Sustainable Development of Multifunctional Landscapes

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Preface

The identification of sustainable pathways for proper land use development will play a crucial role in future management of rural landscapes. While in the past, agriculture and forestry have been the predominant types of land use in most arable areas in Europe, an increasing number of further demands on land use and landscape functions have to be integrated today. One important step towards sustainable land use is the identification of these multiple environmental, social and economic functions and the subsequent analysis of how well specific landscapes perform with regard to those functions. This process requires a joint effort between different interest groups involved in land use decision making. On the scientific part, insight understanding of global and regional processes of landscape functioning, management and rural development is required in many disciplines representing the environmental, social and economic aspects of land development. Two research tasks are inevitable: first, regional knowledge has to be provided for the entire area of Europe in a serviceable way, which implies its transference into a unifying and comprehensive system. Second, the many patches of disciplinary knowledge on landscape and land use processes have to be combined to a multidisciplinary and comprehensive pattern of sustainable land development.

In April 2002, scientists from across Europe installed a research network to be prepared for new challenges of research on sustainable land development in a European perspective. The research network, entitled **Landscape Tomorrow** (www.landscape-tomorrow.net), is based on existing co-operations between major research centres dedicated to interdisciplinary landscape research. By combining these research groups, the network generates a Europe-wide consortium that integrates environmental, social and economic expertise on issues of land use, landscape assessment and rural development. The partnership includes institutions with a focus on basic research as well as those dedicated to applied research and land use management in the field of agro-environmental sciences.

This publication is the first product of the Landscape Tomorrow research co-operation. It deals with (i) the analysis of general principles of landscape multifunctionality, (ii) methods for landscape characterisation and sustainabilty assessment of agricultural and forestry land management, and (iii) the identification of strategies of sustainable land management. The book contributes to the scientific basis for future land development strategies and aims at supporting land use decision making on the political, planning and management level.

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Katharina Helming and Hubert Wiggering, September 2002

The Concept of Multifunctionality in Sustainable Land Development

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Abstract

The identification of sustainable pathways for proper land use development will play a crucial role in future management of rural landscapes. While in the past, agriculture and forestry have been the predominant types of land use in most arable areas, an increasing number of further demands on land use and landscape functions have to be integrated today. One important step towards sustainable land use is therefore the identification of the multiple environmental, social and economic functions of land use and the subsequent analysis of how well specific landscapes perform with regard to those functions.

The identification of landscape functions for a specific region has to be accomplished by relevant groups within a participative process. In this process, sophisticated and complex methods are necessary (i) to reveal the impacts of prospective multifunctional land use on sustainability aspects and (ii) to achieve consensus among stakeholders about most suitable land use combinations. Landscape science involving inter- and transdisciplinary research is one important instrument to support this process.

In this paper the idea of multifunctionality to implement sustainable land use of rural areas is discussed and related research requirements are delineated.

Rationale

Pressures to Land Use

The member and accession states of the European Union experience rapidly changing economic framework conditions and immense structural transformations within the business of land use (agriculture, forestry, in-land fish production etc.). Four categories of change can be delineated:

a) The diminishing importance of agricultural and forestry production within the production industry as well as economic globalisation leads to changing land use politics both on the national and European scale (FAO 2000a, FAO 2000b).

b) The growing verbalisation of ecological goals related to land use and land use planning.

c) Climate change along with increasing probabilities of extreme weather events (floods, droughts, storms) might require adaptations through the modification of land use combinations and patterns.

d) The changing public perception of land use give rise to modifications in subsidy policies within the Common Agricultural Policy (CAP) (MUELLER 1999). Farmers as the main land users have lost their categorical confidence due to various scandals like BSE, foot and mouth disease etc. Environmental, health and ethical aspects of agricultural and forestry production processes as well as the quality of products is increasingly under discussion. The society demands for healthy products of land use and for production processes where negative environmental and social side-effects are minimized.

The changes will induce adaptations of the framework conditions of CAP leading to changes within land use and related impacts on rural areas (economy, social aspects) and the environment (abiotic and biotic sources) (OECD 2000). To find proper solutions for future land use policy and management concepts, the impact of land use combinations on socio-economic, cultural and environmental characteristics of landscapes has to be analysed. This attempt requires the simultaneous and integrative consideration of all intended functions of landscapes and rural areas (COM 2000).

The significance of land use for rural areas

Most rural areas are dominated by agricultural land use, especially when looking at vegetated areas. Therefore, the impact of agricultural land use systems on the environment can be as substantial as its impact on social and economic characteristics of the rural population. Assessing the impact of agriculture on the environment on the one hand and on regional socio-economic conditions on the other hand is crucial for sustainable rural development (OECD 2001).

The recent past has experienced an increase in the intensity of land use with respect to almost all kinds of utilisation, as well as an increase in multiple and overlapping uses. The latter do by far exceed the production purposes and include those of recreation, education, environmental conservation, infrastructure development, storage, buffering and mitigation. Thus, there is an increasing awareness of the importance of rural areas which counterbalance cities and agglomeration areas. Parallel to those expanding land use demands, agricultural production experiences a dwindling share of food expenditures in total consumption expenditures, a high rate of technical progress, and an increasing reallocation of agricultural functions to specialised industrial enterprises. As a consequence, increasing shares of agricultural land cease to be cultivated and agricultural activities are concentrated in few favourable locations.

Furthermore, the demands placed on rural areas by society are often at odds with the wants and needs of the people who live in those areas. Herein lies a decisive reason for land use conflicts between cities and rural areas and for the failure of public and private decision makers to take the functions of rural areas sufficiently into account.

Those changing conditions for agricultural production together with the emerging demands on land use in rural areas placed by an increasing number of interest groups call for an integrated conceptual framework in which the decision making process of land use can be embedded. On the one hand, this framework needs to involve all relevant interest groups including policy makers and the science. On the other hand, it has to consider the entire set of social, economic and environmental aspects of land use and rural development (MÜLLER et al. 2002).

The concept of sustainability

General Approach

Since the UN Conference on Environment and Development in 1992, sustainable development has been raised to a comprehensive conceptual approach and become a pioneering programme for politics to cope with the common future of humankind. This also implies relevancy to the future shaping of rural areas and the development of future land use systems.

Fascinating is, that the model of sustainability promises solutions to economic, social and ecological problems, thus opening up new perspectives. Howevber, it is still unclear how to develop realisable concepts of sustainability and to achieve its implementations (CONRAD 2000, GÜNTHER and SCHUH 2000). The basic idea of sustainability, to orientate economic action and social balancing endeavours towards the conservation of functions of ecological systems, should be irrefutable. Therefore, politics have to be able to determine a development strategy, which does equal justice to reciprocal dependences of economic, social, and environmental development components (WIGGERING et al. 2002). In this context, sciences must show and politics must realise, that, in contrast to the solution of social problems, other strategies are required in order to cope with environemtal problems. Consequently, the separation of the economic development of resources consumption and the impairment of environmental functions could be necessary. However, a drastic reduction in consumption of natural resources within economic activities can only be realised and counteracted out of the overall context (HÜTHER and WIGGERING 1999). In this context, the obedience to so called management rules of a sustainable development is of fundamental importance:

a. the use of renewable resources may not exceed their regeneration rate

b. the use of renewable resources may not exceed the substitution rate

c. the release of harmful substances may not exceed the capability of natural systems to absorb and compensate

With regard to land uses, the limited capabilities of natural systems to respond to changes, to adapt to civilisation systems and to balance anthropogenic impacts are herewith taken into account. The time scale is an important factor in this context of adaptation, buffering and balancing. The speed of civilisation developments with exponential growth curves can dramatically exceed the self organisation and adaptation capabilities of natural systems. The introduction of measures to balance the impact of developing civilisations on natural systems is, if at all, effective only with delay (DALY 1999, MÜLLER et al. 2000). Due to a so called creeping worsening of the ecological situation, a political picking out of this question as a central theme is particularly difficult. The matter hardly exerts any suffering pressure to be experienced. Landscapes are changing constantly and it is difficult to identify its origin, be it natural or anthropogenic.

The orientation of the economic and social development towards the capability of natural systems to self-organise and adapt requires a change in the widely existing understanding of economic progress and economic rationality. Essential aspects of modern environmental planning can finally lead to this goal. Namely, participation and learning by experience must be connected towards a collaboration between policy makers and all interest groups relevant for the subject of planning. Particular with regard to land use demands, which often are conflictive, a strengthening of participative elements in the relevant planning can be an essential step to implement the idea of sustainability. In order to accelerate the planning process towards a sustainable development, scientists have to contribute to the political discussion, to conduct relevant research and information work, and to monitor the implementation achievements of political decisions (MÜLLER et al. 2002). Problem orientated landscape research is one instrument to provide high quality knowledge input into the planning process (ITTERSUM et al. 1998)

Sustainable land development

Sustainable land development has to be based on existing concepts of site adapted land use refined in the domains of environmental protection and regional planning. Uniform and revisable standards of the sustainability of land use management need to be identified and made legally binding. The standards must include those of (i) long-term conservation of biotic, abiotic and cultural resources, (ii) economic welfare of the land users, (iii) social perspectives for the rural population, and (iv) maintenance of technical and cultural infrastructure in rural areas (WIGGERING 1997).

The complex diversity of natural conditions and cultural systems in landscapes and regions prohibit the development of universally valid socio-economic principles of land use and development. Regionally specific objectives of land use and land development must be defined that respond to the specific environmental and socio-economic situation of the respective region. As a result, priority designations set up by sectoral policies should be used in compliance with the above mentioned standards to complement a concept of sustainable land development for the specifically desired uses.

Multifunctionality – a demand oriented approach

With the concept of multifunctionality, an attempt is provided at carrying out and implementing the concept of sustainable development in the specific case of land use and landscape development. However, the concept of multifunctionality often is – if at all – only insignificantly more concrete than the concept of sustainable development and is moreover often used, to sell old ideas by making them look new. This is particularly true, when multifunctional agriculture is equated with multifunctional land use and when the avoidance of negative externalities of agriculture, forestry and fisheries is already interpreted as an honourable achievement of society within the frameworks of multifunctional land use.

Multifunctionality is internationally discussed the by three major organisations, the Food and Agriuclture Organisation (FAO), the Organisation for Economic Co-operation and Development (OECD) and the European Union (EU). This is done equally intensive, though with differing objectives. Generally, the main emphasis is put on multifunctional agriculture instead of multifunctional land use. The FAO assumes an attempt, which orientates strongly towards regional development to support the integration of agricultural land use into the concept of sustainable development (FAO 2000a, FAO 2000b). The analysis of multifunctional land use types contributes to a better understanding of potential interrelations, synergetic effects and trade-offs of the different functions. To the FAO, complex interactions between regional and development politics are of importance. However, it is noticed, that, when describing multifunctionality, present results are of temporary character and require further investigation (FAO 2000b).

The OECD prefers a rather environmental economic attempt. Its analytic framework presents a comprehensive theoretical basis, which outlines the most important problems of multifunctionality (OECD 2000, OECD 2001). In this context, the concept of multifunctional agriculture is based on the assumption, that every economic action fulfill several functions besides its main function. Accordingly, agriculture has always fulfilled various social, environmental and economic functions besides the production of food, fibre and commodities. The OECD subsumes those functions of agriculture to the term "non-commodity-outputs". As the term multifunctionality is defined in many different ways, the OECD has developed a draft definition, which combines the varying demands on multifunctionality. Key elements of multifunctionality are (i) the existence of several 'commodity and non-commodity outputs' being produced by agriculture and (ii) the fact, that some of those 'non-commodity outputs' show features of externalisations and public goods with the result, that markets for these goods do not exist or function unsatisfactorily (BOISVERT 2001a, BOISVERT 2001b).

Within the EU, the term multifunctionality is discussed against the background of changing frame conditions for agricultural production. As a result, agriculture is less put into the context of the production of food (commodity-outputs), but rather into the context of resources protection, leisure and recovering space as well as cultural landscape (non-commodity-outputs). This differentiation of use demands and perceptions coincides with a different understanding of agriculture and forestry being responsible for the management of rural area and thus presenting an aspect of multifunctional land use. To the EU, this concept of multifunctionality presents a powerful opportunity to continue the financial support of farmers, not any longer through subsidies but as remuneration of the production of non-commodity-outputs, i.e. for environmental or other services demanded by the society (COM 2000). Considering the reduction of subsidies for commodity-outputs the publicly financed demand for specific non-commodity-outputs plays thus a decisive role in the existential security of agricultural farms. Within the EU, the concept of multifunctionlity has consequently experienced an increasing relevancy with regard to diversification strategies. In this context, the term multifunctionality describes the various private and public use potentials of land for farmers, for rural areas and for society in general (MAIER and SHOBAYASHI 2001).

Multifunctionality and Sustainability

Above the attempts of FAO, OECD and EU, the concept of multifunctionality is given further importance to sustainable land development. Opposing the reduction in the interpretation of the concept of multifunctionality through the equation of multifunctional agriculture with multifunctional land use by pressure groups, a problem oriented approach of implementing the multifunctionality concept is considered to support sustainable land use and development respectively. This presupposes, that (i) all demands on landscapes are considered simultaneously and (ii) all demands are seen as legitimate. Inevitably, land use conflicts result from different demands. Therefore, the demands on the use of landscapes resulting from the different sectoral contemplation have to be combined to a regional contemplation, which is only effective, when the regional negotiation process is of participative nature. A successful participation requires the provision of all necessary information in a user friendly way.

Demands on land use in a specific region can also derive from other regions. Best examples are urban-rural-relations. If *all* demands on land use are to be considered within a consensus finding process in a specific rural area, demands of the urban areas on the respective rural area need to be included. The same is valid for larger scale, national, international and even global demands on the rural area, which derive from external effects in the context of land use. Corresponding large scale demands must also be considered in the development of local land use concepts in order to follow the idea of the sustainability principle (RUDLOFF and URFEI 2000, URFEI and BUDDE 2002).

This consideration of global demands in regional land use decision making does only apparently contradict with the increasingly occurring competition between single regions, the latter being a result of globalisation. Efficient incentive structures are relevant for the performance of a single region in this global competition, which need to combine the regional responsibility taking with regional decision competence. Another prerequisite is the clear definition of property rights with regard to the use of landscapes. In this context, the principle of subsidiarity demands a far reaching decentralisation of decision competence, while the limits of decentralisation are determined through the spatial expansion of the environmental and socio-economic impacts of the decisions (EWERS and HENRICHSMEYER 2000). Only if those rules following the subsidiarity principle are implemented, the regions have the necessary degrees of freedom to develop and implement their regional specific concept of sustainable land use in spite of globalisation and increasing competition between regions.

Consequences for integrated rural development

Regarding the implementation of new concepts of sustainable land use, it is still unclear, whether the available instruments to do so are actually suitable. Possibly, completely new instruments are required (HODGE 2000). The latter would be true, if the available instruments turn out to be resistant to adaptation because they are still only orientated towards sectoral aspects instead of regional aspects or because new goals just require new instruments.

The sustainability of a certain land use combination can only be defined for a given time span during which the demands on landscape as well as the property rights with regard to land use are valid. New knowledge and information can constantly change the assessment frame for sustainability. Against this background, the planning of sustainable land development must be regarded as a continual process, where iteratively new information on demands, property rights, technologies and expected land use impacts are taken up in order to optimise sustainable land use in the long term.

For successful rural planning, all relevant activities have to be adapted to the three identified major characteristics of the sustainability and multifunctionality concept, namely (i) the demand and goal oriented identification of land use functions, (ii) the participative character of negotiations on possible land use combinations involving all relevant groups including science, and (iii) the iterative character of the decision making process, which allows tolerating uncertainties on the one hand and adapting to emerging information and knowledge on the other hand.

The implementation of these three characteristics within the methodology of rural development would also bring about a new situation to planning organisations, public administration and politics. The consideration of all actual und intended functions of landscape use in the planning process requires a cross-sectoral approach. Especially the definition of relevant problems and the solutions to solve them should be elaborated co-operatively. A feasible way to handle environment protection goals could be explored in organising regional co-operatives for the environment (GLASBERGEN 2000, MÜLLER et al. 2002). Those groups should include farmers, communities, the public administration and any other group interested in the development of rural areas. They should first determine the achievable regional goals, define the sensitive areas within the region and then develop a set of possible management solutions. Public funds intended for environmental protection and ecological services could be distribute through such co-operatives more efficiently than through any general programme (BAHNER 1996). Those institutions could increasingly consider further goals of rural development and become a base for public *sustainability developers* in their region.

The public administration, which is responsible for planning and managing the rural areas will play an important role in this process. All relevant sub-organisations currently working separately (farming, forest, environment, rural planning, etc.) have to be included in these activities. This new approach of achieving development concepts for rural areas results in new tasks and specific demands concerning skills and knowledge for most of the administrative units (WERNER et al. 1997)

Implications for Landscape Research

In order to enhance the understanding and to scan scientific methods of analysing and developing relevant aspects of multifunctionality within landscape use in Europe three levels of investigation can be identified and important requirements for landscape research formulated: (i) inventory of landscape functions and demands, (ii) analysis of the interdependences of land uses and landscape functions, and (iii) methodologies to achieve consensus between conflicting demands

Inventory of landscape functions and demands

One basis for further steps concerning the analysis of multifunctionality is the inventory of the various functions of and demands on landscape use. However, multifunctional agriculture, forestry and fishery is just touching on some functions of landscapes like production and environmental issues (e.g. soil protection, water conservation, biodiversity). A sustainable use and development of landscapes have to integrate those aspects and meet further demands such as providing sites for development, traffic, industry, raw material processing and waste disposal. Further important, though not yet completely understood landscape functions include buffering capacities for matter and energy as well as mitigation abilities to extreme weather events (floods, drought) which might become of increasing importance with evolving climate change effects.

In addition, the use of landscapes has to be regarded as an element of urban-rural-interconnection, by which recreational and educational demands of urban residents as well as issues of cultural heritage are to be included.

A total inventory of multiple landscape functions and of demands addressed by various interest groups concerning the utilisation of landscape requires a joint approach of socio-economic sciences as well as of natural sciences, since people, companies, public structures as well as natural functions and production systems have to be addressed .

The research requirements include the development of methods for the identification of landscape functions as well as current and potential demands concerning the use of landscapes. In general, available methods are based on information of individual views of persons or groups and thus too expensive or not appropriate to identify all demands in a region.

Generally, every distinct landscape within the European regions has its specific set of functions and land use demands. This characteristic set is by itself a characteristic property of the respective landscape. The problem is to properly characterise and delineate landscapes and to derive information of all groups which express demands on the use of landscapes.

One crucial step towards the full inventory is to check whether the various demands on landscapes are synonymous with relevant landscape functions. Some landscape functions might not be addressed by interest groups since their importance is (i) relevant only in the long term (i.e. buffering capacities, genetic pools), (ii) not completely understood (cooling and mitigation functions) or (iii) of relevance only to extreme events (floods, droughts) and will not be publicly anticipated in the near future. Those functions are summarised as *option values* and *bequest values* in the economic terminology but need to be addressed explicitly when sustainable land use is concerned.

The entire process of inventing landscape functions and demands can be structured into the following research topics:

- Adequate delineation of the studied landscapes (e.g. administrative vs. natural, rural vs. urban) considering those problems which arise from inexact or overlapping jurisdiction and those which concern the handling of transboundary landscapes.

- Identification of adequate instruments and procedures to derive information from interest groups about their demands on landscape use. This procedure has to consider culturally distinct means of communication, guarantee the completeness of demand collections, be cost efficient and oriented towards implementable solutions. Research has to answer, whether already existing instruments and facilities can be used or whether new solutions for specific cases are required.
- Development of a procedure to identify and deal with landscape functions not being addressed to by interest groups, but the importance of which might be formulated by the society through a better understanding and/or through a longer period of time (option and bequest values).

Analysis of interdependences of land uses and landscape functions

Approaching sustainability by looking at multifunctional land use requires the consideration of mutual effects of the different types of land use, since particular actions, processes or conditions of land use influence each other specifically. Within a certain setting of land use systems, the spatial patterns of land uses as well as land use modifications can determine specific performances of landscapes with respect to certain functions to a greater extent than the mere type or intensity of its use. By this, modifications of regional patterns in land use systems and their characteristics may require more attention than just local changes in the intensity of land use or its management.

A proper understanding of the interrelations of various land uses and landscape functions is thus indicative in order to develop tools for sustainability impact assessment of land use strategies. Moreover, it can open new opportunities for intelligent solutions in terms of land use modification or pattern adjustments that result in win-win situations of apparently conflicting land use demands. A problem oriented indicator system for land use effects is an important tool to make interdependences of land use transparent and help to derive consensual decision making.

The considerable lack of information (identification, quantification, assessment) concerning mutual effects of land use, the knowledge of which would be an indispensable prerequisite to balance different interests in land use, can only be filled by interdisciplinary cooperation. There are conflicting interdependences as well as neutral or just complementary interdependences. Especially the knowledge and methods of landscape ecology and new landscape sciences have to be used in a cooperation with socio-economic sciences to identify the interrelations. It should be checked carefully, if new knowledge has to be acquired or if already available knowledge just has to be reworked and newly communicated within an interdisciplinary approach. Resultant research requirements may be grouped into:

- Development of new approaches in landscape research that explicitly considers the effects of land use modifications and land use patterns on landscape functions with the aim to generate intelligent solutions for apparently conflicting land use demands. Issues of temporal and spatial scaling have to be considered in those analyses.
- Utilisation of interdisciplinary methodologies to analyse site related effects and interactions of processes and states in land use and its development. Analyses carried out by natural sciences have to be supported by socio-economic competence when land use situations are studied, and people and their actions are involved.
- Translation and proper management of available disciplinary derived knowledge to generate new understanding in a wider and interdisciplinary context.
- Problem oriented definition and implementation of functionally based landscape indicator systems to make interdependences of land use management transparent and generate a basis for multi-objective and sustainable decision making.

Methodologies to achieve consensus between conflicting demands

Sustainable land use and landscape development can only be achieved if knowledge about the multiple landscape functions and its interdependences is transferred to decision makers. Decision makers have to be assisted in balancing interests and achieving consensus between conflicting demands in order to develop sustainable land use strategies. A consensual balance of interests at the local or regional level (oriented at the principle of subsidiarity) can be achieved, when information about these interdependences is prepared and transferred adequately to the users. Precondition for a successful balance of power is, however, a precise definition of the property rights of the various user groups.

Achieving consensual balance of interests requires an institutionalised moderation of the process and sufficient provision of information preceding the discussion. All information has to be prepared and effectively communicated to all groups being involved in finding a consensus in land use decision making. The utilisation of modelling tools and scenario techniques may help to facilitate decision making in a transparent way (KEITH et al. 1999). Those tools have to be further developed according to the specific needs of user groups. To provide highest potential for the successful implementation of the transfer concepts, the specific demands of the administration have to be considered at the earliest possible stage. Research requirements may be formulated as:

- Methods to adequately prepare and communicate knowledge to all groups being involved in decision making considering cultural particularities and demands of specific social groups.
- Development and utilisation of scenario techniques linked to a proper indicator system as a mean to generate transparency of the multiple and interrelated effects of alternative land use options. This tool might facilitate decision making in a comprehensible way.
- Identification of means that motivate the administration to implement innovative solutions and to define, which institutional solutions are appropriate to achieve consensus. In this context, the role of the principle of subsidiarity needs clarification.

Conclusions

The utilisation of the concept of multifunctionality seems to be a powerful tool for the process of sustainable land development. Three important steps could be delineated for this process. The first step towards sustainable land use is the comprehensive identification of land use functions and demands in a specific region involving the environmental, social and economic aspects of land use. The second step concerns the analysis of the mutual interrelations of land use functions and the identification of land use conflicts. The third step addresses the process of decision making and achieving consensus on land use combinations involving a participative co-operation of all interest groups. Interdisciplinary landscape research is an important instrument to scientifically support this process of sustainable land development.

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Sustainable Development of European Landscapes as a Multidimensional Environmental and Societal Issue

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Abstract

On the basis of a brief characterisation of today's European landscapes, the contribution refers to three dimensions of sustainable landscape development, namely cause-analytical, normative and planning dimensions. It describes landscapes from a cause-analysis point of view as a fabric consisting of total human ecosystems, which is proposed to make operational using secondary integration of part models. A variety of different target areas and target categories is illustrated in relation to the normative dimension. In terms of planning, requirements for scientific support of ecologically-holistic, societal multi-sectoral and chronologically continuous decision-making processes within society are listed, together with the manner in which they accommodate supra-regional preconditions, whilst involving both regional and local players.

Keywords: European landscapes, landscape ecology, regional development

1 Landscape development in Europe – The road ahead

1.1 Landscapes at the beginning of the 21st Century

As landscapes have developed in Europe, they have been shaped in many ways by a wide variety of natural conditions and regional cultures (cf. MÚGICA and GULINCK 2000). Agricultural and forestry utilisation accounts for the lion's share of the land cover. Besides, the urban areas have now also reached the size of landscapes in some cases. This is demonstrated in the case of Germany by a settlement and traffic share of 12.3 % (DE-STATIS 2002: 6).

Over and above the expansion of the abovementioned utilisations in terms of land cover (horizontal expansion), there has also been an increase in intensity (vertical expansion). In addition to the production of foodstuffs and renewable raw materials, agricultural land has taken on additional ecological and societal functions, especially for the urban areas (WERNER et al. 1995, EEA 1999: 337). These include, for instance, in comparison with natural forest cover, the increased regeneration of groundwater, formation and efflux of cold and fresh air, nutrient-matter recycling, conservation of cultural landscapes, recreation, tourism, etc. Furthermore, the rural areas perform major societal functions in that they provide housing space, specifically in the areas surrounding the cities. The cities, in turn, supply the rural areas with goods, services and culture. They are interwoven to some considerable extent (SPESP 2000).

The expansion of agricultural, forestry and urban utilisations led to wide-ranging changes in the environment, such as climate change, transboundary air pollution, contamination of surface water (including coastal waters) and of ground water (eutrophication, hazardous substances, acidification and structural changes), water stress, increase in the runoff (floods, low water levels) by reducing the retention of the watersheds, through changes in the soil (sealing, structural change, erosion, contamination), loss of biodiversity, etc. (EEA 1999, ESDP 1999: 62 pp, IPCC 2001, UNEP 2002).

In comparison to historical land utilisation (e.g. KÜSTER 1996), today's European landscapes are hence characterised to a much greater degree by utilisations that are spatio-temporally overlapped several times, interwoven to a considerable extent and linked by highly complex environmental effects. Areas with no anthropogeneous influence whatever are now virtually non-existent in Europe (HABER 1993: 71).

Spatial patterns and the intensity of such utilisations will in some cases also be highly dynamic in future as a result of area-specific societal processes. The EU's agricultural policy and international agreements (e.g. WTO) will have a major impact on the rural areas of Europe. The political transformation also plays a role in the EU accession states (SIEBERT and LASCHEWSKI 2001). The previous migration of the population away from rural areas (ESDP 1999: 66) will therefore continue. In the area around the agglomerations, one may expect a continuation of the increasing use of space settlements and infrastructure, with shrinking in small areas (SIEDENTOP et al. 2002). All these developments will have major impacts on the natural conditions.

1.2 Dimensions of sustainable landscape development

A conceptual framework is constructed below related to the development of landscapes using three content-related dimensions, orientated towards an ecologically-holistic and a multi-sectoral societal approach, whereby each dimension accommodates all three fields of sustainability:

- The *cause-analytical* dimension refers above all to the physical interactions between society and the environment. Over and above this, the economic and social driving forces on which these are based also play a role, as do the consequences of environmental feedback impacts on the societal systems.

- The *normative* dimension is concerned with the prerequisites for the evaluation of these processes. To make use of this, targets must be drafted for the ecological, social and economic aspects of sustainability.
- The *planning* dimension covers the framework and tasks of the societal development of landscapes.

The content of all three dimensions will be outlined below, and descriptions as well as requirements for landscape development will be derived from these and the need for research in this field will be identified.

2 Interactions between naturgenic environments and the - anthropogeneous utilisations (cause-analytical dimension)

2.1 Components of landscapes

Landscapes are a spatio-temporal fabric of interactions between man and his environment (e.g. EGLER 1942, LESER 1997: 22). The natural conditions, potentials and self-organised developments of a landscape, can be interpreted from a human ecological point of view as *naturgenic environment(s)* – in contradistinction to the artificial environment created by man. The term "naturgenic" is intended to express the fact that many processes, structures and ways of life have in some cases been considerably modified by civilisation. They can no longer therefore be defined as natural. However, their genesis and their renewal are still based on nature's self-organisation.

The delimitation between man and the environment, which needs once again to be seen in relative terms using the systemic view taken below, appears to make sense for the following reasons: Firstly, man is bound by a constructivistic and hence anthropocentric perception of the environment (WEIZSÄCKER 1984). Secondly, both systems have differing forms of organisation ("steering potential" versus "self-organisation") by virtue of their differing phylogenetic awareness (cf. e.g. BISCHOF 1985). Thirdly, for reasons of complexity, a separation of societal causes and holistic receptor systems of the environment in comparison with a division into part processes consisting of causes and environmental sub-effects, appears to take priority for immission-orientated protection of the environment.

It is possible when discussing the naturgenic environment to distinguish between the compartments of air and climate (atmosphere), surface waters and groundwater (hydrosphere), geology and soil (lithosphere), species and biocoenosis (biosphere). Their natural dynamics are determined by sphere-specific processes, structures and ways of life. Furthermore, they are linked into an ecosystem and a landscape context via the gas, water and mineral nutrient cycles that are characteristic of the humid conditions, including the concomitant flows of energy.

The totality of human activity which is relevant to landscapes can be referred to as an *anthroposphere*. It can be divided into *intangible* and *tangible* dimensions which closely permeate one another (HABERL et al. 2001: 16). The intangible individual and community processes of thinking, speaking and acting practised by societies are determined by needs, values, experience, etc. In relation to the environment, they are also summarised as driving forces (CSD 2001). The tangible processes induced by these driving forces serve to create the physical context required to meet the intangible demands. At the interfaces with the naturgenic environment, they constitute influences which when they concern emissions are referred to as *pressures*, and when they concern immissions are described as *impacts*.

It becomes evident from the present conditions of European landscapes outlined in general terms at the start that the anthroposphere is not simply two-dimensional land cover. Rather, the complex societal system simultaneously leads to a variety of spatio-temporal utilisations that are intensively interwoven in terms of space. For this reason, the existence of complexes of utilisations with several overlapping individual utilisations is presumed below. If one takes their naturalness into account (HABER 1993: 72 pp), it is possible to distinguish between the following categorical complexes of utilisations:

1. Urban and infrastructural utilisation complexes: housing, services, trades, industry, traffic (overground and underground road and rail traffic, air and maritime traffic), supply (water, energy, raw materials), disposal (sewage water plants, landfill), etc.
2. Agricultural, horticultural and silvicultural utilisation complexes: arable land, meadows, special cultures, parks, gardens, woodlands, forests, species protection, conservation of cultural landscapes, recreation, tourism, hunting, increased regeneration of groundwater, formation and efflux of cold and fresh air, air filtering (incl. CO_2 binding), release of residual materials (e.g. sludge), etc.
3. Natural and near natural utilisation complexes: species protection, recreation, tourism, hunting, extraction of natural products, etc.

2.2 Interactions and systemic definition

Despite a high state of technological development, the anthroposphere is still dependent on the naturgenic environment in a variety of ways. On the one hand, humans depend ecologically (thermodynamically; PRIGOGINE 1973) on consuming and processing the biological net primary production, using renewable and in some cases non-renewable raw materials and sources of energy and relying on the resilience of ecological systems ("disturbance that can be absorbed before the system redefines its structure"; GUNDERSON et al. 2000) to deal with material and structural impacts.

On the other hand, the changes imparted to the naturgenic environment to meet the above mentioned needs have a secondary impact on man as a result of changes to natural phenomena. The EEA (1999: 185) speaks in this sense of expanding the DF/P-S-R model of impacts between state and response. As such, anthropogeneously caused feedback's in the naturgenic environment should be mentioned that are constituted by the gradual changes in the natural potential of particular areas. These also include the amplification of natural hazards, such as storms, avalanches and landslides, floods, etc. (UNEP 2002).

In order to illustrate the interaction between the utilisation complexes of the anthroposphere and the naturgenic environment, holistic systemic approaches are desirable, despite all the unavoidable epistemological and methodical restrictions (NAVEH and LIEBERMAN 1994: 73pp, LESER 1997: 76). At this point, landscapes are hence described as a *fabric of total human ecosystems* (EGLER 1964). Total human ecosystems are understood as they are described as follows in the summarising characterisation by BRECKLING and MÜLLER (1997: 8): *Spatio-temporal delimitable, open systems with anthropospheric components, and their self-organised environment, in which on the basis of internal material cycles and trophical energy transformations high processual links dominate, and all of which have a feedback effect on the conduct of the parts and lead to the formation of specific emerging features.*

The complexes of utilisations can be considered as reference areas for such ecosystems (eco*topes*) in a question-specific utilisation-determined and natural, spatio-temporal resolution (KERNER et al. 1991: A7-4, FRÄNZLE 1998: 15). On the hierarchically superior scale of landscapes, which are interpreted as chorological units having similar natural landscape starting points, and their utilisations (cf. MANNSFELD 1997), characteristic intersystemic interactions exist between these ecosystems. These are both natural flows of energy and material, including the interaction and migration of organisms, as well as anthropogeneous exchange and transport processes.

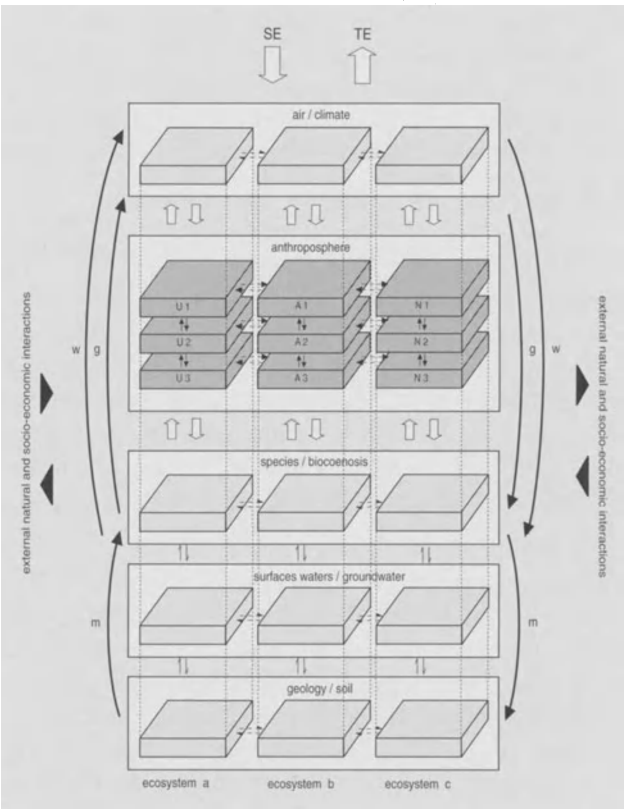
Fig. 1 presents the above context schematically. The utilisations of the anthrosphere are positioned centrally. These are given as examples of multi-layered complexes according to the three abovementioned categories. They form at the same time the reference areas of ecosystems in which the compartments of the naturgenic environment are included. Intersystemic relations are symbolised both for the individual utilisations, and for the compartments of the natural environment.

Between the anthrosphere and the compartments of the naturgenic environment, double arrows symbolise the anthropogeneous removals of net primary production and the utilisation of biotic and abiotic resources, as well as the burden by materials and structural changes, including the reduction of both as a result of utilisation-related feedback from the environment. The reference material shows different definitions of this interaction under the term of *function* (e.g. VAN DER MAAREL 1976: 428pp, FORMAN and GODRON 1986: 11, DE GROOT 1992).

From a human ecological perspective, the functions are understood here, carrying on the definition by DE GROOT (1992: 7), as *the current and potential ability of processes, structures and ways of life in the naturgenic environment to provide and accept energy and material, as well as to use biological activity to satisfy human needs*. 'Ability' replaces DE GROOT'S term 'capacity' since – as will be shown below – the latter already has a normative momentum.

Functionality is determined both by the intrasystemic interactions, and by the intersystemic interactions resulting from the fabric of ecosystems of landscapes. This is made clear, for instance, by the Concept of Differentiated Land Use put forward by HABER (1972). Intra- and intersystemic functions lead to the *multifunctionality* of landscapes.

In order to make operational of such an understanding of 'landscape', it will not be possible in the foreseeable future to rely on comprehensive, *primarily integrating* landscape models (LESER 1997: 93). Instead, approaches are needed to make *secondary integration* possible at the level of ecosystems and on the basis of part models. For this, models can be considered which portray the intrasystemic (vertical fluxes; e.g. WERNER et al. 1997) and the intersystemic processes (e.g. lateral fluxes of landscapes with the anthroposphere being included; e.g. RODE et al. 1995, BACCHINI and BADER 1996). Both types of models should be related to congruent ecotopes by using GIS, and should be coupled by data and method interfaces to create models of the system. Many approaches already exist for such model couplings (e.g. SCHÖNTHALER et al. 1994, REICHE 1996, DABBERT et al. 1999, LUTZE 2000, MOSIMANN 2002). They need a targeted further development to portray the emergent dynamics and the input and output of concrete ecosystems.



SE solar energy, TE thermal energy, w natural water cycle (incl. energy fluxes), g natural gas cycle (incl. energy fluxes), m natural mineral cycle (incl. energy fluxes), U urban and infrastructural utilizations complexes, A agricultural, horticultural and silvicultural utilizations complexes, N natural and near natural utilizations complexes, ⇧⇩ abstractions and pressures of man, ⇅ intrasystemic interactions between components of land use complexes, ⇠⇢ intersystemic interactions between components of utilizations in different ecosystems, ⇅ intrasystemic interactions between components of the naturgenic environment, ⇠⇢ intersystemic interactions between components of the naturgenic environment in different ecosystems

Fig. 1: Regional man-environment model with vertical components and the horizontal pattern of ecosystems in landscapes

Questions of sustainability can be examined on the basis of such ecosystemic approaches. JØRGENSEN and NIELSEN (1998) describe thermodynamic indicators for this like emergy, exergy, ascendy, overhead, the ratio of indirect to direct effects and specific (structural) exergy. From a material point of view, such indicators may refer to the loss of nutrients and soil (HILDMANN 1997). Similarly, in the case of the biotic environment, indicators such as net primary production and specific biodiversity may be used. The degree to which it is possible for the ecosystemic integrating indicators to upscale to the choric and regional hierarchy levels should be the subject of further discussion (cf. STEINHARDT and VOLK 1999).

2.3 The concept of carrying capacity

The environmental problems named at the outset show that the functionality of ecosystems is limited. Both for reasons of cognitive faculty (e.g. VALSANGIACOMO 1998) and because of the system behaviour of ecosystems (including flow equilibrium; NAVEH and LIEBERMAN 1994: 61, MÜLLER and JØRGENSEN 2000), it is not possible for them to presume a *static, precisely analysable* carrying capacity. Rather, it is to be interpreted normatively following delimitation as a critical area of system changes.

In ecology, some concepts have been developed in this context - the concepts of "ecosystem health" (CONSTANZA et al. 1992), "ecological integrity" (WOODLEY et al. 1993) and the "orientator theory" (BOSSEL 1992) which may also prove applicable in the future. "Health" is understood here as a system feature which corresponds to the characteristic metabolism (vigour), organisation and resilience. "Integrity" means the ability of systems to maintain their organisation and to develop in a process of self-organisation. To put it very simply, the orientator theory is based amongst other things on a system development according to the optimal nature of the energy budget.

Furthermore, one presumes for this reason a carrying capacity which *moves between defined ecological system features* (flow equilibrium) and *near natural energy and material fluxes* (non-flow equilibrium) to be *normatively determined*. Its task refers to indicators which represent the systems in a suitable manner, accommodating the specific natural conditions of ecosystems. Because of the overcomplexity of real-world systems, it is considered necessary to have a societal interpretation of the academic delimitation of such stress thresholds (cf. below). A discussion based on the decision-making practical interplay of the two is known from the derivation of critical levels of material loads for soils (e.g. WBGU 1994: 65).

3 Target areas and target categories (normative dimension)

By means of the well-known triangle of sustainability coined by SERAGELDIN (1995: 23), equivalent value and goal areas are stated for ecology, economy and social matters. In accordance with the aboveoutlined ecological sustainability, alternative models of sustainability were developed ("strong sustainability"; OPSCHOOR 1992) in the subsequent period for the only restrictedly "substitutable" natural capital. PRESSCOTT-ALLEN (1995: 3) and BUSCH-LÜTY (1995: 18) relied on a shell model, where the outer shell symbolises the capacity limit of ecosystems. The interests of society lie within this shell. BUSCH-LÜTY goes on to specify that the economic interests of a sub-group of society, and hence the social questions, are embedded in it. This was tackled amongst others by the European Environment Agency (EEA 1999: 49).

3.1 Ecological targets

In order to determine sustainability, no binding weighting of ecological as against the two other interests emerges from the shell model. It does however become clear that ecological goals are needed which have not yet been subjected to a balance with the economic and social goals, and which even afterwards will remain recognisable as long-term goals. These include a goal category which defines the target societal long-term minimum quality of the naturgenic environment. In parallel, it is possible to approach a second goal category, the objectives of which serve to ensure an action-orientated or emission-orientated gradual achievement of the minimum environmental quality. It arises from the societal comparison of the ecological against the other sustainability interests. In order to distinguish between the two, the former are referred to as *environmental quality targets*, and the latter as *environmental activity targets* (REHBINDER 1997, SRU 1998: No. 67).

In order to describe the goals of both categories in words, there are two fundamental challenges. On the one hand, it is a matter of selecting and indicating the relevant processes, structures and ways of life within the naturgenic environment, and on the other of determining critical spatial-temporal thresholds (objectives, standards) of the anthropogeneous influence. In order to *select and indicate* by means of the previously set systemic contexts and their operationalisation, the necessary requirements must be created (e.g. HYATT 1999: 9, MÜLLER and JØRGENSEN 2000: 570). To date, however, such systemically-derived indicators for decision-making practice, and related to these goal criteria, are only available to a restricted degree. The sets of indicators selected by coincidence, used instead of these, do not appear to be suitable (FARINA 1999: 3, KRÖNERT et al. 2001: 13). The determination of spatial-temporal *critical thresholds* may refer to the abovementioned concept of carrying capacity. Methods of area-related determination for fabrics of ecosystems of landscapes in the abovementioned manner are however still in their infancy.

Both points of view are to be placed in a much broader theoretical context over and above the knowledge available to environmental science. Hence, on one hand the epistemological limits of the wording of the goals and the model of technical verifiability (cf. PETERS 1999: 6 pp) are to be reflected with their contemporary specificity (SCHWARZ and TREPL 1998). In the final analysis, this permits one to identify and to disclose the uncertainty and the risks of evaluations for taking decisions. On the other hand, there is a need to become aware of the ethical values on which the goal definition is based and to lend these values intersubjective validity (BECHMANN 1981: 105).

3.2 Social and economic targets

The differentiation between fundamental and balanced goals found for the ecological objectives could also be essentially wise for the social and economic aspects of sustainability. The wording of goals and goal criteria in the interest of social sustainability is generally regarded as difficult, however (ENQUETE-KOMMISSION 1998, SRU 1998). This is caused in particular by the special weighting of the subjective perception, as against the "objective" description (KORCZAK 1995). It appears doubtful whether it will be possible to distinguish further between minimum and action goals, since it appears that the validity of goals in this sense will be difficult to achieve by the means described.

SPEHL et al. (1996: 67; supplemented) allocate to the field of economic sustainability above all the needs for food, clothing, housing, health, communication, education, work, culture, recreation and mobility. For the social field, they name internal and supra-regional reciprocity and equal opportunities, the possibility to take responsibility for oneself, opportunities to participate, equivalent opportunities in life, justice in the supply of goods, transparency of chains of action and effect and decentralised decision-making competences.

Many indicator concepts and indicators exist in order to bring these goals within the operation (BIRKMANN et al. 1999). In most cases there is no determination of target or threshold values in these approaches. It has hence been possible so far to verify goals only to a restricted extent. Instead, sustainability is often determined by business or economic costs for losses of utilisation or measures for environmental protection (cf. e.g. CONSTANZA et al. 2001: 161).

4 Steering landscape development (planning dimension)

4.1 Framework concept of landscape management

Cause-analytical knowledge and multi-sectoral goal definitions form the basis of knowledge and the orientation framework for the sustainable development of landscapes. Building on this knowledge, societal decision-making processes cover in particular the drafting of measures and scenarios, their evaluation and comparison, implementation using planning strategies and tools, and finally success monitoring (FÜRST and SCHOLLES 2001: 26). Special status is therefore attached to a suitable combination of these sub-tasks for the development of landscapes.

