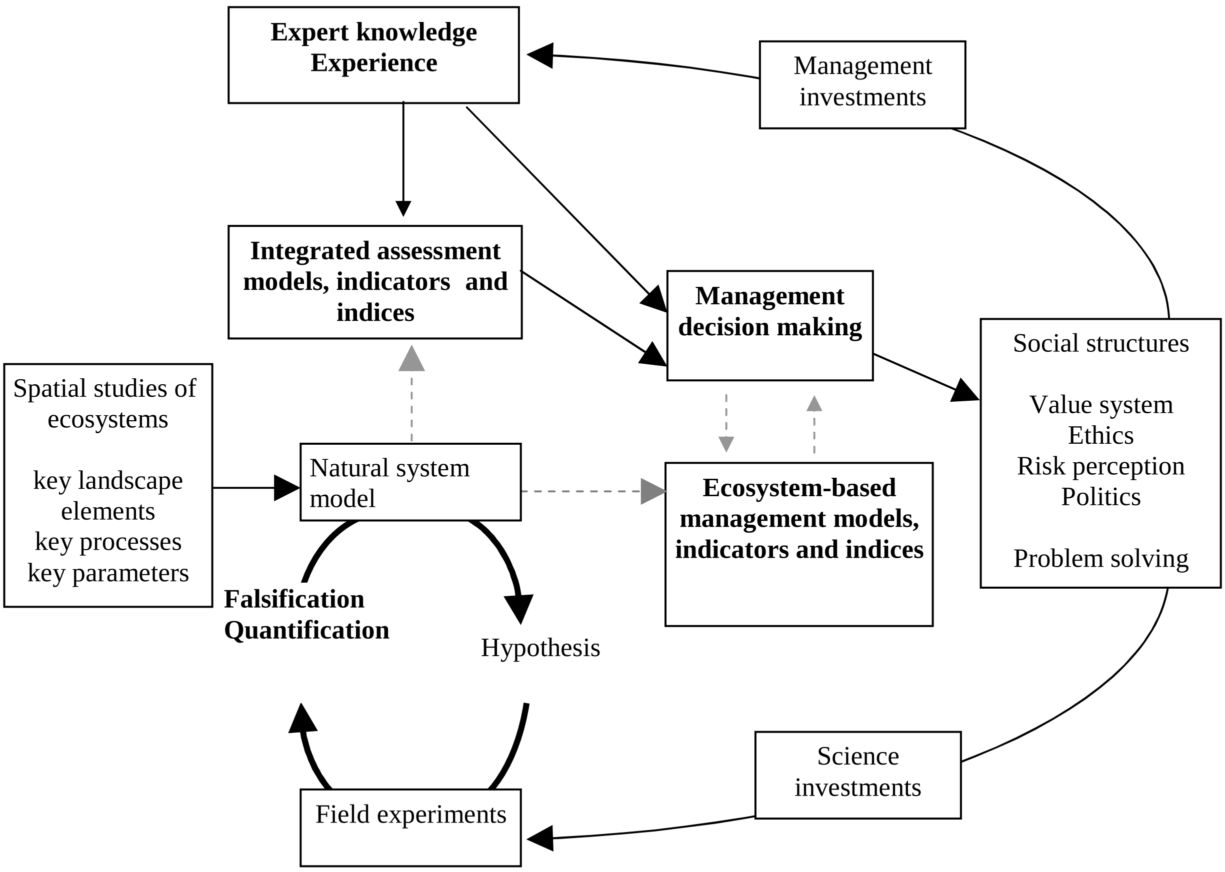


Fig.1. Relationship of ecosystem science and (landscape) ecology to resource management

TECHNICAL DESIGN

The technical instrumentation is based on a PC concept, using Windows NT and application software as mentioned below (cf. Lenz 1997). There are three major inter-linkages to be established**:**

GIS (ArcView) - HTML - DBMS (Access)

When starting the ArcView-projects, Netscape will also be turned on, and the HTML-page will be written, which will give later on access to the choice of maps (dynamical generation).