SCHANZE (2000) developed for this purpose a concept of *decision-making monitoring within environmental science*. In its present form, it is first of all orientated towards interlinking the steps of decision-making processes with knowledge of environmental science. Furthermore, it permits the inclusion of social and economic interests which can be further expanded. The term "monitoring" places the emphasis on the continuity of the basis for decision-making. In contradistinction to final planning solutions, the approach attempts to provide an ongoing reflection of the real development of landscapes (cf. JEDICKE 2002) and its continuing updated steering. Its interactive nature accommodates the strategic steering approaches from the more recent forms of management science (e.g. STEINMANN and SCHREYÖGG 2000).

Fig. 2 portrays this basic understanding of landscape management. On the basis of cause-analysis and goal definition, decision monitoring arises for decision-making processes concerned with evaluation and with the comparison of alternatives. The goal definition and scenario formation linked to a societal setting remain reserved to the direct influence of the decision- makers. For the management of landscapes based on this concept there is a qualified coupling between the paradigms of scientific analyses and prognoses on the one hand and societal settings on the other.

In contradistinction to the previous landscape and environmental planning which had sectoral or static results (e.g. ecological risk analysis), a set of academic tools emerges that is highly complex, chosen for decision-makers using selected indicators that are easy to shape and can be continued. This can be used to estimate the consequences of decisions and to monitor their success, differing from previous environment information systems which primarily serve to collect and maintain environmental data.

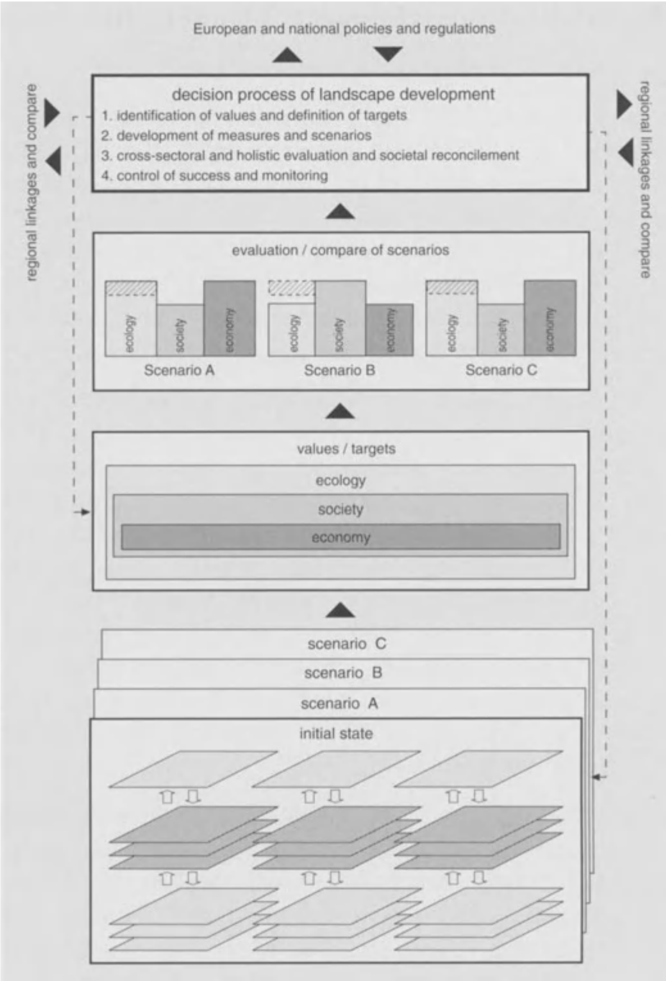


Fig. 2: Concept of the management of landscapes on the basis of an ecologically-holistic, multi-sectoral societal approach

4.2 Political and legal framework

In addition to this operational dimension of landscape management, the policies and regulations of the European Union and the Member States can have significant effects on the development of landscapes. The European requirements include comprehensive instruments, such as the European

Spatial Development Directive, the European Landscape Convention and others. Sectoral European requirements include for instance AGENDA 2000, the Water Framework Directive, and the Framework Natura 2000. Added to these are international agreements such as GATT, the Biodiversity Convention and the Climate Framework Convention.

Moreover, administrative territorial arrangements influence landscape development. This is applied to the congruence of administrative borders and natural landscape units. One up-to-date example of this question is river basin management in accordance with the European Water Framework Directive. It makes particular demands by means of its natural landscape approach, which hence crosses administrative borders.

4.3 Regional decision-making processes and players

The steering of landscape development is, like regional planning, heavily dependent on local societal decision-making processes (MÜLLER 1999). Consequently, this aspect is vital to successfully taking account of scientific process knowledge and the implementation of societal sustainability goals. From the experience of a strict, comprehensive planning scheme which includes the players merely as addressees (e.g. SELLE 1994, FÜRST 2000: 14pp), new approaches have been developed. These include actor-orientated institutionalism (SCHARPF 2000) and the "collaborative planning" approach (HEALY 1997), as well as the named approaches based on management science.

Because of the incongruence of regional and local administrations with the natural landscapes, their development also particularly demands promotion of interauthority cooperation and regional networks (cf. MÜLLER 2001). Also in this vein, important knowledge for cooperation in rural areas and in regional interweaving of urban and rural areas emerges from the above planning approaches.

5 Contribution from the point of view of regional development

Investigation, theoretical processing and conceptual support of spatially relevant societal decision-making processes, including the ecological, social and economic knowledge on which they are based, is an important list of questions in the scientific area of *regional development*. As a sub-area of *spatial development*, it is concerned with researching the societal task of the sustainable development of regions. In its ecological orientation, amongst other things, the link is discussed between the outlined cause-analytical and normative dimensions and the planning tasks.

Regions are regarded as a major standard level for the identification and solution of problems that are of spatial relevance (e.g. LOCHER et al. 1997). They can be defined by different points of view. In the following, they are *understood as methodical delimitable spaces which have characteristic societal structures and interweaving, and which include one, or indeed as a rule several landscapes*. Hence, at these levels supra-locality characteristics of areas are to be described without at the same time having to forego the connection with the concrete localities and their players within society.

The scientific field of regional development uses a transdisciplinary access route combining natural, social and economic sciences with planning and legal sciences. In particular, it develops fundamentals-orientated requirements for the creation of theoretical links and the development of methodical interfaces, and it overcomes the specifics of spatial-temporal scales of processes and data. In its application orientation, it aims to include a variety of fields of societal activities, to accommodate European and national policies and legal provisions, as well as the function of the regional and local players.

For the development of European landscapes, contributions emerge from this viewpoint both towards the integration of the three dimensions, and towards the views of individual aspects derived therefrom. Unless already discussed in the individual chapters, it is possible to discern the following subjects for research in this area:

- Conceptual and methodical integration of relevant physical interactions between the societal demands and environmental components for an ecologically-holistic and societal multi-sectoral landscape development
- Derivation of cross-medial environmental quality targets and development of targets to specify social and economical sustainability
- Spatio-temporal operable decision monitoring of actual states and scenarios by multi-criteria ecological, social and economical evaluation and updating analysis of the real development
- Multi-sectoral analysis to involve the relevant actors and to create actor-orientated steering strategies for regional development
- Analysis of the interrelations between European and national policies and regional demands
- Policy advice at different administrative levels (European to local)

In view of their complex nature, these questions should be dealt with through targeted, transdisciplinary cooperation between academics having skills in various fields of science and with specific regional experience. This is the only way for landscape development to be linked at European level with the regional nature of its concrete local problems. A European landscape research network can make a considerable contribution towards achieving this goal.

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Multifunctionality of Landscapes and Ecosystem Services with Respect to Rural Development

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Most *economic* activities in rural areas directly or indirectly affect the landscape. This is obvious with the traditional sectors of agriculture and forestry, which have shaped the cultural landscapes of Europe for centuries. Many parts of rural Europe are still dominated by a patchwork of private farmland and forests, sprinkled with villages and small towns in unique agricultural landscapes that are a part of Europe's cultural heritage.

However, from the perspective of rural development we are also interested in *non*-agricultural economic activities, such as tourism, rural industry, natural resource extraction and *non*-tourist services. These non-agricultural activities are becoming more and more important for the rural economy, and are therefore also becoming more relevant for the rural landscape. Non-agricultural activities can often alter the landscape in ways that are different to the impact of agriculture and forestry. Usually, they are also utilizing different functions. For instance, for a farmer, landscape aesthetics is only a nice side aspect of the land; it is the soil productivity that is most relevant. For a rural tourist business, on the other hand, landscape beauty is a vital asset.

In this discussion we will focus on five *non*-agricultural landscape functions:

1. The recreational function
2. The water-protection and climate functions
3. The biodiversity protection function
4. The physical resource base function
5. The waste dump and safety distance function

The recreational function of landscapes

Woods, meadows and wheat fields are not only relevant for agricultural production and forestry. Their arrangement also determines the landscape value for a whole range of economic activities in the tourist and recreation industry. Many tourist areas could not survive, if the current landscape would be changed significantly. This, for instance, is obvious with Austria's winter tourism, which is greatly depending on Alpine meadows for downhill ski-slopes, cross-country ski tracks, and many other tourist facilities on the mountains. If those areas would be overgrown by thick forests, the attraction for winter tourists would decline dramatically. Winter tourists like the relatively *open* Alpine landscape with sunny ski lifts on high plateaus with only small patches of (protective) forests on the steeper slopes.

The recreational value of landscapes is also obvious to those who like to hike in valleys or climb mountains, bicycle along a river, play golf, swim in a lake, or fly a model airplane. There are dozens of sports and recreational or leisure activities that require open space in a rural landscape. Imagine how frustrating it would be to picknick in a city environment. We often don't think about it, but there is a reason why *millions* flee from cities on sunny weekends to spend their time in the *rural* hinterland.

The following statistics illustrate the relevance of tourism, sports and leisure activities. In 1995, Germany's tourist sector contributed 8% to the Gross National Product (GNP) – *not* including investments in tourist-related infrastructure. This is far more than the contribution of agriculture which is less than 3% of GNP. Roughly 2.8 million people were employed in tourism. In 2001, more than 107 million visitors of tourist facilities and almost 327 million overnight stays were registered in Germany (Statistisches Bundesamt, DESTIS). Detailed statistics on *rural* tourism are not available, but there can be no doubt that rural landscapes are important attractions. For instance, in 2001 roughly 5.5 million tourists visited Germany's camping sites – which are mostly in rural areas. There were 21.3 million overnight stays on camping sites -. 4.5 million of these were visitors from Germany, 1.0 million came from a foreign country (Statistisches Bundesamt, DESTIS). In its 2000 Annual Report, the German Center for Tourism (Deutsche Zentrale für Tourismus, e.V.) analyzed the major new trends in tourism. They concluded that the "experience of nature and landscape" is becoming more and more important (p.13). With its 13 national parks, 13 biodiversity reserves, 40,000 km long-distance biking trails, as well as 320 wellness and health centers ("Heilbäder und Kurorte"), Germany's rural areas greatly contribute to the country's tourist attractions (DEUTSCHE ZENTRALE FÜR TOURISMUS 2000)

The German Institute for Economic Research (Deutsche Institute für Wirtschaftsforschung, DIW) in Berlin has analyzed the economic relevance of tourism in Germany (FILIP-KOEHN et al. 1999). They found that in 1995, some 395 billion DM were spent in tourism, or about 8% of the GNP. Most of it, 127 billion DM (or 2.1% of the GNP), was spent on *day* trips. These day trips usually consist of short-distance travels. Many of these are short-distance trips on the weekend, where city people visit the rural hinterland for recreation and leisure. Finaly, we can use statistics on *winter*-tourism to estimate the economic relevance of rural landscapes for the tourist sector. Winter tourism typically depends on certain landscape characteristics, such as mountains (for downhill skiing), open meadows and trails (for cross country skiing), lakes (for skating) etc. Some landscapes in Europe are obviously more privileged than others. For instance Austria, with a population of 8.1 million, was visited by 12.4 million foreign guests between November 2001 and April 2002 - (Statistik Austria). During the winter season of 2001/2002 there were almost 53 million overnight stays at Austrian tourist facilities – predominantly in mountain areas. Alpine landscapes are certainly a major "production factor" for Europe's tourist industry.

The water protection and climate function of landscapes

In recent years, large-scale flooding catastrophes in Europe have reminded us that landscape characteristics can play a vital role in flood control. Currently, (August 2002) large parts of Europe are suffering severe flooding. Widespread sealing of the soil in built-up areas, monotonous agricultural fields, deforestation in upstream areas, and canalization of small tributaries are all increasing the danger of disastrous floods. When we transform natural flood-planes into cultivated land or settlements, we not only change the natural landscape – we also destroy one of its most critical functions, namely to temporarily retain excess water in the case of heavy rain.

Another water-related function of certain landscapes is water purification and the protection of our groundwater supply (EWEL 1997). High-quality freshwater supply from watersheds in rural areas can save urban areas *millions* in water treatment costs. Germany has designated almost 12% of its land area as water protection areas with strict regulations concerning the use of fertilizers, pesticides, and other substances that might pollute the groundwater, such as oil or gasoline. Most of these sites are located in agricultural areas (50%) and forestland (40%) (See table 1). This is necessary, because high-intensity agriculture (such as in vineyards or vegetable production areas) can pose a high risk on our freshwater supply. Here the groundwater is often polluted with the residuals from nitrogen fertilizers, in particular nitrate, which is converted to healththreatening nitrite in the human body. Only recently, the EU commission has warned Austria to apply more efficient measures for reducing nitrate levels in the most affected agricultural areas.

Tab. 1: Germany: Water protection areas by Federal State in 1997
Source: LAWA-AG: Grundwasserschutz und Wasserversorgung (16-42); extracted from http://www.umweltbundesamt.de
[1)] Estimated

Federal States	Area	Water protection areas			Used for					
		Number	Area		Agriculture		Forestry		Other	
	(km^2)		(km^2)	%	(km^2)	%	(km^2)	%	(km^2)	%
Baden-Württemberg	35751	2552	7253	20,3	4134	57	2713	37,4	406	5
Bayern	70548	3794	2401	3,4	1321	55	1008	42	72	3
Berlin	889	19	248	28	0	0	87 [1)]	35 [1)]	161 [1)]	65 [1)]
Brandenburg	29476	988	1790	6	859	48	752 [1)]	42 [1)]	179 [1)]	10
Bremen	404	4	29	7	6,8	23,4	1,9	6,6	20,3	70
Hamburg	755	3	88	11,7	47,6	54,1	12,8	14,5	27,6	31,4
Hessen	21114	1605	5800	27,5	2670	46	2710	46,7	420	7,3
Mecklenburg-Vorpommern	23170	1100	4370	18,9	2491 [1)]	57 [1)]	1516 [1)]	34,7 [1)]	363 [1)]	8,3
Niedersachsen	47606	310	4524	9,5	2334	51,6	1697	37,5	493	10,9
Nordrhein-Westfalen	34072	390	4501	13,2	2250	50	1350	30	900	20
Rheinland-Pfalz	19848	1353	547	7,8	774	50	696	45	77	5
Saarland	2570	51	403	15,5	137	33,9	163	40,5	103	25,6
Sachsen	18413	1495	2280	12,4	1053	46,2	1042	45,7	185	8,1
Sachsen-Anhalt	20446	423	1593	7,8	792,4	49,7	625,9	39,3	175	11
Schleswig-Holstein	16175	15	172	1	112 [1)]	65	15 [1)]	9	45 [1)]	26
Thüringen	16175	3482	4916	30	2087	42	2262	46	600	12
Germany	**357412**	**17584**	**41915,3**	**11,7**	**21068**	**50,27**	**16651,6**	**39,73**	**4226,9**	**10,08**

Finally, we have to think about the climate functions of certain landscapes. Extended forests are not only CO_2 sinks (BROWN 1999); they can also dampen storms and reduce erosion (MYERS 1997) Open landscapes with (seasonally) little or no vegetation, such as many intensive agricultural landscapes, are more vulnerable to wind and water erosion and provide little protection against storms.

The biodiversity protection function of landscapes

A lot has been written about the value of certain landscapes for the protection of endogenous animals and plants, which we have to preserve for future generations. (PERRINGS, C., MALER, K.G., FOLKE, C., HOLLING, C.S., JANSSON, B.O. 1995) Conserving the genetic diversity of plant and animal species should *not* be seen as the romantic idea of nature lovers. It has important economic and human health implications (GRIFO, F., ROSENTHAL, J. 1997). It could help future generations in the breeding of new food crops and domestic animals; it might serve the pharmaceutical industry in the development of new drugs (BALICK, M., ELISABETSKY, E, LAIRD, S. 1996) and it provides a broad basis for research in the study of evolution (LEUNG, A.Y., FOSTER,. S. 1996). Many insect species provide valuable pollination services to farmers (NABHAN, G.P., BUCHMANN, S.L. 1997).

However, one should not be naïve in biodiversity questions. Many people (in particular farmers) would prefer to have fewer species of insects around, particularly fewer mosquitoes and flies, but also fewer mammals such as mice and rats and fewer birds, such as saw craws. A huge industry serves farmers with pesticides for that purpose. We also should not forget that worldwide *more* people are dying from waterborne diseases transmitted by insects, such as malaria, than from *any other cause of death*. Humans might also be better off without the tuberculosis bacteria, the smallpox or the human immunodeficiency virus (which causes AIDS) – a species, which is currently killing some 30 *million* people. From a human perspective, the protection of biodiversity is a delicate balancing act. We have to protect our own species, but we must also preserve ecosystems (and thus certain landscapes) for those other species that do not harm us or might even provide us with valuable services (WILSON, E.O. 1987).

It is obvious that human intervention in the natural environment can change conditions for other species – sometimes to such an extent that this species is threatened by extinction. Most European countries have therefore created natural parks and other protected areas. In Germany, almost 19% of the land is covered by natural parks (See table 2). For the outside observer this seems like a large percentage of protected landscapes.

However, a detailed investigation by the Umweltbundesamt found that 69% of all biotope types in the country have to be classified as endangered.

Protected areas in many parts of Europe are often relatively small and isolated from each other. There are many more unique landscapes where one finds habitats of rare or even endangered species. To protect these landscapes, the European Union is promoting the "Natura 2000" network. (EUROPEAN COMMISSION 2000) It should help to re-establish a favorable conservation status for key habitats through a variety of measures, including land purchase or renting, habitat restoration, income compensation for land-owners (farmers), site protection and control. The total size of Natura 2000 sites in Europe is currently unknown because the program is still being developed; however the EU Commission recently estimated that all "Natura 2000" areas might cover about 15% of the EU territory (or approximately 485,000 square kilometers) (see: EU NATURA 2000).

While the Natura 2000 network is certainly a most welcome initiative from the overall perspective of nature conservation, the designation of 2000 sites has sometimes met stiff opposition from local populations. Despite financial compensation, farmers are sometimes rather unwilling to "give away" some of their land. For these farmers, land primarily has a production function, while for the environmentalists the site may have a key function in the habitat protection of a species. These two perspectives are not always compatible.

People often believe that *cultural* landscapes always have a lower biodiversity than *natural* landscapes. But this is not necessarily the case. Recent research has shown that Alpine meadows used for cattle ranging (the so-called "Almen") typically display a wide range of animal and plant species. If these meadows are abandoned and "natural" forest re-growth occurs, they often *loose* many plants and animal species, which had previously flourished on the open grassland spaces.

Another interesting example are golf courses. They are often considered the ultimate pseudo-natural landscape, managed to such an extreme that only few animal and plant species (in particular certain types of cultivated grass) can survive. Surprisingly this is not always the case. The author has recently visited a large golf course in the Eastern part of Austria and joined a local bird watcher, who counted and *documented* more than 54 bird species nesting on or close to the golf course. Some of these bird species actually found such generous food supply on the shortcut "grassland" that they multiplied in numbers.

Tab. 2: Germany: Nature parks by Federal State (as of 31.12. 1998)
The total number of natural parks in Germany is 78; six of these parks are crossing borders between two Federal States (hence the difference in the total number calculated from the Federal States)
Source: extracted from http://www.umweltbundesamt.de

Federal State	Number	Area (ha)	In % of area of Federal State
Baden-Württemberg	5	354 50	9,9
Bayern	16	2 145 52	30,4
Berlin	–		–
Brandenburg	9	571 70	19,4
Bremen	–		–
Hamburg	–		–
Hessen	9	620 41	29,4
Mecklenburg-Vorpommern	4	182 45	7,9
Niedersachsen	12	795 31	16,7
Nordrhein-Westfalen	14	1 001 10	29,4
Rheinland-Pfalz	6	458 91	23,1
Saarland	1	103 26	40,2
Sachsen	1	149 50	8,1
Sachsen-Anhalt	2	98 98	4,8
Schleswig-Holstein	5	196 00	12,5
Thüringen	–		–
Germany	**78[1)]**	**6 677 67**	**18,7**

These two examples should illustrate that the relationship between landscape characteristics and biological diversity is rather complex. The simplistic dichotomy of *natural*, in the sense of high biological diversity and *cultural*, in the sense of low biological diversity is certainly incorrect (HÖCHTL, F. 2001). Biodiversity conservation, agricultural land use and rural development must not be seen as zero-sum games, where one side must loose what the other wins. Instead we have to balance these activities in smart ways, so that the overall benefit for the environment *and* for the people is greatest (PLIENINGER, T., WILBRAND, C. (2001).

The physical resource base function of landscapes

We often forget that the raw material we use for building our houses and roads are extracted from rural areas, as is the material used for most of our urban-industrial infrastructure. Pit mines for minerals, gravel, marble, sand, clay, chalkstone, and many other raw materials for the construction industry are shaping some of our landscapes in most significant ways. Large-scale extraction landscapes are the marble quarries of Carrara, the China clay mines of Cornwall, or the coal, brown coal and steel mines in many parts of Europe.

In any modern society with its brick or concrete houses, tarred roads, bridges, railways, and factory buildings, the demand for raw materials is *enormous*. In 1997, the German construction industry ("Bauhauptgewerbe") used some 412 million tons of gravel and sand, 170 million tons of other stones, almost 37 million tons of cement, 62 million cubic meter of concrete ("Transportbeton"), 13 million cubic meters of brick, and 797 million roof tiles (DEUTSCHES INSTITUT FÜR WIRTSCHAFTSFORSCHUNG 1997). The raw material for all these construction products has to be extracted *somewhere*.

It is one of the responsibilities of regional planners and local decision makers to designate areas for natural resource extraction that are not too far away from the major construction or production sites. Otherwise trucks and trains would have to transport these raw materials over large distances, causing rather negative side effects on the environment (NIEDERSÄCHSISCHES LANDESAMT FÜR BODENFORSCHUNG 2001). Regional governments across Europe have set up plans for locating resource extraction sites in an attempt to balance the needs of the (construction) industry for raw material, and the desire of the population for an undisturbed landscape (KREUTZER, L.H. 1993).

A major problem in this context is what to do with these extraction sites when the deposits have become exhausted. In some places, landscape planners and ecologists have developed sophisticated schemes for the re-cultivation of former mining areas ("Bergbaufolgelandschaften"), such as the "Ruhrgebiet" or the open pit mines for brown coal in Eastern Germany (HÜTTL, R.F. 2001, BROLL G., DUNGER, W., KEPLIN, B., TOPP, W. 2000). Sites for gravel extraction ("Sandgruben") are often converted into recreational lakes. However, these re-cultivation programs do not proceed without conflicts (PIRKL, H., LETOUZEZEZULA, G., HEINRICH, M. 1991). Some groups have criticized the "beautifying" of former mining areas, instead favoring the conservation of "*industrial* landscapes" as an important element of our cultural heritage.

The waste dump and safety distance function of landscapes

Landscapes are also used to dump the (solid) waste of our civilization. We use certain ecosystem functions in these landscapes for detoxifying and decomposing the waste, or at least to prevent it from contaminating other environments (for instance, when we use deep salt mines to store radioactive waste). In 1997, Germany produced almost 387 million tons of solid waste; including some 45 million tons of household waste, almost 58 million tons of mining waste, 62 million tons of industrial waste and 222 million tons of waste from the construction industry (Source: Statistisches Bundesamt). There are various concepts for solid waste treatment and recycling in order to minimize the need for landfills. Environmentalists have promoted the idea of reducing material flows in our production and consumption systems; and if this is not possible, to *close* the cycles of material flows by feeding back waste into the production process. While the concept of de-materialization (or reducing material flows) is certainly beneficial, it would be unrealistic to assume that *all* (solid) waste can be recycled. Landfills will be unavoidable in the foreseeable future. For practical reasons, these landfills will be located in rural areas.

Finally, a landscape function should be mentioned that might seem a little odd: the safety distance function. However, this function is used, when nuclear power plants are placed in the middle of rural areas in some distance of big cities. Rural landscapes typically have *lower* population densities than urban landscapes. Hence, they can be used to minimize the risk of technical disasters. On the same principle we use remote areas for high-security prisons, military exercise grounds, nuclear test sites, ammunition storages, hazardous chemical dumps, nuclear waste sites, or other potentially dangerous facilities. The German Federal Office for Radiation Protection (Bundesamt für Strahlenschutz) reported that by the end of 1998 Germany had to dispose 34,299 cubic meters of *untreated* nuclear waste (including 454 cubic meters of heat producing, untreated nuclear waste) and 62,323 cubic meters of *conditioned* nuclear waste (including 1428 cubic meter heat producing, conditioned nuclear waste) (Source: Bundesamt für Strahlenschutz). This, by the way, does *not* include the fuel from nuclear power plants ("Brennelemente der Leichtwasserreaktoren").

We may not like it, but it is a fact that we use certain landscape characteristics (such as remoteness or certain geological characteristics of the ground) to hide some dangerous materials and facilities as far away as possible from densely populated areas.

Some conclusions

The above discussion might surprise those readers, who had expected an analysis of more traditional rural landscape functions and ecosystem services, such as those related to the food and fiber supply or to the preservation of plant and animal species (ALEXANDER, S., SCHNEIDER, S., LAGERQUIST. K. 1997). But European landscapes are no longer shaped by agriculture or forestry. There are many other economic activities in rural areas that utilize landscape functions. Many of these primarily serve the *urban* population. They may serve vital urban needs as in the case of water purification and protection services; but they may also provide recreation for those seeking relaxation from the stress of city life. We also have activities in the industrial, energy, and waste sector that make use of certain landscape functions. From the perspective of rural development this broad range of non-agricultural landscape functions are highly relevant: They provide new opportunities for rural entrepreneurs *outside* the agricultural and forestry sectors, und might thus help slow down the economic, socio-cultural and demographic decline in rural areas.

We have also seen that landscape functions are not always compatible. In fact, conflicts between landscape functions are common in Europe's rural areas (DOLLINGER, F. 1988). There is, for instance, stiff competition between those who are interested in the land for cultivation, environmental protection, tourism, and human settlement construction. Land prices reflect these diverging interests. Much of the land is "given up" by farmers not because it is unsuitable for agriculture, but simply because tourist developers and city people pay astronomical prices (as compared to the prices between farmers). The land is then used for ski-slopes, golf courses, or appartment houses. In other words, landscape functions are changing due to market conditions and economic pressure.

We also emphasized the fact that one particular landscape typically has *different* functions for different people. An Alpine meadow is a place of recreation and beauty for the hiking tourist; it is a source of income (and subsidies) for the mountain farmer; and for the environmentalist it may be the natural habitat of a rare animal and plant species. The challenge is to *balance* these views and interests. We must accept that *universal* criteria for evaluating landscapes are not available – and will probably never be available (RICCABONA, S. 1982). Obviously, the beauty of a landscape is often just in the eye of the observer. But the value of many other landscape functions also depends on the (economic) interest of those who use them. Finding markets for ecosystem services, for instance through the trading of permits for using particular services, might be a promising strategy to balance the various interests.

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Some Aspects of Multifunctional Landscape Character in the Interdisciplinary Environmental Study

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Abstract

The interdisciplinary character of landscape study stands behind the numerous concepts regarding the proper object of research which are issuing from the multifunctionality of the landscape. The following text presents some aspects of essence and character of multifunctional landscape and some ideas on the relationships between landscape study and other sciences, as seen from a geographer's point of view. The presented reasoning confirms the complexity of the nature of landscape, but also emphasises the role of landscape study, as the interdisciplinary domain of knowledge in the cognition of this nature. Simultaneously, the demonstrated connections between the geographical, biological, social and humanistic sciences and landscape research, give us the right of stating that landscape ecology constitutes a sui generis bridge between many domains of knowledge.

Keywords: landscape, geodiversity, pedoheterogeneity, abiotic elements.

1 Introduction

Landscape as an expression was created by Humboldt in the beginning of XIX century and it was defined "as a complex of properties in one piece of the Earth, which is a space of life" (DEGÓRSKI 2002b). Evolution of the landscape definition strongly connected with its multifunctionality was a reason to develop a special scientific discipline of the study. Actually, the scientific discipline connected with landscape research is landscape ecology. The term - "landscape ecology" already exists now for more than 60 years (see TROLL 1939), although the domain has been functioning as an autonomous research domain for less than twenty years (NAVEH and LIBERMAN 1984). Hence, as a very young scientific discipline it is still at the stage of defining its object of research and the relations to other natural and socio-economic disciplines. In view of its interdisciplinary character and the associated very differentiated study toolbox, it was regarded yet at the beginning of the last decade by some scholars as an interdisciplinary research direction (LESER 1991), and not a self-standing scientific discipline: „Landscape ecology is the study of spatial variation in landscapes at a variety of scales. It includes the biophysical and societal causes and consequences of landscape heterogeneity. Above all, it is broadly interdisciplinary." The very term of "landscape ecology" is also often critically assessed (PIETRZAK 1998) as not fully adequate to the object aspect of the discipline.

Landscape ecology has its roots in Central Europe in comprehensive geography (RICHLING 1992, ANTROP 2000b), and hence, just like geography, it has empirical and non-empirical aspects. Scholars try to define the functional aspect of the discipline, formulating both its cognitive and utilitarian functions. This specific functional dualism makes the landscape ecology a scientific discipline of a broad scope of subject matter. Landscape in the common usual meaning is an abstract notion and it requires a precise ontological definition. Numerous concepts and attempts of defining landscape as the object of study in landscape ecology appeared in recent years (FORMAN and GORDON 1986, NAVEH 1987, 2000, GREEN et al. 1996, FARINA 1998, 2000). One can hardly treat this process as terminated, though. Making use of the expression of Putnam's (after CHOJNICKI 1999), namely that the world of science is not a ready-made product, but that the disciplines and domains are being shaped during the course of development of science and its evolution, and that their definition takes place mainly through object conceptualisation, that is – determination of the object models, which organise the field of study of the discipline, landscape ecology might still be regarded as being in the conceptual phase.

The approach to the object of study and the definition of the scope of research in the interdisciplinary domains is in a sense subjective, since the perception of each of us is biased by the domain of knowledge constituting our scientific background. The considerations presented herein are conducted from the point of view of a geographer, and their purpose is to indicate the relations between the landscape ecology and the geographical, biological as well as social-humanistic sciences. They also constitute an attempt at defining the object of study of the scientific discipline here in question by analysis of landscape essence and its character.

2 Essence and character of landscape

In the analysis of landscape essence and character the particular regards were structured into three items being of importance for the current scientific discussion. They are the definition of:

- significance of abiotic components, particularly soil cover in process of landscape creation,

- landscape thickness, understanding as the depth of a landscape (PIETRZAK 1998),
- role of human in the landscape creation (ZONEVELD 1990, ODEH 1998, PIETRZAK 1998, FARINA 2000, DEGÓRSKI 2001, TRESS and TRESS 2001).

2.1 The role of abiotic element in determination of landscape

There is a variety of approaches to the subject of study, constituted by landscape within the domain of landscape ecology. The dominating directions are the holistic, or “system” ones, without hierarchisation of the importance of components in the global setting (NEEF 1967, NAVEH 1982, ANTROP 1997). Those oriented at geocomplexes, understand it as system of mutually connected components, having definite structure and functions (PRIEOBRAZENSKIJ 1967, FORMAN and GORDON 1986), and further there is the ecosystemic approach, in which landscape is treated as the landscape ecosystem (LESER 1991). Irrespective, though, of the research approach (study paradigm), the object of study remains the same – landscape. Likewise, as already noted before, the perceptions of landscape and first of all of its component parts are diverse. This applies primarily to the abiotic element, which is often not distinguished as a separate category, but is treated jointly with the biotic elements. Such an example is provided by FARINA (1998), who points out three perspectives in landscape ecology: human, geobotanical, and zoological. From the geographer’s point of view such treatment of the structure of space gives rise to reservations, since it is exactly the differentiation of the abiotic element, which is the generator of the diversity of biotic as well as cultural and social, elements, and so it constitutes one of the most important elements of landscape (BOYDEN 1979, DEGÓRSKI 1986, 2000). Even if the very determination of the origins of the abiotic phenomena belongs to the sphere of interest of the geographical sciences, their heterogeneity and the spatial relations with the biotic elements ought to constitute the object of study of landscape ecology. That is also why these two features, the abiotic (geo-) and the biotic (botanical and animal) ought to be treated in landscape ecology as mutually complementing, with due account of the role of the abiotic elements in determination of landscape.

During recent years the problem of diversity of the abiotic elements of the natural environment taking part in the shaping of landscape structure, was referred to as geodiversity by EBERHARD (1997). Three fundamental functions that are fulfilled by it in the landscape are distinguished:

- "existential" values - understood as those resulting from the very existence of an entity (KIERNAN 1997);

- ecological values – understood as the aspect of the environmental system that is jointly responsible for the maintenance of ecosystem structure and stability (FOX 1990, NASH 1990);
- social values - further divided into the scientific and the aesthetic (LEGGE and KING 1992).

The diversity of abiotic elements is looked upon as a set of components (geodiversity), as well as individually, in regard to each separate element like lithodiversity, geomorphological diversity and pedodiversity.

A special role is played by the soil cover, which being itself an essential element of landscape formation, is genetically and structurally dependent both upon the abiotic and biotic elements, with which it remains in interaction. The spatial variability of the soil properties is characterised by high differentiation, irrespective of the level of spatial organisation of a soil unit (HUGGETT 1975, BOUL et al. 1989, DEGÓRSKI 1990, 2002a). That is why the landscape-forming soil units, determining the heterogeneity of the landscape, are by many authors considered independently of the properties of soils (IBANEZ et al. 1998, IBANEZ and ALBA 1999). This separation appears to be justified, since pedodiversity understood in morphogenetic terms as a developing of the pedosphere still belongs to the realm of study of soil sciences, while pedoheterogeneity (soil spatial variability) as an aspect of landscape is already the object of landscape study, irrespective of its level of organisation considered (DEGÓRSKI 2001). Soil landscape created by the mosaic of soils should be analysed as an aggregation of soil body on the earth surface in the determined landscape (BOUL et al. 1989, ODEH 1998).

The abiotic elements form a landscape by themselves, and at the same time constitute its integral component. They make up the object of research of the physical geography. So the determination of a strict boundary between the areas of interest of geographers and landscape ecologists is very difficult indeed. At this point another question appears: whom can we call a landscape ecologist? If we admit the trivial definition that the landscape ecologist is the person who deals with landscape ecology, then the boundary mentioned will be located at the level of pedoheterogeneity. Yet, in view of the already mentioned differences in the object of study, resulting from a large number of sub-disciplines within geography, from which a lot of landscape ecologists originate, the boundary is not clear. Hence, definition of the background concepts for integrated landscape analysis is not an easy task and requires a very broad knowledge (ANTROP 2000a).

2.2 The vertical boundaries of landscape

Another issue, which is of importance in the definition of the object of study is the determination of the vertical boundaries of its reach, that is – of its so called thickness or depth. The literature of the subject contains the attempts of quantitative definition of both the upper and the lower bound on landscape (PRZEWOŹNIAK 1991, BERUCZASZWILI and ŻUCZKOWA 1997). Adoption of concrete dimensions or limitations resulting from the course of natural factors shaping landscape (like, for instance, groundwater table level) is very imprecise and often hard to determine in an unambiguous manner (see the case of transitorily appearance of surface and groundwater bodies). In view of the diversity of the landscape structure and different abiotic conditions, the thickness of landscape varies and is highly differentiated in space. The vertical dimension of landscape is entirely different on the urbanised areas than on the natural or even semi-natural ones, meaning that the thickness of landscape depends also on its function.

In the natural and semi-natural landscapes the floor layers of the landscapes are defined by the differentiation of the abiotic conditions (geodiversity), while the roof layers are defined mainly through the differentiation of the biotic element (biodiversity). In this perspective landscape ecology becomes a bridge between the sub-disciplines of physical geography and the biological sciences. In conditions of the anthropogenetically transformed landscapes the lower bound on landscape is constituted by the spatial structure of the agro-urban industrial elements, being the consequence of human activity in natural environment, in guise of landscape moderator and creator. The upper bound on landscape is constituted, on the other hand, by the spatial forms resulting from the social and culture-forming human activity, constituting the ontological elements of landscape. Determination of the respective categories must also be done with due account of the behavioural element of human community, as the moving factor in the establishment of structures. This approach, in turn, makes out of landscape ecology a bridge between geography, biology, and the social and humanistic sciences.

The approach presented refers to the paradigm of the landscape studies, which reduces to the postulate of the objective (ontological) character of its complexes and the application of the relatively uniform taxonomic systems of landscape units, with, simultaneously, differentiated methods of delimitation (PIETRZAK 1998).

2.3 The role of man in landscape

Man became long ago the object of geographical studies (anthropogeography), similarly as of the social sciences. Human beings play several roles as elements of landscape, namely they appear as:

- existential (ontological) landscape elements (by the very fact of existence),
- a landscape moderator, forming its structure, and creating urban-and-industrial, as well as cultural space,
- a social element, that is through collaboration within a group, while remaining under the influence of a group.

Human societies have enormous influence upon individuals in their behaviour relative to the generation of landscape structures, with different spatial scales, from the ones of very large scale down to single objects. Social relations, and especially the political and legal system, influence the spatial structure of the anthropogenic elements, ranging from the vast agro-urban lands down to singular entities, where the manner of spatial organisation is essential as well, between the very orderly and the very chaotic (GOLLEY and BELLOT 1991). This specific object of study, located at the junction of natural, economic, and socio-humanistic sciences still constitutes an enormous niche, which soon should get filled with adequate contents. Until now, the spatial aspect of land economy was the subject of economic geography and town planning, the cultural heritage of history of art, while social issues of philosophy and social sciences. It is obvious that the methodologies of all these fields of knowledge are necessary for the study of the place and role of man in landscape.

Modern human beings make use of the experience gathered by numerous generations, which impacted upon landscape, participating in its formation. Through concrete behaviour in space men do build a kind of a bridge between cognition and evaluation (ARLER 2000). In the relationship between human beings and nature the ethical aspect is also of importance, as mediating our behaviour with respect to natural environment (NORTON 2000). In view of the multifunctional character of landscape, its formation requires planning activities aiming at optimisation of use of the environment's potential, and the preservation of its correct structure. These activities are by virtue of assumption subjective and strongly rooted in our perceptions and value hierarchy. A rapid increase of the population number and the development of urbanisation lead to distinction of new landscape categories, such as urban-industrial landscape. This requires an extension of the research instruments, adequately to the subject of study, in terms of monitoring (WARD et al. 2000), of the structural-and-spatial analysis (FREEMAN 1999), and of the historical transformations of landscape from the viewpoint of analysis of the human influence on the environment (DEGÓRSKA 1996). New methodological solutions are being sought for the so-called eco-cultural module (HANDLEY 2000), that would encompass in a comprehensive manner four streams of landscape studies, expressed through the following postulates: strengthen, conserve, create, restore - depending upon the respective object's character and condition.

3 Interdisciplinary character of the landscape study

The complexity of the character of landscape along with its multifunctionality cause that it appears appropriate to treat landscape as a very complex system in accordance with the theory of BERTALANFFY (1950) and HUGGETT (1950). This approach is increasingly often being applied in landscape analysis and hence landscape is perceived as a fully integrated space in which individual geo-components constitute dynamic subsystems (HUGGETT, 1975, BOYDEN, 1979, ZONNEVELD, 1990, FARINA 2000). The study of landscape requires a multidisciplinary analysis of individual components (subsystems), the scope of analysis being associated with the character of each of the scientific disciplines. The scheme proposed in the considerations (Fig. 1) the strong connection of the landscape study into account with the sciences of the Earth, being the sub-disciplines of geography.

The spatial differentiation of the abiotic components of the environment, resulting from their geographical variability, is the subject matter of physical geography, while that of the biotic elements – of biogeography and ecology, which is in agreement with the concept of division of landscape ecology proposed by TROLL (1971), who suggested its division into geo-ecology (encompassing the abiotic elements of the natural environment) and bioecology (encompassing with its analysis the biotic elements). The effect of the geographical differentiation of these two groups of components of the environment, mutually interconnected, is the spatial heterogeneity of the soil cover and vegetation, as the indicator of the differentiation of natural landscape. Integral subsystems of landscape are also constituted by the set of the socio-economic components, forming the so-called social and cultural-industrial landscape, being a component of the anthropogenic differentiation of landscape, which is the subject of study of social and economic geography, as well as other human sciences (Fig. 1).

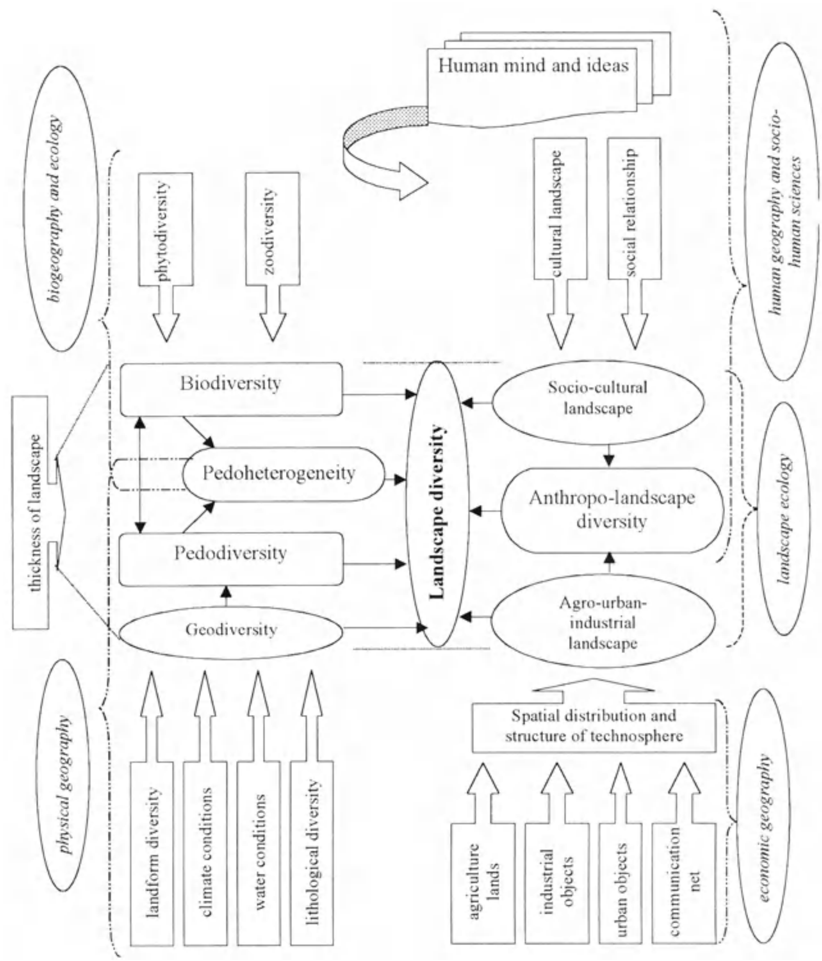

Fig. 1: The object of study of landscape ecology and the position of the discipline in the system of geographical, biological, and social and humanistic sciences.

The complex structure of landscape, presented here, and its multifunctionality emphasise the necessity of conducting interdisciplinary research. An opinion that there is no self-standing scientific discipline in the study of landscape can be found in the literature (HAASE 1986, LESER and RODD 1991). In accordance with this point of view the particular subsystems of landscape are being studied by separate scientific disciplines, making use of their own specific methods, and even the very manner of defining the subject matter of study is different. Following this course of reasoning, and developing also the views of NAVEH and

LIBERMAN (1984), one can pose the question whether landscape study should not be continued as interdisciplinary study. On the one hand this makes possible to use research methods in landscape study, being verified over years, both in the assessment of the components of the natural environment and of the socio-economic space. On the other hand it allows the interactive functional analysis of the system constituted by landscape, as it is conducted by scholars having a wide spectrum of interests, both regarding natural environment and the socio-economic space.

4 Summary

In view of the complex nature of landscape study and a specific duality of its perception (holistic or systemic) the further development of landscape study may concern both creation of the direction of research and the strengthening of development of the scientific discipline dealing with comprehensive analysis of landscape. Depending upon whether the integrated multidisciplinary analytic approach, treating landscape as a group of components (subsystems), or the holistic approach, seeing landscape as an integral entity, will prevail, the scientific discipline having landscape as the object of study will take a different course. Still, the scientific discipline, concerned with the integrated analysis of multifunctional landscape must have not only a well defined object of study, such as landscape, with empirically established depth, functions and structure, but also be equipped with an own research toolbox and methodology, which will allow to cognise the essence of phenomena taking place inside the system and influencing its development.

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Indicators of Agricultural Sustainability - the Moral of a Story

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Abstract

It has become obvious that serious attempts at achieving sustainability cannot be based on changes of technologies. An applicable system of sustainable land use requires both the termination of isolated searches for "greener" technologies in agriculture and the beginning to understand agriculture as an integrated part of a broad range of activities taking place in a region. Sustainability should be analysed at regional level (in catchments) rather than at the level of individual human activities - agriculture, transport, industry etc. A truly sustainable system of rural land use should incorporate protection of biotic and abiotic resources while maintaining an acceptable level of local economy and achieving satisfactory social conditions. In this process science cannot be regarded as the leading force. Its results are only of advisory value and the burden of responsibility to take steps towards sustainability remains on the shoulders of decision-makers. The search for sustainability must be based on the broad consensus of all stakeholders and the result always reflects the influence of various preferences. Science loses its character as a trusted leader and becomes a partner for discussion. The complexity of sustainability allows us to assume that it will never be totally achieved. Nevertheless, we could move close to it. In the case of regional sustainability, the following steps are necessary:

- identify a state of a region which its inhabitants assume sustainable and the practices they are willing to follow in order to achieve the goal
- define environmental, economic and social indicators of sustainability respected by a local community
- use environmentally sound technologies in a whole range of activities
- create a political system which respects sustainable land use and controls local investment activities

Keywords: local community, regional development, watersheds, sustainability, sustainability indicators, sustainable agriculture, participation, localisation

1 Introduction

The term "sustainability" has become the criterion of various aspects of human activities during the 1990's, but it should be stressed that sustainability has more of the character of a moral principle than a precise definition – as was expressed by DE VRIES (ex PEET 1992): „Sustainability is not something to be defined, but to be declared. It is an ethical guiding principle". Nevertheless the main aspects of sustainability can be identified:

- Social sustainability - reflects the relationship between development and valid social norms, it is achieved only by systematic community participation and strong civil society. Activity is socially sustainable if it complies with these norms both written and nonwritten or if it does not violate them more then a society is willing to tolerate.
- Economic sustainability - depends on the analysis of costs and benefits. It is easily measurable because it can be expressed in money terms. Generally speaking development should be economically effective within the framework of ecological and social limits. The struggle for reduction of costs must not result in a violation of these limits, otherwise the economic effectiveness would lead to unsustainability.
- Environmental (ecological) sustainability - can be characterised with relatively less effort (VAN PELT et al. 1995). The development process must respect the carrying capacity of life-supporting systems and by doing so contribute to their preservation including biodiversity protection. Renewable resources can be used within the limits of their renewability, non-renewable resources must be used in the most careful way.

Sustainability cannot be quaranteed in the long term because many factors remain unknown or can be anticipated only with difficulties. For practical use it is therefore necessary to search for and to support activities which will be likely sustainable and to repress activities unsustainability of those is evident. In this process we can observe attempts to apply the idea of sustainability not only to separate economic activities (sustainable transport, agriculture, forestry, resource use) but also to human activities in a broader sense. This trend is illustrated by the search for principles of sustainable cities (CAMAGNI 1998, BANISTER 1998), regions (REDCLIFT

1990, UNCED 1992, D'SOUZA and GEBREMEDHIN 1998, DE HAAN et al. 1997) or sustainable living (IUCN/UNEP/WWF 1991, VAVROUŠEK 1993, KELLER et al 1996) as the manifestation of an individual responsible behaviour that is beneficial to a whole society. In both cases the situation calls for a tool which would inform about a character and consequences of human behaviour. Sustainability indicators (SI) are accepted as such a tool (see WCED 1987, UNCED 1992, MOLDAN and BILHARZ 1997, OECD 1997, BELL and MORSE 1999, RILEY 2001, WANG et al. 2001) although there are authors stressing the temporary character of indicators (MITCHELL, MAY and MCDONALD 1995), and expecting that they will be gradually replaced by methods directly combining environment and economics ("green accounting"). Methods of qualitative assessment matrix (GRAY et al. 1993) and methods of ecological-economic models (PEARCE and TURNER 1990) are also suggested for sustainability assessment. Compared with these methods, the SI are more useful because they can be defined more precisely. SI can quantify information so their content is more distinct and at the same time they are also able to simplify the characteristics of complex phenomena. From this concept of gradually aggregating indicators the concepts of “environmental space” (HILLE 1998, CARLEY and SPAPENS 1998) and “ecological footprint” (WACKERNAGEL and REES 1996, 1997, WACKERNAGEL et al. 1998, HOLMBERG et al. 1999, CHAMBERS et al. 2000) have been derived.

2 Perceptions of sustainable agriculture (SA) and its indicators

Despite their broad diversity the definitions of SA usually stress the necessity of maintaining or re-establishing environmental, economic and social qualities of agricultural systems or rural space - but not always explaining what is actually meant by the term “qualities”. The study of definitions of SA gives us information about different approaches. A considerable number of authors (e.g. USDA 1991, HUFFMAN 1990, NEHER 1992, DORAN 2002) stress that SA should use methods of integrated pest management, soil conservation technologies and should save non-renewable resources. These authors do not omit economic aspects of SA, but its social conditions are mentioned only vaguely. The approach adopted by the OECD (1995) can be included in this category. The works of J. PRETTY (1995, 1997a,b, 1998) represent a rather rare, truly balanced approach which understands the SA as based on the effective use of biophysical and human resources.

2.1 The OECD approach

The main difference between the approach adopted by Pretty and the one of OECD is the importance given to the full participation not only of farmers but all inhabitants of a region in the process of creating of sustainable agricultural system. Among the agricultural practices with a high potential for sustainability the OECD (1995, 1997, 1999, 2001) includes the following: conservation tillage, crop rotations, intercropping, silvipasture, scientific management practices; other aspects of agroecosystem stability are mentioned only vaguely. By doing so authors cover only the environmental side of SA. At the same time, however, they do not aim at preparing an authoritative list of recommendations, but they stress that "sustainability should be judged with respect to each farming system as a whole, not simply in respect to particular practices" (OECD 1995: 24). Another OECD material (1997) on indicators of SA on national and sub-national level is based on the general OECD framework of sustainability assessment "pressure-state-response" which lists the following criteria for the selection of indicators: policy relevance, analytical soundness, measurability, level of aggregation.

Different sets of indicators selected by international institutions such as OECD are often criticised for reasons summarised by REID (1995). First, they are environmentally oriented and they tend to omit the social aspects. Second, they usually do not include such important aspects of a problem as patterns or levels of consumption and ecological footprint. Third, international institutions usually give no or very limited space to members of communities to influence the process of the indicator selection. The insufficient technical coordination between the sets of indicators and policy targets and objectives is another, fourth, reason of criticism. Fifth, it is not clear whether the information needed for identification of comparable indicators is available in various countries.

2.2 The holistic approach towards SA

The detailed synthesis providing a truly holistic overview of SA is presented in the work of J. PRETTY "The Living Land" (1998). PRETTY characterises the present state of European agroecosystem and formulates institutional and individual preconditions of sustainable agricultural and food systems and especially of establishing sustainable rural communities. He begins with the description of a modern industrial agriculture characterised by a narrow spectrum of crops and animals, intensive use of pesticides, fertilisers, machinery, irrigation and external information (research, advisory service). This system leads to a degradation of natural capital (air, water, soil, biodiversity) and human health (both farmers and consumers) and a "rationalisation" of farming results in a loss of biological and cultural diversity and a degradation of landscape and rural space, thus reducing the social capital.

Based on the analysis of the development of European agriculture Pretty formulates three steps towards the sustainability of a rural space. The first step is the increase of economic and environmental efficiency by the use of information technologies (GPS, GIS) and methods of precision agriculture. Natural resources are not wasted and the costs fall. Nevertheless, the goals of farming remain unchanged and existing values and principles are not fundamentally challenged.

Dropping some conventional technologies and incorporating regenerative ones is characteristic for the second step. In practice this means using of nitrogen fixing plants, biopesticides, creating habitats for predators, using IPM and biological pest control, decreasing specialisation of farms and emphasising soil and water conservation technologies. During this phase, the environmental impact of agriculture is taken into account, rural communities remain uninvolved in farming and food matters and farmers are usually not motivated to form new relationships.

The third step is characterised by the situation when agriculture begins to be a central part of economic and social activities of a rural community that understands the necessity of a regional sustainability. This situation is based on new approaches and the participation of individual members of local communities is based on following principles: emerging of locally specific resource conserving technologies; high self-reliance and cohesion of local people; changing situation of external institutions - experts are facilitators and enablers of local change rather than distributors of information; agriculture as a whole is structured to emphasise local economic regeneration. The revitalisation of regionally-based rural social and economic activities can be illustrated by the emergence of local food processing and marketing including direct marketing, farm shops, local markets and especially by the systems of community supported agriculture (ISEC 1993, Steele 1995, Henderson and van En 1999) and local exchange and trading systems – LETS (Williams 1996). Farmers also spent more money locally on goods and services and they employ more people. This third phase has not been reached yet broadly and it requires an extensive institutional reform not only of agriculture but also rural development policies.

3 Participation and regional character of sustainability

From the review given above, it becomes evident that no matter how attractive the technological side of agriculture and indicators derived from it are for experts, the undefinable, value-based character of sustainability requires the full participation of all members of communities. In other words - visions of sustainable future, not only of agriculture but all activities in a region, cannot be formulated without the involvement of its inhabitants. The idea of indicators of SA therefore broadens into the identification of indicators of rural regional development (see REDCLIFT 1990, D'SOUZA and GEBREMEDHIN 1998, DE HAAN et al. 1997, NOVÁČEK and MEDERLY 1996, SCHMEIDLER 1996, COCKS and WALKER 1994, HOLMBERG and KARLSSON 1992, HRNČIAROVÁ 1996, VOLKER 1997, BOSSHARD 2000, STEVENSON and LEE 2001). Also the idea of sustainable urban areas should be taken into account (CAMAGNI 1998, BANISTER 1998).

It is surprising how often the importance of general acceptance of sustainability is neglected in debates on its value, character and implementation. Those convinced on the necessity of sustainability concentrate on ways of its achieving, its opponents do not fight against but ignore it, but it can be said that the majority remains unconcerned with this issue. Either because they do not know the concept or because its long-term character leads them to the attitude "we still have time, others will solve it". This approach was illustrated by a sentence of a young manager quoted by MACNAGHTEN and JACOBS (1997:15): "I can't see further than another 2 years, let alone 30". Therefore it is of great use to ask whether the public supports the idea of sustainability and whether they are ready to demonstrate this support during the election. But how can they accept or refuse this principle if it is presented in a way they cannot understand, especially whether the indicators of sustainability are able to demonstrate the concrete manifestation of achieving sustainability. But if the public is not willing to accept the information, then it remains useless. As illustrated by MACNAGHTEN and JACOBS (1997): "...without understanding the concept becomes curiously sterile: a technical, managerial goal without purchase on the real world of political debate and decision making, and with little hope of implementation".

The extent to what the public accepts an indicator is influenced by the method of its selection. These methods can be sorted into three groups according to level of their "exactness". Subjective intuitive approach, the first group, is based on often irrational preference of an indicator which a community accepts as the most informative. This approach is adopted in the works of BERKES et al. (1998) and MÜLLER (1995) and is often mentioned namely in relation to the indigenous knowledge. The "salmon indicator" from the Sustainable Seattle project (WARBURTON 1998) or the method used in Český Krumlov (LAŽA 1997) are examples of this approach. The most important aspect of this approach is represented by fact that the distinctions between the science and society, between what is considered "objective" and "subjective", are diminishing, as described by LATOUR (1999, 2000).

A choice from a menu derived from previous experience represents the second group – the subjective expert approach. This method is based on an assumption that the experts' knowledge of certain past situation enables them to create a broader set of indicators and to select the most important ones. Experts usually think in a reductionist way, they may split complex situations into independent variables and their individual perceptions are central. Professionals control their clients from a distance, they tend not to trust farmers etc. who are simply the objects of enquiry. The lack of understanding and trust between experts and people and the difference between the long-term character of an agricultural system and a short-term experience of an expert can be the main disadvantages of this approach. Examples are quoted by PRETTY (1995) and WARBURTON (1998)

The third group is represented by an analytical approach based on rational acceptance of science as a provider of information and solutions. As the discussions on sustainability are mainly of academic character, this approach is the most common one (ANDREOLI and TELLARINI 2000, LOAKE 2001, HANSEN et al. 2001). Methods mentioned by SMITH (1998) and MITCHELL (1995) that sometimes use exact ways to get results from information obtained by previous two approaches are examples of this attitude, apart from the "hard" OECD procedure already mentioned. This approach neglects the fact whether there is someone (politicians, farmers) who has to be willing to accept its recommendation, which is its main disadvantage. The detailed analysis of various ways of formulating indicators of SA given by SMITHS (1998) identifies their main principles and their strengths and weaknesses. Smith finds out that most of the methods verbally appreciate the participation of the public and they give it an appropriate position but none of them solves the question how to achieve it in practice.

So far we have dealt with the indicators of SA understanding agriculture as an activity separated from other aspects of the society. However this reductionist approach is in the case of sustainability assessment unacceptable. Agriculture and its effects must be understood in unity with other economic activities in the landscape and in a concrete region. It is surprising how often even projects verbally accepting the holistic character of sustainability (MOLDAN and BILHARZ 1997) separate even activities which are so close in a sense of regional land use such as agriculture and forestry. Thus both influence the character of road network and therefore also a system of transport, quality of life not only in rural areas but also in urban space (air, water quality, recreation possibilities) and up to a certain point set limits for the industry. For these reasons we prefer sustainability assessment on a regional level.

4 Conclusions

- Sustainability is a social construction, therefore it is a regionally unique process.
- Sustainable agriculture cannot be reduced to a set of environmentally friendly technologies.
- Agriculture must be understood as an integral part of human activities in a region.
- Regional (national) policies on sustainable agriculture/ sustainable regional development are required, using environmentally sound technologies in a whole range of activities
- Regional codes of proper agricultural practice are required.
- Policies and codes need to be formulated with the participation of stakeholders in order to be very applicable.
- More decentralised political system which respects regional identity and controls local investment is required.

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The Unconscious Driving Forces of Landscape Perception and Formation

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Abstract

On the one side the perception and formation of cultural landscapes by humans are traced to their phylogenetic roots. The evolutionary adaptation to beneficial habitats and the non-conscious psychological processing of biophilic and biophobic stimuli is described. The savannah-, biophilia- and prospect-refuge hypotheses are identified as complementary theories.

On the other side the usually unaware driving forces deriving from our general mainstream societal design are explained. I. e. an economy based on non renewable organic raw materials, an economic thinking which treats the production function as the overruling aim of agriculture neglecting other essential functions contributing to common welfare, trade rules which institutionalise this thinking, and the evolvement of a corresponding inappropriate technology.

It is proposed to treat the desire for pleasing landscapes as a 'basic need', and the necessary changes in economic theory and the institutional framework - especially in international trade rules - are recommended.

Key words: landscapes and humans, unconscious, unaware driving forces

Introductory remarks

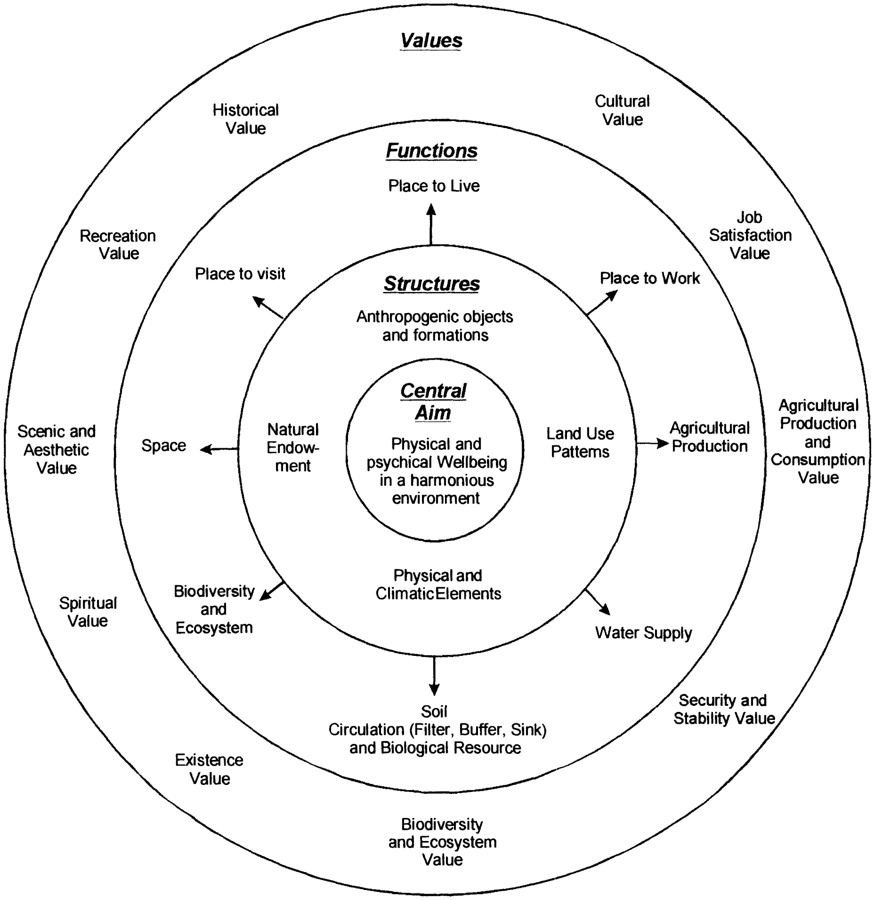
Since pleasing, stimulating and sheltering landscapes have become a scarce good in densely populated, urbanised and industrialised countries, a multitude of theories concerning the functions and values of landscapes has been developed as well as numerous proposals for their conservation, development and husbanding have been made. This contribution tries to add to the scientific perspective some basic driving forces in landscape perception and formation usually either not recognised or belonging to patterns of perception and action acquired and <automated> during the course of human phylogeny. Also, an attempt is made to present a more balanced view in this concern, since the personal rivalries between representatives of the different schools have blurred the picture and entailed premature judgements on the relationship between biological and cultural evolution. For this aim the author can draw on the practical experience of work in and for various cultural landscapes, in regional development and in his functions as a mountain farmer, as well as a former academic teacher in the field of economic aspects of landscape planning and landscape ecology.

Landscapes - a complex object of cognition, influences and management

Landscapes can be seen as the <territorial face> of a society. They are more complex than a human face and can be modified in the various cultural contexts. But as with a human face we were able to discover beyond the multitude of cultural formations and individual preferences, that certain basic proportions have to be fulfilled to meet the human demand for basic well-being (E 1) in the environment concerned. The following graph tries to elucidate the complexity and major societal values influencing human action in and on landscapes and the various related functions and structures. But this extremely instructive graph of BERGSTROM, which was adopted by OECD and modified by AAER is just a snapshot of what is presently perceived and partly accepted at the leading edge of landscape related sciences and it does not take into consideration the unaware and non-conscious driving forces. Nevertheless it can serve as a good starting point, since it focuses on the overruling aim of physical and psychical well-being. This central aim can also be seen as the <phylogenetic aim> of those acquired and now innate patterns of perception and reaction, which humans are endowed with in order to survive, and which normally rest in the realm of unconsciousness.

FAIRBROTHER (1970) - starting from a different professional point of view and therefore using a slightly different terminology - has urged a rethinking in the direction of regarding landscapes from additional, so far neglected, essential angles by incorporating biological (ecological) insights as early (late?) as 1970: "'*Proper land use planning is applied human ecology.*' This sets out an enlightened new conception of planning as the conscious management of the environment, and even though present knowledge of human ecology is primitive and sketchy, in theory at least, we are now moving towards this all-embracing concept of the relationships between man and habitat. Total environment (a current phrase so far avoided) is also a different expression of a similar approach, recognising the need for a complex but unified setting, where we live in balance with all the different factors, which make up our lives."

Fig. 1: Landscape Management with the 'Physical and Psychical Wellbeing'



Source: Bergstrom, 1998 and OECD: Environmental Indicators for Agriculture: Methods and Results - The Stocktaking Report, March 2000, modified by AAAC

Graph 2360 b   Austrian Association of Agricultural and Environmental Research

Unaware and unconscious driving forces

It seems appropriate to differentiate between driving forces in landscape perception and formation deriving from our present societal design, i. e. from the present state of *cultural evolution*, but which we are not aware of, and such driving forces originating from our phylogenetic outfit, i.e. from our *biological evolution* as genetically secured stimulus-response-reactions, which have been 'automated' in our behavioural patterns.

In order to provide a better base for the judgement of those driving forces entailed by our present economic and societal system and widely recognised neither by the public nor by scientists, I will not begin with the easier task of depicting the latter, but by trying to explain the first.

Unconscious driving forces

a) Basic arguments to accept unconscious driving forces:

In order to justify the reference to our (usually unconscious) biological phylogenetic imprint it is necessary to refer to the discussion about the <Standard Social Science Model (SSSM)> (E 2), which was very much shaped by a collective reaction (also of scientists) against the abuse of the insights of evolutionary biology, biological anthropology, behavioural ecology, neurobiology and psychology and the resulting evolutionary theories for the sociobiological justification of racism, sexism and 'pregiven' class differences. The reaction to the ideological abuse was, that all biological pre-dispositions were denied and a perfect malleability of humans in their individual ontogenesis by the way of socialisation, was presumed (E 3). In his famous Viennese lecture on "Knowledge and Ignorance – the Dilemma of Evolution towards Homo sapiens" SEIDLER (1990) pointed to this abuse-induced mainstream cognitive self-limitation of social science. But he asked to consider that biology and culture are inseparably interrelated by co-evolution and mutual influence. If the innate long term biological adaptation is ignored not only the non-conscious processing of certain stimuli, but also the understanding of the <heritage – environment – interrelationships> and their dynamics are left out of consideration. However, he also warns of the reductionist view of human evolution. A living being born with only about 23% of the final weight of the brain and whose individual ontogenesis mainly takes place during the post-natal period (as late as with an age of 10 years about 96% of the final weight of the brain is achieved) is much more malleable and flexible than any other creature. Therefore it is not admissible to transfer <social patterns> even from biologically closely related mammals, like the chimpanzees (E 4), to humans. This holds even more for transfers from insects (like ants and bees) (E 5). But this should not impede us to accept, that we carry in us certain basic stimulus-reaction patterns which were beneficial for our survival in the long periods of our evolutionary past. Our pride as "the crown of creation" should not bar us from recognising our instinctive roots and biological limitations. To undergo this 'humiliating shock' to our consciousness is the door to a better understanding of human behaviour. In addition, TOOBY and COSMIDES (1992) proposed that the divergent programmes and claims in the minds of social scientists are partly due to the failure to distinguish between adaptionist evolutionary biology and behaviour genetics. The latter questions which differences between individuals or sets of individuals are due to differences in their genes. It has to be differentiated from the adaptionist inquiry into our inherited, species typical design. ZEIER (1980) reported on the existential tension brought about by our slow biological evolution on the one hand and the rapid cultural unfolding of humans on the other hand. This conflict will not be resolved until we become conscious of the chasm between our present mainstream culture and our biological programme. The neglect of our genetic predisposition must lead to collective neurotic reactions. ABT (1988) pointed to another long term driving force, the collective memory of societies manifested in dreams and symbols influencing human action which are emerging from past experiences. In his book "Progress without Loss of Soul" (E 6), he makes a plausible plea for not neglecting this source of orientation especially concerning the nature and risks of habitats. RIEDL (1990, 1996) and the school around K. LORENZ brought convincing arguments (coined in the term "evolutionary theory of cognition" that our cognitive outfit has strong biological adaptations and simplifying ways to deal with complex systems. The latter insight should also be applicable to the complex system of landscapes. Finally the well known German Biologist H. MARKL pleas for the breaking down of the "Cartesian wall" between humans and animals in the sense that we should be prepared to accept evolutionary adaptations, which we at least partly share with other creatures. On this sketched background we should be prepared to accept that there are adaptations, which humans (we) acquired during their (our) phylogenesis - especially concerning the judgement of their habitats as beneficial or non-beneficial for a pleasant survival. But it should also be seen that particularly in the realm of cultural landscapes as objects of cognition - due to their manifold socio-cultural over-formations and because the perception of the cognitive subject is often considerably influenced by emotional experiences in the landscape concerned - positivist, transcendental, semiotic and, relating to the historic contents, also hermeneutic elements are intermingling (see the survey of receptiontheoretical models in LINK (1976)). But this should not bar us to see the woods for the trees.

b) The Savannah Theory

It is established scientific knowledge (EIBL-EIBESFELT 1984, ORIANS and HEERWAGEN 1992, ULRICH 1993, (E 7)) that humanisation took place in a savannah environment. The oldest forms of humans have been found there. It can be assumed that we have spent in this environment most of the time of our evolutionary past. Therefore we are biologically adapted to these surroundings. This environment provided the best chances for a good living after the rain-period. Then it was green and bloomed and even had puddles and larger accumulations of water. Scattered trees gave shelter, refuge and orientation. The deduced hypothesis is the following: We respond with a basic feeling of well-being and security if we are placed in a similar environment. Therefore our places of public well-being - our parks (E 8) - are designed in accordance with this basic pattern. The same holds of private gardens and especially of golf courses. The latter are probably the most expensive artificial savannah environment (E 9).

Three personal experiences may be added:

a) During a lecture-trip to China I visited a bonsai exhibition and a bonsai museum. All the little landscape imitations showed the basic elements of the savannah pattern. It seems that the stressed city dwellers in ancient and present china tried and still try to bring into their relatively narrow homes the pacifying and pleasing view of a savannah landscape in form of a <peep show box>.

b) In the course lectures and exercises on economic aspects of landscape planning and landscape ecology we found that all rest- and recreation homes and especially rehabilitation centres were placed into a landscape environment where the savannah elements dominated. It is apparently a practised integral part of rehabilitation-medicine to support rehabilitation by providing an environment which gives the unconscious signal of well-being.

c) When students were asked to rate local landscapes, blooming old fruit orchards got the highest scores. These traditional orchards are characterised by large trees scattered in green meadows. This evaluation can be explained by a powerful syndrome of savannah stimuli, i. e. the green meadow, the large trees scattered therein and the flower element in the blooming trees. Looking at tourist advertising brochures for rural areas it can be noticed, that a green flowered meadow and a blooming fruit tree belong to the standard outfit. Thus it can be concluded, that humans have a very positive response to a mutatis mutandis savannah-like landscape.

c) The biophilia – biodiversity – hypothesis

The notion "biophilia" was coined by WILSON in his small book <Biophilia> in 1984. This line of looking at human behaviour was well accepted and enlarged. A rich bouquet of views to amplify and refine the concept was tied in the anthology "The Biophilia Hypothesis" edited by KELLERT and WILSON in 1992.

The essence of the hypothesis can be described as follows: An innate positive response of humans to a rich and lush nature around us can be identified. The phylogenetic sense of this basic human reaction is plausible. Such an environment is good for survival, i. e. a pleasant place to live in. Biodiversity also enhances ecological stability and the number of options in food gathering. Pictures of desired landscapes in most biodiversity brochures refer to this richness in features and species (e.g. Ministère de l' Aménagement du Territoire et de l' Environnement 1998). But as the following <prospect-refuge theory> the <biophilia-biodiversity-hypothesis> can be seen as a subordinate facet of the overruling savannah imprint.

d) The prospect refuge theory

This hypothesis argues about the "powerful effect on human behaviour of ecological features providing expansive views important for learning about the environment and opportunities to view potentially hazardous elements from a position of safety" (ORIANS and HEERWAGEN loc.cit. p. 570) and that "an environment will be judged as more pleasant, if there is a balance between prospect and refuge opportunities"(p. 571). Thus, a highly productive savannah environment is perceived as the most pleasant, if the prospect-refuge need is satisfied, too.

e) Final reflections to the three hypotheses

The individual over-forming of our inherited cross-cultural universal behavioural patterns will always give "sufficient evidence" for questioning the general rule. Statements like "My son is preferring to sit in front of his computer in our flat in a multistoried house and feels no attraction to those 'ideal landscapes', you describe", are often encountered. Such individual reactions are more frequent, when children were deprived of the chance to experience nature during their decisive phases of individual ontogenesis. The lack of stimuli inhibits activation of the inherited reaction patterns.

One should finish this short excursion into the unconscious driving forces with a word of the critical realist KARL POPPER in his quest for constructive critique: "Do you have a more useful working hypothesis? If not, let us employ the plausible and useful as long as it cannot be substituted by a better one."(Symposium in Laxenburg near Vienna 1982 - 80th birthday).

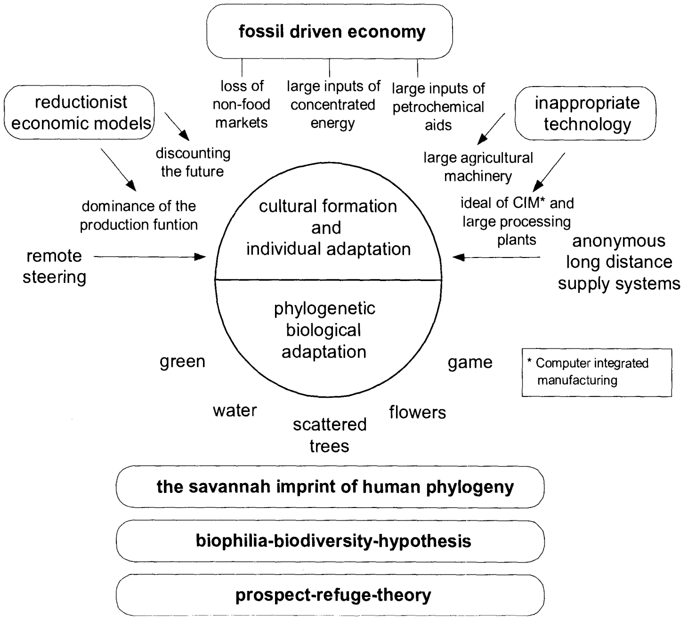
I would even say, that the savannah hypothesis and related ones indicate a basic need of humans. A minimum endowment of the environment with essential elements of our long time savannah homeland is a precondition for a basic feeling of well-being. It seems that the time is not too far, when a <human right> for the satisfaction of this basic need, like for water, food, clothing and shelter will be derived from refined scientific evidence. This would in turn entail that economists - especially agricultural economists - and international institutions, like OECD, would have to integrate this so far unconscious basic need into their concepts and models, which then would have to be changed fundamentally. The animosity of main stream economists against these 'unproven' theories can be mainly explained by the fact that well established <theoretical homes> and institutional designs are questioned widely. The latter directly leads us to the unaware driving forces of our present societal design. The following figure tries to give an overview over both, the unconscious and the unaware driving forces and their antagonisms.

The unaware driving forces

Landscape planners and landscape economists, people who want to protect nature, and especially agricultural and environmental politicians usually have a narrow phenomenological approach. Undesired developments are denominated and action against them is demanded within the present societal regime. Since the main undesirable phenomena are the consequence of complex economic and societal driving forces beyond their local reach, the measures taken often resemble very much Don Quichote's fight against windmills.

In the context of a world society employing fossil organic resources at a plundering price (without the costs of caring for replacement or substitute technology) and using inappropriate technologies based on the short term mining of finite fossil stocks, and backed by reductionist economic models must lead to undesired effects - especially with respect to landscapes. Therefore it is mandatory to point to this usually neglected syndrome of major driving forces.

Fig. 2: Overview of the major unaware or unconscious driving forces of landscape formation



According to the magnitude of influence I will start with the fossil base of our world economy.

a) The fossil driven economy

The strategies of our ancestors to cover human needs practically without fossil raw materials and primary energy carriers led to a strategy to achieve a maximum net harvest of solar energy in forms beneficial to humans. In addition, since transport was expensive and dangerous, and the energy content of grain was consumed by the traction animals when a distance of about 300 km was exceeded, manifold local supply was demanded. Therefore our landscapes were designed and <furnished> in a way to deliver all basic foodstuffs, organic raw materials and primary energy carriers on a local basis. This resulted in manifold, subtly structured, garden-like landscapes. The fossil plundering campaign of humanity destroyed the former supply circles. Now agricultural goods in rising quantities are shipped around the world. This leads to an economic setting in which the unmitigated driving forces ask for large scale production and large shipping lots. The energy intensive cooling chains allow to ship over long distances also perishable goods like meat, fruits and vegetables. This in turn means cleared landscapes apt for the employment of large agricultural machinery.

Furthermore, fossil inputs allow to push up agricultural production in the short term. The resulting surpluses entail falling product prices, and farmers try to compensate the income losses by rigid cost-reduction programmes. The latter strategies include mono- and oligocultures, as well as the intensive use of pesticides, herbicides and mineral fertilisers. The situation is aggravated by the loss of non-food markets, since the production of re-growing raw materials cannot compete with the plundering mining of fossil organic stocks.

This mainstream pattern of production and landscape management is in contrast to the desiderata of biodiversity, high natural soil fertility and diverse cultural landscapes. Thus, it can be concluded that subtly structured biodiverse landscapes will only be economical, if the prices of fossil inputs will be raised to the value of their replacement or substitute technology. As long as this unsustainable societal mainstream lasts, end of the pipe countermeasures will be necessary to avoid the worst consequences.

b) Reductionist economic models

In mainstream agricultural thinking, optimisation of the production function is the over-ruling aim. Macro- and microeconomics are reduced to this narrow view. But society - especially in densely populated regions - demands a multifunctional landscape covering a bouquet of human needs and amenities (see figure 1). Husbanding of attractive and sustainable landscapes should be seen as a social vectorial strategy, in which the overall vector of physical and psychical well-being of a maximum of people for an unlimited period is to be optimised.

The narrow conception of mainstream economics *mutatis mutandis* leads to the same results as the world wide fossil campaign. It is reflected by the thinking in OECD (see OECD 2002) and institutionalised in the WTO (GATT and AoA). In the recent Pan- European Conference on

Agriculture and Biodiversity, convened by the Council of Europe and UNEP, WOHLMEYER and SCHÜTZ (2002) contributed a background paper on the "Impact of globalisation and agro-industry on the evolution of agricultural policies, practices and production systems", which points out the main consequences of the present institutional design especially for landscapes and biological diversity. It highlights the trends towards concentration and segregation and the dismantling of agricultural and related environmental policies from the necessary steering instruments, since only declining tariffs are permitted in the future and competition of systems is neglected completely. Therefore they ask for a reform of the world trade rules particularly concerning (see also WOHLMEYER and QUENDLER 2002, p. 317 ff):

- differential treatment with reference to product-related process and production methods (PPMs), i. e. benign or not benign PPMs
- permission to compensate for the costs of higher environmental and social standards according to Art. III of GATT
- treating biodiversity, living soils and water as exhaustible resources under Art. XX lit. g of GATT
- Interpreting Art. XX lit. b of GATT (<measures to protect human, animal or plant life or health>) to comprise also the protection of life supporting ecological systems and
- executing environmental and social agreements at the same level as the rules within the WTO

One additional major negative bias should be mentioned. Besides the neglect of the multitude of functions of agriculture and forestry to the detriment of present welfare one common practice especially endangers the welfare of future generations: the discounting practice which dramatically underestimates future needs. This holds especially for manifold biodiverse landscapes, since biological information is a key resource for human survival and pleasing and supporting cultural landscapes are in general an irretrievable basis of life.

As early as in 1933 KEYNES criticised this position in his article on "National Self-Sufficiency" with the dramatic words "Or again, we have until recently conceived it a moral duty to ruin the tillers of the soil and to destroy age-long human traditions attendant on husbandry if we could get a loaf of bread thereby a tenth of a penny cheaper. There was nothing which it was not our duty to sacrifice to this Moloch and Mammon in one…". Looking at mainstream agricultural economics and the international negotiations on the AoA he would probably feel compelled to use similar words also today … .

c) Inappropriate technology

Technology widely is the answer to the societal design and its economic incentives. In a system where labour is the main source of revenues and therefore made expensive, and where the plundering use of fossil stocks and environmental media (biodiversity, manifold landscapes, living soils, water and air) is de facto permitted, technology concentrates on the one-sided maximisation of the productivity of labour. This leads to a high input of cheap energy and fossil based raw materials and to more or less isolated production systems (computer integrated manufacturing being the ideal), which externalise damages to natural resources and systems. In the Pastoral Message of the bishops of the USA <Economic Justice for All> of 1986 (see homepage of USCC) in the remarkably well researched chapter on agriculture, public efforts to provide appropriate technology for small and medium sized farms are urged. In reality the process of concentration of ownership, increase in farm size and the trend towards large scale technology continued. Since the European market for agricultural machinery is already dominated by US-owned companies or their partners, this trend is transferred to Europe. The trend is highlighted by a declaration published by 42 German agricultural economists in 2001 entitled "Small and eco leads into a dead end street". They underline their conviction, that under the present conditions large streamlined enterprises represent the future-oriented structure, everything else is 'romantics' (TOP AGRAR 2001).

One facet of inappropriate technology is the passion for remote steering of large agricultural production units by employing GPS and computerised information. This in principle beneficial technologic achievement induces a loss of direct contact with the living system concerned. Emotional and aesthetic factors are excluded. Thus, the function of the right half of our brains - location of the centres for recognition of complex interrelationships and of harmonies and the relevant reactions - remains inactivated.

The overall trend also entails inappropriate technology within the supply chains. Large scale long distance anonymous supply systems dominate and - by their very nature - cannot show an interest in local ecological and social concerns, including landscape aesthetics and sustainable management of cultural landscapes.

If agricultural and environmental politicians and also spatial planners do not become aware of the identified persistent driving forces they cannot try to cure the undesired phenomena at their roots … and cultural landscapes will continue to deteriorate or to fade away.

Final remarks

The above survey of unconscious and unaware driving forces intends to be an attempt to bring the unconscious needs to the surface and to direct attention to those decisive driving forces we usually are not aware of. It tries to provide some complex information not only for decision makers. There is also a deficit in scientific underpinning of an array of issues. The initiative <Landscape tomorrow>, due to its interdisciplinarity could be a platform for identifying weaknesses and deficits, for designing the necessary research and for organising the work to be done.

Explanatory Notes (E x)

E 1) It is assumed that this basic aim of landscape management is out of dispute.

E 2) The SSSM can be seen as a set of assumptions and inferences about humans, their minds and their collective interaction, that provided the conceptual foundations of social science for nearly a century – see COSMIDES, TOOBY, BARKOW (1992).

E 3) In a striking contrast to the dominating SSSM the representatives of the mainstream in neurobiology are convinced "that every thought and even the ego can be explained by neurochemical reactions within a few years" (personal experience 120 and discussions at the European Forum Alpbach 1998). This runs danger to result in a new determinism, with the same undesired consequences as the racist ideologies, since it undermines personal responsibility and even human dignity as a subject endowed with the ability to decide between good and bad.

E 4) They have more than 98% convergence in the DNA with humans.

E 5) This is an indirect critique on WILSON's "Sociobiology" (1975).

E 6) ABT is a rural planner as well as a graduated and practising psychologist. He works along the theories of his compatriot C. G. Jung, the discoverer of the <archetypes> in human psychology.

E 7) See also the homepage of the Ludwig Boltzmann Institute for Urban Ethology, link to <Landscape and city aesthetics>, http.//evolution.anthro.univie.ac.at/institutes/urbanethology/landpro.html.

E 8) The German term for <savannah> is "Parklandschaft" (park-landscape)

E 9) The architecture of golf courses shows all elements of a savannah environment – including little ponds. The personal experience of the author in talks with stressed managers who "confessed" that "in the milieu of the golf course things were easier and more pleasant – even business talks" underpins this judgement.

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A European Landscape Stratification Reflecting Drainage Density

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Abstract

The European continent is characterised by a large diversity in landscapes. The distribution, density and pattern of drainage channels (including lakes, wetlands and lagoons) are major characteristics of these landscapes. GIS tools nowadays allow for the combined analysis of digital elevation data and ancillary information in order to derive these characteristics over extended areas.

This article presents a new approach for the derivation of drainage networks and drainage basins for the pan-European area, making use of medium resolution digital elevation data and information on climate, vegetation cover, landform, soils and lithology. Based on these data we propose a landscape stratification that reflects the environmental aptitude to develop a certain drainage density. In the subsequent channel extraction a dedicated threshold for the critical contributing area is used for each landscape type, resulting in a spatially variable drainage density.

The described methodology has been implemented for the pan-European area. The resulting GIS with river networks, lakes, lagoons and drainage basins and their characteristics supports the environmental monitoring activities of the European Environment Agency as well as the current efforts for the implementation of the EU Water Framework Directive.

Keywords: landscape characterisation, drainage density, modelling drainage networks, Water Framework Directive

1 Introduction

Rivers and lakes are dominant features of the landscape. The pattern and density of the drainage network reflects the interaction between hydrological and geomorphic processes at geological time scales as well as the effects of human interventions in the recent past. Along the branched network of stream channels water and material are transported from the hillslopes to lakes and eventually to the sea. The drainage basins of these streams are basic entities of the landscape. Most processes related to the movement and quality of water are best studied at the catchment scale and many associated processes such as mass movements, soil erosion, sediment transport and even the distribution and change of certain land cover types are strongly linked to this reference unit.

Digital data sets of the geographical location of rivers and lakes as well as information on the size, shape and characteristics of their drainage basins are, therefore, important for modelling hydrological and landscape processes and for the calculation of environmental pressure indicators. The increasing need for these data has even been reflected in more recent environmental legislation. An example is the EU Water Framework Directive (EC 2000), which asks for the provision of digital data sets on water bodies and drainage basins and their characteristics as well as for the analysis of pressures and impacts on water resources at the river basin level. Similarly, the European Environment Agency (EEA) requires digital data on river networks and their catchments in the frame of its water monitoring activities over the whole European continent.

At the European scale such information is, however, not readily available. While adequate data sets may exist at varying scales and in differing formats in the Member States, to date no homogeneous layer of a fully connected river network with associated drainage basins is available over the whole of Europe. The sheer extent of the area to be covered (pan-Europe covers some 11.5 million km^2) requires the implementation of automatic tools for the derivation of the desired information. In order to fill this gap, the Eurolandscape project of the Institute for Environment and Sustainability (IES) of the Joint Research Centre (JRC) has recently developed methods for mapping and characterising drainage networks and catchments over large areas (http://eurolandscape.jrc.it). The methodology is based on the automatic derivation of river networks and drainage basins from digital elevation data and ancillary information on climate, vegetation cover, landform, soils and geology.

In this paper we present this methodology, giving special emphasis on the development of a landscape stratification for drainage density. In section 2 the various data types used are mentioned and in section 3 the approach towards a landscape stratification is described in more detail. First results are presented in section 4 and section 5 summarises the main conclusions from the study.

2 Data

In order to derive a landscape stratification for the entire European continent, it was necessary to consider data that are available for the whole area of interest. Based on this restriction, the following data were used in the frame of this study:

1. Digital elevation models (DEMs) with a grid cell size of 250 meters. These data stem from various sources and have been compiled in the frame of the activities of the Eurolandscape project. They cover the EU and the Accession Countries. Vertical accuracy varies according to the source of the data but is typically 5 to 15 meters.

2. CORINE Land Cover data on a 250 meter grid. These data have been acquired from the Eurostat-GISCO database (http://europa.eu.int/comm/eurostat/) They represent 44 land cover classes (CEC 1993), which have been reclassified according to the needs of the project.

3. Meteorological data from the European database of the MARS project (Monitoring Agriculture by Remote Sensing) at the Joint Research Centre (VAN DER VOET et al. 1994, TERRES 2000). These data are available on a 50 km grid and for a time series of 25 years (1975-1999).