Establishment of new views/layouts/themes: ArcView → DBMS → HTML

When one of the documents is in ArcView, three steps will follow while storaging:

1. In the DBMS the following will be inscribed: author, record date, last change, name of ODB-files (the name should be put together with the date).
2. Storage of the new document as ODB-file (ODB-export) with the adequate name.
3. The HTML-page, which contains the map and therme register will be updated with an Avenue (which is the programming language in ArcView) script (as line file of the corresponding HTML-syntax).

Call of existing views/layouts/themes: HTML → ArcView → DBMS → ArcView

1. Via Netscape a selection of the view /layout/theme will be carried out. The chosen name will be delivered to a Visual Basic-file (communicate.exe).
2. VB-program will call an Avenue-script and it will deliver the (view/layout/theme)-name.
3. In the DBMS, the ODB-file will be searched for by this name.
4. The ODB-file will be loaded and displayed (ODB-import)

Documentation of a theme: HTML → ArcView → HTML

1. In order to get information about an active theme, "documentation" has to be selected on the HTML-page. This calls the VB-file, which starts an Avenue-script.
2. Via the script, the HTML-documentation-page will be generated dynamically.
3. The HTML-page will be displayed.

RESULTS

The technical system is fairly elegant and powerful. Especially in combination with scenarios, it is getting accepted in administration. Nevertheless, only few people in the district administration are able to run the software, although it has become the standard in all districts in several lands of Germany. Hence, this is still the most relevant restriction in the use of the system. In addition, we got various feed back about the system from our target groups, such as: "technically and scientifically very good, but too complicated/oversized for policy and administration…." But there was unanimous appreciation of a graphical illustration of the outcome of environmental balancing in a very aggregated way (cf. Ten Brink 1991), as shown in fig. 2 (cf. WG 2000).

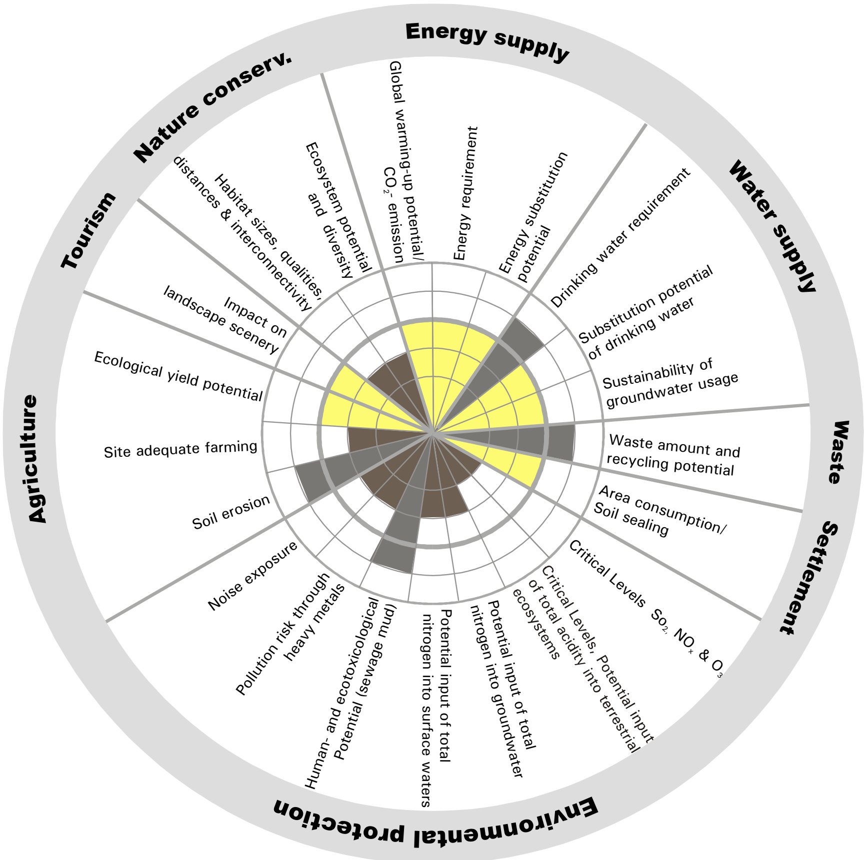


Fig. 2: Amoeba with Environmental Indicators and action fields "Regional Eco-balances in the district of Pfaffenhofen." The darker the gray color, the less good is the environmental status of an indicator in the action field, respectively.