4. Soil data, including information on the geology, from the European Soil Database (ESBSC 1998).

In addition, the Bartholomew 1:1,000,000 digital river network has been used for estimating drainage densities (www.bartholomewmaps.com). Data from the Eurowaternet station network of the EEA (NIXON et al. 1998, BOSCHET et al. 2000), the Bartholomew river network and detailed river networks for a few sample catchments have been used for validation purposes (COLOMBO et al. 2001a, VOGT et al. 2002).

3 Deriving a Landscape Stratification

The reason for implementing a landscape stratification is to overcome the shortcomings of using a single contributing area threshold for estimating the channel heads. The landscape strata, therefore, need to be based on a combination of environmental factors governing drainage density. The underlying hypothesis states that a few basic environmental factors exert a strong control on the channel initiation process and, therefore, on the development, pattern and density of the drainage network.

The resulting landscape types are assumed to be homogeneous with respect to drainage density and to exhibit a characteristic relationship between local slope and contributing area. As a consequence, the threshold for the minimum contributing area necessary to start a drainage channel can be varied in space, thus producing different drainage densities for different landscape types.

Based on a literature survey, a set of five variables describing climate, relief type, vegetation cover, soil transmissivity, and rock erodibility were selected as the most important factors determining drainage density (see VOGT et al. 2002 for a more detailed discussion).

For the climate, the mean annual precipitation (1975 – 1999) was used as an indicator (MOGLEN et al. 1998). The influence of the terrain morphology has been considered through the relative relief, defined as the maximum altitude difference in a moving window of 3 by 3 grid cells (OGUCHI 1997, ROTH et al. 1996). The percentage of surface covered by vegetation was used in the analysis due to its effect on critical shear stress and thus its control on channel initiation (TUCKER et al. 1997, FOSTER et al. 1995). CORINE Land Cover data with a grid-cell size of 250 m were reclassified into 14 classes and monthly cover percentages were assigned to each class according to the scheme derived for Europe by KIRKBY (1999). A yearly average surface cover has then been calculated for each land cover class as the mean of the monthly values. As a proxy indicator of saturated soil hydraulic conductivity, soil texture has been chosen as the main soil factor affecting drainage density (e.g., DIETRICH et al. 1992, TUCKER and BRAS 1998). Soil texture was derived from the European soil map (ESBSC 1998). The rock erodibility was calculated according to the scale proposed by GISOTTI (1983). From the European soil map the parent material corresponding to each soil mapping unit was extracted by deriving the dominant lithology. Data were then scaled, with the highest erodibility assigned to unconsolidated clastic rocks and the lowest erodibility assigned to igneous rocks. Such a generalisation is consistent with studies of WILSON (1971), DAY (1980) and GARDINER (1995), which show that higher drainage densities are generally associated with impermeable rocks, even though differences become less pronounced with higher mean annual precipitation (DAY 1980).

The different parameters have been classified into three to seven classes and their relationship to drainage density (Dd) was further studied by calculating an average drainage density for each parameter and class. This calculation was based on the drainage density as derived for a regular 10 km x 10 km grid overlaid on the Bartholomew river network at

1:1,000,000 scale. As an example the graph resulting for the relation to relative relief is shown in Figure 1.

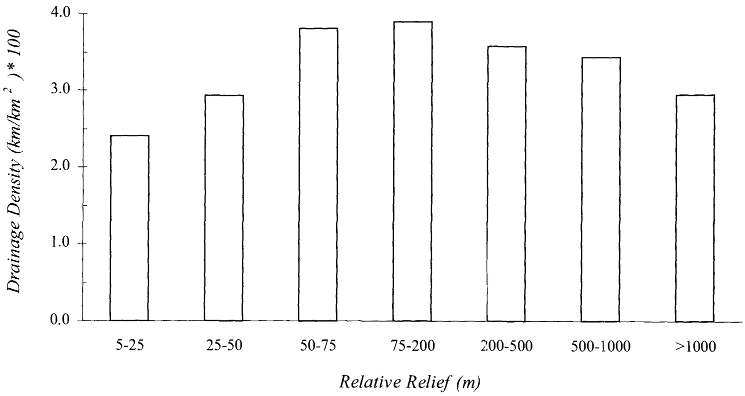

Fig. 1: Relationship between relative relief and drainage density (calculated from the Bartholomew river network at 1:1,000,000 scale).

According to the results of this analysis a weight has been assigned to each of the classes (*cw*) according to equation 1, resulting in a minimum weight of 10 for the class of lowest drainage density and a maximum weight of 100 for the class of highest drainage density (see Table 1).

$$cw = \frac{Dd - Dd_{\min}}{Dd_{\max} - Dd_{\min}} * 90 + 10 \qquad (1)$$

Tab 1: Classes of environmental variables and corresponding weights for each class (*cw*) as used in the calculation of the LDDI.

Class - Code	*Environmental Variable*		*Weight (cw)*
	Class	*Description*	
	Annual Precipitation (C) [mm]		
1	< 250	Arid to Semiarid	10
2	250 – 500	Semiarid to Humid	100
3	500 – 750	Humid	90
4	750 – 1000	Very Humid	80
5	> 1000	Wet	60
	Relative Relief (R) [m]		
1	< 5	Flat or almost flat	-
2	5 –25	Undulating	10
3	25 – 50	Undulating – Rolling	42
4	50 – 200	Rolling – Hilly	100
5	200 – 500	Hilly	81
6	500 – 1000	Hilly – Steeply Dissected	73
7	>1000	Mountainous	43
	Vegetation Cover (V) [%]		
1	0 – 25	Scarce	100
2	25 – 45	Low	33
3	45 – 60	Moderate	25
4	60 – 80	High	15
5	80 – 100	Very high	10
	Rock Erodibility (I) [-]		
1	Low	Igneous, Metamorphic, Calcareous	10
2	Medium	Sandy, Loamy, Pyroclastic	57
3	Very high	Clayey, Flysh, Unconsolidated Clastic	100
	Soil Texture (S) [-]		
1	Coarse	clay < 18%, sand > 65%	10
2	Medium to Fine	8% < clay < 35%, 15% < sand < 65%	27
3	Fine	35% < clay < 60%	48
4	Very Fine	clay > 60%	100

Finally, a Landscape Drainage Density Index (LDDI) was derived from a combination of these environmental variables. To this end different techniques have been tested, among them a simple scoring technique (summing-up of the different weights for each grid cell), a multi-criteria evaluation technique and a standard clustering technique. The results of these tests are further described in COLOMBO et al. (2001b). For the final stratification the multi-criteria evaluation technique has been retained.

The multi-criteria evaluation technique allows to assign a (relative) parameter weight (*pw*) to each of the environmental parameters, following a pairwise comparison of their relative importance. The analyst initially rates the influence of each parameter on the studied process against each of the other parameters on a scale ranging from 1/9 (very little importance) to 9 (very high importance). Best parameter weights are then produced by a principal component analysis of the pairwise comparison matrix. The process further calculates a consistency ratio of the matrix that measures the degree of consistency in the original pairwise ratings and thus allows to control the quality of the final parameter weights (EASTMAN et al. 1995). The parameter weights modulate the class weights according to the importance of each parameter in the whole system.

In order to distinguish the main geomorphic processes controlling the channelisation (i.e., runoff erosion produced by saturation overland flow and shallow landsliding), four different cases were considered. The first and second cases take into account channelisation due to saturation overland flow, assuming that this process prevails in areas with a relative relief of less than 200 meters. To consider the combined effect of vegetation cover and rainfall, a further distinction according to the vegetation cover percentage (<20% and >= 20%) was made.

The third and fourth cases represent channelisation due to shallow landslides, assuming that this process prevails on steep slopes with a relative relief greater than 200 meters. Also in this case a subdivision was made between low and high vegetation cover percentages, taking a threshold of 20 percent.

For each of the four cases the pairwise comparison matrix was established and the parameter weights and the consistency ratio were calculated. An example is given for the third case (relative relief >200m and vegetation cover percentage <20%) in Table 2. The consistency ratio for this case was 0.08, indicating good consistency between the different pairwise weights.

Tab 2: Pairwise comparison matrix for the different environmental parameters and final parameter weights (*pw*) for case three (relative relief > 200m, vegetation cover < 20%).
C: precipitation, V: vegetation cover, S: soil texture,
I: rock erodibility, R: relief

Environmental Parameter	C	V	S	I	R	Parameter Weight (*pw*)
C	1					0.3462
V	1/3	1				0.1791
S	1/5	1/3	1			0.0929
I	1/3	1/5	1/3	1		0.0762
R	1	3	3	5	1	0.3290

Based on the weights for each class (*cw,* Table 1) and the parameter weights (*pw,* Table 2) the Landscape Drainage Density Index is then calculated according to equation 2:

$$LDDI = \sum cw_{ij} * pw_j \qquad (2)$$

where: cw_{ij} = weight for class i of parameter j

pw_j = parameter weight for parameter j

From the resulting LDDI, seven drainage density classes have then been defined.

For each drainage density class a critical contributing area was derived by analysing the relationship between the local slope and the contributing area, both derived from the DEM. In order to have a better representation of the partitioning of water flow, local slope and contributing area were estimated from the DEM using the D∞ method (TARBOTON 1997). The log-log diagrams of local slope and contributing area were analysed for each landscape class. Figure 2 shows an example of such a plot for the class of highest drainage density.

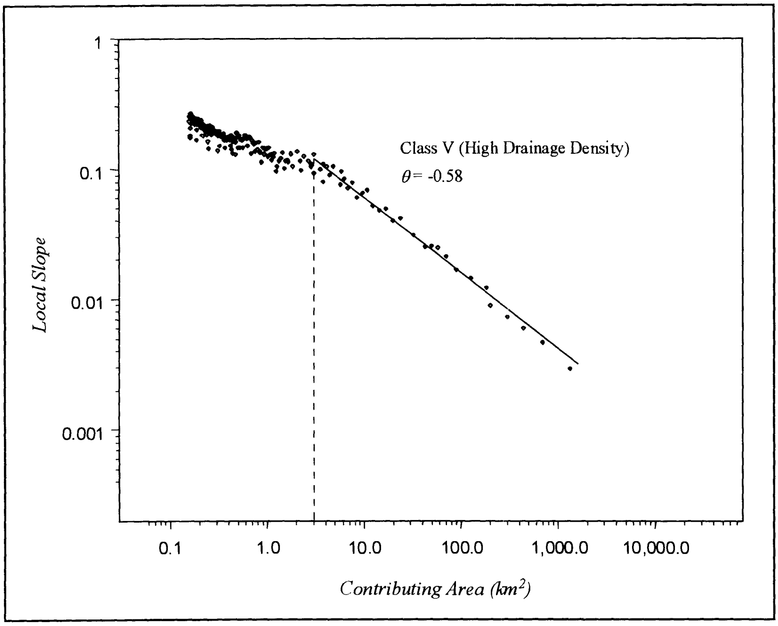

Fig. 2: Log-log graph of critical contributing area versus local slope for the landscape type with highest drainage density. The vertical line defines the threshold for the critical contributing area in this class.

The transition from undistinguished hillslope processes to fluvial processes is marked as a break in the slope of the scaling line in these plots (indicated by the vertical bar in Figure 2). The zone to the right of this break represents the fluvial regime, while the zone to the left of the break appears to be the result of a transition between several hillslope processes (TARBOTON et al. 1992). In the zone of fluvial transport, the slope of the scaling line (θ) generally approaches a value of 0.5. In order to guarantee that a grid-cell belongs to the fluvial network, it was decided to extract a drainage channel based on a contributing area greater than the value defined by this break point.

The resulting landscape stratification with seven drainage density classes is shown in Figure 3.

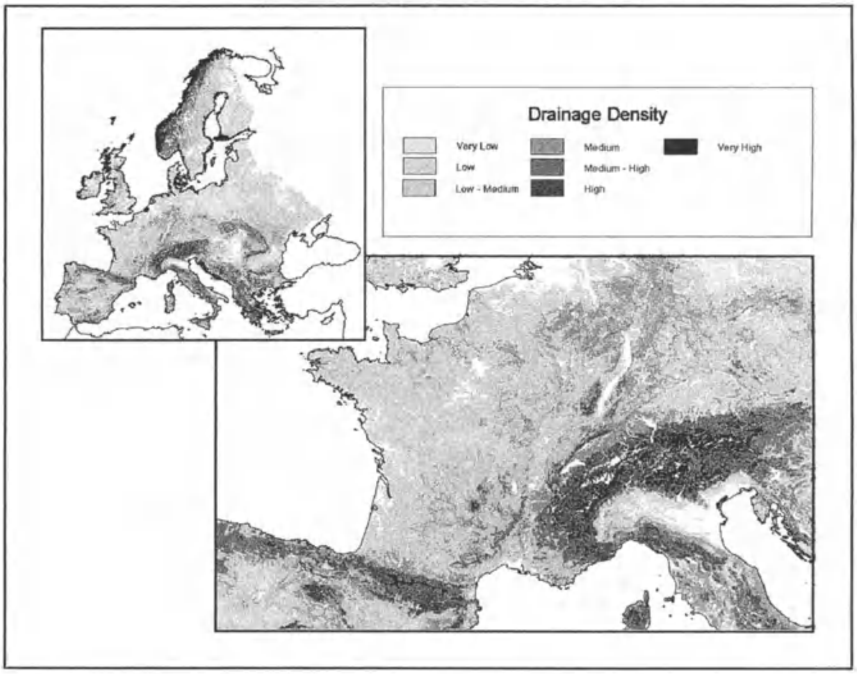

Fig. 3: Landscape stratification for drainage density.
Drainage density varies from very low (light grey) to very high (dark grey).

4 Extracting the Drainage Network

The drainage network has been extracted from the DEM by calculating the flow direction and flow accumulation matrices. This poses the problem of spurious pits interrupting the flow path. An effective and widely used method for removing pits in DEMs consists in filling them until they overflow (SOILLE and ANSOULT 1990, SOILLE and GRATIN 1994). This method, however, may result in large flat regions, which in turn pose a problem for the determination of accurate flow directions. This problem has been solved by developing a new algorithm based on the concepts of morphological image analysis (SOILLE 1999). More precisely, each pit is suppressed by creating a descending path from it to the nearest point having a lower elevation value. This is achieved by carving, i.e., lowering down, the terrain elevations along the detected path. In addition, the proposed approach is suitable to an adaptive drainage enforcement, whereby river networks coming from other data sources are imposed to the DEM only in places where the automatic river network extraction deviates substantially from the given networks (i.e., areas of low relief energy). Flow directions on truly flat regions (i.e., plateaux) are determined by interpolating the elevation values on the plateau so as to create a relief taking into account the morphology of the plateau. This interpolation procedure is related to the morphological interpolation of DEMs from elevation contour lines as described by SOILLE (1991). In addition, priority queue data structures allow for an efficient implementation of the algorithm, which in turn enables the processing of files such as the complete pan-European DEM. Typically, continental Europe represents a raster file of 400 MBytes of data. It is processed in less than an hour on a personal computer with a clock rate of 2 GHz. By processing the whole data at once, edge problems that always occur at the borderline between subsets, are avoided. Details about the algorithm can be found in SOILLE (2002).

Finally, the landscape stratification is considered during the determination of the channel heads. As a consequence, the derived drainage network reflects the natural variability in drainage density. Lakes and lagoons are taken into account through a specific layer, which is based on CORINE Land Cover (CLC) data as well as other land cover data in areas where CLC data are not available. It is ensured that rivers flow along the centre line of the lakes. The derived drainage network is fully connected and hierarchically structured from the smallest tributary to the largest river flowing into the sea. Based on this hierarchy river basins and sub-basins are then delineated according to the surface morphology. A view of the resulting drainage network is shown in Figure 4.

Data validation is performed against existing European and national datasets, as well as against a few large-scale datasets for selected drainage basins. The validation is implemented in two ways: (a) through the assessment of the position of the river reaches by overlaying them to the reference datasets and evaluating their correspondence through a series of buffers of varying size/ and (b) through the comparison of the calculated size of a sample of river basins with the officially reported size in the Eurowaternet database (more than 3000 basins). First results of this validation have shown that the river network is of high quality and corresponds to a mapping scale of roughly 1:500,000. More information on the validation procedure can be found in VOGT et al. (2002) and COLOMBO et al. (2001a).

As a final step, a coding system will be introduced. This coding system will provide a unique identifier for each river reach, lake and drainage basin, which will encode its position within the hierarchically structured system. The coding system will follow the recommendations given by the European Working Group on GIS under the Common Implementation Strategy for the Water Framework Directive (http://europa.eu.int/comm/

this Working Group, a Guidance Document on GIS issues under the Water Framework Directive will be published in early 2003.

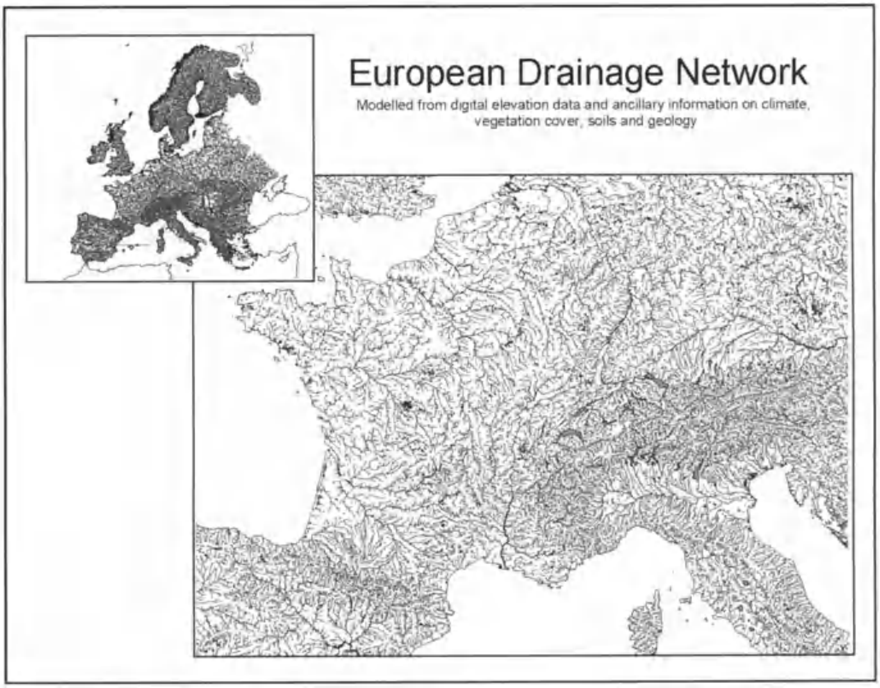

Fig. 4: European drainage network. Note the variation in drainage density according to the landscape stratification.

5 Summary and Conclusions

Drainage networks and drainage basins are important entities for environmental monitoring and, more specifically, for modelling hydrological and landscape processes. As a consequence, the lack of small-scale digital datasets of river networks and drainage basins has been highlighted repeatedly. In order to fulfil the requirements for a European-wide monitoring, these data should cover the whole European territory with comparable detail and quality.

The methodology presented in this paper allows for the derivation of such datasets from digital elevation data and ancillary information on climate, vegetation cover, landform, soils and geology. It includes a landscape stratification for drainage density, which allows to retrieve a drainage network reproducing the natural variation in drainage density. It will serve the immediate needs of the European Environment Agency in will serve the immediate needs of the European Environment Agency in the frame of its European-wide environmental monitoring activities and will support the implementation of the Water Framework Directive.

In addition to the landscape stratification, a second important asset of the presented methodology is that it has been implemented with a fast and reliable algorithm based on the concepts of morphological image analysis. This algorithm allows for iterations even for extended areas such as the entire European continent, which is a major asset for implementing corrections after further validation steps.

In the current version, the LDDI is subdivided in only seven classes for practical reasons of calculating the critical contributing area. Improvements of the methodology are expected through the use of more drainage density classes or the implementation of a continuous Landscape Drainage Density Index (LDDI).

A first version of the River and Catchment GIS, including a set of catchment characteristics and a coding system, will be finalised by the end of the year 2002. It is expected to become part of the Eurostat-GISCO reference database in 2003.

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Integration of Spatio-Temporal Landscape Analysis in Model Approaches

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Abstract

The subject of examination in landscape ecology covers landscapes of various spatial as well as temporal dimensions. Landscapes are complex, spatially and temporally multi-layered systems, which change and develop naturally but are also subject to anthropogenic changes owing to their multifunctional use. Landscape ecology models are an important instrument in establishing better access and understanding of the spatio-temporal behaviour of systems and processes. The recording of the structural function and dynamic of landscapes is closely linked to the inclusion of the variables space (structure) and time (dynamic). When examining precisely the variables of space, time and dynamic in system models, it nevertheless becomes apparent that in model approaches the implementation of these variables is treated very differently. The subject of this paper deals with issues of integrating the variables of space and time into models and observations of models for the landscape dynamic. Furthermore, there is an overview of the current linking methods of space and time and the system model as well as new approaches in the creation and implementation of spatial landscape models.

Keywords: Spatio-temporal simulation, linking spatial-temporal-dynamic and simulation models

1 Models in Landscape Ecology

Landscape ecology is a growing discipline that needs to and can build on the multidisciplinary approach to represent a link between a wide variety of scientific disciplines. However, landscape ecology will only do justice to this very demanding requirement if it is continuously developed and applied not only in its "own interdisciplinary mode of thought" but also particularly in its "own inter-methodical approach". And yet this demand seems difficult as the variety and diversity of knowledge of one scientific discipline is increasing on the one hand, and on the other the necessary inter-methodical approach requires a high degree of creativity, versatility and openness in research. Attributes that may sometimes appear alien to the programmer with his source code, the biologist with his enzymes and antigens and the social scientist with his questionnaires.

Group discussions, fieldwork, data analysis, the use of space-related data and geographical information systems (GIS), simulation models, the analysis of landscape metrics and spatial statistics and the constant "search" for "interfaces" between the substantial and methodical approaches between specialist disciplines such as biology, ecology, geography, computer science, social science are just some of the few areas that should distinguish the interdisciplinarity of the thinking and methodical approach of a landscape ecologist.

The subject of examination in landscape ecology covers landscapes of various spatial as well as temporal dimensions. Landscapes are complex, spatially and temporally multi-layered systems, which change and develop naturally but are also subject to anthropogenic changes owing to their multifunctional use. To analyse and evaluate them instruments and models are required that represent and interpret the variety and complexity of the connections between biotic and abiotic landscape structures and objects and are able to forecast the effects of natural changes and anthropogenic impacts as reliably as possible.

Landscape ecology models are an important instrument for gaining access to and understanding of the spatio-temporal behaviour of systems and processes. The recording of the structure, function and dynamic of landscapes is closely linked to the integration of the variables space (structure) and time (dynamic).

But what does this mean for the scientist as a user or "creator" of models and what approaches currently exist for creating landscape models with relation to space and time? The landscape ecology modeller faces an even greater problem here. An ever-broader "knowledge" is required of him concerning the deployment, use and handling of GIS, spatial and temporal statistics and the formation and creation of models. GIS, modelling and simulation tools are not currently regarded as one methodical unit. They were developed with different aims, whereby a coupling of the two systems can only mean a loss in quality on the part of simulation as well as reference to space and time.

Only very slowly – much too slowly for users of landscape ecology models –the interfaces between both methodical approaches or between spatio-temporal-integrating modelling languages are being developed. But in which system "landscape ecology model formation" is currently taking place and where are landscape ecology simulation models being operated?

2 The Role played by Space and Time in Models – Observations of Space and Time in Models

2.1 The Variable Space in Models

Landscape ecology tries to determine the landscape around us with the aid of qualitative observations as well as quantitative descriptions through theories converted into values. The precondition for this is the precise observation and characterisation of space, time and processes. Space and time are dimensions that continually accompany us, but which are not easy to record.

The observation of the spatial variable is postulated in numerous model approaches, but with a more precise observation of the "spatial reference" in the model there are already a wide variety of approaches to and perspectives of the object of "spatial reference". The classical ecosystem theory disregards the spatial reference in its approaches. A wide range of model types can be listed here, which especially use differential equations and statistics for modelling building on mathematical approaches (non-spatial model). (cf. Table 1). are On the other hand a large number of model types follow on from this, using raster-based approaches for space delimitation. Spatial reference is realised here by the use of grids or patches. The use of cellular automata has proven to be useful here for conversion into simulation models. The advantages of this method lie in the setting up of control systems for cells that act with one another. The objective is a greater simplification of the structuring of objects and the spatial variables observed. In a spatially realistic mode (SRM) the characterisation of space goes one step further. With the use of standardised grids attempts are made to represent existing structures of actually existing landscapes in cellular automata. These approaches are already very close to the GIS-integrated model approaches. However, the cost of characterising each cell with a value (network or street, buildings, forest) is very high. This approach is particularly restrictive in representing or integrating space-related abiotic parameters such as a digital elevation model or the spatial variability of climatic parameters. In recent years gis-integrated model approaches or spatially realistic gis-integrated models (SRGM) have become more strongly established in landscape ecology process research. This is no surprise, as the development of spatio-temporal models is very closely linked to the development of suitable methods and tools. The particular strengths of geo-information systems are the integration of space-related realistic information on both the abiotic and biotic structuring of the landscape as the well as the broad opportunities for spatial analysis between the individual layers of information. It is therefore not surprising that GI systems have found rapid acceptance in landscape ecology system research. However, if one believes that the creation of space and time-related landscape ecology models is methodically comparable to the already common simulation tools, one is quickly brought back to the "cold reality of the modeller's problems". There already exists a range of direct and indirect linking methods, to exploit the strengths of GI on the one hand, and on the other not to have to do without the efficiency of standard model languages (C++, Pascal) (see Chapter 3).

Tab. 1: Implementation of the spatial variable in the model

Model – Term	Definition	Example
Non spatial model **(NSM)**	• no "direct" spatial reference • description of the change of a state size per time unit • spatial reference is achieved through the integration of space-dependent parameters (e.g. capacity parameters) • Spatial reference achieved first through the analysis of key parameters taken from the "space – GIS"	Classical model approaches • differential equations • partial differential equations • statistical approaches (dis-criminance analysis, logistic regression) • matrix models (matrix population models, Leslie model) • individual-oriented ap-proaches (probability density function)
Raster-based approaches without the use of GIS		
Spatially implicit model **(SIM)**	• model in which all local popu-lations are equally connected • Patches formed from aggre-gated cells • homogeneity of the patches is dependent on the observation level (type, individual, process size) • all patches are linked to each other to the same extent	• island model • patch model

Spatially explicit model **(SEM)**	• regular grids (cells) • patches are identical cells in a regular grid	• lattice model, grid model • cellular automata model (neighbourhood models) • stepping stone model • matrix models • linking of grid and matrix model • linking of grid model and individual-oriented approaches (probability density function) • linking of grid – control-based fuzzy expert systems • linking of grid – neuronal networks
Spatially realistic model **(SRM)**	• representation of "realistic" patches, networks, landscapes	• simulation models • incidence function model
GIS – integrated model approaches		
Spatially realistic gis-integrated model **(SRGM)**	• integration of "real" patches, networks, landscapes, abiotic and biotic data on the basis of space-related GIS data • 2D, 2.5 D, 3D geodata	• GIS-based simulation models • linking of GIS – control-based fuzzy expert systems • linking of GIS – neuronal networks • linking of GIS – transfer functions

2.2 The Time Variable in Models

In addition to realising the attribute of "space", an important component in models is the integration of "time" as a variable. Landscape ecology processes such as urbanisation, the spreading of fires, landscape change, erosion, the spreading of pollutants and many others, are spatio-temporal processes. If one wants to simulate a process, space (structures / geo-objects) and time have to be taken account of in the model.

If reference to space has already been realised for a long time in model approaches (grid models, cellular automata) in spatially implicit and spatially explicit models, the use of spatially realistic gis-integrated models is closely connected with improvements in the GI systems. The same also applies to the integration of the variable time in model approaches.

Tab. 2: Implementation of the variable of time reference in the model

Model - Term	Definition	Examples
Non temporal model **(NTM)**	• no reference to time in the model • time reference through the integration of time-descriptive parameters	• differential equations • partial differential equations • matrix models (matrix population) models, Leslie model)
Raster-based approaches without the use of GIS		
Temporally implicit model **(TIM)**	• time as a coincidental event (stochastic)	• island model • patch model
Temporally explicit model **(TEM)**	• time reference and time unit integrated in models • relative time data such as relative points in time, relative time intervals	• differential equations • partial differential equations
Temporally realistic model **(TRM)**	• integration of "real" time units in the model • absolute time data such as absolute sections in time, absolute time intervals, absolute time segments • arrival of events to characterise changes in states	• time-segment approach • event-oriented approach
GIS – integrated model approaches		
Temporally realistic gis-integrated model **(TRGM)**	• time integration in various thematic GIS layers (geometry) • time integration in GIS databases (attributes) – temporal databases • 4D GIS information (space and time reference)	• time-integrative Geographic Information System (currently still in the planning stage) • 4D-GIS

The current state of the art (cf. Table 2) in GIS modelling permits the analysis of changes in spatial information over a time period/ time span, however individual layers of information here (e.g. land use structures of various sections in time) are compared to each other temporally. Current GI systems are therefore also described as atemporal GI systems

(LANGRAN 1989). By comparing objects and structures (land use data) from two different sections in time, a change analysis is possible on a "secondary" basis.

In recent GIS developments, however, particular significance is given to the variable time in the spatio-temporal model (4D GIS). Geo-objects, structures and functions, which in turn have an effect back on the objects and structures, change over time. Landscape types with a high dynamic (e.g. open-cast mining landscapes) lead to completely difference in spatial structures over the course of time. Without the integration of the time factor (e.g. through different temporal land use data) the system model always works from the same static states of the landscape structure. And yet processes are frequently simulated in landscape models over a very long period of time. Simulation times of 50 to 100 years and more are not uncommon. If the temporal changes of the spatial structures are not included in the model, completely different model results occur.

2.3 The Dynamic of Structures, Patterns and Landscapes – Models of Landscape Transformation

The landscape is highly complex. Its structure and composition is the reflection of a culturally and economically historical development process. Structures and objects in our landscape are subjected to forces of varying kinds as the cause for movement changes in direction as well as intensity. For all objects there is at first a certain "equality of stasis and movement". The intensity and direction of the movement is determined by driving forces that have various causes. The aim of models about landscape transformation is to analyse the direction and locality of object changes and record the driving forces as the causes for changes to the landscape. These changes in dynamic as well as strength, directions and trends are important variables of dynamic landscape models.

But how can the dynamic of objects be recorded? The dynamic can only be defined relative to a reference object. However, there are only few objects that remain in an actual state of rest. We can measure the dynamic of objects by using temporal and spatial reference units, which we have to set up and define ourselves. Whether these spatio-temporal reference units actually exist in the landscape is not frequently called into question. For a long time we have known that there is no reference unit to which one can properly refer the spatio-temporal activity of landscape changes. A dynamic is a constant process without a directly measurable "beginning" and a "directly measurable end". The difficulty of categorising the process of landscape change and its quantification can be seen in the models for recording the landscape dynamic and its causes:

We distinguish here between:

- **Methods and models for analysing changes** between objects and structures
  1. Statistical techniques (spatial / aspatial change models)
     a) descriptive statistics (frequency distribution, mean values, proportions of space, min, max)
     b) Markov models (estimates of the probabilities of changes)
  2. techniques of image processing (map algebra) – (spatial change models)
     c) matrix image calculation/ formation of differential images
     d) technique of change detection
  3. techniques of structural analysis (spatial/aspatial change models)
     e) determining the composition/ configuration of structures (land-scape metrics) with the subsequent use of methods 1 and 2 (see above)
- **Methods of analysing the causes of land use structures and land use changes**
  4. statistical techniques (spatial / aspatial change models)
     f) regression models
     g) discriminance analyses

For the examination of landscape dynamics we first compare the landscape structures, which we can represent with our data – either topographical data or remote sensing data. Here each scientist establishes "his or her landscape" with the characterised structures (reflection of the available data material) as well as his or her "own examined sections in time" for the examination of the landscape change. As no direct "beginning" nor a "direct end" can ever be defined for this process, changes in landscape use structures are examined as a relative measurement (relative landscape dynamic). This means that a given object and spatial structure has to be defined as a spatio-temporal reference unit (master image). Working from this reference unit, all the subsequently examined structures (slave images) are then established relative to the master image.

If possible causes and trends in landscape change can be ascertained, these are in turn important input variables for landscape ecology simulation models.

3 Linking between Spatio-temporal and Simulation Models

In order to gain an understanding of the dynamic of the landscape and therefore the potential spatial changes over long sections of time, landscape ecology simulation models are important methodical tools. However, here the gap between the scientifically theoretical necessities of a landscape ecology simulation model and the practical implementation of the simulation in the computer is extraordinarily large. If a standard programming language for realising the models is used, problems arise both in the difficulty of managing the integration of basic space-related information (geodata with space and time reference) and often in the difficulty of mastering and being able to modify the computer code of the programming language used. Therefore often only a small number of programming experts are "granted the pleasure" of producing system models and using them in landscape ecology process research. The scientific specialist in landscape technology is often "left to his or her own devices" with his or her knowledge of space and time reference or the various interdisciplinary interfaces that exist in landscape ecology research.

Simulation models for landscape ecology processes must be able to reflect the complex structures and relationships that exist in the landscape, albeit in a simplified form. At this an important component is the space and time reference of objects and structures in the simulation model. Spatio-temporal modellings are the basic functionalities of existing GI systems. Geo-information systems provide the opportunity of recording actual as well as geometric data of different data layers in complex spatial and temporal connections with a logical content. The particular strength of spatial analyses (neighbourhood analyses) via data layers of various themes and cell sizes have helped to make geo-information systems an important aspect of spatio-temporal modelling.

An overview of various couplings between space and time-related models and simulation models is set out in Figure 1 and Table 3. They range from loose coupling to full integration of landscape ecology simulations in GI systems (embedded coupling). In the planning of the possible use of one of the systems referred to, the advantages and drawbacks mentioned here play a decisive role. The exact mastering of a higher programming language for scientists and model creators, which allows the integration of even complex GIS functionalities in the simulations, is frequently an absolute prerequisite. However, specialist landscape ecology disciplines often falter because of this difficulty.

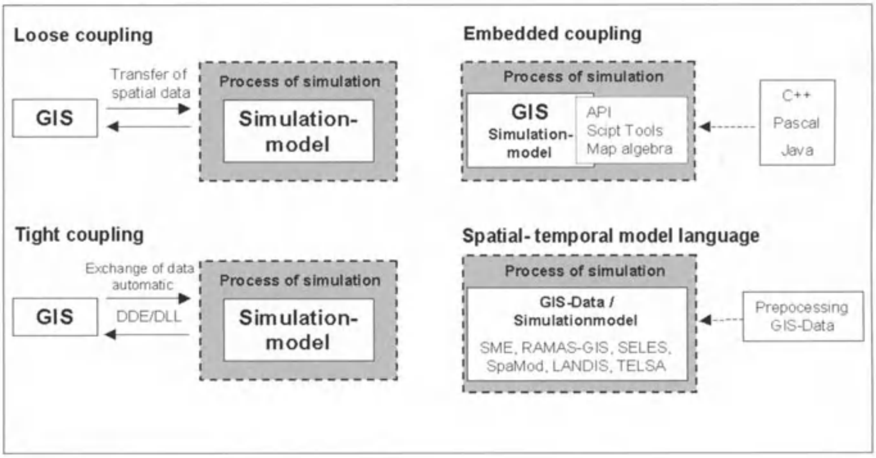

Fig. 1: Possibilities of linking between spatio - temporal and simulation models

In recent times model languages (domain-specific languages) or complex spatio-temporal system models have increasingly been developed that enable an equilibrium between the flexibility and difficulty of programming and the integration of space and time-related information (geo-information) into the system modelling. In Figure 1 and Table 3 a range of possible simulation models has been listed, which range in part from complete simulation models with their own parameter inputs to model languages for the creation and extension of one's own system models.

The use of models for representing different systems and processes in the landscape is playing an increasingly important role. This development process is strongly linked with the ever-advancing development in computer technology as well as the ever-increasing understanding of processes in landscape ecology.

A model abstracts or represents a system or a process. Of importance here is the integration of the variables space and time in the system modelling. Simplified model languages or language environments, which realise a direct linking between space and time reference and the running model simulation, are opening the way for a new generation of efficient space-time observations by landscape ecological system models.

Tab. 3: Approaches for a linking between spatio-temporal and landscape ecology

Term	Description	Advantage	Disadvantage
Loose coupling	• exchange of space-related geodata via loose file exchange (ASCII)	• the use of already available simulations models is possible after adaptation • the use of programming languages well-suited to the creation of simulation models (C++, Pascal) • very rapid (temporal) operation of the simulation is possible	• the ASCII file format takes up a lot of memory • when the geodata is updated there is no automatic updating in the model • the user has to possess very good programming skills • specialists with no programming experience are unable to carry out their own simulations • if partial models are created, complete reprogramming is always necessary • implementation of the advantages of map algebra (GIS functionalities) in standard programming languages is difficult
Tight coupling Full integration - under a common Interface	• space-related geodata is integrated automatically into the system models via the interfaces DDE/DLL	*as already mentioned above* • when the geodata is updated, it is transferred directly into the simulation model	*as already mentioned above*
Embedded coupling Full integration	• full integration of the simulation in a GIS environment • simulation realised via a) API	• use of the analytical power of a GIS platform for the simulation • language (e.g. script language) is relatively easy and quick to learn	• simulations run "more slowly" • programmer libraries are only useable within the GIS functionalities (e.g. no processing

	b) Script Tools c) Map algebra	• users do not have to be programmers • changes in the model structure are possible relatively quickly • no data transformation, data transfer required • processing of large quantities of raster data within the simulation	of programming loops) • it is difficult to create partial models that are in connection with one another
Domain-specific language	• use of a domain-specific language • coupling of GIS functionalities and simulation model - SME (MAXWELL and COSTANZA 1997a,b, COSTANZA et al. 1998) - RAMAS-GIS (BOYCE 1996) - SpaMod (GAO 1996) - SELES (FALL and FALL 1999) - LANDIS (MLADENOFF et al. 1996) - TELSA (KLENNER et al. 1997) - FORSUM (KRAUCHI 1995) - STORM (FRELICH and LORIMER 1991)	• use of the analytical power of a GIS platform for the simulation • language easier / quicker to learn without programming knowledge • users can also be "non-programmers" and create their own simulation models • creation of partial models is possible • relatively quick changes within the model structure / data are possible • partial models can be composed differently • inclusion of the spatial reference (GIS functionalities) • simulations via "large raster data quantities" are relatively simple	• no full functional scope as with classical simulation languages (C++, Pascal, Simula) • no full functional scope of the GIS functionalities

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Integrated Land Use Zonation System in Hungary as a Territorial Base for Agri-Environmental Programs

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Abstract

The prerequisite for sustainable agriculture is that land should be used everywhere with appropriate intensity for the most suitable purpose or for what it can tolerate without damage (ÁNGYÁN 1988). Therefore, one of the most important characteristics of sustainable production practice is the establishment of a system of activities and degree of intensity that fits to the landscape and the environment; and a promotion of a land use system that directly descends from the environment and its potentials and limits.

The objective of the study is to evaluate the suitability of these areas for agricultural production (i.e. agricultural potential) and environmental sensitivity. The study serves as a basis for a regionally different but harmonized agricultural, rural and environmental policy making; provides a direct base in the field of land use for a long-term national rural development concept; can help in the development of a sustainable land use structure, which is adjusted to the ecological conditions, and also in the realization of the sustainable development in practice.

Keywords: agricultural suitability, environmental sensitivity, GIS analysis, multifunctional European agricultural model, National Agri-environmental Programme.

1 Introduction

The role of and the approach to rural areas and the environment has undergone dramatic changes in recent decades as close relations between sustainable, multi-functional agriculture and preserving natural resources were realised.

A significantly wider interpretation of the concept of agriculture is needed today, increasingly supplemented with environmental and landscape management aspects. Modern society values the environmental benefits to a rising extent that arise as joint outputs with primary land use.

The long term provision of natural resources could be ensured through a land use intensity that considers the environmental potentials of an area to the greatest possible extent (ÁNGYÁN 1998).

The resettlement process of agricultural and rural development policy of the EU and its adaptation may only give advantages for Hungary if the special conditions of the different measures to be taken are precisely determined (ÁNGYÁN 1999, 2000, 2001). I.e. a land use zone system shall be formed which

1. completely takes into consideration either the agricultural production or non-productive potentials of different regions,
2. classifies the different areas of the country along these coordinates, and
3. applies different strategies for agricultural and rural development in the different zones that have been formed in accordance with the above mentioned methods.

Given the common need for zonality that characterizes both nature conservation and agriculture, the categories of this system can be summarized as follows:

1. Basic nature conservation zones: areas that can be used exclusively for special functions of nature conservation and totally restricted for other types of land use.
2. Buffer zones of nature conservation and protection zones for water bases: areas that are cultivated with respects to the guidelines for landscape and environmental protection, mainly used for environmental, employment, cultural and recreational functions.
3. Mixed zones: areas that can be used for agricultural production with special additional protective functions, cultivated by organic farming and other extensive-type farming systems, with ESA areas and undisturbed biotope network systems.
4. Zones for agricultural production: areas that are used for agricultural production in form of integrated and sustainable production systems.
5. Non-cultivated land: urbanized areas with infrastructural, service and industrial functions.

The basic elements of the concept that integrates the land use and nature conservation in compliance with the conditions of the given region are shown in Fig. 1.

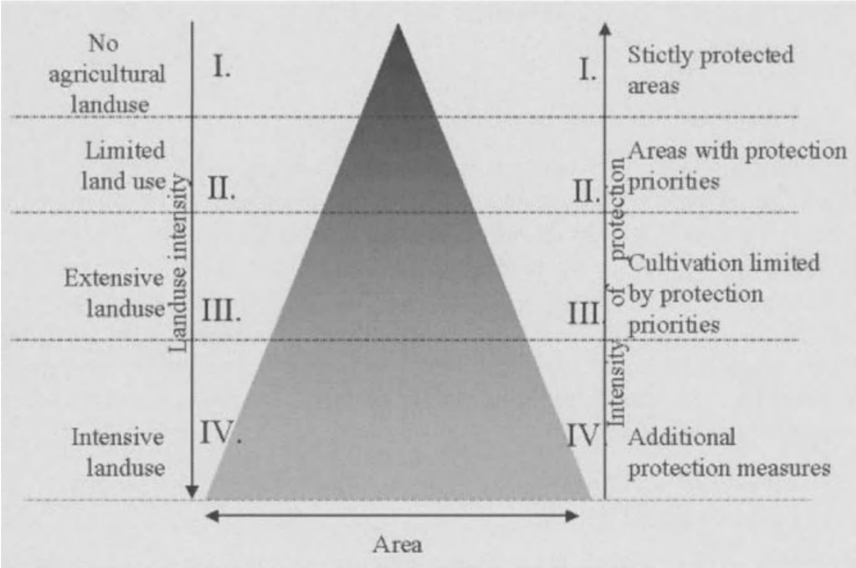

Fig. 1: The land use pyramid (adapted from ERZ,1978)

I. At the top of the land use pyramid are those areas – with regionally different sizes – which shall be classified categorically as areas for nature conservation (i.e. nature reserves, landscape protection areas or basic areas of biosphere reserves). These areas are characterized by the total prohibition of land use for any other purposes.

II. The areas with special need for land use limitations (such as the buffer zones around the basic zones) are standing underneath the above mentioned category of the pyramid. In this case land use is restricted to such types of agricultural production which provide nature protection.

III. Beneath these two levels, the areas with different limitations in land use (such as protection areas of water catchments and buffer zones) can be found, where semi-intensive production may be allowed as well, as long as these comply with the given limitations.

IV. Finally, the broad base of the pyramid is composed of the zone of agricultural production, either semi-intensive or intensive, but in both cases it shall be environment-friendly and adjustable to the environment and to the area of production. Its vertical extent depends on the location of the given region (i.e. an area for intensive agricultural production with high production capacity or area with high potential for environmental protection but low in agricultural production. The degree of intensity is determined by the capacity for environmental protection and the sensitivity of the values to be protected.

2 The main objectives of the study

The realization of the concept outlined above i.e. the basic aim in developing Hungary's integrated land use zone system is to develop an objective and ecologically-based analysis in several respects: to evaluate the suitability of these areas for agricultural production (i.e. agricultural potential) and environmental sensitivity, and to make a comparison between these two sides in order to balance natural resources (agricultural and environmental standards). The land use zone system can be developed by comparing the standards of suitability for agricultural production and of environmental sensitivity. This zone system can:

- be a basis of a regionally different but harmonized agricultural, rural and environmental policy;
- provide a direct base in the field of land use for a long-term national rural development concept;
- support in the development of a sustainable land use structure, which is adjusted to the ecological conditions, and also in the realization of the sustainable development in practice;
- contribute to the discussions on EU-accession in agricultural issues by giving an objective land use base to these issues;
- indicate the potential Hungarian target areas of the EU subsidizing system.

The fundamental questions the study seek to answer are the following:

1. What changes can be observed in the suitability of agricultural production, agro-ecological standards and environmental (nature, soil and water protection) sensitivity of Hungary's area?
2. How can the problem of harmonizing land use of areas with low agricultural potential or changes in the degree of intensity and the land demand of environmental protection and nature conservation be solved?
3. What categories can be developed for different regions of the country through comparing these two standards?
4. Where and to what extent can the areas with protection priorities, agricultural priorities and the overlapping priorities be found, i.e. where

can the protective, extensive and intensive agricultural zones be identified?

5. What are the effects of this categorization on agricultural land?
6. Which agricultural and arable lands are to be placed in the intensive farming category, where is a need for decreasing the intensity of farming, and where is a need for changes in the land use system or for the formation of a protective land use system?

3 Database and methodology of the examinations

During the examinations the most common regional databases on the environment, terrain, soils, climate, water resources, wildlife, habitats and also the land use types were processed with the help of GIS methods. The basic data layers are shown in the Figure 2:

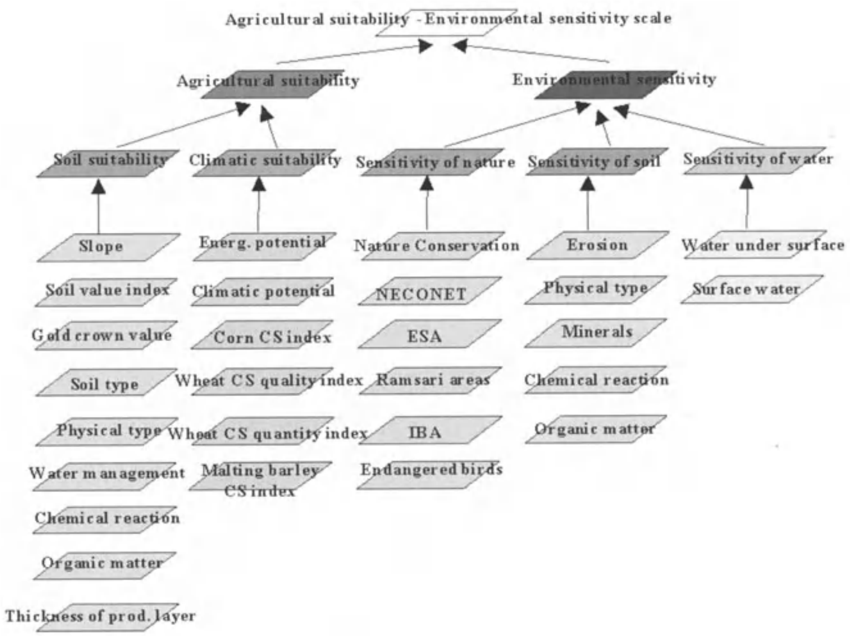

Fig. 2: Basic data layers of the land use evaluation

4 Information processing methods

The features were classified, all variables and categories have been weighted according to their role in the determination of agricultural production and environmental sensitivity, and in the decision process of agricultural suitability and environmental sensitivity of the area in question. For this weighting method we used the results of former analyses and examinations (ÁNGYÁN 1991) as well as the recommendations given by experts and institutes who host the databases.

The area of the country was divided into 9,3 Million 1 hectare squares by grid with a cell size of 100x100 metres. Then the values of each feature were determined for each hectare of the country, by placing this grid onto the map of regional distribution of the described variables. As a result 28 values were produced for each cell.

The weighted 15 agricultural suitability characteristics and the 13 environmental sensitivity characteristics were summarized by 1 hectare observation units respectively resulting the agricultural suitability index (ASI) and environmental sensitivity index (ESI). Plotting ASI and ESI on a map resulted in the national map of agricultural suitability and environmental sensitivity of land. By combining the standards of climatic and soil suitability - i.e. by summarizing the weighted values of the 15 characteristics - the country's map of suitability for agricultural production was developed (Figure 3).

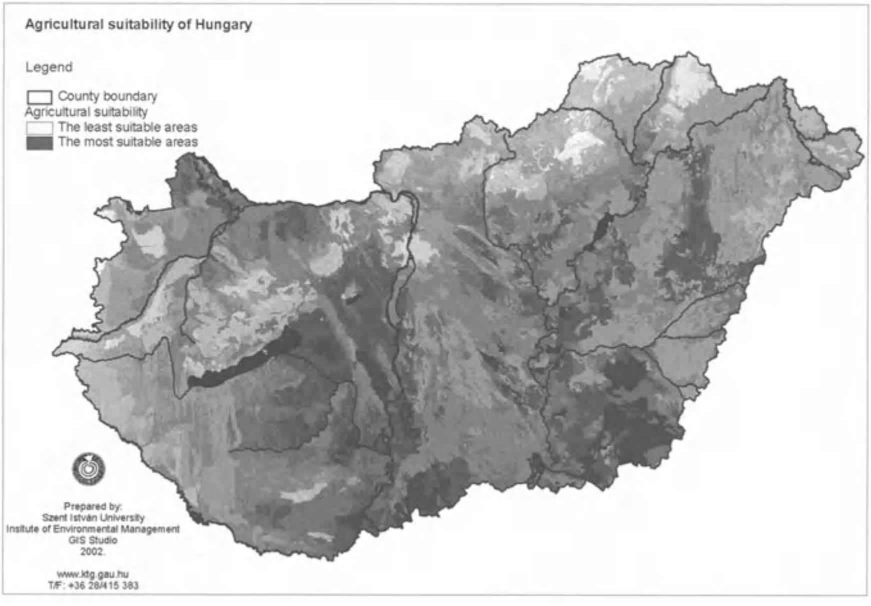

Fig. 3: Agricultural suitability of Hungary

On the grounds of this table and the map, when measuring on a scale between 0 and 99, it can be stated that 35 % of Hungary's total land and 43 % of its total agricultural land have excellent qualities for agricultural production.

The 13 parameters - with regard to flora and fauna, soil and water bases - used for the estimation of environmental sensitivity were summarized by groups. By combining the 13 parameters, the map of synthetic environmental sensitivity of Hungary's landmass was developed (Figure 4). 21-22 % of Hungary's total land and nearly 13 % of its total agricultural land is situated on definitely sensitive land.

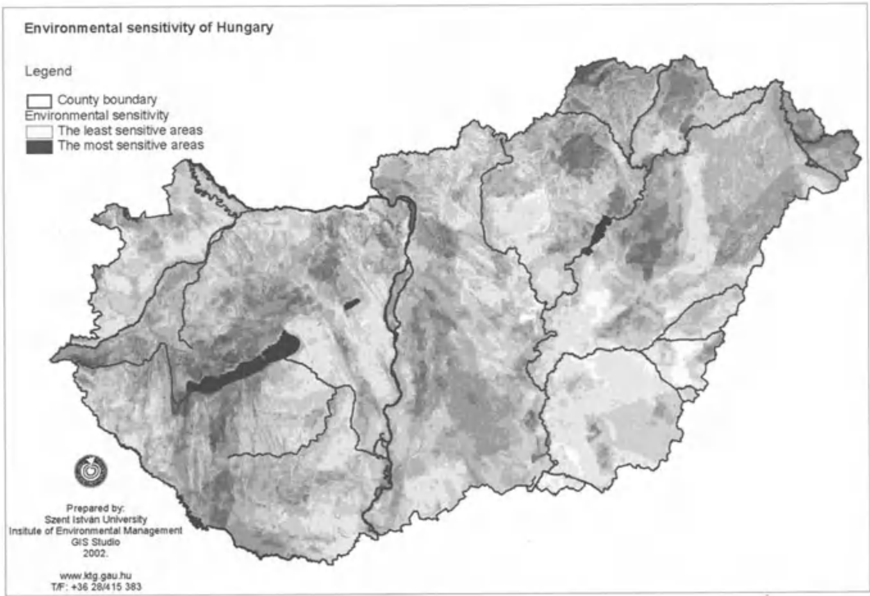

Fig. 4: Environmental sensitivity of Hungary

5 Combining agricultural suitability and environmental sensitivity characteristics

In the next step the environmental sensitivity index (ESI) was subtracted from the agricultural suitability index (ASI) for each cell, then 100 was added to the difference in order to produce a scale of 0 and 198. The values under 100 reflect to the determinant role of environmental sensitivity, the values above 100 reflect determinant role of the agricultural suitability (Fig. 5).

By the combination of the values of environmental sensitivity and agricultural suitability performed by the methods mentionedabove, we produced the basic map of zonality for Hungary's area, which incorporates each hectares of the country on a scale of environmental sensitivity and agricultural suitability, with the values between 0 and 198 (Figure 6).

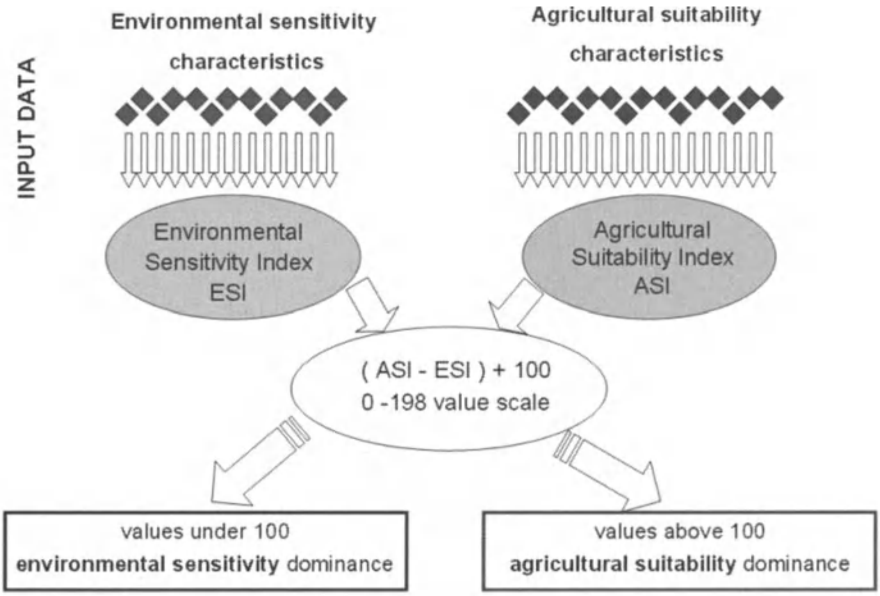

Fig. 5: Combining agricultural suitability and environmental sensitivity characteristics

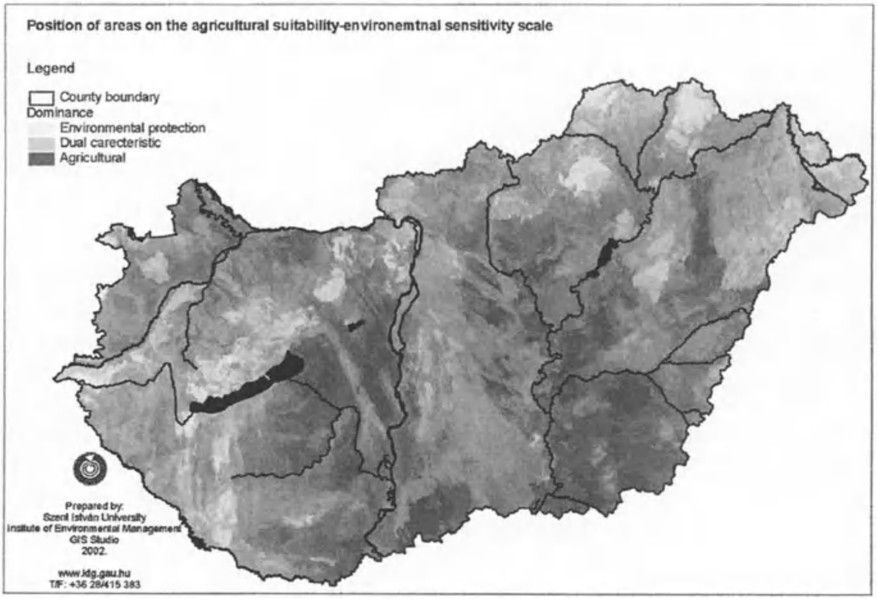

Fig. 6: Position of areas on the agricultural suitability-environmental sensitivity scale

More than 20 % of the total land of the country and for about 12 % of the total agricultural land the environmental sensitivity far exceeds the agricultural potential of the area.

Here is an example of how the basic zonality map (the scale between 0 and 198) could be used for developing various policy options for identifying land for supporting extensive and intensive agriculture. In the example it is supposed that the areas with values under 100 points are to be protection zones, areas between 100 and 125 points are to be zones for extensive agricultural production, and those areas with more than 125 points are to be zones for intensive agricultural production. In order to realize this land use ratio conversion of arable to either grassland and forest would affect roughly 2 million hectares of land.

6 Links to area differentiated agricultural policy

The above maps help identifying what intensity of agriculture should be supported in which part of the country. The future way could be a differentiation in farming families' income according to what sort of values they produce. This is simply explained by different land use intensity categories in Figure 7.

For farmers working in areas with better agricultural suitability the income from quality agricultural produce sold at the market will dominate, while in areas less suitable for agriculture income from environmental payments for producing amenity values shall play a big role beside quality agricultural production.

The more natural limiting factors or the more sensitive/vulnerable natural conditions and/or the more severe unemployment problems are at present, the more weight of second pillar agricultural outputs (local social and environmental services and state payments for rendering these) have in the maintenance and development of a region in question.

The natural limiting factors of farming are defined by the Less Favoured Areas (LFA) programme Europe wide. Mountain areas, low fertility areas and/or areas with other environmental limits (e.g. nature or water conservation) belong to this category. Figure 8 plots LFA areas in Hungary by settlements.

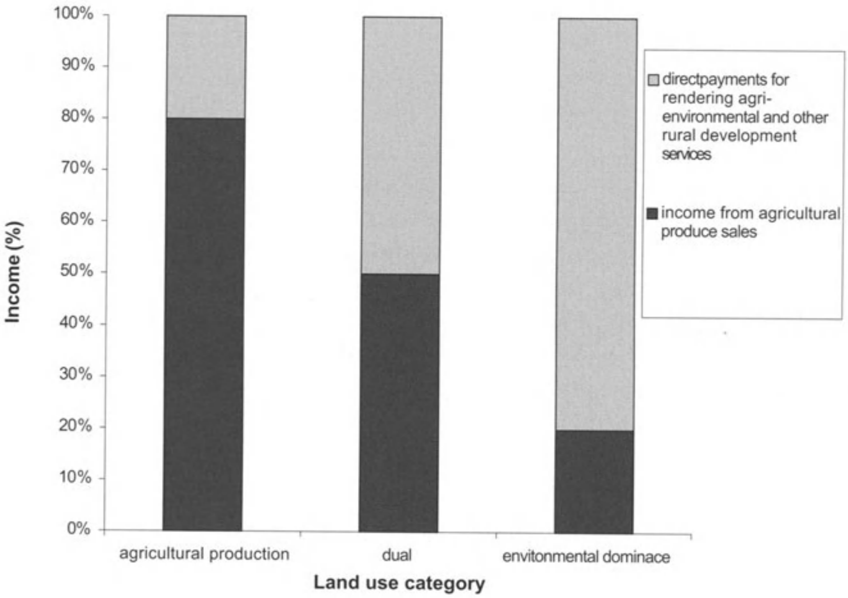

Fig. 7: Farming families theoretical income structure according to the location of the farm in the land use zone system

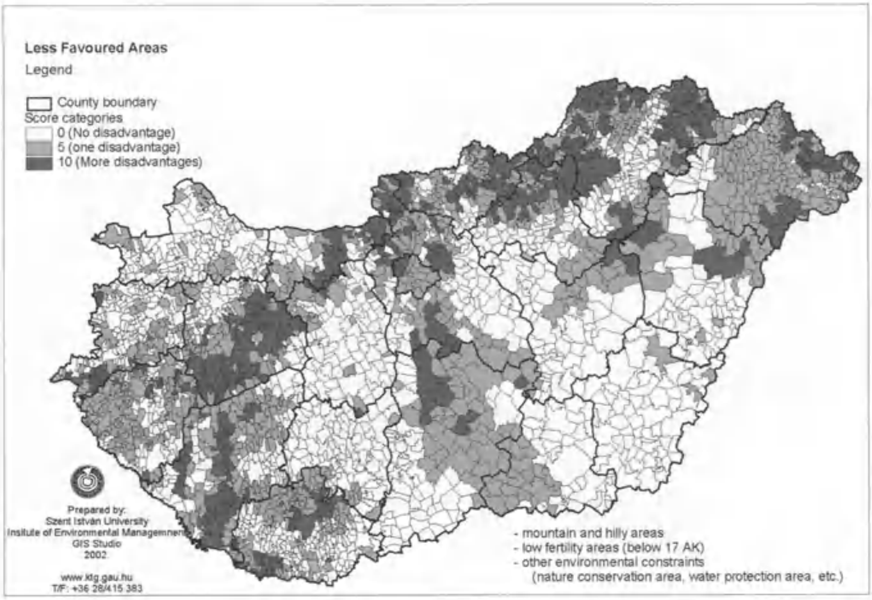

Fig. 8: Less Favoured Areas in Hungary by settlements

The natural limiting factors of farming are defined by the Less Favoured Areas (LFA) programme Europe wide. Mountain areas, low fertility areas and/or areas with other environmental limits (e.g. nature or water conservation) belong to this category. Figure 8 plots LFA areas in Hungary by settlements.

The environmental sensitivity from nature, soil and water conservation aspects (Figure 9) of a settlement or farm also represents limits to production intensity that has an increased role if the area in question is vulnerable from more aspects. In sensitive areas the environmental outputs of agriculture has an increased importance.

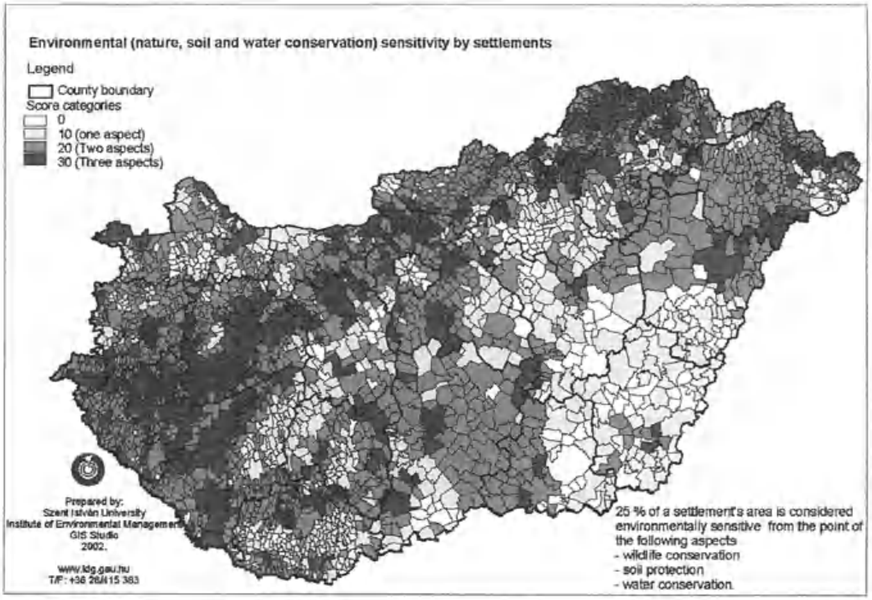

Fig. 9: Environmental sensivity by settlements

Finally contribution to rural employment (taking unemployment rate into account) (Figure 10) represents the social aspect of a spatially differentiated multifunctional agricultural and rural development strategy.

When these three aspects are considered together (Figure 11) we will understand for real in how large areas the implementation of such agricultural and rural development strategy approach might be an inevitable issue on the way of realising a multifunctional European agricultural model through a good paced development.

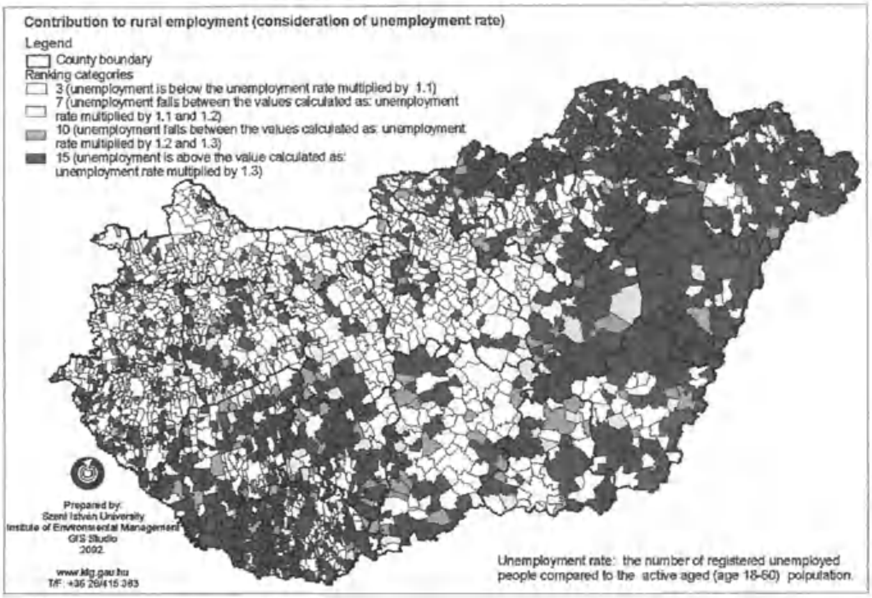

Fig. 10: Contribution to rural employment

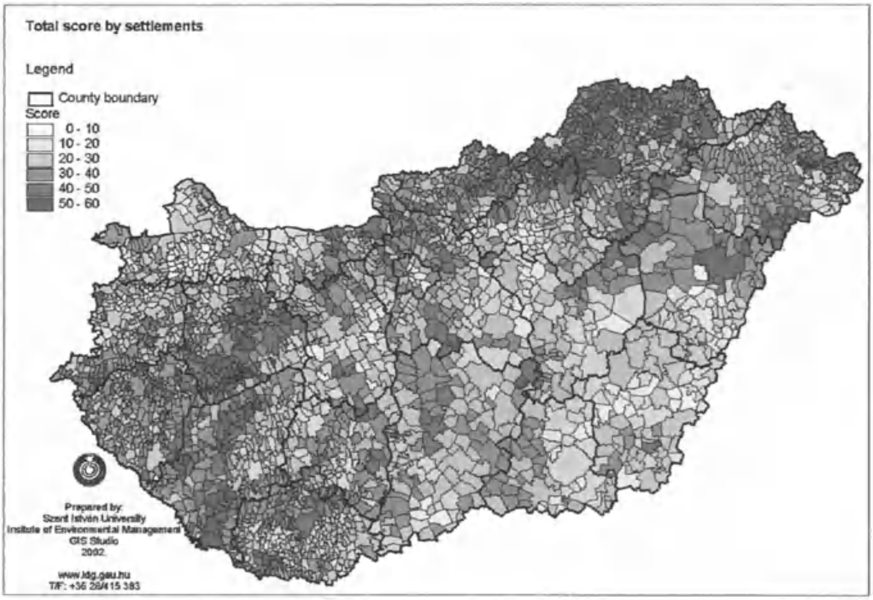

Fig. 11: Total score by settlements

7 Converting the theory into practice

The land use zonation study was an essential basis for the preparation of the National Agri-environmental Programme (NAEP) adopted by the 2253/1999(X.7.) Government Decree that function as one important pillar for the maintenance of environmentally sound agriculture all over the country help preserving the environment and rural heritage.

The primary goal of the programme is to promote farming systems that rely on the prudent use of natural resources while conserving natural values and biodiversity and managing the countryside beside producing healthy food and providing job opportunities for rural communities. The policy therefore does not support individual production sectors but whole farming systems that meet the above criteria. The Programme sets out the following objectives that correspond to the 2078/92 and 1257/1999 EU regulation:

- wide scale introduction of environmentally friendly agricultural production methods, achieving through this the sector level realisation of environmental targets, and the preservation and improvement of our natural values, and the quality of the countryside, the soil and the water resources;
- contribution to the establishment of a sustainable agricultural land use, a rational system of area utilisation, and a balanced and stabile land use and production structure, that is adapted to the agri-ecological potentials of Hungary;
- increasing the production of competitive, high quality, valuable products so improving the export opportunities of the agriculture;
- diversifying the rural employment and income earning opportunities, contribution to the improvement of rural life, establishing alternative income earning opportunities;
- improving and utilisation of the tourism potential, primarily through improving the look of the countryside and the landscapes, and the conditions for ecotourism and rural tourism;
- contribution to the success of other rural development measures, to the production-environmental education of the rural population and the producers and to the changing of attitudes.

The NAEP consists of horizontal schemes and of regional schemes. Horizontal schemes are announced for the whole agricultural area of the country and aim to support environment friendly production in various land use categories to help the development of a long term sustainable and competitive Hungarian agriculture.

The regionally differentiated scheme that is the Environmentally Sensitive Areas Scheme assist the environmental and nature protection focused land use of the given region contributing to the spread of farming practices adapted to the local conditions and, to the establishment of landscape management, for the protection and improvement of the environmental and natural values of the region. The target areas of these programmes can be small regions, which from a nature protection, land protection or water protection aspect require special utilisation.

Beside acreage based payments capital investment supports are also available (e.g. conversion of arable to grassland, planting orchards, purchase of ancient traditional animal breeds, restoring and establishing facilities connected to animal grazing, purchase of machinery required for rendering agri-environmental services, restoring soil water management, processing, marketing etc.)

The schemes of programme are voluntary and open to those who have management control (possess or have long term lease contract) over either at least 1 ha of arable or grassland land or 0.5 ha horticultural land or 5 ha fishpond. The applicants might participate in one or more schemes and must engage for five years in a management contract with the state to undertake all prescriptions of the chosen scheme(s) and in turn receive annually determined payment per hectare for the contract period. The payment shall cover the income loss resulting from the undertake of the prescriptions, the additional costs emerged plus contains a 20 % incentive that remunerate the ecosocial services of the farming system making it more attractive and more competitive. A participating farmer must participate in an official agri-environmental training course and must keep farming operations' registry and spraying registry. The applicant should facilitate the conditions for control and provide relevant data in connection with the scheme undertaken and contribute to its use in the evaluation of the scheme.

8 Summary

In contrast to the approach of industrial agriculture to boost artificial inputs and increasingly decouple natural factors from production, the chief principle of sustainable farming is environmental adaptation. According to this principle farming systems with appropriate intensity and practices should be applied in every region that best suit to the natural conditions, production potentials and take environmental loading capacity into account. On the basis of the land use pyramid this principle are is applied for Hungary in the land use zonation system assessing the agricultural potentials and environmental sensitivity of areas on a unified scale of values that has been generated with GIS process of 28 features. The land use zone system helps evolving the contours of a spatially differentiated intensity agriculture that produces safe and healthy quality food and non-food values while preserving natural resources, landscape, wildlife and rural communities.

It is indeed not an exaggeration that adaptive land use is the basis for sustainable agriculture and rural development and a basic measure for realising multifunctional environmental and landscape management model. The National Agri-environmental Programme of Hungary gives the framework for putting this ecologically oriented agricultural strategy change into practice.

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The Structure of Landscapes in Poland as a Function of Agricultural Land Quality

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Abstract

This paper presents the evaluation of impacts of natural and organizational conditions, which determine agricultural production, on landscape structure. Statistical data for 297 land powiats (counties) were used in this analysis. 23 indicators characterizing site conditions, the structure of land use, farm size, population density, and technical infrastructure were selected for multivariate analysis. The relationship between the share of agricultural land, arable land grasslands, forest, natural and socio-economic indicators was characterized using stepwise regression and cluster analysis. Significant differentiation was identified between powiats, in the structure of land use, and in consequence in the structure of landscapes. Cluster analysis allowed classification of powiats into six different groups with unique features in terms of natural conditions, landscape properties and socio-economic situation. This approach seems to be useful for classification of regions for the purpose of assessment of natural and socio-economic conditions needed for formulation of environmental policies and strategies.

Keywords: landscape, land use, land quality

Introduction

The definition of landscape is not well established and different specialists such as geographers, architects, environmentalists or economists have different understanding of this term. In environmental and natural science context landscape is defined as a part of geographical space within which there is a mosaic of different ecosystems representing different land uses such as arable land, meadows and pastures forest, parks, rivers lakes and reservoirs as well as elements of infrastructure including roads, power lines, buildings and urban facilities. Spatial organization of landscape ecosystems and their infrastructure components with its biotic and non-biotic elements is defined as landscape structure (ANDRZEJEWSKI 1992). Historically large changes in landscape structure resulted from gradual settlement. It is estimated that within the last thousand years within the current territory of Poland the share of agricultural land increased from 20 to 60%, mainly through conversion of natural habitats such as forests, wetlands and meadows (MARUSZCZAK 1988). Areas with soils of higher quality which were more suitable for agricultural production were deforested in a first row. It is proposed that landscape can be also defined in economic terms as it provides different functions fulfilling various individual and community needs, such as production, recreation, tourism, health care, research etc. Today, individual landscape features and their combinations are crucial factors controlling attractiveness and competitiveness of rural areas.

The main objective of this work is to establish the relationship between natural conditions controlling agricultural production and its impact on landscape structure as characterized by selected agricultural indicators for land powiats (counties) of Poland.

Materials and methods

The background data characterizing environmental and habitat conditions used in this work refer to powiats which are administrative units according to new regional and administrative organization of the Polish territory which was introduced in 1999. Environmental data were combined with basic statistical indicators for 297 of so called land powiats (powiat ziemski) which reflects over 95% of the whole country area. Data used in this analysis include 23 indicators related to:

- Characterization of habitat conditions and land suitability for agricultural production given as appropriate numerical indicators reflecting soil quality, climate conditions, soil water availability and relief. Synthetic index characterizing quality of agricultural land was included in this analysis as well as the percentage share of areas with flat, undulating and mountainous relief.
- Land use structure, farm size and number of animal units according to the comprehensive state farm survey conducted in 1996 for all holdings in Poland (VOIVODESHIP STATISTICAL YEARBOOK 2000).
- Indicators characterizing infrastructure, population density and unemployment (STUCZYNSKI et al. 2000).

Simple statistical methods used in this analysis were combined with multivariate methods such as stepwise multiple regression and cluster analysis (FILIPIAK and WILKOS 1998) .

Results and discussion

According to GUS statistical data (GUS 1998) the share of agricultural land came to 59.3% of the whole territory – 45.2% was covered by arable land, 13,1% by grasslands and 1% by orchards. Forests and woody areas represented 29.1% of the total area, urban zones 3.4%, roads 3.1% and surface waters 2.7%.

Data presented in Table 1 demonstrate very large diversification of land use in powiats which corresponds with the variability of the landscape structure. It is worth emphasizing that in smaller administrative units such as "gmina" or village this variability is often even greater as compared to powiats. The share of arable land in powiats is ranging from 21% in bieszczadzki powiat (Bieszczady Mountains) to 89% in kazimierski powiat. The contribution of arable land is highly positively correlated with soil quality indicators and the synthetic index of agricultural land quality and is negatively correlated with the share of mountainous areas. The share of agricultural land can be fairly well described by the following multiple regression equation:

$$Y=25.6+0.84x_7-3.95x_{10}+0.11x_{12}\ (R^2=30.1\%),$$

where Y is the percentage of agricultural land in powiats and x_n are variables corresponding to indicators listed in Table 1.

The share of arable land to the total area of powiats is ranging from 5% in tatrzanski powiat, which includes Tatra Mountains, to 81% in radziejowski powiat and is highly correlated with the contribution of agricultural land (0.92 correlation coefficient). Considering natural and environmental conditions the share of arable land can be described by the following equation:

$$Y=2.27+1.22x_7+3.73x_9+8.45x_{10}-0.07_{x13}\ (R^2=48.7\%)$$

The share of orchards is ranging from nearly 0% in over 10 powiats to 14.8% and 25.3% in sandomierski and grojecki powiat, respectively. This type of land use is strongly correlated with climate conditions, local tradition and accessibility to markets. The share of permanent grasslands is also greatly varying between powiats and is ranging from less then 5% in powiats such as mogilenski, krasnicki, radziejowski, lubelski olkuski, to 25-31% in powiats with flat and slightly undulating relief (mlawski, walbrzyski, brzeski, kamiennogorski, grajewski, bielski and ostrolecki) and up to 32-38% in powiats with dominating mountainous relief (tatrzanski and nowotarski). This type of land use is negatively correlated with soil quality and climate indicators and strongly dependent on the share of areas with mountainous relief which is confirmed by selection of variables to the respective multiple regression model:

$$Y=22.07-0.32x_7-0.38x_8+3.22x_{10}+0.05_{x14}\ (R^2=38.4\%)$$

Tab. 1: Statistical characteristics of indicators analyzed for 297powiats
*statistically significant coefficients

No.	Variables	Average	Variability range	Variability ratio	Correlation coefficient	
					UR	GO
1	Agricultural land (%)	61.1	21.0-89.1	21.4	-	0.92
2	Arable land (%)	47.0	4.6-80.9	30.3	0.92*	-
3	Orchards (%)	0.93	0.0-25.2	215.8	0.22	0.11
4	Permanent grasslands (%)	13.1	3.9-38.0	42.2	-0.07	-0.43
5	Forests (%)	27.0	1.7-68.9	46.4	-0.95*	-0.87
6	Other uses (%)	11.9	5.6-34.6	35.4	-0.30	-0.26
7	Soil quality index	49.5	26.5-79.7	21.0	0.46*	0.54
8	Climate quality index	10.4	2.0-15.7	21.7	0.24	0.36
9	Relief index	3.8	0.7-4.81	19.8	0.23	0.34
10	Soil water availability index	3.3	1.8-4.8	21.4	0.17	0.11
11	Synthetic agricultural land quality index	66.7	34-100	17.2	0.48*	0.59
12	Share of flat relief land (%)	65.2	0.0-100	49.9	0.16	0.16
13	Share of undulating relief (%)	28.6	0.0-100	98.6	-0.07	0.03
14	Share of mountainous relief (%)	6.1	0.0-100	294.7	-0.19	-0.34
15	Legally protected areas (%)	29.4	0.0-100	73.3	-0.26	-0.25
16	Population density persons/km^2	99.2	26-553	70.3	0.01	-0.21
17	Rural population (%)	58.9	18.0-98.1	29.3	0.29	0.21
18	Population using wastewater treatment plants (%)	37.8	2.8-92.5	46.2	-0.32	-0.21
19	Roads network km/km^2	0.69	0.2-3.2	53.9	0.20	0.16
20	Average farm size in ha	8.8	1.9-23.8	50.8	-0.10	-0.01
21	Cattle units/100 ha	38.8	8-81	33.7	0.27	0.09
22	Pigs units/100 ha	99.7	5-4.09	69.5	0.28	0.42
23	Registered unemployment (%)	16.2	2-32	37.7	-0.18	-0.11

The share of forest to the total area of powiats is also greatly varying as only 2-5% represents this type of land use in proszowicki, radziejowski and kutnowski powiat , whereas 15 powiats characterized by flat relief but very poor quality soils have 50-60% of the area occupied by forest. The contribution of forest comes to over 60% of the area in bieszczadzki and krosnienski powiat which is driven mainly by relief features which are unfavorable for agricultural production. As indicated by variables selected to the regression model the share of forest is mainly controlled by soil quality, soil water conditions and to a less extent by the share of mountainous relief:

$$Y=64.83-0.89x_7+4.07x_{10}-0.11x_{12} \; (R^2=37.21\%)$$

More detailed analysis of indicators used in this study was performed for powiats which were grouped according to increasing share of agricultural land to the total area (Table 2, Fig. 1). There are 16 powiats where the contribution of agricultural land is over 80% of the total area. Powiats which belong to this group are spatially scattered throughout the country and do not create a greater region, however their common feature is that conditions for agricultural production are favorable as the average land quality index for this group is 83.4 which is in contrast with the country average being 66.6. There are only two powiats (kolski and rawski) within this group with the land quality index lower than Poland's average. Relief conditions are also better in this dominantly agricultural group of powiats except to kazimierski powiat which, on the other hand, is characterized by very good soil quality. This large contribution of agricultural land in this group is clearly due to the dominating role of arable land (on average 72% of the total area) and its share is ranging from 57% in sandomierski powiat to 81% in radziejowski powiat, however sandomierski powiat has considerable amount of orchards (15%).

The other contrasting group with less than 40% of agricultural land in relation to the total area consists of 22 powiats (Table 2). These powiats are typically less favorable for agricultural production and the average of agricultural land quality index is 58. Only in zgorzelecki powiat this index is higher than Poland's mean. Regarding terrain conditions there is a large variability of relief within this group which includes powiats with dominating mountainous areas (tatrzanski, bieszczadzki, zywiecki) as well as powiats with prevailing flat terrain (policki, zielonogorski, miedzyrzecki) characterized by poor quality soils which explains the considerable contribution of forest to the total area.

It is well accepted that in general with the increasing share of agricultural land the esthetic attractiveness of rural landscapes decreases. On the other hand esthetic features and values of landscapes improve with the increasing share of legally protected areas which is typically negatively correlated with the percentage area of agricultural land. In powiats where agricultural land covers less than 50% of the total area, the average share of legally protected zones is 37% and it continuously decreases to as low as 14% in powiats with more than 80% of agricultural land.

Tab. 2: Characterization of powiats grouped according to share of agricultural land to the total area

No.	Variables	Percentage area of agricultural land (number of powiats)					
		<40 (22)	40-50 (43)	50-60 (61)	60-70 (86)	70-80 (69)	>80 (16)
1	Arable land (%)	22.9	31.9	40.3	50.2	60.3	71.9
2	Orchards (%)	0.2	0.5	0.6	1.0	1.2	2.4
3	Permanent grasslands (%)	11.7	12.9	14.7	13.4	11.8	9.1
4	Forests (%)	51.4	41.8	31.1	23.2	16.0	6.9
5	Other uses (%)	13.9	13.0	13.3	11.7	10.3	9.4
6	Soil quality index	42.1	45.2	46.5	49.9	53.2	64.5
7	Climate quality index	9.2	9.4	9.9	10.6	10.4	11.0
8	Relief index	3.5	3.6	3.6	3.9	4.0	4.0
9	Soil water availability index	3.1	3.3	3.2	3.3	3.4	3.9
10	Synthetic agricultural land quality index	58.1	61.5	63.1	65.7	71.1	83.4
11	Share of flat relief (%)	54.9	55.6	64.3	67.7	72.4	64.9
12	Share of undulating relief (%)	33.2	34.1	26.6	27.3	25.9	34.2
13	Share of mountain relief (%)	11.9	10.6	9.2	4.9	1.3	0.9
14	Legally protected areas (%)	37.3	38.2	30.3	27.5	26.5	14.3
15	Population density persons/km^2	81.2	89.8	113.1	112.0	84.1	93.2
16	Rural population (%)	48.2	53.6	56.2	9.4	66.7	65.4
17	Population using wastewater treatment plants (%)	50.6	44.9	39.6	35.7	32.0	28.8
18	Roads network km/km^2	0.5	0.6	0.7	0.7	0.7	0.9
19	Average farm size in ha	9.9	9.8	8.5	8.2	9.1	7.8
20	Cattle units/100 ha	30.1	34.0	38.8	40.1	42.1	42.6
21	Pigs units/100 ha	58.7	83.7	93.2	94.6	128.6	126.4
22	Registered unemployment (%)	18.8	19.8	16.8	15.6	15.0	15.4

Collected data do not allow to conduct a full analysis of all conditions which are important for agricultural production. However, it is evident that a decreasing share of agricultural land is accompanied by a dramatic decrease of production intensity as reflected by the declining number of animal units of cattle per 100 ha and in particular that of pigs (Table 2).

The population density varies among powiats which are grouped according to percentage share of agricultural land. The most populated units are those characterized by medium share of agricultural land (50-

70%), whereas powiats below and above this range are less populated with the density strongly decreasing with the increase or decrease of the percentage of agricultural land. However, rural population given as the percentage of general population increases with the increasing relative area of agricultural land.

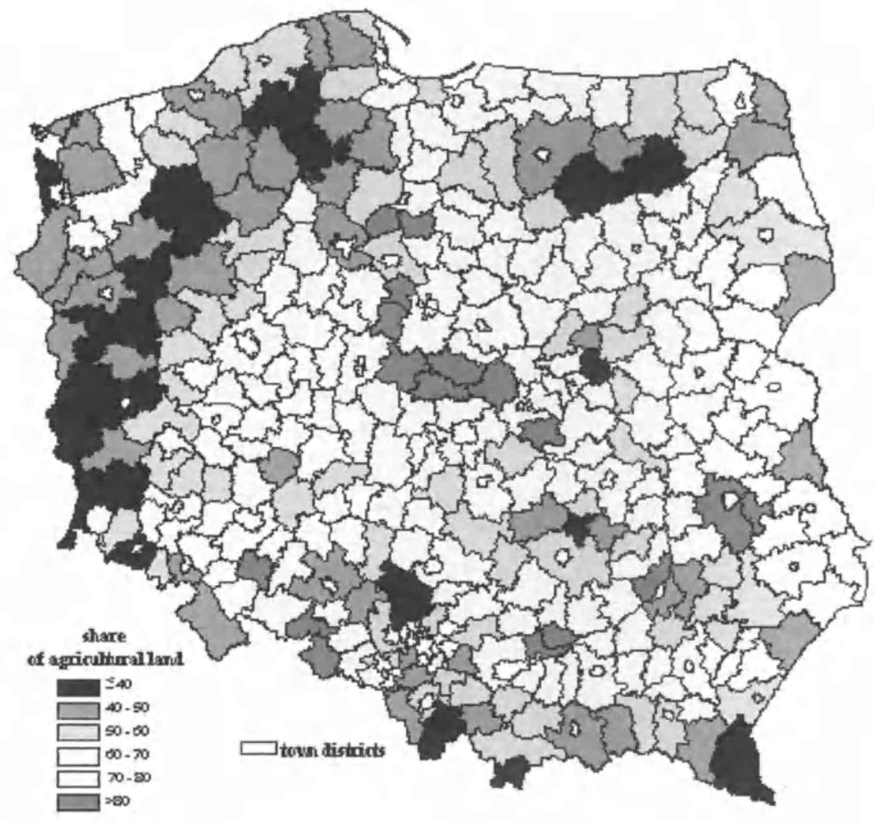

Fig. 1: Share of agricultural land as % of the total area of powiats

The registered unemployment shows a decreasing trend as the percentage of agricultural land increases. The highest unemployment is observed in powiats with the smallest share of agricultural land which indicates an urgent need for initiating strategies effectively promoting creation of alternative sources of income.

Technical infrastructure in rural areas and its relation to the share of agricultural land does not demonstrate a simple pattern as some other indicators discussed above do. However, the road network is highly correlated with the share of agricultural land, whereas the percentage of population with access to sewer systems and waste water treatment strongly decreases with decreasing contribution of agricultural land to the total area. This indicates that non-agricultural use of rural areas provides much better stimuli for investment in wastewater facilities as compared to agricultural production as a dominant activity in terms of a land use.

Another type of classification of powiats which is based on the synthetic index of agricultural land quality is presented in Table 3. The mean value of this indicator of Poland is 66.6. Powiats such as tatrzanski and nowotarski characterized by mountainous relief and ostrolecki and koscierski with light textured soils have a very low land quality index ranging from 34 to 45 points. Whereas in another contrasting group of powiats (prudnicki, kazimierski, strzelinski, glubczycki, hrubieszowski and proszowicki) this index can be as high as 95-100 points. Eleven powiats provides very favorable conditions for agricultural production as their land quality index is higher than 90. On the other end there are 17 powiats with land quality index below 50 where a cost efficient agricultural production is strongly restricted by natural conditions. In 113 powiats the agricultural land quality index is ranging from 60-70 and Poland's mean is within this range.

It is remarkable, that with the increase of the land quality index the percentage share of agricultural and arable land to the total area of powiats also increases, whereas the share of forests and grasslands decreases. In powiats exhibiting less favorable soil and relief conditions combined with relatively larger share of grasslands the cattle production is evidently higher. In areas demonstrating average conditions as described by the land quality index pig production plays a more important role (Table 3). A strong shift towards crop production as the main source of income is the main feature of agricultural production in powiats with the best habitat conditions represented by the highest land quality index.