The following map (fig. 3) shows the main land use types in the municipality of Mulfingen, where we also applied an eco-balance by means of a GIS. One of the easiest exercises is to calculate area consumption in the past or in the future. Municipality planning can, therefore, be compared and assessed.

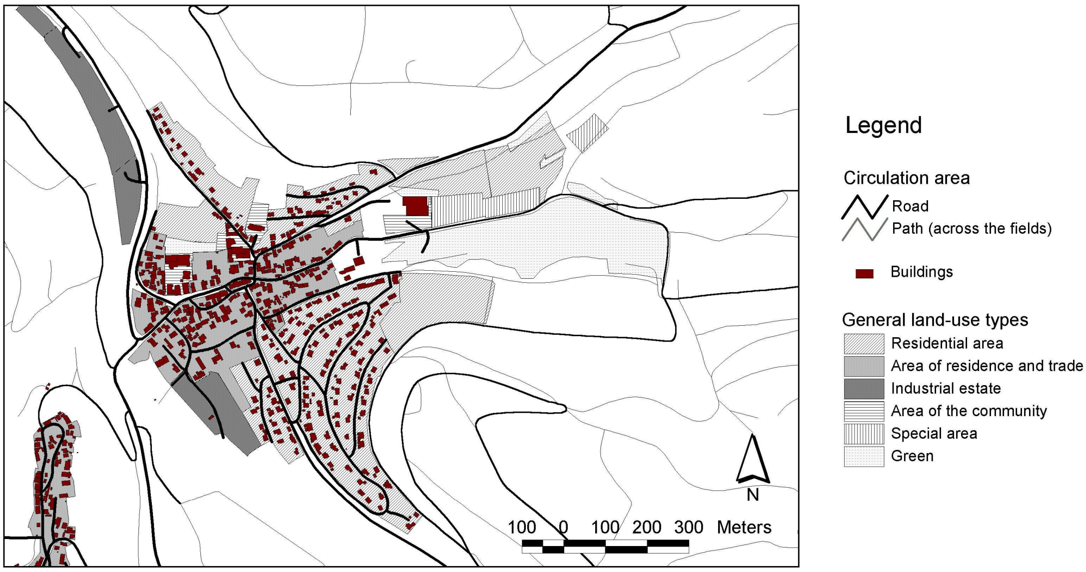


Fig. 3: Land use types in the Municipality of Mulfingen

For environmental balancing, we use a Geographical Information System (GIS), because it allows us a spatial as well as a consistent relation between basic data and results of calculations, and vice versa. Firstly, in the GIS, the basic data (ATKIS = digitales Amtliches Topographisch-Karthographisches Informationssystem, ALK = Automatisierte Liegenschaftskarte, ALB = Automatisiertes Liegenschaftsbuch) are stored and prepared for further overlays. Secondly, we add data provided by additional sources, such as interpretations of aerial photographs to delineate land use types, a soil and fauna map. The district administration has provided us extensive data on protected areas (nature conservation, water), which can be used by the municipalities. Besides these spatial data, further information is used for the calculation procedures of the indicators, whose collection and preparation is supported by the specific administrations.

The data digital preparation and processing enables an extensive environmental information pool for the municipality. This analysis aims at finding the weak points as well as the development potentials.

The following examples will illustrate the possible applications for the municipality.

SOLAR ENERGY POTENTIAL

In using the GIS software ArcView3.2, roof areas can be derived from ALK data. After the subtraction of areas with expositions, inclinations, shading, and other restrictions, which make them unsuitable for solar energy use, the actual roof area can be multiplied with the annual insulation. The result is the amount of regenerative energy from solar radiation, which could be used by the municipality either for heating or for power supply (fig. 4).

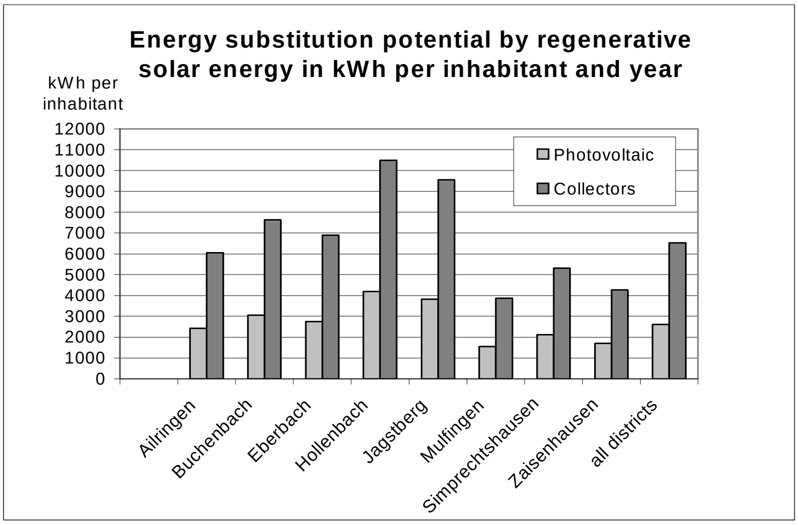


Fig. 4: Energy substitution potential by regenerative solar energy in several areas of the Municipality of Mulfingen

Hence, we could produce 2,600 kWh per inhabitant by photovoltaic, or 6,500 kWh by collectors for the whole Municipality of Mulfingen.

In comparison, if we take the annual average energy consumption of every inhabitant in Baden-Württemberg in 1998, which is of about 24,000 kWh (household, traffic, etc.), solar energy could potentially provide 10% or 25% of this consumption, respectively.

A concrete example of the future use of this energy substitution potential by solar radiation is a proposal accepted by the municipality government: the investigation of the optimization potential for solar energy in all new building areas!

Furthermore, within the restoration of the primary school, a solar energy collection will be established.

AREA CONSUMPTION

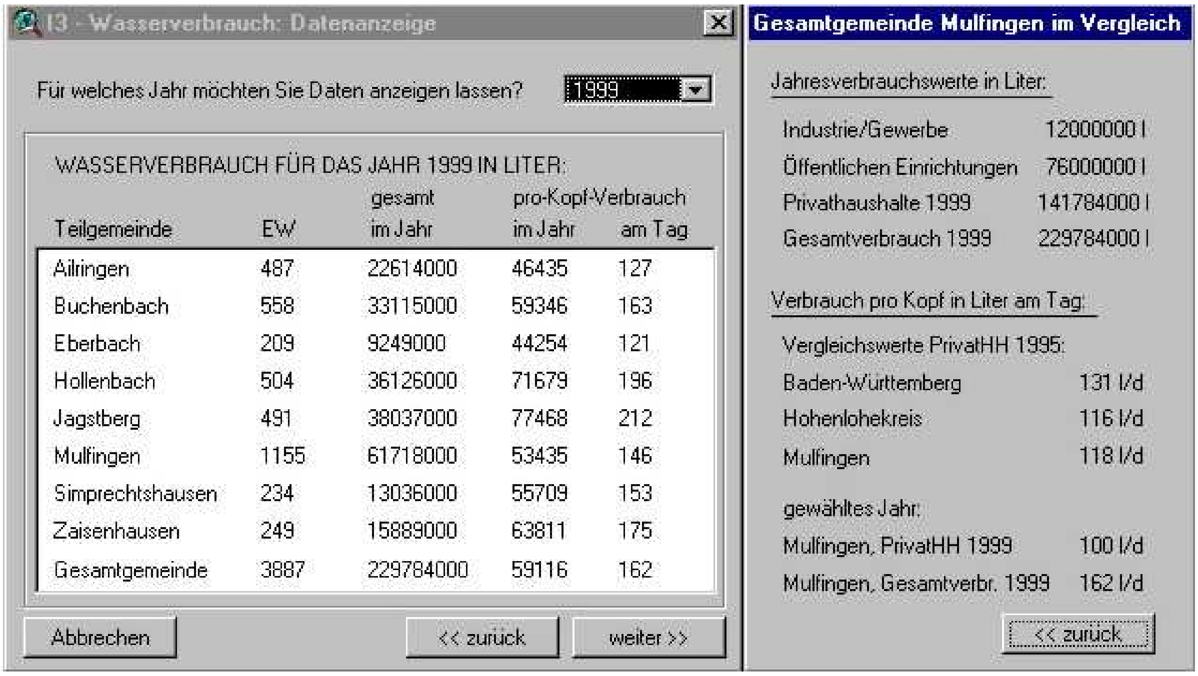
Table 1 shows that area consumption in Mulfingen has been increasing since 1981-90, but it is still in the average category of “sparingly consuming” compared to many other municipalities in the state Baden-Württemberg.