In such areas the number of animal units of cattle and pigs greatly decreases. Landscape attractiveness of areas with the best land quality is lower as agricultural land becomes a dominant type of land use in such areas. The spatial structure of legally protected areas is a good indicator reflecting the landscape attractiveness aspect. The percentage share of protected areas continuously increases from 15%, in powiats with the highest land quality index, to 31-37% in two groups of powiats with the lowest values of this indicator (Table 3).

Powiats which belong to groups demonstrating contrasting habitat conditions (below 50 or above 90 points) as characterized by the agricultural land quality index have remarkably smaller farm sizes than average (Table 3). These two contrasting groups of powiats are also the most populated. Rural population is less dense and the farm size considerably larger in powiats characterized by average, or slightly below average, habitat conditions as reflected by the land quality index. The percentage of rural population is not correlated with natural conditions and is ranging from 57 to 63%. It is worth emphasizing that the registered unemployment is remarkably smaller in powiats with the best land quality and smaller farm size but also in areas with the unfavorable natural conditions (Table 3).

Tab. 3: Agricultural production space valuation ratios in groups of powiats

No.	Variables	Synthetic index of agricultural land quality (number of districts)					
		<50 (17)	50-60 (70)	60-70 (113)	70-80 (60)	80-90 (26)	>90 (11)
1	Agricultural land (%)	51.2	56.0	59.1	65.1	73.2	77.6
2	Arable land (%)	31.2	40.4	45.4	51.9	62.5	66.3
3	Orchards (%)	0.4	0.6	1.0	0.9	1.2	1.9
4	Permanent grasslands (%)	19.5	15.0	12.6	12.3	9.6	9.4
5	Forests (%)	37.8	32.7	28.9	21.9	15.6	9.7
6	Other use (%)	11.0	11.2	12.1	13.0	11.2	12.7
7	Soil quality index	33.0	39.6	47.9	56.8	65.8	75.2
8	Climate quality index	7.6	9.7	10.2	10.4	11.3	12.2
9	Relief index	2.9	3.9	3.9	3.7	3.8	3.7
10	Soil water availability index	2.9	2.7	3.2	3.7	4.0	4.4
11	Share of flat relief (%)	56.6	73.4	70.2	57.9	53.6	43.0
12	Share of undulating relief (%)	24.6	20.6	26.1	33.8	48.0	55.2
13	Share of mountainous relief (%)	19.9	6.0	3.7	8.1	4.8	1.8
14	Legally protected areas (%)	31.0	37.1	27.4	30.9	19.0	15.3
15	Population density persons/km^2	106.6	76.0	96.0	119.6	118.1	112.4
16	Rural population (%)	62.0	60.3	57.3	58.5	58.5	63.5
17	Population using wastewater treatment plants (%)	33.0	35.6	39.5	37.7	41.0	33.0
18	Roads network km/km^2	0.7	0.6	0.6	0.8	0.8	0.9
19	Average farm size in ha	6.8	8.8	9.6	8.6	8.0	7.5
20	Cattle units/100 ha	52.3	40.2	37.0	38.3	36.2	36.3
21	Pig units/100 ha	72.4	85.4	107.4	107.4	106.8	94.4
22	Registered unemployment (%)	15.5	16.5	16.2	16.2	16.5	13.9

It seems that areas where income from farming is restricted either by farm size, overpopulation, land quality or combination of these factors the adaptation skills of labor force are greater as compared to other regions with average natural and socio-economic conditions.

Ward's cluster analysis was used as another way for classification of data collected for powiats. The objective of this analysis was to distinguish groups of similar powiats where the variability of indicators represents a similar pattern and therefore should be driven by analogous mechanisms.

Two approaches for cluster analysis were tested: i) using all variables (indicators), ii) using 6 variables (percentage share of agricultural land to the total area, soil quality index, relief index, percentage share of areas with flat, undulating and mountainous relief. In both approaches the best grouping was achieved using classification based on six clusters. In principle each of the six clusters (groups) contains powiats with similar characteristics. The deriving clusters based on all variables as compared to six variables produced very similar results and there was over 91% match between these two methods of grouping powiats into clusters. Therefore for further analysis and discussion clusters generated based on six variables were used (Table 4, Fig. 2). Group I and II include 179 powiats covering 33.2 and 30.5% of the country's area, respectively. These two groups of powiats are characterized by very poor soils with the soil quality index 44-45 points. The mean synthetic index of agricultural land quality for powiats which belong to these two groups is about 62 points. The relief is dominantly flat. In terms of physiogeography group I and II cover Polish lake regions, Polish Plain and partially Malopolska Upland. The difference between group I and II mainly relates to the structure of the land use. Group I demonstrates a smaller share of agricultural land (49%) and a relatively large contribution of forests (38%).

Whereas in group II, regardless of poor quality soils, the share of agricultural land is as high as 68% - arable land itself covers 53% and the percentage area of forest is 21% only.

Group III contains 21 powiats covering 6.7% of the country located in regions with dominating mountainous relief. Geographically these powiats belong to Karpaty and Sudety Uplands and also Swietokrzyskie Mountains.

Natural habitats such as forests and permanent grasslands are dominant types of the land use in these regions, covering 40% and 21% of the total area, respectively. The farm structure within this group is very diverse - the average farm size is 4.9 ha only and land is not consolidated as these farms often consist of up to 10-20 separate and spatially scattered parcels.

Group IV contains 24 powiats which are irregularly spread throughout the country, covering 9% of the total area. Areas with undulating relief are dominating type of terrain covering 83% of the area. Soil and climate conditions are slightly worse than Poland's average as the average synthetic index of agricultural land quality in these powiats is 62 points. The land use structure of this group is similar to the country's average with a little smaller share of agricultural land and slightly more forest. Legally protected areas are considerable and their share to the total area is 41%.

Tab. 4: Characterization of powiat clusters

No.	Variables	Concentrations / number of districts					
		I (84)	II (95)	III (21)	IV (24)	V (54)	VI (19)
1	Agricultural land (%)	49,2	68,0	49,7	53,5	69,7	76,1
2	Arable land (%)	36,5	52,8	28,2	41,6	55,8	66,6
3	Orchards (%)	0,4	1,3	0,6	0,6	1,4	0,7
4	Permanent grasslands (%)	12,2	13,9	20,9	11,4	12,4	8,6
5	Forests (%)	38,3	21,0	40,3	32,9	17,5	12,0
6	Other use (%)	12,6	10,9	10,0	13,5	12,8	11,8
7	Soil quality index	44,5	44,9	46,1	46,9	61,9	66,3
8	Climate quality index	10,5	10,3	6,6	9,3	10,6	11,9
9	Relief index	4,0	4,3	2,0	3,3	3,4	4,3
10	Soil water availability index	3,0	3,0	4,2	2,9	3,9	4,1
11	Synthetic agricultural land quality index	62,0	62,4	58,4	62,4	79,8	86,6
12	Share of flat relief (%)	72,3	94,4	14,3	15,3	38,0	84,6
13	Share of undulating relief (%)	27,4	5,6	21,6	83,3	54,3	14,8
14	Share of mountainous relief (%)	0,1	-	65,3	1,4	7,3	-
15	Legally protected areas (%)	31,2	28,0	36,3	40,8	26,2	13,4
16	Population density persons/km^2	78,5	93,7	120,6	108,4	132,3	88,2
17	Rural population (%)	54,4	61,8	64,0	52,0	61,6	58,5
18	Population using wastewater treatment plants (%)	44,1	32,0	32,4	44,5	36,4	39,7
19	Roads network km/km^2	0,5	0,7	0,8	0,7	0,9	0,7
20	Average farm size in ha	10,2	8,6	4,9	110,6	7,4	10,0
21	Cattle units/100 ha	32,8	43,5	49,3	37,3	37,5	35,7
22	Pigs units/100 ha	84,5	127,4	30,4	102,2	92,0	123,4
23	Registered unemployment (%)	18,0	13,8	16,6	18,2	15,6	18,3

Group V together with group VI consist of 73 powiats with the most favorable conditions for agricultural production. The structure of landscape is less complex in these groups as compared to other areas. Group V consists of 54 powiats and is covering 15% of the total area – the percentage area of agricultural land is 70% and arable land itself covers 56%. The quality of agricultural land is relatively high here as the synthetic index is 79.8 points. Terrain conditions are limiting agricultural production due to the fact that over 54% of the area has undulating relief and 7% is mountainous. Additionally, farms in this group are spatially scattered (divided into large number of parcels) even though the average size (7.4 ha) is close to country's mean. The smaller farm size and larger diversity of farm structure within this group is a serious problem in powiats located in regions such as Podkarpackie, Malopolska, Swietokrzyskie, and Lubelskie.

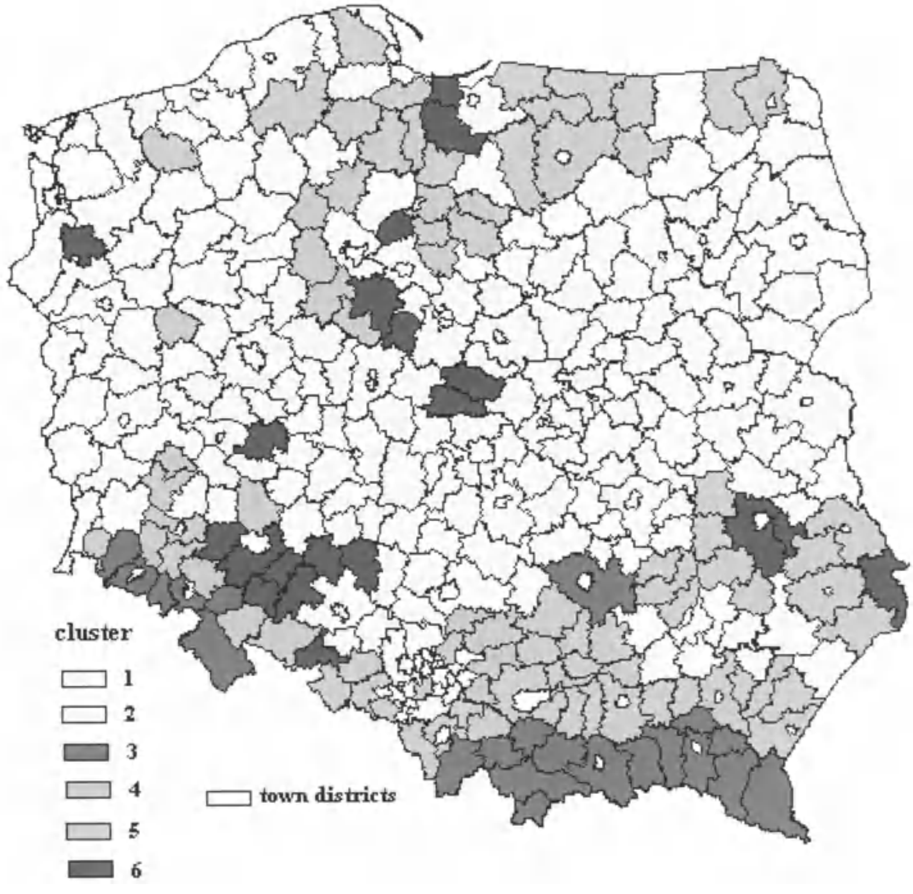

Fig. 2: Division of powiats into 6 groups on the basis of cluster analysis (as in table 4)

Group VI consists of 19 powiats covering 5.6% of Poland's territory only, however it demonstrates exceptionally good natural conditions which are favorable for agricultural production. The average land quality index in this group is 87 points. Agricultural land covers 76% of group's total area, whereas the share of arable land is 67%. Natural habitats including permanent grasslands and forests cover 21% of the area and the percentage share of legally protected areas is 13% only.

Presented data analysis indicates that there are numerous powiats with landscapes of a relatively less complex nature with dominating agricultural land and arable land in particular, as the main type of the land use. Such conditions create landscapes which are less attractive for alternative functions which would be not associated with agricultural production. Simplified structure of a landscape enhances impacts of climate variability and extreme events on both agricultural production and environmental quality through increased wind and water erosion, more abundant plant diseases and populations of detrimental insects as well as through increased movement of nutrients and chemicals into the ground and surface waters (BALAZY and RYSZKOWSKI 1992). Additionally, this more intensive use, which is driven by economic and organizational factors leads to decline of biodiversity and landscape attractiveness of rural areas. It is expected that in the near future regions with more diverse agriculture will be subjected to land consolidation process, which will cause a dramatic change in the landscape structure. Simple traditional farming practices, which are commonly used in these less developed areas, as a significant part of cultural heritage will be replaced by mechanized operations. Some of the animal production currently located in small units will shift towards more concentrated industrial type operations, which will also have a negative impact on landscape and environmental quality. Other expected changes in rural landscape include increased abandonment of marginal lands and expansion of infrastructure. These changes should be controlled by proper polices and spatial planning strategies based on criteria and protocols which will minimize these unavoidable impacts.

Conclusions

Regions of Poland are diversified in terms of land use and landscape structure. Characterizing powiats as larger administrative units seem to be useful approach to analysis of environmental and landscape conditions. Boundaries of powiats do not always fully correlate with physiogeographic regions, however environmental management and land protection is in responsibility of the administration on the powiat level. The variability of landscape structure can be extreme as reflected by the structure of land use. The percentage area of agricultural land is ranging from 21 to 89%, whereas the contribution of orchards covers from nearly 0 to 25%, forests from 2 to 69% and permanent grasslands from 4 to 38%.

The contribution of agricultural land is clearly increasing with the increase of the agricultural land quality index. The percentage area of grasslands and forests is negatively correlated with the land quality and climate index, however these types of land use show a clear positive relationship with the relative area of mountainous relief.

With the increasing share of agricultural land the attractiveness of rural landscapes decreases. The share of legally protected areas is a significant factor controlling attractiveness of landscapes, however it is strongly negatively correlated with the percentage area of agricultural land. For the purpose of spatial planning and comparisons there are six distinctive groups of powiats distinguished. Powiats within these groups are similar in terms of landscape social and production indicators. Differences between groups are mainly driven by land quality and relief features as reflected by the relief index and the percentage area of flat, undulating or mountainous terrain.

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Pressure, State and Response Indicators in Landscape Assessment: An Attempt on Nitrogen Fluxes

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Abstract

This paper presents a concept of landscape assessment for planning and decision-making purposes with a final goal of sustainable landscape management. It is based on the analysis of landscape capacity to perform its essential economic, ecological and social functions. We used the **D**riving Forces → **P**ressures → **S**tate → **I**mpact → **R**esponses (DPSIR) framework to analyze the functional landscape indicators for environmental sustainability of landscapes. As an example we used nitrogen cycling in agricultural landscapes for state and response indicators. As the state indicator we used the concept of potential excess nitrogen (PEN), which is estimated based on the main fluxes of nitrogen in agricultural landscapes. The Porijõgi River catchment (258 km^2) in southern Estonia served as a study area to test the GIS-based attempt of the PEN analysis in main land cover categories. Negative values of PEN indicate the land cover categories as potential N sinks and positive values as potential N sources. Due to significantly less intensive agriculture from 1987 to 1997, the average PEN in the Porijõgi River basin has been decreased several times. It coincides with the measured data of nitrogen losses from this catchment (25 and 5 kg ha^{-1} yr^{-1} in 1987 and 1997, respectively). However, the absolute values of PEN (in kg ha^{-1} yr^{-1}) are not the same like the measured or modeled with empirical land use and soil data models values of nitrogen losses. Regarding the response aspect of indicators, we have used a model helping to estimate nitrogen removal capacity of new and reconstructed wetlands in agricultural landscapes.

Introduction

Landscape assessment for planning and decision making process is a key issue with respect to sustainable landscape management (BASTIAN and SCHREIBER 1994, MEYER 1997, PALMER and LANKHORST 1998, LEE et al. 1999, CLAY and DANIEL 2000, MEYER 2001, NAKAMAE et al. 2001). There are various indicator models for evaluating performance functions of agriculture landscapes widely used in landscape planning and management (MEYER et al. 2002). However, due to large variety of landscape functions and possible indicators it is not easy for end-users of the landscape assessment to find out the optimal solutions. In following we describe a DPSIR framework for landscape indicators, which is combined with the landscape functions.

DPSIR framework. Regarding the EU policy in biological and landscape diversity management (*e.g.*, PEBLDS, The Pan-European Biological and Landscape Diversity Strategy) it is useful to follow the **D**riving Forces (Drivers) → **P**ressures → **S**tate → **I**mpact → **R**esponses (DPSIR) framework for reporting the environmental issues (Fig. 1; EEA 1998, 1999). This approach treats the environmental management process as a feedback loop controlling a cycle consisting of these five stages. In addition, this introduces the term "Pressures" and adds "Impacts" – a concept that implies the cause-effect link. At the same time, the EEA (European Environmental Agency) concept is seeking to make a better distinction between static features (stocks) and dynamic changes (flows).

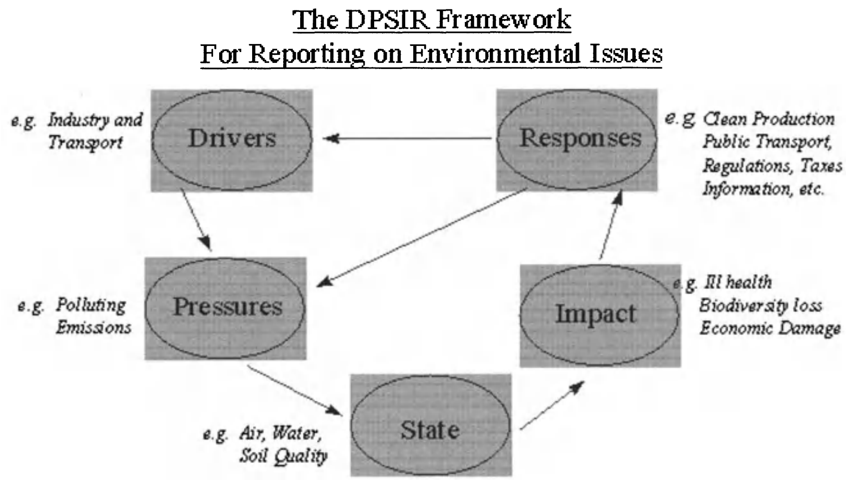

Fig. 1: The DPSIR framework for reporting on environmental issues as a possible basis for indicator classification and landscape assessment (EEA 1998; WASCHER 2000).

Drivers are the underlying causes, which lead to environmental pressures; e.g., human demands for agriculture, (drinking) water. These driving forces lead to pressures on the environment, e.g., extraction of (drinking) water, emission of agrochemicals to non-target areas. The pressures in turn affect the state of the environment. This refers to the quality of the various environmental media (air, soil, water, groundwater, landscape) and their ability to support the demands placed on them (e.g., supporting human and non-human life, supplying resources, etc.). Changes in the state may have an impact on human health, ecosystems, biodiversity, etc. Impact may be expressed in terms of the level of environmental harm. The task of managers or decision-makers is to assess the driving forces, pressures, state and their ultimate impact. From the impact, they must determine appropriate responses, in order to direct the final impact in the desired direction (a reduction in environmental harm). These responses will influence the **drivers**, **pressures** and **states**, thus completing a feedback loop.

Main types of indicators regarding the DPSIR framework approach are (WASCHER 2000):

- state indicators,
- pressure indicators,
- response indicators

State indicators describe the environmental condition (stock, pattern) that can be observed when undertaking a snapshot assessment. Typical state indicators would be the number of species, landscape pattern diversity or the water quality of a given site. The key aspect about information on "state" is that it is considered as the passive or receptive entity when it comes to determining cause and effect relations. Measuring the environmental condition at different time intervals allows changes to be assessed over time. For instance, the effects of changes triggered by agricultural activities are occurring on the "state"-side of the environmental media and systems. Testing the success of policy measures such as protection of series of changes in land management is hence always to measure through state indicators. At the level of EU environmental policy, the compiling of the core set and the set of candidate indicators is one of the most actual questions (EEA 1999; WASCHER 2000). However, when comparing candidate indicators against data availability at the regional or European level demonstrates that the actual scope for finding "feasible" indicators is relatively narrow.

Pressure indicators are related to the negative influence of various anthropogenic activities (e.g. intensive agriculture or forestry) on the environment media and systems. Frequently, the list of both core and candidate indicators is much longer than in the case of state indicators. This is because the potential pressures on the media and systems can be derived from a large variety of possible sources that can all contribute to the impacts.

Response indicators reflect the reactions of society on the worsening environmental quality aiming to improve or stabilize the critical situation. For instance, re-establishing and restoration of wetland ecosystems in catchment areas will help to remove nutrients (especially nitrogen) and sediments from water, will create additional habitats for biota and recreational areas for society, and stabilize the microclimate.

Landscape functions. For the landscape assessment functions that landscapes have to perform and indicators, which are related to certain functions, have to be specified. Growing land use pressure and environmental problems encouraged development of a complete multifunctional approach. Thus there will be high demands on the landscapes of the future, which will have to serve simultaneously various functions: ecological, economic, socio-cultural, historical, and aesthetic (TRESS and TRESS 2001). As people use the land in different ways, landscape receives also different meaning and values as well. Landscape is a very complex phenomenon that is studied by different disciplines. However, this complexity also requires more interdisciplinarity and a holistic approach to landscape issues is to be developed. Several authors have been considering the landscape functions and their assessment (DE GROOT 1984, FORMAN and GODRON 1986, BASTIAN and SCHREIBER 1994, FORMAN 1995, BASTIAN and RÖDER 1998, FARINA 2000, LEIBOWITZ et al. 2000, BASTIN et al. 2002). However, the most comprehensive and applicable in the same time is the system used in German landscape planning process (BASTIAN and SCHREIBER 1994). According to this model, there are three main groups of landscape functions – economic, ecological and social – , which are subdivided into several detail functions. In Table 1 we tried to combine the main landscape functions and several functional/structural landscape indicators used in different case studies.

Objectives. For testing the DPSIR framework indicators the nitrogen cycling in a rural catchment in Estonia has been chosen. In particular, we studied the pressure (fertilization), state (nitrogen excess in landscape) and response (re-establishment and rehabilitation of wetlands) in the Porijõgi River catchment, South Estonia. The main goal of the paper was to check the concept of the potential nitrogen excess as pressure/state indicator in the assessment of landscape regulation functions in this area.

Tab. 1: Landscape functions (adopted from BASTIAN and SCHREIBER 1994) and selected pressure and state indicators (adopted from Washer, 2000). Driving factor: intensive agriculture.

LANDSCAPE FUNCTIONS	INDICATORS	
	PRESSURE	STATE
PRODUCTION (ECONOMIC) FUNCTIONS		
Renewable resources: plant and animal biomass (agriculture, forestry, fishery, game, and short-rotation energy wood production)	Large proportion of intensively used and fertilized patches, low proportion of semi-natural and natural habitat types; Small number of natural habitat types bordering at intensively used area; Few key indicative natural landscape elements, Increasing road length and growing rate of urbanisation along roads, rivers, lakes, and coasts)	Loss of natural coherence (NC): adequateness of land use according to biophysical conditions [Coherence according to MANDER and MURKA 2002]; Loss of natural landscape character; Fragmentation
Non-renewable resources (water retention, surface water, groundwater, local mineral resources and building materials, fossil fuels)	NC, intensity of production, percentage of grasslands, proportion of irrigated/drained grasslands, large proportion of grassland changed into cropland, large proportion of fossil fuel-driven machines and systems	Loss of natural landscape character, less available water resources, sinking groundwater levels, desertification, exhausting of mineral resources (peat), disturbance of regional CO_2 and SO_4 balance in atmosphere
REGULATION (ECOLOGICAL) FUNCTIONS		
Regulation of material and energy fluxes		
pedological functions: soil protection against erosion, flushing and desiccation, soil capacity to actively break down disturbing factors (filtering, buffering and transformation of materials and energy)	NC, too high intensity of production, percentage of grasslands, proportion of irrigated/drained grasslands, large proportion of grassland changed into cropland, large proportion of fossil fuel-driven machines and systems	Fertility loss of soils, soil erosion and deflation, humus mineralisation, nutrient leaching, pollution and contamination of soils, health risk
hydrological functions: groundwater recharge capacity, water retention, discharge balance, self-cleaning capacity of surface water	Large proportion of intensively used and fertilized patches, change of grassland into cropland, too intensive drainage	Desertification, sinking of groundwater level, loss of wetlands, nutrient leaching, decreasing drinking water quality, decreasing quality of

		surface water, health risk
meteorological functions: temperature balance, increasing air humidity and evaporation, windfield influence	Large proportion of intensively used and fertilized patches, low proportion of semi-natural and natural habitat types; Small number of natural habitat types bordering at intensively used area; Few key indicative natural landscape elements	Changing meso- and microclimate, disturbance of regional CO_2 and SO_4 balance in atmosphere, changing wind energy pattern, desertification
Regulation and regeneration of populations and biological systems (biodiversity aspects)		
biotic reproduction and regeneration of biosystems, regulation of organism populations	Fragmentation, less connectivity between related landscape elements	
maintenance of genetic pool: natural organisms		
maintenance of genetic pool: domestic animals		
LIVING SPACE (SOCICAL) FUNCTIONS		
Psychological, aesthetic (landscape scenery), information (perception) functions, and ethic functions (genetic pool, cultural heritage); Recreational functions (complex of psychological and human ecological functions)	Decreasing share of characteristic habitat types (natural or cultural); Less cultural features: historical and cultural monuments, archaeological sites; Smaller proportion of traditional land use (recognised for its scenic or scientific value); Less land use diversity Less cultural identity: decreasing adequateness of key cultural features [Coherence according to VAN MANSVELT 1997; see also KUIPER 1998, HENDRIKS et al. 2000]	Loss of rural-cultural patterns, loss of scenic values; Decreasing recreational potential
Human ecology, particularly bioclimatic (meteorological) functions	Increasing noise and worsening atmospheric air quality	Health risk

Materials and methods

DPSIR framework application. The above described DPSIR approach was applied as following.

Driving force – intensive agriculture

Pressure – use of mineral fertilisers

State – intensive loss of nitrogen from agricultural fields, high nitrogen concentration in rivers and groundwater, intensive gaseous N flux into the atmosphere

Impact – loss of biodiversity, eutrophication of water bodies, methemoglobinaemia, cancer risk

Response:

a) less mineral fertilisers and optimisation of crop rotations with leguminous plants, especially in sensitive and potential source areas
b) establishment of riparian buffer zones
c) establishment of riverine and riparian wetlands.

State indicator: nitrogen loss from farmlands (potential excess nitrogen).

Mass balance model for the estimation of potential excess N (X) for a particular land cover type (Fig. 2; GARTEN and ASHWOOD 2002):

$$X = (I + F + M) - (U + D + V), \qquad (1)$$

where I is atmospheric N deposition, F is fertilizer N inputs, M is net N mineralisation, U is uptake of N by plants, D is denitrification, and V is volatilisation of fertiliser N. All parameters are in g N m^{-2} per unit time (one year).

Estimated values of nitrogen fluxes have been found for the main land cover categories according to GARTEN and ASHWOOD (2002). In the areas of intensive agricultural activities, the average values for I vary from 5 to 30 kg N ha^{-1} yr^{-1}, being on an average 10 kg N ha^{-1} yr^{-1}. The fertiliser input F varies a lot from crops and years being between 20 and 300 kg N ha^{-1} yr^{-1}. On an average, over all agricultural lands, this value can be taken as high as 100 kg N ha^{-1} yr^{-1}. However, in most cases the cultivate grasslands receive more fertilizers than the arable lands. Denitrification (D) also depends on many factors ranging in wetlands and hydromorphic soils between 10 to 350 kg N ha^{-1} yr^{-1}. The median values for N uptake by crops (U), herbaceous vegetation (grasses), and herbaceous wetlands were ranging from 120-140 kg N ha^{-1} yr^{-1}. This is greater than the median value of N uptake in forests (62 kg N ha^{-1} yr^{-1}). The median values of the net soil N mineralisation (*M*) were 70 and 50 kg N ha^{-1} yr^{-1}in forests and herbaceous vegetation, respectively. Volatilisation, organic N accumulation, and microbial immobilisation have not been taken into account because of the lacking data (GARTEN and ASHWOOD 2002).

The Porijõgi River catchment

We tested the PEN approach in the Porijõgi River catchment which is located in south-east Estonia (Fig. 3). The Porijõgi River drainage basin (258 km^2) is one of the tributaries of the Emajõgi River that flows into Lake Peipsi. Landscapes of this area are representative of the entire of southern Estonia. The catchment is located on the border of two landscape regions: the South-East Estonian Moraine Plain and the Otepää Heights. The central and northern parts of the catchment lie within a ground moraine plain 5-10 km south of Tartu (58°23′N; 26°44′E). The absolute altitude of the plateau is from 30 to 60 m with undulated relief (slopes achieve normally 5-6%) and intersected by primeval valleys (0.5-3 km wide and up to 40 m deep) formed by streams during the Pleistocene and remodeled by glaciers during the last glaciation. Portions of these valleys are filled with glaciofluvial sands and gravel. The southern part of the drainage basin (10-13 km south of Tartu) lies on the northern slope of the Otepää Heights, which are composed of moraine hills and kames with a great variety of glacial deposits. The altitude of this region is up to 120 m; the relative heights reach 30-35 meters.

The upland soils are predominantly podzoluvisols, planosols, and podzols on loamy sand and fine sandy loam with a surface soil organic matter content of 1.6-1.9%. The soil pH is 5.6-6.5 with a declining trend during the last decades, due to intensive fertilization that was practiced up to the end of the 1980s (150 kg N, 70 kg P, and 100 kg K ha^{-1} yr^{-1} on arable lands and cultivated grasslands. More detail information about the catchment see MANDER et al. (2000).

Land use intensity has been decreasing since the beginning of 1990s in accordance to the drastic decrease in agricultural sector in the whole Baltic region, which was due to the political changes in this region. Figure 4 characterizes these changes in which the decrease in arable lands and increase in fallows was the main trend. In the beginning of the XXI century, this trend has been stopped or even turned back towards more intensive development.

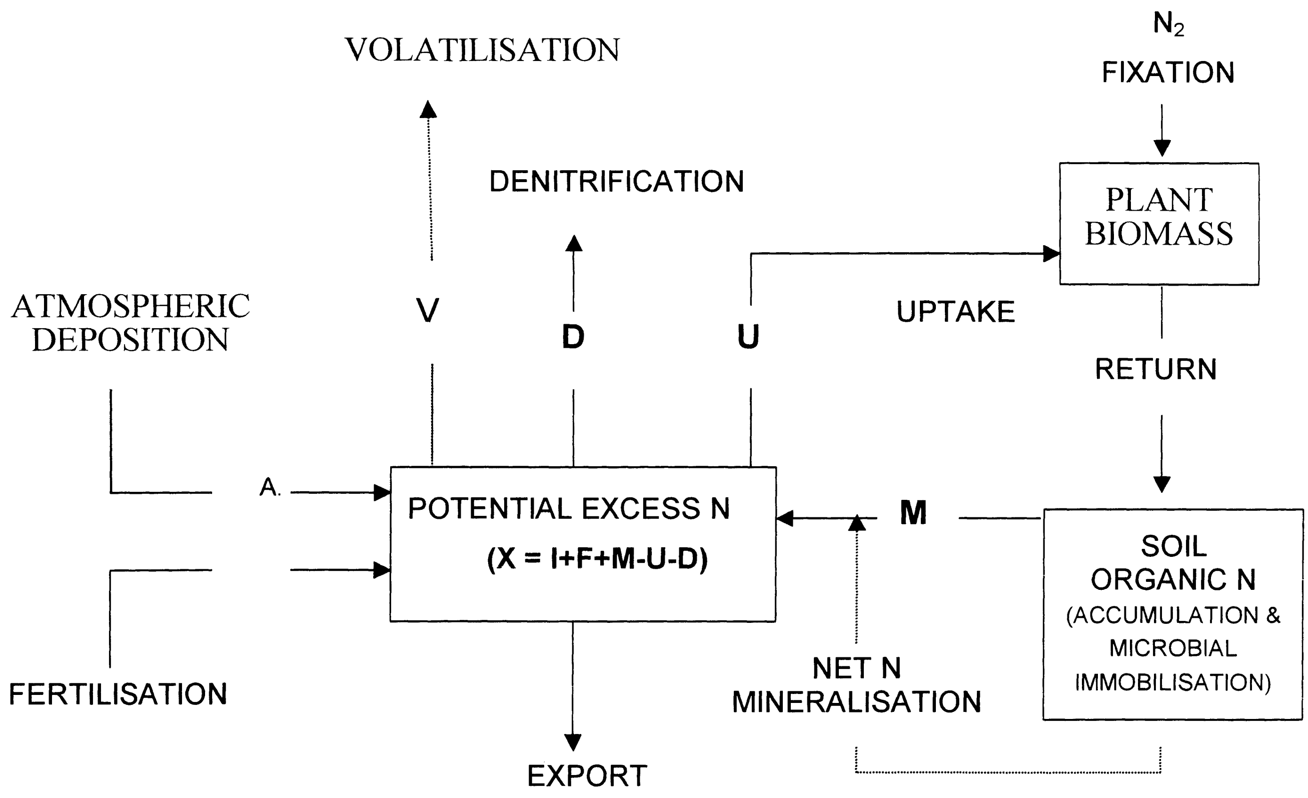

Fig. 2: Simplified conceptual model for N mass balance in terrestrial ecosystems (adopted from GARTEN and ASHWOOD 2002).

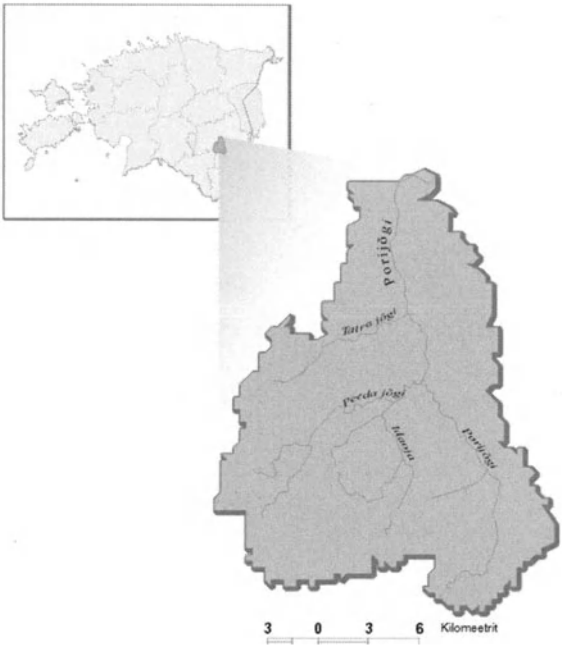

Fig. 3: The Porijõe River catchment area in South Estonia.

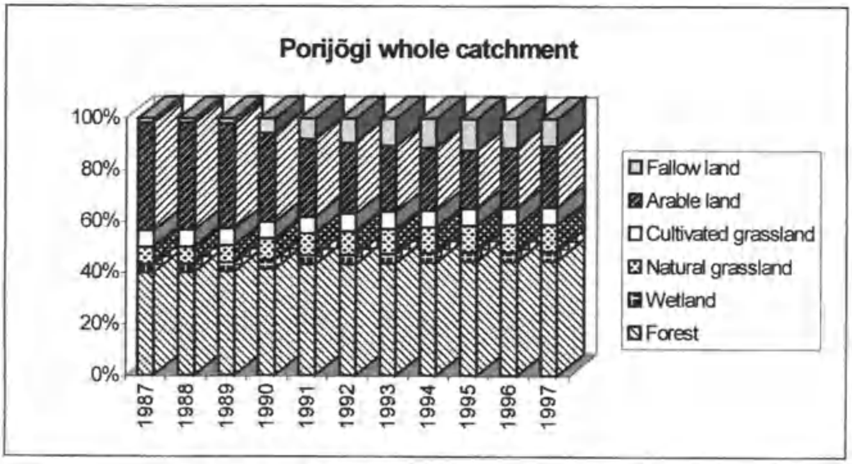

Fig. 4: Change in land cover in the Porijõgi River catchment (258 ha) in 1987-97 (%; MANDER et al. 2000).

Nitrogen removal capacity of wetlands as response indicator

The nitrogen mass balance model in combination with the appropriate land cover data, GIS models, and relevant geostatistical methods can give satisfactory results regarding the excess nitrogen assessment. Additionally, this kind of models can be very easily combined and compared with empirical models, which have been used for the assessment of N losses from catchment areas (MANDER et al. 2000).

Regarding the **response** aspect of indicators, we have chosen a model helping to estimate nitrogen removal capacity of various wetlands (TREPEL and PALMERI 2002). Regarding this model, three different equations can be chosen for the estimation of nitrogen removal in wetlands: (1) a linear, (2) an exponential, and (3) a hydro-exponential.

(1) The linear approach:

$$Nret = (WL \times 0.61) - 0.005 \qquad (2)$$

where *Nret* is the nitrogen removal in wetlands (kg N ha^{-1} yr^{-1}) and WL is the Wetland Nitrogen load from the upstream catchment area (kg N ha^{-1} yr^{-1}; MANDER and MAURING 1994).

(2) The exponential approach:

$$Nret = 7.56 \times WL^{0.49} \times WA^{0.51} \qquad (3)$$

where *WA* is the wetland area (ha) (BYSTRÖM 1998).

(3) The hydro-exponential approach:

$$Nret = WL \times (1 - e^{-K_{TN} \times \tau}) \qquad (4)$$

where K_{TN} is the first order removal rate for total nitrogen.

$$KTN = \frac{C_{NO3}}{C_{TN}} K_{dn} \qquad (5)$$

with C_{NO3} as mean nitrate concentration, C_{TN} as mean total nitrogen concentration, and K_{dn} as specific denitrification rate, and τ as the hydraulic residence time:

$$\tau = \frac{Wd \times Wl \times Ww}{Qin \times Aup}\left(1 - e^{-0.59\frac{Wl}{Ww}}\right) \qquad (6)$$

with W_d, W_l, and W_w as wetland depth, length and width.

All three equations (2-4) require the calculation of the inflowing wetland nitrogen load from the wetlands upstream basin area (A_{up}):

$$WL = Aup \times N\exp \qquad (7)$$

where N_{exp} is the mean annual nitrogen export coefficient (GARTEN and ASHWOOD 2002 , methods see above).

For finding optimal locations for surface flow wetlands in watersheds the GIS-based analysis of suitable areas can be considered as the best method. There are many possibilities how to create the evaluation scales and how to manipulate with the results of single factors. TREPEL and PALMERI (2002) used a set of eight data layers and calculated a the suitability as the average score of these layers for each grid cell:

$$S = \frac{\sum_{i=1}^{n} li}{n} \qquad (8)$$

where S is the suitability value for each cell, n the number of data layers and l_i the score value of the data layer i: $(1\ldots n)$.

Data layers used by TREPEL and PALMERI: (1) soil substrate, (2) land use, (3) topography features, (4) slope, (4) river distance, (5) acceptability (density of livestock and human population), (6) elevation, (7) historical wetland distribution. Topography aspects have been found from a digital elevation model, land use from the digital land cover maps. Soil maps were used for the substrate analysis. Historical wetlands were found from older map series and the acceptability aspects were found from the official cadastral data.

The sizing of surface flow wetlands was made based on the retention time and optimal area calculations. Following equations have been used.

$$T = \frac{V}{Qin} \qquad (9)$$

where T is the residence time in days, V the wetland volume in m^3 and Q_{in} the inflowing water volume in $m^3\ d^{-1}$.

$$A = \frac{T \times Qin}{D} \qquad (10)$$

where the required area A in m^3 depends on assumptions of the residence time T in days, wetland depth D in meters and the inflowing discharge Q_{in} $m^3\ d^{-1}$. Four depths of wetlands have been used: 0.25, 0.5, 0.75, and 1.0 m.

This complex GIS-based method allows to achieve quite exact assessment quality for the nitrogen removal by created wetlands.

Results and discussion

Main results of the analysis of the PEN in the Porijõgi River catchment for 1987 and 1997 are presented in Table 2 and Figure 5.

Tab. 2: Estimated annual total nitrogen (N) fluxes (kg ha^{-1}) in fertilization, soil mineralization, plant uptake, and denitrification that contribute to potential excess N in the Porijõgi River catchment in 1987 (numerator) and 1997 (denominator). Negative values – potential N sinks, positive values -potential N sources.

	Atmos-pheric depo-sition	Fertili-zation	Net mine-ralization	Plant uptake	Denitri-fication	Potential excess N
Arable land	15/6	150/20	50/45	70/60	15/10	30/10
Grasslands cultivated	15/6	35/5	45/40	55/50	28/15	12/4
Grasslands natural	15/6	0/0	35/35	45/38	20/15	-15/-12
Coniferous forests	15/6	0/0	40/40	60/60	4/4	-9/-10
Deciduous forests and bushes	15/6	0/0	60/60	80/80	25/20	-30/-34
Urban	15/6	0/0	0/0	0/0	0/0	15/6
Water	15/6	0/0	2/0	2/1	5/2	10/3
Fallow land	15/6	0/0	10/10	15/13	10/5	5/-9
Wetlands herbaceous	15/6	0/0	100/80	100/80	300/100	-285/-94
Wetlands woody	15/6	0/0	100/100	80/80	350/150	-315/-124
Raised bogs	15/6	0/0	1/1	2/1	14/6	0/0
Weighed average						4/-106

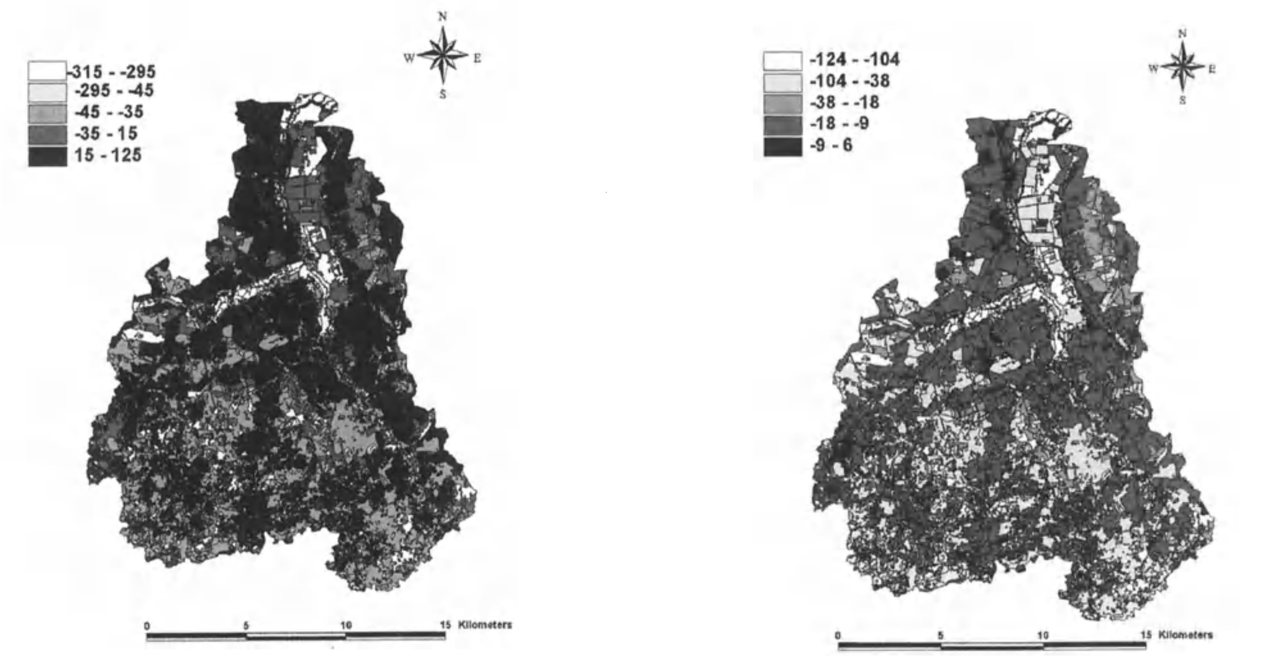

Fig. 5: Potential excess nitrogen (kg ha^{-1} yr^{-1}) under different land cover categories in the Porijõgi River catchment in 1987 (left) and 1997 (right). Negative values indicate the land cover categories as potential N sinks and positive values as potential N sources. Due to significantly less intensive agriculture, the average potential excess nitrogen of the basin has been decreased from +4 to 106 (Tab. 2)

As expert estimation we have found values for main N fluxes in accordance with the GARTEN and ASHWOOD (2002) model for 1987 when the intensity of agriculture was the highest during the second part of last century, and for 1997 in the middle of largest stagnation of the agricultural development. It is presented in the Table 2.