In order to ensure a sustainable development of the settlement areas, in the long run the annual area consumption must not exceed 0.01% of the total area of the municipality (Enquete-Kommission des Deutschen Bundestages 1997).

Tab. 1: Annual area consumption in the Municipality of Mulfingen (1981-2010). Drinking water consumption

Eco-balance municipality Mulfingen		
Annual area consumption (average)		
1981-1990		0.0157%
1991-2000		0.0219%
2001-2010		0.0505%
1981-2010		**0.0294%**
Assessment of the area consumption		
more than average	> 0,1%	
Nation 1993-1995		
sparingly consumed	< = 0,1%	
sustainable	< 0,01%	
Enquete 1997		

For further detection of possible weak points, the indicator of "drinking water consumption" will be illustrated. Using annual consumption data and the number of inhabitants in several areas of the municipality, we calculate the daily drinking water consumption per person. The different results indicate increase values in some areas compared to reference values in our documentation (Zeisel 1998, see fig. 5). It is the task of the municipality to detect the causes of these weak points and to take measures to reduce consumption.



Teilgemeinde	EW	gesamt im Jahr	pro-Kopf-Verbrauch im Jahr	pro-Kopf-Verbrauch am Tag
Ailringen	487	22614000	46435	127
Buchenbach	558	33115000	59346	163
Eberbach	209	9249000	44254	121
Hollenbach	504	36126000	71679	196
Jagstberg	491	38037000	77468	212
Mulfingen	1155	61718000	53435	146
Simprechtshausen	234	13036000	55709	153
Zaisenhausen	249	15889000	63811	175
Gesamtgemeinde	3887	229784000	59116	162

Fig. 5: Water consumption in several areas of the municipality in 1999 compared to reference values from state statistics (screen shot, in German language).

The "drinking water potential" indicator is suitable – due to its basic data – to annual balancing. For the environmental balancing in Mulfingen we have used the programming language Avenue in ArcView3.2 with a view to develop a user-friendly tool for calculations. With this user interface, it is easy for the administration to update the data annually (see fig. 3) and "control" the trends. Controlling the evolution of the environment is an important function of environmental balancing. A regular data collection enables us to follow the status of indicator values. Digital processing makes the ongoing balancing easier, as well as other planning activities in the municipality.

Restrictions in the availability of (digital and other) data are a typical limitation of this approach. Single indicators can only be roughly estimated, because data are missing or can be only collected with high expenses. Especially the so-called impact- and reaction indicators (in comparison to status indicators) need extensive data sets for balancing. For example, soil erosion information needs detailed soil as well as relief and land use data, which are not generally available. The traffic noise impact can only be assessed where traffic counting has been done. A positive aspect of this situation is that data gaps can be detected better and specific sets of problems can be solved. In the future, more data will be provided by district administrations for better use in low level planning by municipalities, so that data quantity and access will be improving (Lenz 1997, 1999).

CONCLUSION

Eco-balancing is understood in various ways – as a standardized procedure according to ISO guidelines, as well as a cataster-like inventory of the environment. Our approach is very close to that used for (normally) single environmental issues, such as critical levels and loads in various spatial scales (cf. CCE 1995 and following). Up to now we have not seen any other more or less complete balancing of the environmental status based on an environmental indicator set AND explicitly balanced spatially. It is the spatial reference to all land use activities that allows regional planning not only in order to set priorities in action fields but also in order to relate them to priority areas. Hence, powerful GIS software, although still causing limitations in administrative use, is necessary.