The average value of the PEN has been changed significantly: from +4 to –106 kg N ha^{-1} yr^{-1}. It means that from a potential N source this landscape has been turned to a sink. This trend is also reflected in the Figure 5 which indicates significantly less source patches in 1997 to compare with 1987.

However, in our earlier investigations (MANDER et al. 2000) we analysed the average annual N losses from the Porijõgi River catchment (Fig. 6) which are not coinciding with the PEN values. According to our model and monthly measurements, the N losses have been decreasing from 25 to 5 kg N ha^{-1} yr^{-1}. The differences can be caused by many factors but we can consider that only with regarding mineral N cycling, which is basically provided by GARTEN and ASHWOOD (2002), and also in the case of very mosaic landscape structure as in the southern part of the basin, it is very hard to quantify and estimate the N transformation.

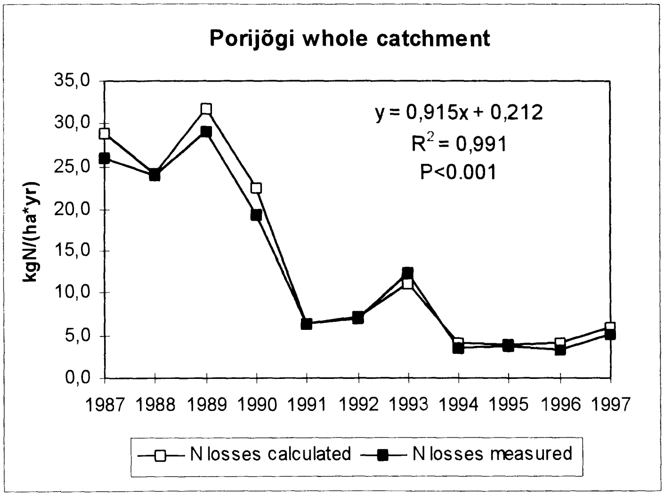

Fig. 6: Measured and calculated by empirical model total nitrogen runoff from the Porijõgi River catchment in 1987-97. Parameters in linear regression equations: x - modeled runoff, y - measured runoff (MANDER et al. 2000).

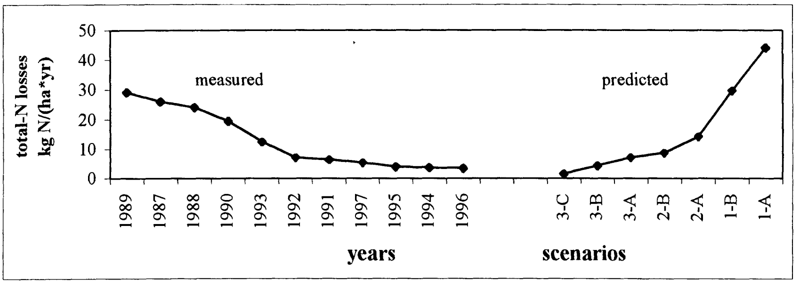

Fig. 7: Measured and predicted by scenarios average annual nitrogen runoff from the Porijõgi River catchment. Years ordered according to regressive values of measured nutrient losses. Intensity of agricultural use decreases from 1A to 3C (MANDER et al. 2000).

However, as rough and quick estimation of the landscape regulation functions the PEN approach serves more attention in future investigations. If the agricultural use will be intensified in coming years, as predicted based on the scenario approach (Fig. 7), there is a need for more intensive analysis and regulations of the environmental load due to the agricultural activities.

Conclusions

DPSIR framework is a useful tool for clarifying and logically ordering the main processes and environmental problems in landscape planning. However, in many practical cases, it is hard to subdivide the problems and processes as foreseen by this framework.

Potential nitrogen excess approach can give a quick and brief overview about the landscape regulation functions in respect with nutrient cycling. However, even if the nitrogen flux estimations are approximately close to real ones, this approach does not give exact numbers on nitrogen losses from catchments. It does not take organic nitrogen into consideration estimating only the mineral nitrogen flows. Also, the weathering is not included into this simple model as well as the soil N pool is fairly underestimated. However, the PEN can be used as a simple indicator of the landscape state and pressure, indicating roughly the sinks and sources of nitrogen in landscapes. Its value is in consistence with the main trends in N fluxes. Nevertheless, more investigations are needed in this particular field.

Acknowledgements

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Analyzing Spatial Habitat Distribution to Improve the - Assessment of Land Use Impacts on Habitat Functions

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Abstract

A methodology is introduced, which intends to improve assessments of habitat function in agrarian landscapes by ways of integrating spatial aspects of land use, remnants of biotopes and site specific biotope potential. This approach integrates two basic requirements for the floristic habitat function: i.) the relationship with biotic site potential and ii.) the consideration of threats, directly related to land use. The biotic potentials are interfered with a combination of site quality, site heterogeneity, the structure of landscape and the requirements of region-typical biotopes or species. Threats on habitat functions are regarded as a complex of influences by agricultural management, land use structure and potential effects of land abandonment. The methodology offers possibilities for the identification of biotic hot spots and preferred areas for counter-actions as well as areas with the highest potential in order to enhance habitat function on the landscape scale by restoration measures.

Keywords: biotope potential, threats, spatial differentiation, hierachic modell

Introduction

The Convention on Biological Diversity and the 6.th EU Environment Action Programme has identified agriculture as the key sector to have an impact on natural environment. The occurrence of many of the European species depends on specific farming systems to maintain suitable habitat conditions; above, many species are more influenced by agriculture than by anything else (AZEEZ 2000). Providing appropriate habitat conditions for regional wildlife organisms is an important ecological function of agriculture in landscapes and should get more acceptance both from society and from farmers. Stimulating those management systems which contribute to the maintenance of biological diversity on arable land, is a central component of the European Biological and Landscape Diversity Strategy (ECNC 2000).

One of the most important tasks in maintaining or improving habitat function of agrarian landscapes is to make recent regional values, their potentials and their threats transparent and visible. This is especially needed, if we want to assess the impact of new agricultural policy guidelines or new techniques and to evaluate the effects of agricultural management. The definition of targets for habitat function as well as the assessments of land use impacts should take into account the natural differences between different landscapes to attain objective criteria and results. Due to their geomorphologic, climatic and historico-cultural background, landscapes result in different current biotope inventories and biotope potentials. Heterogeneity and the structure of natural site conditions are basic factors influencing the species richness and diversity in landscapes. These factors create the baseline, which will be influenced by the kind, diversity and structure of land use. When evaluating the influences of land use we should consider, that land use "per se" will modify natural habitats. The criteria for evaluation of land use impacts can therefore only be the degree to which the regional baseline state in habitat function will be modified by land use for every single region.

With exemplary applications for North-East Germany methodological tools will be introduced, which show up new possibilities to help taking into account regional specific potentials and the role of spatial configuration of abiotic and land use patterns within the assessments of habitat function in agrarian landscapes. The presented research results are part of the national German network "Approaches for Sustainable Agricultural Production in North-Eastern Germany" (GRANO).

Material and Methods

Spatial transferability and usability in different regions was the basic criteria for the whole methodology. Related to this, the following basic definitions have been made: i.) the method should base on available spatial data; ii.) all necessary detailed investigations and evaluations should be able to be linked or translated to spatial available data, iii.) biotic potentials and evaluations need to be adjusted regionally and iv.) biotic potentials should be oriented to actual existing biotopes and not to historic ones.

Investigations have been carried out at two different levels: 1. at regional level in the county "Uckermark" (3058 km^2) and the county "Elbe-Elster" (1890 km^2) in North-East resp. East Germany and 2. at the landscape level in one local landscape in Klein/Groß Ziethen (24 km^2). Analyzes have been performed using following spatial data: a.) site map (medium scale soil map MMK, 1:100.000), b.) soil estimation map (RBS, 1:25.000), c.) digital biotope maps (1:10.000) and d.) digital elevation data (1:10.000). At the local investigation sites the digital biotope map has been complemented by exemplary field investigations on specific flora composition and soil nutrient contents, based on a previous representation analysis. All data has been held and linked within a geographic information system (GIS). Statistical data analysis was performed by using multivariate statistics (cluster, correspondence and discriminant analysis). Spatial configuration of data has been investigated by using the spatial analysis package “Fragstats”.

All analyzes have been carried out regarding agrarian landscapes. Therefore, large closed forests, settlements and lakes have been excluded.

Results

Basic methodology

The procedure of assessing and evaluating habitat functions within agrarian landscapes consists of 5 basic modules. They are as follows:

- Analysis of the current state of habitat function with regards to the kind, composition (quality), share and spatial configuration of all currently existing biotopes
- Classification of typical biotope qualities, identification of the driving forces of their composition as well as their site requirements by linking with available soil and elevation data
- Transfer (extrapolation) of site requirements for semi-natural biotope types to arable land under use to show up their edaphic potential for potential restoration into semi-natural habitats
- Thematic interpretation of regional state and site potential for different biotope types; f. i. balancing the current state and the potential for different biotope types; assessing the potential for diminishing land use impacts on sensitive biotopes, assessing the potential for improving biotope connection, assessing the potential effects of land use changes and so on
- Conclusions of different interpretations, comparison with the recommendations of regional biotope action plans and the objectives of main stakeholders, identifying hot spots for protection measures as well as for restoration efforts.

Assessments of biotope function and biotope potential

The characterisation of biotope inventory as well as the determination of biotope potentials is a significant prerequisite for the definition of regional goals and for evaluations of land use impacts. Against this background it is insufficient to assess habitat function only with regards to the actual occurrence or missing of biotopes or species associations. For good assessments it is also necessary to take into account the driving forces and limiting factors for biotope occurrence in landscapes or, in other words the biotope potential in a certain landscape. Besides outlooks on restoration possibilities, the biotope potential delivers information on the degree to which regional potential is limited by the current land use structure. In addition to inventory and potential, structural parameters of the current biotope inventory should be included. Numerous functional aspects of biotopes and aspects of their sustainability are related to their shape and connectivity in space, e.g. genome exchange through the landscape; endangering through lateral immissions, minimum core area for the sustainability of populations and so on. Paying attention to these parameters results in a more complex methodology for assessing and evaluating the current biotope inventory (see table 1).

Tab. 1: Parameter and criteria for evaluations of biotope inventory and biotope potentials

parameter	Criteria
biotope and species inventory	• number/share of different biotope types • degree of protection • biotope or species diversity • occurrence of target species (e.g. for regional specificity)
edaphic biotope potential	• abiotic heterogeneity/diversity • share of sites, suitable for target biotopes • heterogeneity/diversity of land use impacts
landscape structure	• configuration of used areas and current biotope inventory • disharmony between biotope potential and recent land use structure • biotope connectivity/fragmentation

The most common practice to describe the current biotope inventory is listing different kinds of biotope types and their summarized share for a given area (see table 2).

Tab. 2: Proportion of the current state of semi natural grassland biotopes compared with the proportion of agriculturally used area within the investigation area "Klein/Groß Ziethen"

	semi natural grassland biotopes			used grasslands and pastures	used arable fields
	moist	slightly moist	dry		
Biotope inventory	4,2 %	2,2%	4,1%	13,7%	55,3%

Depending on the available data, this description can be given more or less detailed. For larger areas, available biotope data is often strongly generalised, e.g. aggregated in biotope types. This is a necessary restriction for sustaining spatial transferability, but also a limiting factor for evaluating the biotope quality in a given area. This is caused by the fact that nearly all biotic evaluations are related to single species. To meet both interests, it will be necessary to find solutions to underpin the available spatial data with more detailed information on their quality or species composition. There are at least two known paths given in literature: i.) to give expert assessment of the region-typical composition of aggregated biotope types or ii.) to complete the spatial data with a sampled data for the species composition in selected areas.

In landscape analyzes, the spatial configuration of the recent biotopes becomes a central focus. Spatial analyzes can either be performed for single predefined biotope types (class indices) or for the whole biotope set (landscape indices). While class indices delivers information on the state and sensitivity of some target biotopes, e.g. for nature protection issues, landscape metrics results in a more general information on the landscape, e.g. diversity, fragmentation gradient lengths an so on.

Tab. 3: Selected landscape structure parameters for the group of moist semi natural grassland biotopes within the investigation area "Klein/Groß Ziethen"

Class indices	Moist grasslands
Mean patch size [ha]	1.10
Mean perimeter:area ratio [m/m²]	0,044
Mean nearest neighbour distance [m]	1523
Mean patch fractal dimension	1.42

When assessing the current biotic inventory it is necessary to identify regional characteristics within the biotope and species occurrence besides the use of diversity measures and the consideration of the occurrence of endangered species respectively. This step can be carried out on the level of biotopes through the analysis of available biotope mapping. Very often, biotope types contained in these mappings are qualitatively characterized with regards to species groups combined in the single types. Based on that, it is possible to characterize the site conditions beyond the recently existing biotopes through the linkage with available soil information (soil maps, field data). Via statistic procedures (e.g. multiple discriminant analysis) the found algorithms for the site requirements of different biotope types can be used for the spatial extrapolation on areas of arable land and grassland (figure 1).

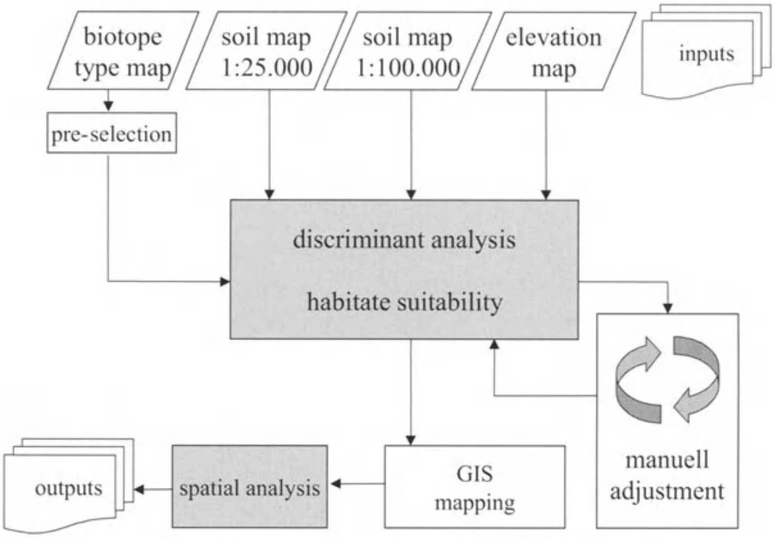

Fig. 1: Multiple parameter discriminant analysis is used as a method to identify differences in site requirements between different groups of biotopes

Fig. 2: Edaphic potential of the establishment of dry, half-dry meadows and dry herbaceous perennial communities in the agricultural landscape Klein/Groß Ziethen (analysis following the procedure as described in figure 1)

The results can be interpreted as the edaphic potential of arable land for the restoration of those biotopes or composite structures, that recently occurred in the given area. Figure 2 shows an application of this method for the example area “Klein/Groß Ziethen”.

Examples for the use of spatial information on current biotope inventories and edaphic biotope potentials for the evaluation of land use impacts

The kind and the intensity of land use can influence the manifestation of currently existing and region-typical life communities in agricultural landscapes. In our approach, the assessments of land use effects orientate towards the influence of land use measures on the current inventory as well as on the reflection/manifestation of potential habitat function. Above, the effects of land use structure (e.g. field sizes, presence and quality of field margins) and threats originating from land use abandonment will also be taken into account (see table 4).

Tab. 4: Parameter and Criteria for the identification of potential threats/ interference with habitat function through land use

parameter	Criteria
landscape structure	• disharmony between existing habitat potential and current land use structure • disharmony between existing habitat quality and connectivity and the demands of target species
threats through land use measures	• threats through immissions (pesticides, fertilizer) • threats through usage related soil erosion • threats through single treatments (soil treatment, crop rotation, treatment dates etc.)
threats through land abandonment	• threats through afforestation • threats through conversion from arable land to permanent grassland • Abandonment of extensive farming or landscape conservation practices • decreasing diversity within the main land use types

As principle for the evaluations carried out, it was assumed that threats can only be identified if valuable biotic inventories or potentials meet immediate spatially or neighbouring with threats arising directly from land use (e.g. erosion, use of fertilizer, pesticides). This definition is essential for circumventing general convictions of land use effects. Our approach is strictly oriented to the spatial determination of potential conflicts between habitat function and land use.

Concerning the structuring of agricultural areas, a land use structure adapted to the spatial heterogeneity (e.g. in hydrology, soil quality, elevation) of the open space is demanded. This principally corresponds to the demand for site adapted farming, as it is valid for the principle of "good agricultural practice". This approach requires definitions of target parameters for biotope inventory and land use structure, taking into account regional specificities in the heterogeneity of soil substrate, elevation and soil water conditions. In order to characterize regional specificities, diversity and structure measures can be used. Agreed regional target values for the land use and landscape structuring are not available at the moment, because they may differ concerning different landscape functions (e.g.: regulation of pests and diseases, habitat function, soil protection).

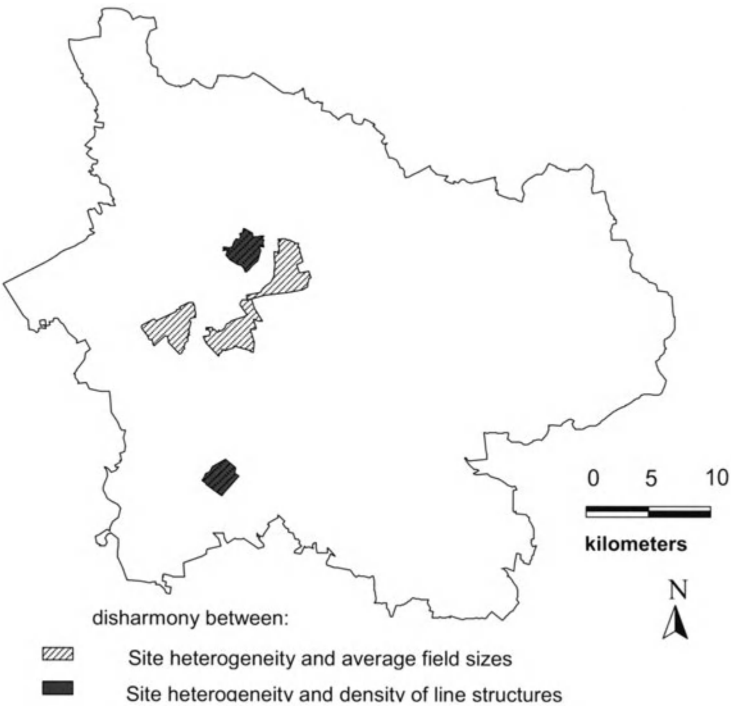

Fig. 3: Disharmony between the predominant site heterogeneity and the configuration of agricultural landscapes with structural elements and the current land use structure in the county Elbe-Elster respectively.

A first step towards the identification of the need for action in order to change land use structure and land use structuring respectively is shown by figure 4 for the county Elbe-Elster (Brandenburg state). This diagram shows the areas of those districts, where more than 50 % of agriculturally used areas are characterized by strong heterogeneities in soil substrate, elevation and/or in soil water conditions and whose provision with structure elements as well as average field sizes diverge clearly from the regional average (line structure approx. 6 km/km²; average field sizes 44 ha).

The revealed districts in figure 3 can be considered as priority areas for measures, to improve the landscape structure (e.g. establishing additional line structures, splitting the fields, biotope restoration).

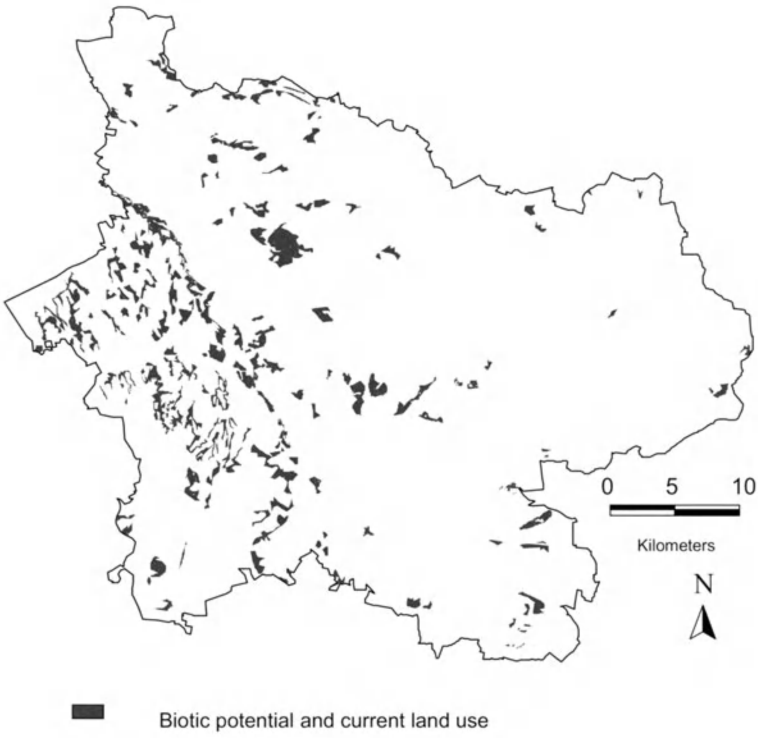

Fig. 4: Sites with edaphic biotope potential for semi natural wet grasslands which are currently used as arable land or intensive meadows in the county Elbe-Elster (disharmony between biotope potential and current land use)

Concerning the assessment of the habitat function of agricultural landscapes, it is also necessary to consider – besides structural aspects- the site potential for the occurrence and the establishment of target species for nature protection. Areas with a particularly high edaphic biotope potential, which however, is currently used as arable or grassland, present priority areas for the biotope development, because restoration success can be expected higher than in other areas. One circumstance reducing the conflict between habitat function and land use is in many cases the fact, that areas of highest interest for biotope development are often limited in their agricultural usability or have clear usage difficulties. In figure 4 an example is shown from the county Elbe-Elster. All those areas with strong back- or ground water influx are identified, which are currently still used as arable and grassland.

The marked areas in figure 4 are to a high degree in accordance with the objectives of regional planings concerning future nature development, which among other things strive for the establishment of further wet grassland areas and the extension of extensive use on existing semi natural wet grasslands respectively within the county Elbe-Elster.

Semi natural wet grasslands is regarded as a region-typical landscape element, which due to current land use is limited in its occurrence particularly strong. With the exception of extensive farming, all kind of land uses on those extreme sites are to be seen as threats to the species groups of those biotopes and to the further existence of biotope potential respectively.

Lateral effects of land use measures are the most important and dominant impacts on existing biotopes. Immissions (fertilizers and pesticides combined with soil erosion, wind or lateral water fluxes) in semi natural biotopes lead to eutrophication and the disturbance of the current biocoenoses. Eutrophication especially should be regarded as the most relevant problem in nature protection (ELLENBERG, 1989). Lateral nutrient input contributes highly to losses in species richness and diversity, due to the disappearance of species of nutrient poor conditions and the increasing dominance of competitive, ruderal species. Spatial determination of threat hot spots can help to show up the need for action (e.g. additional field margins and so on). Combined with information on edaphic biotope potential of neighbouring areas, a more realistic outlook on restoration possibilities can be given. Figure 6 shows an example of spatial identification of sensitive semi natural biotopes (sensitive against lateral immissions) within agrarian landscapes.

The algorithm of the biotope sensitivity bases on following parameters: i.)

size, ii.) area: perimeter relation, iii.) share of agricultural land within a 100 m buffer zone and iv.) elevation within the 100 m buffer zone for every single existing biotope.

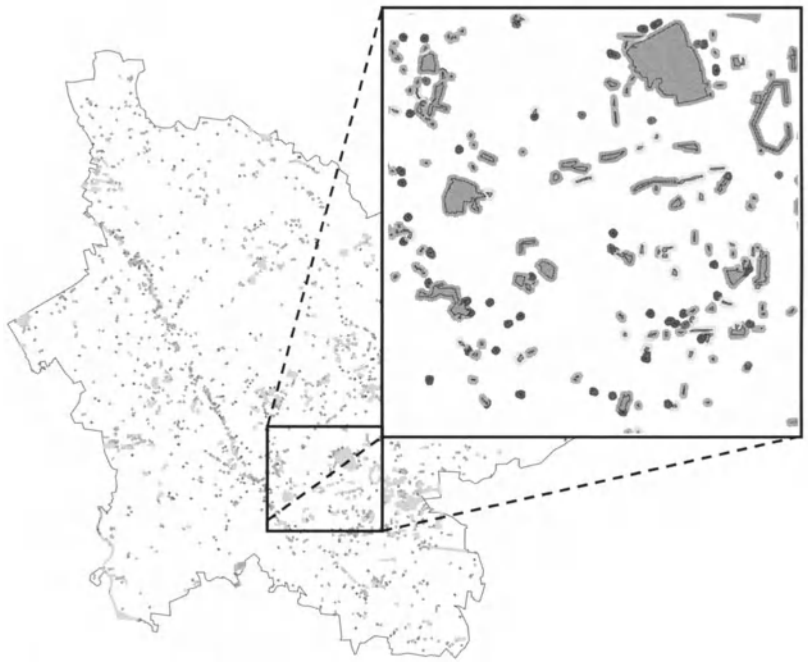

Fig. 5: Sensitivity of currently existing biotopes against immisions arising from agriculture in the county Elbe-Elster, analysis was based on the spatial characteristics of the existing biotopes and the elevation of neighbouring arable areas.

Discussion

The partly introduced methodology aims at the assessment of land use effects on habitat function on the landscape scale. At the same time, it will be suitable to regionalize nature and species conservation objectives and to estimate possible effects of land use changes in the framework of scenario techniques, analogous O'CALLAGHAN (1996), KNOL et al. (1994), BORK et. al. (1995). One basic element is a consequent comparison with available inventory and edaphic potentials as well as the concentration on immediate influences of the type and intensity of land use. These aspects will be regarded as necessary for improvements in transparency and acceptance of nature conservation objectives and necessary measures at the land users. Above, the method can contribute to increasing the efficiency of restoration efforts. One can expect the analysis outcome as an emergence of regions with little need of action and main focus areas with increased or multiple need of action.

The availability of coherent, widespread data often is the limiting factor for the implementation of biotic analysis on landscape level. This is particularly the case in attempts which include the parameter “biotic inventory”. Biotope maps, which recently have become available in most German states, are most suitable for these analyzes (SCHULTE et al. 1993). However, they only have a limited resolution as regards content. Works by CHERILL et al. (1995) and KNOL et al. (1994) however, show, that through linking assignment tables (occurrence probability of target species or species assemblages in the area) to the biotope map, it will be possible to give interpretations on a more detailed species level and to join species related evaluations. Further development of the introduced methodology in this direction is intended. However, the question arises if in large scale analyzes it is generally useful to strive for a higher resolution as regards content. In the course of this, miscalculation and over interpretation respectively of dominant species compositions are very likely. An apparent detail degree will be achieved which is accompanied by information loss (e.g. exclusion of subdominant species). The introduced concept intends a particularizing of relevant biotope types according to their typical species composition through regional expertise.

Considering regional objectives and characteristics respectively for the assessment of land use impacts on the habitat function plays a central role in the introduced method. Regional objectives can be drawn up for various aims (generally social, nationwide, regional etc.). For single landscapes, several objectives, which possibly have to be put into hierarchy, can be valid at the same time. As a basis for interpretations, the strived for aim and the spatial validity should always be given. This enables flexible work with multiple objectives. Besides the use of objectives with external origin as inputs, regional targets can also be derived from analyzes of the current landscape inventory. Those aim primarily at the conservation of regional characteristics or at the diminishing of identified conflicts or problems. A complex and applicable method for deriving regional biotic goals and standards based on landscape analyzes has been introduced by WALTER et al. (1998).

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Landscape Functions in Relation to Agricultural Management in Norway

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Abstract

Norwegian landscapes are very diverse. Agricultural land constitutes a small but very important part. The landscapes are thus very sensitive to agricultural changes, hence the multifunctional role of agriculture has been an important part in policy design with regard to agriculture, environment and rural development. A strong public involvement in agriculture with the use of economic and legislative instruments have been a prerequisite for the maintenance of a rather small scale, decentralised property structure and environmentally sound practices. This is likely to be needed in future also to avoid undesirable changes of the landscapes in Norway. A high diversity in landscapes and variability of landscape functions generate a corresponding variability in terms of soil-water interactions including soil erosion and nutrient losses. Interference in the basic landscape functions, e.g. the hydrological processes, may have substantial direct and indirect impacts on the environment.

Keywords: Landscape functions, agriculture, management strategies, Norway

Introduction

Landscapes are multifunctional with quantifiable and less quantifiable variables. The quantifiable variables may include e.g. water quality and bio-diversity characteristics, while the less quantifiable variables are more indirect and often relate to interactions between human welfare and landscape values. Landscape changes may thus affect the society in many ways. The "driving forces" are of great interest, particularly because the landscape changes may develop slowly and as unexpected side effects of the different sectors policies.

The European landscapes are to large extents agricultural landscapes. In Norway, however, around 70 % of the mainland area consist of more or less unproductive land (i.e. mountain areas, bogs, lakes, glaciers, etc), and only 3 % are cultivated for agricultural uses. Thus from the viewpoint of landscape functions, most areas in Norway can be considered "agriculturally sensitive areas". The multifunctional agriculture is consequently an important aspect of the agricultural policy in Norway, in which the so-called "non tradable concerns" are becoming an increasingly important part. Substantial changes in land use and production systems over the past 50 years have modified landscapes and landscape functions in several regions. These changes are mostly due to political decisions, but have resulted in secondary effects also on the environment, i.e. in terms of soil erosion and water quality, and bush development in former pasture areas.

The paper provides a brief presentation of landscape issues in Norway in relation to agriculture and water quality management.

Land use and agricultural structures

Agriculture in Norway is by tradition a small-scale family business, and mostly combined with forestry. Today, part-time agriculture is common. In general, the conditions for growing agricultural crops are less favourable and much more variable in Norway in comparison to most other European countries. The length of the growing season in the main agricultural districts ranges from around 100-140 days (mean daily temperature > 6 ° C). The total length of the country from south to north is about 1700 km, i.e. the distance from Oslo to Rome is approximately equal to the distance from Oslo to the northernmost point of the country. Thus the climatic conditions vary considerably, e.g. precipitation may range from less than 400 mm to more 5000 mm per year. In the grain growing districts of southeastern Norway precipitation ranges between 500 and 1000 mm. Soils are usually frozen with a more or less permanent snow cover during the winter period. A large part of the agricultural land is systematically drained by tile and plastic drains. Good agricultural soils with high yield potentials are limited, and they are mainly located on marine deposits in low land areas in southern parts of the country. The range in growing conditions have resulted in a range in crop rotation systems, land use and farm structures, and a corresponding range in political instruments and governmental support programs. The southeastern parts of the country are characterised by a rather homogenous lowland landscape with relatively large farm units on marine deposits. In central parts, there is a typical valley landscape with agricultural land on fluvial deposits and moraine soils on steep valley slopes. In the western and northern parts a fjord and river valley landscape with scattered pieces of agricultural land along the waterways is the predominant picture, often at very steep slopes.

The population density is one of the lowest in Europe (13 per km^2). Area of agricultural land comprises only 0.22 ha per capita, which is the smallest in Europe. Agricultural land constitutes only 3 % of the total mainland area, and is unevenly distributed throughout the country. Around 350 000 ha (35 % of the agricultural land) is used for cereal crops, of which a minor part is for food cereals. Currently, around 60 % of the food cereals and 40 % of the animal feed cereals are imported. The most intensively used areas are located in southeastern and southwestern Norway. The number of farm holdings decreased significantly during the past decades (30 % during the last 10 years and 85 % after 1949), to the current number of 70 000, in average 14 ha land per farm.

Forested areas comprise around 30 %, of which roughly 70 % can be considered economically productive forest. Mountains, partly bedrock and partly covered with thin soil layers and bushes, are large parts of the remaining areas. The total area of economically productive land (forest and agriculture) covers around 25 % of the mainland area.

The Norwegian landscapes are thus diverse and very fragmented. Agricultural land constitutes a small but important component. The fragmented landscape is one of the main pillars in making rural areas attractive, e.g. for the tourist industry, which is an important economic sector besides for fisheries and the oil industry. The agricultural policies and the resulting effects on landscapes may therefor influence significantly on other sectors development.

Land use and landscape changes

Protection of cultivated land against other uses has been a major political issue with political consensus in Norway due to the small area of land suitable for crop production. Nevertheless, it could not prevent considerable parts of the best agricultural soils from being allocated for other purposes during the past decades (e.g. urban areas, industry, etc). For example, during the past 50 years more than 75 000 ha of our most productive soils were lost for irreversible, non-agricultural uses. It indicates that in spite of legislative measures, short-term economic interests tend to be given priority in conflicts with long-term "non-tradable" interests or assets that are difficult to quantify in terms of economic figures.

Increased self-sufficiency, food security, viable rural areas and the maintenance of a decentralised population structure have also been integrated parts of the post-war policy in agriculture. In the mid 70's the Parliament declared a particular income goal for the agricultural sector to break a widespread pessimism, aiming at equal income level with the industrial employees.

The policy was supported by relatively strong economic incentives, in particular through subsidies attached to grain production and milk production. This resulted in a contemporary change in land use structure and crop cultivation, and a profound regionalization of production systems. Milk and animal production were concentrated in "remote" areas (the valley districts, western, northern and highland parts of the country) while grain production in the central eastern parts, e.g. the Oslofjord region (figure 1). Grain and milk prices were differentiated between districts, and a milk quota system was adopted to preserve milk production for the benefit of the "grass districts" and southwestern Norway.

Substantial changes in topography and hydrology have modified the landscape functions of several agricultural areas in Norway. This includes extensive land levelling and transfer of ditches and streams into closed systems, resulting in more coherent fields, increased soil erosion and loss of e.g. the nutrient retention potentials. These measures, supported economically by the government until the mid 1980-ies were aimed at increasing the suitability and viability of cereal cultivation in South Eastern Norway.

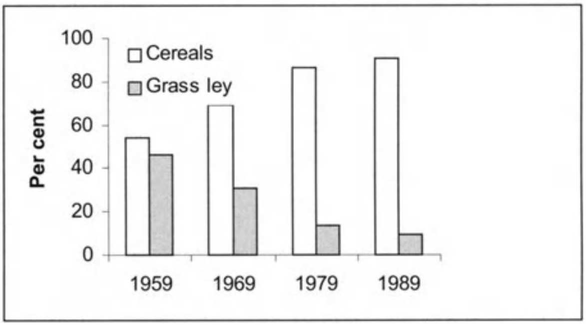

Fig 1: Relative changes in distribution between cereal crops and pasture in South Eastern Norway, 1959-1989.

Increased animal density in southwestern parts of Norway resulted in manure and nutrient surpluses and corresponding decreases in water quality of surface waters. Certain areas reached a density of 3 livestock units per ha. Relatively high precipitation (1000-2000 mm) and mainly surface application of manure and slurry created high losses of N and P. Meanwhile, more intensive cultivation methods and artificial land levelling in southeastern parts created an erosion problem.

The land levelling occurred mainly during the period 1960-1980. It was especially intensive after 1972, when subsidies were introduced, but ceased after 1985 when subsidies were withdrawn. It is now not allowed to level land without special permission. In total about 35 000 ha were levelled, 10 % of the total area in grain production. For Akershus county, in the vicinity of Oslo, levelled land corresponds to 25 % of the grain area. In some municipalities up to 40 % of the agricultural land was artificially levelled. The land levelling operation reduced the slope gradients of the ravines from about 1:3 to 1:6 or less, which was considered necessary for safe operations with tractors and combines. Depths of cutting and fillings were up to 15 m at a maximum. As a result, important parts of the original landscape with pastures and ravines changed totally its visual appearance as well as functional characteristics. Poor technical performance of the levelling operation in the early years moved the original topsoil and the weathered dry crust to the bottom of the filling and left a kind of C horizon without organic matter at the top. Extremely low aggregate stability and infiltration capacity created severe erosion problems and resulted in very low yields. During the later years, the original topsoil was preserved and returned to the top of the new surface.

In many levelled areas severe gully erosion was observed, caused by reduced infiltration rates, longer slopes and inadequate measures to handle concentrated surface flow. Off site effects were also very visible like silting of creeks, rives, lakes and eutrophication of water bodies. LUNDEKVAM (2002) has found that the erodibility increased 3- 13 times after levelling depending on the quality of the levelling operations. Today, artificial levelling is prohibited or only allowed after a special permission.

The above examples illustrates how political means to achieve particular goals may have secondary effects that were not accounted for when designing the policy. However, from the early 1980-ies it was a growing awareness of the resulting problems, and a new policy aiming at counteracting and decreasing the negative effects gradually developed. The severe erosion caused by land levelling led to the financing and the start of the erosion research in Norway. This research was from its initial stage focused on finding practical measures for farmers to reduce erosion, like reduced tillage methods, timing of tillage (NJØS and HOVE 1984, LUNDEKVAM and SKØIEN 1998, ØYGARDEN 2000). It has been a close co-operation between policy makers and researchers, and implementation of new measures and corresponding support programs have therefore been introduced shortly after start of research. For instance, subsidies for establishment of buffer zones and sedimentation ponds were given before research projects were finally reported. All the different subsidies for different land uses and measures in landscapes were adopted by farmers when they were introduced. This led to expected changes in management practices, and the official statistics related to subsidised areas enable the documentation of the progress in implementing environmental measures. It also shows that by economic incentives it is possible to influence on land use in whole regions and districts. For issues such as soil erosion and degradation of water quality this is of special importance since environmental effects often are side effects of the economic policy in agriculture.

Land use - water quality linkages

Soil-water interactions are very important parts of the landscape functions, which to a large extent determine the environmental effects in terms of soil erosion and water pollution. These interactions are sensitive to land use changes as well as to interference in the hydrology of the landscape. The final load to the aquatic environment can be linked to two counter-acting processes in the soil-landscape system; (i) the mobilisation and transport potentials of e.g. nutrients and soil particles, and (ii) the capacity of retaining mobilised particles and nutrients through various processes such as sedimentation, adsorption and denitrification. Variable soils and diverse landscapes, and a range in agricultural practices may cause substantial variations in the load of e.g. nutrients to the aquatic environment.

Monitoring is basically a decision support tool e.g in watershed management, but also an important means for research on cause-effect relationships and thereby indirectly an instrument for the design of measures and strategies. In Norway, a nation-wide environmental monitoring program in small agricultural catchments has been in operation since early 90's. In the National Agricultural Environmental Monitoring Programme (JOVÅ) nutrient loads (e.g Nitrogen and Phosphorus), soil losses and pesticides are measured based on continuous recording of water discharge and automatic sampling of flow proportional water samples. Additionally, farm practices are recorded annually at field level, enabling the study of long-term linkages between land use and management practices and losses to the aquatic environment. Results from the Programme is reported annually and used in policy support by the Ministry of Agriculture and Ministry of Environment. Figures 2 and 3 present data on nutrient losses to surface water in 6 catchments (area < 20 km ^{2}) dominated by cereals and cereal-grass rotations.

Results show substantial variations, with mean losses ranging from less than 0.4 to 5.5 kg P ha^{-1} and 20 – 100 kg N ha^{-1} (BECHMANN et al. 2001). It can also be noted that P losses in 2000/01 (May-May) were more than twice the mean losses for several catchments, probably due to extremely high precipitation on October-November 2000.

The corresponding loss figures in similar catchments in other Nordic and Baltic countries tend to be lower than the Norwegian figures. For example, N losses to surface water in these catchments rarely exceeded 30 kg, whereas the P losses mainly were below 1 kg P ha^{-1}. As suggested by VAGSTAD et al. (2001), this may be a result of fundamental differences in the hydrological processes, in particular the hydrological pathways by which nutrients are transported. In this context the residence times of surplus water are of particular interest, the longer they are the larger are the potentials for various soil-landscape retention processes. The Norwegian catchments are characterised by predominance of fast-flow processes in contrast to e.g. the Danish and Baltic catchments where the base flow contributes much more to the water discharge. Studies by GRANT et al. (1997) showed that only 10 % of the N lost from the root zone reached the surface waters in some sandy soil catchments in Denmark. This indicates substantial losses through e.g. denitrification along the pathway from the soil profile via the ground water to the first order surface water recipient. These results may also provide an example of how important the landscape functions are in terms soil-landscape-water quality interactions. They also illustrate the need for including basic landscape hydrology competence in the design of cost-efficient land use and environmental management strategies.

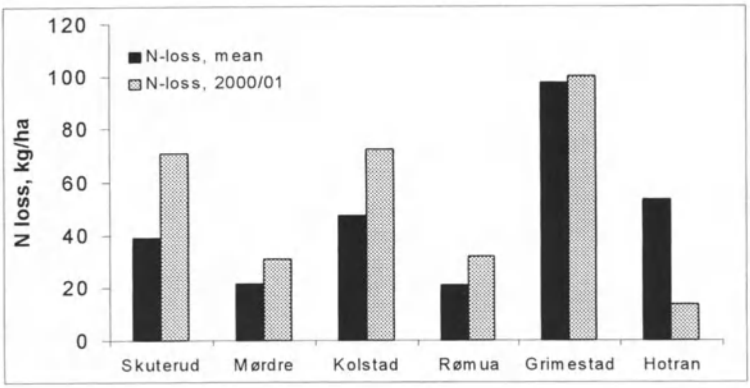

Fig: 2: Nitrogen (Total-N) losses to surface water in 6 small catchments dominated by cereals and cereal-grass rotations. Mean losses during the past 10 years and losses during May-May 2000/2001. Catchments in the Agricultural Environmental Monitoring Programme.

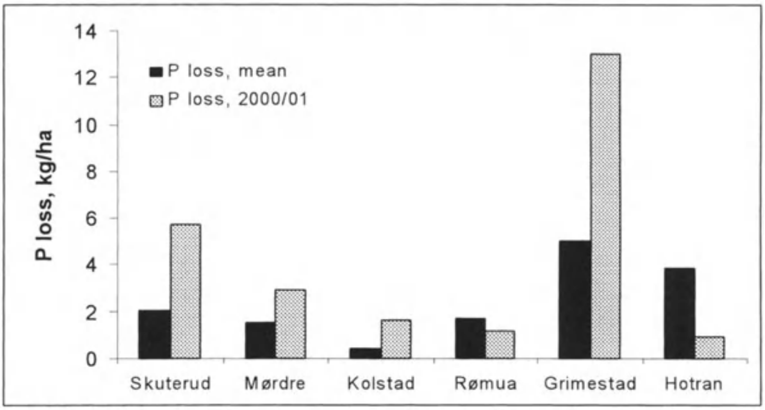

Fig. 3: Phosphorus (Total-P) losses to surface water in 6 small catchments dominated by cereals and cereal-grass rotations. Mean losses during the past 10 years and losses during May-May 2000/2001. Catchments in the Agricultural Environmental Monitoring Programme.

Landscape functions and watershed management strategies

The diversity of soils and landscapes calls for revised land use strategies in order to increase the potential benefits for the society and to meet future requirements emerging from e.g. the EU Water Framework Directive. Issues such as soil-water interactions and integrated watershed management are closely linked to the multifunctional character of landscapes. The ideas and concepts of precision agriculture with emphasise on site specific practices according the variability and natural capability of soils and landscape may serve as a useful approach in this regard also. The key issue is to understand the interactions between soil processes and hydrology and its variability across scales, and include this understanding into land use management strategies. In terms of watershed management, the identification of sources and sinks are of great importance, e.g. to identify which areas contribute relatively much to the pressure on the water resources and which areas contribute less. Moreover, the identification of potential retention areas, e.g. for sedimentation/adsorption of P or denitrification of nitrates, are integrated parts in such strategies.

Norway has attempted to implement parts of these approaches into current land use and watershed management strategies. Almost the entire area of agricultural land has been thoroughly surveyed and classified according the soil erosion risk. High risk and low risk areas are identified, and erosion risk maps are produced to help local advisors and administrators in planning and implementing soil conservation measures. Specific government supported programs for restoration of important landscape functions are implemented, e.g. for the establishment of sedimentation ponds, constructed wetlands and buffer zones between arable land and surface waters (BRASKERUD 2001, SYVERSEN 2002). A particular support program for soil conservation measures was established in early 1990's. Currently, around 40 % of the total area of cereals is included in this program, making farmers eligible for a particular support ranging from around NOK 500-1500 per ha land (depending on erosion risk). In cases of more severe erosion problems caused by overland flow and gully formation, the government may also provide support for the establishment of grassed waterways and improvements of various hydrotechnical installations, e.g surface water inlets. The use of economic incentives in combination with information and technical support has proven to be an efficient instrument in changing land management practices and last but not least, changing attitudes of the farming communities. There has been a rapid adoption and response for these environmentally motivated subsidies. This indicates that political decisions have a direct effect on landscape activities and landscape functions in terms of water pollution.