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REFERENCES

BEUTTLER A., LENZ R., BILLEN N. and KIRCHNER-HEßLER R. (1999) Ökobilanz Gemeinde Mulfingen. In: Flake, M., R. Seppelt & D. Söndgerath (Hrsg.): Umweltsystemanalyse – *Dynamik natürlicher und anthropogener Systeme und ihre Wechselwirkunge,.* Tagungsband GEOö*Kon'99*, Braunschweig: 41-44.

CCE (Coordination Center for Effects) (1995) *Calculation and Mapping of Critical Thresholds in Europe: Status Report 1995*, RIVM Report No. 259101004, Bilthoven.

Enquete-Kommission des Deutschen Bundestages (1997) Konzept Nachhaltigkeit; *Fundamente für die Gesellschaft von morgen, Zwischenbericht der Enquete-Kommission "Schutz des Menschen und der Umwelt – Ziele und Rahmenbedingungen einer nachhaltigen zukunftsverträglichen Entwicklung"* Deutscher Bundestag, 13. Wahlperiode, Bonn.

KIRCHNER-HEßLER R., KONOLD W., LENZ R. and THOMAS A. (1999) *Ökologische Konzeptionen für Agrarlandschaften – Modellprojekt Kulturlandschaft Hohenlohe – ein Forschungskonzept*, Naturschutz und Landschaftsplanung, 31.Jg., H. 9: 275-282.

LENZ R. J. M. (1997) *Design and prototype of an information system for regional eco-balances*, Proceedings of the International Symposium on Environmental Software Systems, Whistler, B.C., Canada, 1997, eds. R. Denzer, D. Swayne & G. Schimak, Chapman and Hall, London: 57-63.

LENZ R. (1999) *Landscape Health Indicators for Regional Eco-Balances*, In: Pykh/Hyatt/Lenz (eds.): Advances in sustainable development: Environmental Indices – Systems Analysis Approach. EOLSS Publisher, Oxford: 12-23.

LENZ R., MALKINA-PYKH I. G. and PYKH Y. (2000) *Introduction and overview,* In: Special Issue on the outcome of the INDEX workshop 1998; Ecological Modelling 130:1-11.

LENZ R., HABER, W., TENHUNEN J. D. (2001) *A Historical Perspective on the Development of Ecosystem and Landscape Research in Germany*, In: Tenhunen, Lenz, Hantschel (eds.): Ecosystem Properties and Landscape Function in Central Europe. Ecolog. Studies 147, Springer: 17-32.

SRU (Rat von Sachverständigen in Umweltfragen) (1994) Umweltgutachten, Metzler-Poeschel, Stuttgart.

TEN BRINK B. (1991) *The AMOEBA approach as a useful tool for estimating sustainable development*, In: In search for indicators of sustainable development, eds. O. Kuik and H. Verbruggen, 71-87, Kluwer academic publishers, Dortrecht.

UBA (Umweltbundesamt) (1995) *Methodik der produktbezogenen Ökobilanzen*. Wirkungsbilanz und Bewertung, UBA Texte 23/95, Berlin.

WG (Working Group) *Regionale Ökobilanz Pfaffenhofen (2000)* Regionale Ökobilanzen für eine umweltgerechte und nachhaltige Raumnutzungsplanung auf mittlerer Maßstabsebene, Final report to the Deutsche Bundesstiftung Umwelt (in German), unpublished.

ZEISEL J. (1998) *Grauwassernutzung; in Innovation Betriebs- und Grauwassernutzung*, Schriftenreihe des fbr 3, Frankfurt.

Figure captions:
Fig. 1: This figure shows the central role of environmental indicators and indices in a complex, integrative and transdisciplinary relationship of the environment-society system. “Assessment science” should help in order to optimise the interconnectivity of various compartments and interactions (Lenz et al. 2001).
Fig. 2: Amoeba with Environmental Indicators and action fields “Regional Eco-balances in the district of Pfaffenhofen.” The darker the gray color, the less good the environmental status of an indicator in the action filed, respectively.
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