The EU Water Framework Directive is action oriented in the sense that its primary goal is to maintain or achieve good ecological status of water resources. It approaches quantitative as well as qualitative parameters, and expresses a strong intention of end-user and stakeholder involvement. Diffuse agricultural sources are throughout Europe the predominant cause of decreased water quality, and in some regions water abstraction for agricultural uses may affect water quantities and indirectly also qualitative parameters at unacceptable levels. In practical policy these issues would need to be combined with other considerations, e.g. the cost-efficiency of implemented measures, the viability of farming and rural societies, etc. Improved understanding of the variety in landscapes, the variability in soil-water interaction processes across scales and the cause-effect relationships linked to aquatic effects are fundamentals in watershed management and thus for the implementation of the EU Water Framework Directive. An integrated land-water approach will be necessary based on a systematic approach to the variety in landscape functions.

Conclusions

A strong public involvement in agriculture with the use of economic and legislative instruments have been a prerequisite for the maintenance of a rather small scale, decentralised property structure, and is likely to be needed in future also to avoid undesirable changes of the landscapes in Norway. Emphasis on diversity and variability aspects is a key message with regard to future challenges in landscape management, particularly in issues related to land use–water quality linkages.

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A Review of Sustainable Landscape Management in the UK

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Abstract

This paper provides a brief review of the principal issues of sustainable land management in the UK. The main focus of the review is on issues of soil quality, although water and air quality and biodiversity are also considered. In England and Wales alone, more than 70% of the land is used for agriculture. The other major landuses of the UK, after urban landuse, are commercial forestry, military, recreation, conservation, water collection and mineral extraction. With unsustainable management, all of these landuses experience common problems, including soil erosion and degradation, water, soil and air pollution, and reduced biodiversity. In addition to a general description of these threats, the principal systems and schemes created for the promotion of sustainable land management in the UK are presented.

Introduction

It is increasingly recognised worldwide that more sustainable approaches are needed for planning and managing landscape development and that new tools are needed to effectively apply sustainable principles in the environment (LEITAO and AHERN 2002). Sustainability refers to a better quality of life, enhanced air, soil and water environments and wiser use of natural resources (EA 2002), or, in the words of the UK government, to ensure "a better quality of life for everyone, now and for generations to come" (DEFRA 2002).

Unsustainable management of the landscape causes problems for soils, water, natural vegetation and wildlife, with knock-on effects on drinking water and food security. This review first discusses some of the principal issues of sustainable landscape management in the UK. This is followed by descriptions of some of the compulsory measures and voluntary incentive-based schemes available in the UK and designed to monitor practices and promote sustainable landscape management. The review cannot comprehensively discuss all of the problems or solutions, but should help provide an overview of some of the issues associated with the development of sustainable, functional landscapes in the UK.

Issues of sustainable land management in the UK

The issues with which landscape sustainability in the UK is concerned are best described in terms of the resources they affect. While environmental resources such as soil, water, air and biodiversity are crucial components of a co-ordinated strategic approach to sustainability, cultural aspects of the landscape, including archaeology, are also important. Many of these concerns are highlighted in Table 1, which details the recent progress of the UK's Environment Agency, a key partner in the delivery of the UK's sustainability targets.

Tab. 1: Environmental trends in the UK (EA 2000), © Environment Agency

	Some progress (1990 to 2000)	Lack of progress (1990 to 2000)
State of the environment 2000	• Urban air quality (some pollutants reduced) • General river and bathing water quality • Otter populations • Rare bird species • Acidification • Contaminated land recovery	• Rural air quality (ozone) • State of soils • Aesthetic quality • Water vole populations • Farmland and woodland birds • Salmon and marine fisheries
Continuing stresses on the environment	• Emissions from industry, environment and transport • Water and energy efficiency by industry • Discharges from sewage-treatment works • Inputs of contaminants to sea • Serious water pollution • Emissions from waste management sites	• Energy use and carbon dioxide emissions from road vehicles and aircraft • Household energy and water • Quantities and fly-tipping of waste • Radioactive waste stocks • Use of non-renewable resources

In the following, specific threats to sustainable soil systems, and to the quality of water and biodiversity, are reviewed. Soil degradation is one of the most crucial processes of land damage and environmental change: over a quarter of the world's agricultural land has already been affected by long-term soil degradation (LINIGER and SCHWILCH 2002). As soil health can be defined as the capacity of soil to sustain and promote plant and animal productivity and to maintain or enhance water and air quality (HERRICK 2000), the direction of change of soil health with time is a primary indicator of sustainable management (DORAN 2002).

Specific threats to the soil resource in the UK include contamination and pollution by pathogens and nutrients, soil erosion and flooding. Frequency, timing, intensity and duration of landuse, including agriculture, forestry and recreation, can also impinge upon soil quality (SSLRC 2000).

Soil erosion

Although soil erosion is a natural process, accelerated removal of soil by water, wind and frost action is encouraged when vegetation is removed and when landuse compromises the structural stability of the soil (EVANS 1996, MCHUGH 2002). One third of the arable area of England and Wales is estimated to be at moderate to high risk of erosion (EVANS 1996). In a survey of 300 ha of the uplands, meanwhile, MCHUGH (2000) measured soil erosion on 2.5% of unenclosed land above 250m.

The primary impact of soil erosion is the loss of a valuable resource but greater problems may be associated with the deposition of eroded material, including sedimentation within fish spawning gravels and loss of fish, decreased reservoir storage capacity, diminished water quality and increased costs of potable water supply. There are additional impacts when nutrients or pesticides are associated with the soil. Currently, one of the most topical impacts of soil erosion is the increased risk of flooding that occurs as a result of the reduced rainfall infiltration capacity of denuded hillslopes and of the inability of sediment-filled channels to deal with flood flows.

Soil contamination

The Environment Agency estimates there are at least 300,000 hectares of land contaminated by previous industrial use in England and Wales and recognises that this land presents a potential hazard to the general environment. As recent targets set by the Government demand that 60% of all new houses should be built on these "brownfield" sites to help preserve the countryside (EA 2002), reclamation of contaminated land is a priority. This move complements the EA policy on land conservation, which acknowledges that land is a limited resource and that the greatest value for much of the land in England and Wales is in tourism, environmental and economic terms (EA 2000). The principal sources of contamination of soils in the UK include heavy metals (lead, copper and cadmium), oil, fire ash and explosives.

In remediation of contaminated soils, it is important to prevent further damage, either on-site or elsewhere. In England and Wales, sustainable land recovery options, including the use of naturally occurring bacteria to bioremediate oil and fuel spills *in situ*, are being explored in favour of non-sustainable management options, such as removing polluted soil to alternative locations (EA 2002). Extraction of heavy metals by accumulating plants is currently in development for the "gentle" phytoremediation of contaminated agricultural soils (VON STEIGER et al. 1998).

Soil quality

In addition to the threats to soil of erosion and of loss to housing, industrial and infrastructural development, the quality of soils in the UK are adversely affected by a range of landuse practices. Machinery traffic can cause severe structural degradation and may result in surface runoff, restricted availability of water, oxygen and nutrients to plant roots and in reduced crop yields (WIERMANN et al. 1999).

The acidification of soil, through deposition of rainfall contaminated with acidic sulphur and nitrate, results in mobilisation of aluminium, loss of calcium and magnesium, compromised or complete loss of vegetation, and decreases in numbers of birds, amphibians and insects. Nutrient enrichment of soils, particularly by nitrate and phosphorus, occurs through inappropriate timings and quantities of fertiliser applications and poor agricultural practice, and causes eutrophication of watercourses. Soil and watercourses are also at risk of pollution from motorways and railways (RIVM 1992).

Soil organic matter in agricultural topsoils, derived from plant residues, organic manures, microbial biomass and soil microflora and fauna, plays a key role in maintaining soil quality, structural stability, water holding capacity and buffering capacity. The loss of soil organic matter from soils can lead to a decrease in structural stability and an associated increase in vulnerability to erosion. In Canada, studies showed that loss of soil organic matter and soil aggregate stability were standard features of unsustainable land use (CARTER 2002), with major implications for the functioning of soil in regulating air and water infiltration, conserving nutrients and influencing soil permeability and erodibility. In the UK, organic matter levels decreased in 904 arable or ley-arable soils by an average of 0.49% between 1980 and 1995 (SSLRC 1998). The largest declines were on grasslands ploughed for arable use, and on cultivated peaty or organic soils.

A further threat to quality of both soil and water comes from pathogens in agricultural slurries and manures, which make their way into water used for recreation or drinking. Farm organic materials are not only a rich source of nitrogen, phosphate and potassium (NICHOLSON et al. 2000) but also contain large numbers of pathogenic bacteria, many of which are harmful to animal and human health. Spreading manures when soil or weather conditions prevent incorporation of the organic material into the soil may be responsible for the failure of bathing water quality to comply with the EU Bathing Waters Directive (KAY et al. 1999).

Air and water quality

Water quality is threatened by a variety of pollutants, including nitrate and phosphorus, which have already been mentioned. Pesticides used in agriculture, horticulture, amenity land, public hygiene, wood preservatives, boat anti-fouling paints or veterinary medicines can contaminate river waters and groundwater even through approved uses (EA 2002).

As well as the threats to water quality from suspended sediment, and from sediment-associated nutrients and contaminants, poor land management greatly increases the risk of flooding (DOE 1995). Flooding is increasingly associated with poor land management practices and relatively minor rainfall events, with the potential for flooding modified by human presence and practices in the landscape (DOE 1995). Although the causes of floods depend on climate and basin characteristics, interactions between these, soil, vegetation and human activities has significant effects on erosion risk (DOE 1995) and when humans compromise soil and vegetation, the risk of flooding is even greater.

Groundwater provides 35% of abstractions used for potable supply in England and Wales, although this varies regionally (over 70% in the Southern Region). For the water industry, environmental sustainability means reductions in inputs, waste and emissions. However problems reported by the water authorities include cataloguing and measuring effects, assessing relative significance and making sensible choices between competing environmental claims and complex ecological interactions (EA 2002).

Compliance with air quality standards has improved in some parts of the country and, overall, tighter regulations and enforcement, as well as changing industrial practices have reduced emissions to air. Stresses continue, however: in 2000, for example, air traffic was reported to be growing by 4.5% per annum (EA 2000). Also in 2000, the EA reported widespread improvements in both water and air quality over the previous 10 years (EA 2000), with many rivers now support thriving fisheries and recovering populations of certain types of birds and otters.

Biodiversity

Intensification of farming systems in the UK in the last century has been responsible for widespread reductions in numbers of farmland birds and in semi-natural vegetation. In the uplands, overgrazing and afforestation have reduced the area of heather moorland, whilst lowland heaths have become fragmented and many wetlands have been drained, with associated loses in plant and animal species (EVANS 1996, PHILIPS et al. 1981). In Scotland, recent reviews of biodiversity have revealed considerable reductions in semi-natural vegetation communities, including heather moorland, grassland, woodland and open water, and increases in commercial forest plantations and arable land (USHER and TUDOR 1997).

Archaeological and cultural landscape features

Hedges, walls and ponds can be attractive landscape features of the countryside, provide a valuable habitat for wildlife, demarcate land and control livestock and can help reduce soil erosion. With the intensification of farming, many hedgerows have been removed to facilitate the efficient use of machinery, although government regulations now protect important hedgerows in England and Wales. Archaeological resources also under threat from landscape development include settlements, ancient monuments, field walls, defence structures and graves and other burial sites.

Achieving sustainable land management in the UK

The UK is unusual in the quantity, quality and scale of species and habitat data available for monitoring habitat quality, although differences in sampling methodologies between habitat and species surveys present difficulties for integrated monitoring systems or for nature conservation (CHALMERS 1997, GRIFFITHS et al. 1999). Problem-oriented planning in rural areas requires a holistic approach in which different spatial levels are combined (HERRMAN and OSINSKI 1999). Sustainable land use in agricultural systems may require the implementation of agricultural practices at the landscape level instead of at the field level (DI PIETRO 2001). In recognition that spatial scale and heterogeneity affect ecological processes, landscape ecologists have drawn on principles from both physical and human geography to focus on the interrelation between landscape structure (pattern) and function (processes) (KUPFER 1995). Geographical information systems and modelling approaches are very efficient for doing this. Such systems have been successfully used to assess the environmental sensitivity of land and to prioritise land for conservation protection (LATHROP and BOGNAR 1998). DROOGERS and BOUMA (1997), meanwhile, combined soil survey information with dynamic simulation models to define indicators for sustainable land management and highlighted the importance of pedological input in sustainability studies.

Tools are also needed for assessing the effects of human activities and for monitoring the impacts of rural development projects on land quality, functionality and sustainability at the landscape scale. The impact monitoring procedure presented by STEINER et al. (2000) involved seven basic steps: identification of stakeholders, identification of core issues, formulation of impact hypotheses, identification and selection of indicators, selection and development of monitoring methods, data analysis and assessment of sustainable land management, as well as information management. LEIBOWITZ et al. (2000) proposed a linear transport model to assess the landscape-level effects of impacts to the functioning of a given ecosystem unit.

Any comprehensive landscape valuation requires the integration of ecological, economical and social values (KRAUSE 2001). In line with this, the UK government developed a set of indicators of sustainability (MAFF 2000) and provides continuously updated reports on progress by the UK towards sustainable development (DEFRA 2002). The design and use of such indicators can be extremely useful in that they allow those involved in the discussion of sustainability to identify and assign weights to the key aspects of sustainable agriculture (RIGBY et al. 2001). The general set includes such indicators as emissions of greenhouse gases, populations of wild birds, conditions of Sites of Special Scientific Interest (see Table 2), household waste and recycling and river water quality.

The UK government have also developed a specific set of indicators for sustainable agriculture, defined as ensuring the availability of food whilst maintaining an economically viable rural society, prudent use of natural resources, landscape, wildlife and cultural conservation and animal welfare (MAFF 2000). These specific indicators include land converted to organic farming, nutrient and pesticide concentrations in soil and water, organic matter and heavy metal content in soils, farmer commitment to conservation, bird populations and the area of semi-natural vegetation. A review of each of these indicators will be completed every five years, with the first review in 2003.

Currently sustainable landscape management by individual stakeholders in the UK relies upon *ad hoc* uptake of a variety to schemes and proposals. A variety of national bodies have sustainable long-term objectives, which include minimising waste, increasing reuse, recycling and efficient use of energy and materials, reducing exposure to pollutants, promoting healthy, nutritious food production without damaging wildlife or human health and restoring contaminated land. Although there is currently little concerted action from the general public, this may change in the future as the benefits of sustainable management are recognised and schemes are expanded and connected. Table 2 summarises some of the key measures available to policy-makers to enforce and encourage sustainable management, and to stakeholders wishing to practice sustainable management of land in the UK. As research in Germany demonstrated, restoring, creating and connecting a variety of smaller ecosystems within a landscape contributes significantly to stabilising the landscape and improving overall ecosystem functioning (SCHULLER et al. 2000). Such a comprehensive, participatory approach involving stakeholders and local knowledge, monitoring, information and training (HURNI 2000) has enormous potential for the development of sustainable management solutions within a favourable environment.

Tab 2: Some of the key schemes and actions promoted in the UK to encourage sustainable landscape management

Agri-Environment Schemes	A range of incentive-based schemes designed to encourage environmentally friendly farming and practices sensitive to wildlife, archaeology, landscape and access. The two main government schemes are the Environmentally Sensitive Area scheme (ESA) and the Countryside Stewardship Scheme (CSS).
Biodiversity Action Plans (BAP)	The UK BAP was created in response to the Rio Summit and recognises 391 species and 45 habitats as priorities for conservation and enhancement. Every region, county and local authority has been encouraged to produce a BAP tailored to the needs of the local biodiversity resource and contributing to the delivery of the national BAP.
Common Agricultural Policy Livestock subsidy scheme	These are headage or area-based and comprise the Hill-Farming Allowance, Sheep Annual Premium, Suckler Cow Premium and Beef Special Premium schemes. Whilst headage payments have been criticised for encouraging overgrazing, payments to individual farmers can be withheld if the numbers of grazing animals have been shown to cause damage to sward quality or biodiversity. Extensification payments are also available to encourage farmers to graze stock at sustainable rates.
Codes of Good Practice (for Air, Soil and Water)	These three codes were designed to provide the farming industry with a benchmark of good practice and good advice on how to avoid pollution while farming profitably.

Farm Waste Management Plans	To reduce pollution arising from farm manure management, these plans encourage farmers to manage the land application of solid manure, slurry and dirty water so as to avoid run-off to surface or ground waters.
Local Environment Agency Plans	LEAPs are being prepared for each catchment in England and Wales. Each contains a Consultation Report describing the vision for the catchment and an Action Plan that represents ongoing dialogue between the EA and environmental individuals and organisations to identify actions necessary to resolve catchment problems.
Nitrate Vulnerable Zones	These zones have been identified as vulnerable to nitrate loss from land to water and non-compliance with the EU Directive on Nitrate Pollution (Directive 91/676/EC). Strict management guidelines are issued for NVZs.
Sites of Special Scientific Interest:	Certain areas of land may be designated as a SSSI for their wildlife or geological interest. Notification as an SSSI is primarily a legal mechanism to protect sites of particular conservation interest.
Tir Gofal	Voluntary whole-farm agri-environment scheme, available in Wales, to encourage agricultural practices that protect and enhance the landscape, its cultural features and its wildlife.

Sustainable land management in the future

One of the most significant recent trends in environmental management in the UK is that it increasingly takes a holistic view of the environment where, rather than dealing with individual problems, an approach based on the concept of sustainable development is used (MURLIS 1997). However, defining landuse sustainability is complex and may require the application of concepts such as Human Carrying Capacity to integrate the different dimensions involved in sustainable land use whilst allowing effective environmental planning and management (ISKANDER 1999).

Modulation, in which direct production payments are transferred towards public goods, occurs to a small degree in the UK and helps to pay for the Rural Development Programme in England which, along with similar agri-environmental schemes, is oversubscribed. Reform of the Common Agricultural Policy, to refocus on environmental and other public goods rather than on subsidising overproduction, was encouraged by the POLICY COMMISSION ON THE FUTURE OF FARMING AND FOOD (2002). It was also recommended that, for as long as direct payments are continued, they should be decoupled from production and cross-complied with environmental standards (POLICY COMMISSION ON THE FUTURE OF FARMING AND FOOD 2002).

Further research is also required, both into specific topics, such as increasing the power of soil quality indicators to predict the capacity of soil to function under a range of disturbance regimes, and into more general indices of sustainability. Such research and its outcomes should be accessible to land managers, conducted within a landscape context (HERRICK 2000) and encompass as wide a range of indicators of sustainability and functionality as possible.

Conclusions

Sustainable development and sustainable land management have been receiving increasing attention around the world (HURNI 2000), although practical tools which can help understand and apply these general concepts at local and regional levels have emerged only recently.

In the UK, a combination of relatively small land area and large population has resulted in intensive use of the landscape. Sustainable management of that landscape is, therefore, vital to ensure its availability for future generations.

The UK government's policy on sustainable development aims to ensure a better quality of life now and into the future by addressing four objectives relating to progress in society, protection of the environment, sensible use of natural resources and high employment and economic growth. Progress towards sustainable development is measured by a system of indicators, which prioritise issues such as climate change, and contamination of air, water and soil. Today, agreed standards of water quality remain to be achieved and both urban and rural air quality in England must be improved (EA 2000). Of continuing concern are the loss and degradation of natural habitats and diminished aesthetic quality of the environment, which is important to overall quality of life.

Only a comprehensive, participatory approach will have the potential to develop sustainable management solutions within a favourable environment. This, and resistance to change, particularly when associated with cost (GUERIN 2001), is one of the biggest challenges facing researchers and policy-makers who wish to improve the sustainable use of landscapes.

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Land Management in a Period of Transformation in Poland

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Abstract

Land use structure in Poland is dominated by agricultural land and forests. The highest proportions of land are assigned to agriculture in those areas in which such use is favoured due to soil conditions and/or a high proportion of rural population. The last decade has witnessed a decline agricultural land use, to the benefit of forest and other uses. An intensification of this trend is to be expected in the coming years.

Above, there have been major changes of ownership since 1989. The collapse of the State Farms brought a major transfer of land resources into private hands via the intermediation of the Treasury Agricultural Property Agency.

Land prices vary greatly from region to region, with the costliest land being in urban and suburban areas. Most of the times, new owners are seeking to take land out of agricultural use in order to possibly gain higher prices from its sale.

Introduction

The changes in the political and economic systems of Poland went along with the associated transition from central steering of economy to free market. This gave rise to a series of processes connected with the adaptation of society and economy to the new conditions. What has been subject to transformation is the entire economic system of the country, as well as particular facets of it. In association with that, changes within land use – which is one of the main manifestations of human activity - are also in progress. The changes concerned are first and foremost ones of ownership, which are linked with the fall of the State Farms and the recovery of lost property following the Second World War. Partly in connection with these factors, there is a steady decline in agriculturally used land to the benefit of other forms of use.

The spatial differentiation of land use

Natural conditions favouring agriculture, an increase in the number of people and a relatively low level of economic development (compared with Western European countries) are all elements that have previously led to a rapid increase in agriculturally used land in Poland (BAŃSKI 1998). This mainly occurred at the expense of forests; to the extent that the occupation of ever-greater areas of agriculturally used land led to excessive deforestation in many parts of the country. As a result, the landscape changed from diverse natural vegetation to monocultures.

Until today, agricultural land has remained the dominant form of land use in Poland (tab. 1). It is above all concentrated in the uplands (Malopolska and Lubelska), where natural conditions are highly suitable for agriculture. The result is that more than 80% of such areas in the country have been brought under agricultural management (fig. 1).

Tab 1: Land use in 2000
Source: Statistical Yearbook 2001, Central Statistical Office, Warsaw, Poland

Category	Area (`000 ha)	Share of total land	Ha per inhabitant
agricultural land	18540	59,3	0,48
Forests	9094	29,1	0,24
Waters	833	2,7	0,02
Roads	959	3,0	0,02
Settlement	1050	3,3	0,03
waste land	49	2,5	0,01
Other	38	0,1	0,0

An equally high concentration of agricultural land is to be found in central Poland. Here, the quality of productive agricultural space (abbreviated to *jrpp* in Polish) is not as favourable as in the uplands. Thus, the fact that a high share of the land has been brought under agricultural use must rather be associated with non-natural factors like the high proportion of rural population, limited industrialization and conditions stretching back to the times of Poland's partitioning between Prussia, Russia and Austria.

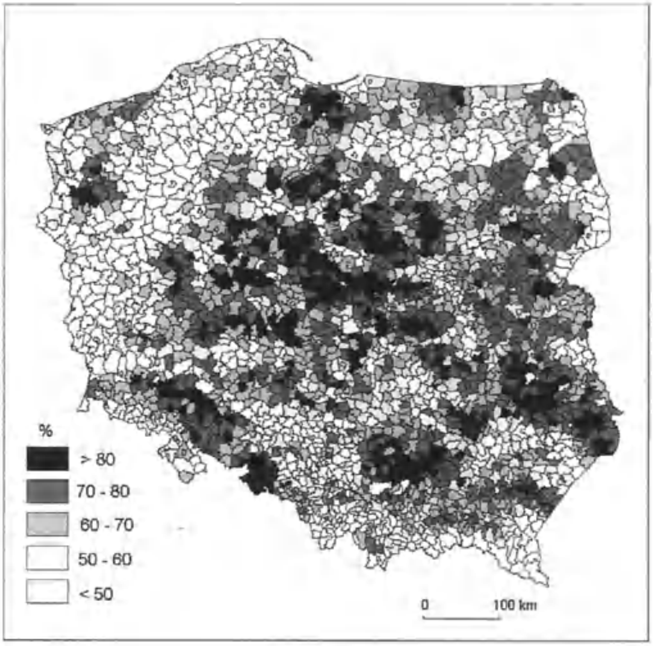

Fig. 1: Share of agricultural land in the total area of communes, 1999
Source: Central Statistical Office, 2000, Warsaw, Poland

The purposes to which agricultural land is put vary markedly from area to area in connection with different agroecological conditions and socioeconomic development. Natural conditions retain the leading role. The linear correlation coefficients calculated for the relationship between the above mentioned *jrpp* index and the share of different categories of land use in more than 2000 of Poland's gminas (units of local government administration) are as follows:

arable land +0.479 (+)

orchards +0.156 (-)

meadows -0.478 (+)

pastures -0.384 (+)

This shows that the quality of agroecological conditions exerts the greatest influence on the distribution of arable land and grasslands. The share of the former in agricultural land use structure is greater where the quality of agroecological conditions is relatively favourable/more favourable. The reverse situation applies in the case of grasslands, most especially meadows.

Crop production plays a very important role in Polish agriculture (fig. 2). Arable land is concentrated in areas with good soil conditions. Its share in agricultural land even exceeds 90% within the above mentioned areas - a situation that must be regarded as unfavourable, since it encourages soil erosion, steppification and a deterioration in water relations.

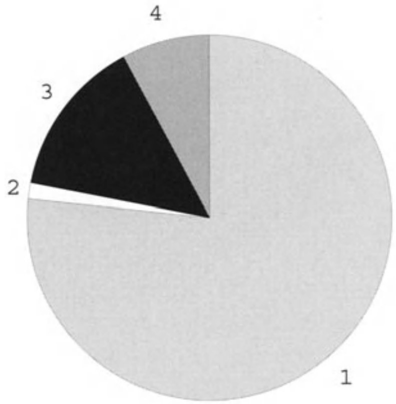

Fig. 2: Structure of agricultural land, 1999
1-arable land, 2-orchards, 3-meadows, 4-pastures
Source: Statistical Yearbook 2000, Central Statistical Office, Warsaw, Poland

The fact, that there is only a small area of orchards results not only from relatively unfavourable cultivation conditions offered by nature, but also from the lack of any great tradition and experience in the pursuit of this kind of activity. There are only a few parts in the country (like the Vistula valley) with larger areas of orchard cultivation.

The share in Polish agricultural land that is taken by agricultural grasslands seems to be relatively low. Little urbanization, rural overpopulation and limited opportunities to find work in other branches of the economy have all contributed to encourage the agricultural population to bring every scrap of land under field cultivation. A generally fragmented agriculture with substantial labour force shows a preference for field cultivation, to the point where only a little over 20% of all agricultural land currently takes the form of grasslands (STOLA and SZCZĘSNY 1982).

Poland's more than 2 million farms have an average area of just about 7 ha. The most fragmented farming is to be found in the south-east, where farms rarely cover more than 4 ha (fig.3). A further problem is created by the mosaic or checkerboard patterns of land ownership. It is by no means uncommon for a farmer to own 10-20 small pieces of land, all situated in different places.

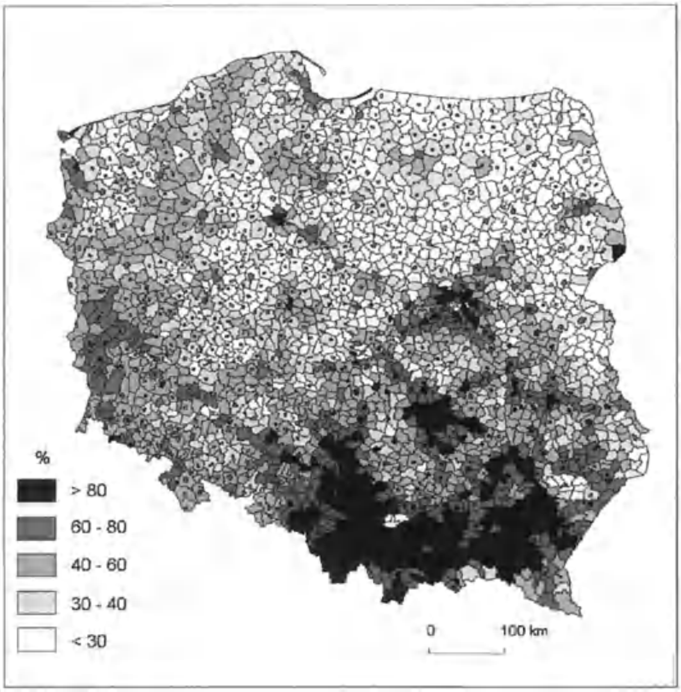

Fig. 3: Share of private farms under 5 ha in the communes, 1996
Source: National Census, 1996, Central Statistical Office, Warsaw, Poland

The area under forests or planted trees amounted to 8,970,000 ha in 1999. The highest level of forest cover is to be found in the west and north-west of Poland, as well as in the mountainous areas. In contrast, the share taken by forests in the centre of the country falls well below the national average, with many areas having cover of less than 10%.

Coniferous species prevail in approx. 77% of the forest by area, with Scots pine being predominant (accounting for c. 65% of the area). This is in fact the main species across the Polish Lowland, and it is only in mountainous areas or - to some extent – in the uplands, that a more diverse species composition of tree stands holds sway.

Other forms of land use include settled areas, areas associated with transport, waters, mining areas, and wastelands of various sorts. The first two categories are naturally concentrated in urban and suburban areas (especially in Warsaw, Łódź and the Tri-City of Gdańsk, Gdynia and Sopot), as well as in the industrialized agglomerations (of Silesia, Tarnobrzeg, Bełchatów, etc.). Waters and wastelands take up the greatest areas in the Lakeland and in the Baltic coastal belts. Elsewhere, the share taken by other forms of land use does usually not exceed 5-6%.

The dynamics of land-use transformations since 1989

The last few years have brought a small but steady decline in agriculturally used land (Fig. 4). As a consequence, all other categories of land use have become better represented.

In general, the poor-quality agricultural land has been designated for afforestation or other kinds of tree planting. It is anticipated that some 680,000 ha of land nationwide will be excluded from agricultural production and afforested, though at present, the process of transformation is very slow and is likely to remain so.

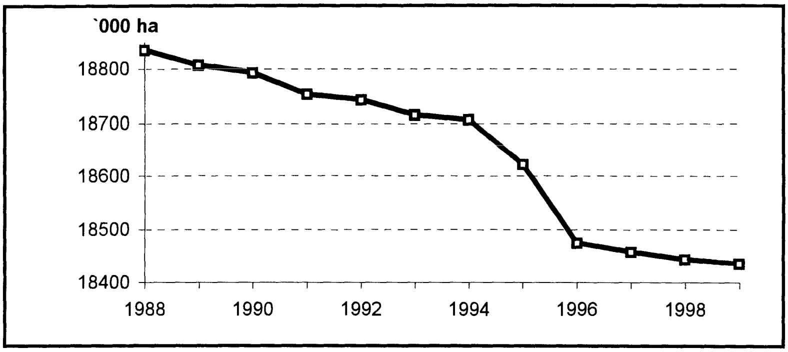

Fig. 4: Area of agricultural land, 1988-1999

The 1990s did not bring major changes to the structure of agricultural land use. However, within the agricultural category, there was a decline in arable land and meadows, with concomitant increases in orchards and pastures. Similar processes had been observed previously (BAŃSKI 1992).

The planned afforestation of agricultural land is leading to an increase in forest cover (Fig. 5). However, as has been mentioned, this increase is not satisfactory, as the area of forest per inhabitant still continues to fall.

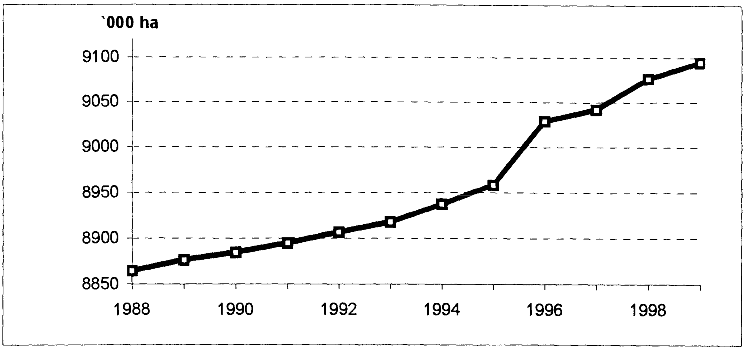

Fig. 5: Area of forests, 1988-1999

The increase in non-agricultural land has tended to occur evenly across the period i.e. without fluctuating markedly. On this basis, a constant process that will also characterize the coming years can reasonably be considered. While its intensity remains hard to foresee, in the light of dynamic economic development, the expansion of urban areas, the planned construction of modern transport networks, the need to adjust agriculture to EU requirements and the "loss" of agricultural land since 2000 can probably be expected to increase quite sharply compared with the situation in recent years.

Ownership changes

The historical past brought breaks in ownership rights of land in Poland. The systemic changes in the country after World War II for example saw the state take large areas of land unlawfully from their owners (dispossessions and partition of large-scale farms). Attempts are now being made to return land, or else to compensate those who lost it in the past.

After World War II, traditions of family farming and attachment to land were the main barriers within the processes of collectivizing and nationalizing land. In fact, Poland diverged ever further from her Eastern Bloc neighbours in that most of her land remained in private hands.

Still, the state sector came to account for a large share in agricultural land within northern, western and south-western parts of the country (more than 40%). This situation reflected historical conditions, as the cessation of wartime hostilities and the subsequent shifting of borders left huge areas of land without owners in the west and north. Formerly German areas of farmland or fallows were thus taken over by the State Farms.

The return to democracy led to further major changes in land-use structure from 1990 onwards. The nationalized sector in agriculture collapsed, with considerable areas of land being taken back by individual farmers. While the state-run agriculture still actively managed nearly 24% of Poland's agricultural land in 1989, this figure fell to just 7% by 1996 (although the state still owned approx. 20% of all agricultural land). The Treasury Agricultural Property Agency established in 1992 took on the State Farms land that had been closed down, and some of this has been bought back by, or rented out to, individual farmers. Still, in the face of lacking *de facto* owners, a considerable part of the land remains fallow (JASIULEWICZ 1998).

Tab 2: Agricultural land by ownership
Source: Statistical Yearbook 1998, Central Statistical Office, Warsaw, Poland

Detail	1990	1997
private sector	14233	14506
in this: private farms	13497	14112
cooperative	736	394
Public sector	4551	4102

While farmland is mostly private, forests overwhelmingly remain in state hands: in 1996, 83% of all forests were in the public sector. Almost all forests are state-owned in those parts of the land which were gained from Germany after the War. This is in great contrast to Central and Eastern Poland, where large parts of forests are private.

Conflicts in land management

One of the more important conflicts to have emerged in land management is that which occures where land can be used by either agriculture or forestry. The areas poorest in forests are mainly those where agricultural production is intensive, leaving other forms of economic activity subordinated to it.

However, the strongest conflicts over land use are those occurring in the suburban zones of larger cities. Among the processes in operation here are two that are in opposition, namely an absorbent market stimulating agricultural intensification and an increase in agriculturally used land, along with a growth in size and population of cities which leads to a steady loss in such land (BAŃSKI 1998a). Rising land prices favour a cessation of agricultural use and the transfer of land to other economic purposes (WĘCŁAWOWICZ 1996).

Since about 30% of Poland is now protected in one way or another, it is inevitable that conflicts will arise on designations and the use of land in agriculture, industry and transport, especially since the latter tends to pollute the former, along with destroying or distorting natural forms of landscape (DEGÓRSKA 2001).

Another conflict is that concerning land ownership. Poland has certain land-hungry areas, as well as other parts in which land is going spare and left fallow. The degree of attachment to the land also varies, *inter alia* on account of the ownership situation. The greatest demand for land is to be noted in areas of high population density with high-quality natural conditions. Here, conflicts arise easily. In contrast, depopulated areas with poor agroecological conditions face quite the opposite situation, as considerable areas of land are left unowned and unmanaged.

The market for land

Investors are first and foremost interested in urban areas, above all Warsaw and Poznań. However, land prices there are that high that many investors get attracted by land in smaller urban centres or even rural areas.

The greatest turnover in land is characterized in northern Poland, where ground formerly in the hands of the State Farms can be bought relatively cheaply. Such land is also of interest to foreigners - mainly German, Dutch and Danish citizens - although their acquisitions are a frequent source of mistrust and dissatisfaction among Poles. In the course of negotiations with the EU, those fears have translated into a 12-year protective period which concerns the sale of agricultural land to EU companies and non-farmers. In practice, such limitations on the purchase of land by foreigners can be evaded by way of numerous "informal" methods, such as the "fictional marriage" with a Polish citizen or the putting forward of a fictional purchaser who is Polish.

Land prices vary markedly from place to place. The highest value is put on land within large urban agglomerations, though turnover is minimal in this case. Where smaller localities are concerned, the land sold at the highest prices is that in the vicinity of Warsaw, where figures of up to 400 zł per square metre can be encountered. Hotels, restaurants and warehouses can be built there, but not industrial objects. Land in the Warsaw area on which factories can be built tends to cost between 60 and 200 zł per square metre.

Further expensive land is that surrounding spa towns or other areas of interest to tourists. Sites upon which a guesthouse or restaurant can be built go for between 30 and 120 zł per square metre, depending on the locality. Land for agrotouristic use is much cheaper, with a square metre costing between 1 and 3 zł. in the region of the Karkonosze Mountains.

The last decade has brought increasing interest in the construction of second homes on recreational plots. Land for such purposes is mainly falling into the hands of the inhabitants of large cities like Warsaw, Łódź and Kraków. The greatest interest are shown in such touristically-attractive areas as the Carpathian and Sudety Mountains and the Mazurian Lakes region, as well as in afforested suburban areas. Agriculture is dispensed with on such (usually low-quality) land, which is then sold to the purchaser at very high prices. During the last ten years, the prices for such land in the most attractive places have increased between several fold and 10-20 times.

The prices of agricultural land are markedly lower, and above all, dependent on quality, location and parcel size. The average cost of 1 ha sold in 1998 was 4379 zł. Record prices are those obtained in the former voivodship of Warsaw (86,000 zl per hectare on average). In contrast, the land resources of Treasury agricultural property are sold at the lowest prices in the former Tarnobrzeg, Chełm and Krosno voivodships (at c. 1300-1400 zl per ha).

Conclusions

Poland's land-use structure is dominated by agricultural land and forests. The distribution of the former largely depends on agroecological conditions and population density. The highest proportions of the land are assigned to agriculture in those areas in which such use is favoured by soil conditions or high population density. This situation poses many problems, notably agrarian fragmentation and mosaic ownership, excessive deforestation and an unfavourable structure to the benefit of agricultural land use.

The last decade has witnessed a decline in agriculturally used land to the benefit of forest and other uses. An intensification of this trend is to be expected in the coming years.

Above, there have been major changes of ownership since 1989. The collapse of the State Farms brought a major transfer of land resources into private hands via the intermediation of the Treasury Agricultural Property

Agency. Those who are leasing or buying land include a certain number of citizens of other countries.

Land prices vary greatly from region to region, with the costliest land being in urban and suburban areas. Most of the times, new owners are seeking to take land out of agricultural use in order to possibly gain higher prices from its sale. Still, demand is exceeding supply, to the extent that interest in land to be available in rural areas or small urban centres is growing.

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Studies on Agricultural Landscape Management in Western Poland Plain

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1 Rationale for a landscape approach in the reconciliation of agriculture and environment as well as the protection of living resources

1.1 Ecological evidence for environmental hazards caused by agriculture

Increasing production farmers subsidise energy in order to simplify plant cover structure both within cultivated fields (selection of genetically uniform cultivates and elimination of weeds) and within agricultural landscape (elimination of hedges, stretches of meadows and wetlands, small mid-field ponds). Animal communities are also impoverished in cultivated fields. Farmers interfere with the matter cycling in agroecosystems directly by inputs of fertilisers, pesticides, etc., or indirectly by changing water cycling and decreasing holding capacities of soils for chemical compounds. In addition agricultural activity often leads to decrease of humus contents. Powerful machines used in modern tillage technologies not only strongly affect upon soil properties but also enable land surface levelling, modification of water drainage systems etc., which leads to changes in geomorphological characteristics of the terrain. All these effects of farming activity result in the development of a less complex network of interrelations among the components of agroecosystems. As a consequence of this simplification, relationships among agroecosystem components are altered, so that there is less tie-up in local cycles of matter. Thus increased leaching, blowing off, volatilisation and escape of various chemical compounds and materials from agroecosystems should be expected (RYSZKOWSKI 1992, 1994, RYSZKOWSKI et al. 1996).

Many environmentally significant effects of agricultural intensification in order to obtain higher yields are connected with the impoverishment or simplification of the agroecosystems structure. Such ecological analysis leads to a conclusion of major significance for a sustainable development of rural areas. Applying intensive production methods farmers cannot prevent such threats to countryside as leaching, blowing-off, volatilisation of various chemical compounds, which cause an increase of diffuse pollution of ground and surface waters, evolution of greenhouse gases (N_2O, CO_2) and water or wind erosion. It must be clearly stated that although farmers can moderate the intensity of these processes through proper selection of crops and tillage technologies, they are not able to eliminate them entirely regardless if they use integrated, intensive or organic farming system.

The higher control efficiency of environmental threats evoked by agriculture could be achieved by structuring agricultural landscape with various non-productive components like hedges, shelterbelts, stretches of meadows, riparian vegetation, small ponds and so on. Therefore, any activity to maintain or increase landscape diversity is important not only for aesthetics and recreation reasons, but even more so for environment protection, and by the same for the protection of living resources in the countryside.

1.2 Policy for the integration of agriculture with environmental protection

The above considerations lead us to conclude that activities aiming at optimisation of farm production and environment as well as biodiversity protection should be carried out in two different but mutually supportive directions. The first one involves actions within the cultivated areas. Their objective is to maintain possibly high level of the storing capacities of soil and to preserve or improve its physical, chemical and biological properties. It includes agrotechnologies, which increase humus resources or counteract soil compaction, and rely on differentiated crop rotations. Integrated methods of pest and pathogen control and proper dosing of mineral fertilisers adapted to crop requirements and to chemical properties of soil allow to diminish to same degree non-point pollution. The effectiveness of so directed activities, which could be called methods of integrated agriculture, depends on good agricultural knowledge.

The second component of the integration programme of farm production and nature protection is the management of landscape diversity. It consists in such differentiation of rural landscape as to create various kinds of so called biogeochemical barriers, which restrict dispersion of chemical compounds in the landscape, modify water cycling, improve microclimate conditions and ensure refuge sites for living organisms. In landscapes having mosaic structure higher inputs of fertilisers can be safely applied than in homogenous ones which are composed of arable fields only. This is a very important conclusion for the program of sustainable development of the countryside. Implementation of those landscape ecological guidelines into the integrated agriculture policy will help to develop new environmentally friendly agro-technologies which at the same time enable intensive production balanced with the ability of natural systems to absorb side effects of agriculture without being damaged. Saving natural capital of resilience capacities of environment the farmers will increase competitiveness of farms in a similar way as Jacques Delors – former president of the European Commission - showed in the so called White Paper (1993) that improving environmental performance in industry increases its competitiveness at the world market. Adoption ecological guidelines for sustainable development will also help to save the Central and Eastern European Countries (CEEC) agriculture against errors of the Common Agricultural Policy (CAP) which led to serious environmental problems in the European Union (EU).

Such policy requires redefinition of accepted up to present conceptions. The emphasis on an increase of production and its economical protection without much respect for interrelations of processes and interests should be changed to more holistic one including environmental issues. The heart of dilemma at national level is the failure of economies to elaborate efficient ways for incorporation of environmental costs into proposals for rural areas development.

During the 2nd Pan-European Seminar on Rural Landscapes held in Poznań (Poland) in 1995 (RYSZKOWSKI et al. 1996a) the conclusion was adopted and then approved by the Council of Europe that "The diversification of activities in rural areas be it on farm or off farm will be a key issue for implementation of multifunctional role, which should play the farmer implementing new integrated policy of agriculture". Thus landscape approach for integration of agriculture and environment protection was clearly recognised.

This issue was recently expanded in the communication of the Commission of the European Communities (COM 1999, 22 final) on "Directions towards sustainable agriculture".

The Commission of the European Communities considering more efficient steps for an integration of environmental elements into CAP found that "comprehensive analysis of a landscape enables identification of all processes and features in a holistic way". This new approach to the CAP should help to elaborate guidelines for policy on sustainable development of rural areas. The competing interests of agriculture and nature protection could be easier balanced with positive elements maximised and negative aspect reduced within the landscape framework of analysis. It seems therefore that landscape issues are strongly incorporated not only in scientific but also in political analyses of the modern agriculture (COM 1999, 22 final).

1.3 Need for a landscape approach in the development of agriculture

The recent progress in agroecology and especially in studies on agroecosystems and rural landscapes functions like energy flows, matter cycling and maintenance of biodiversity have shown that the following threats to environment and protection of living resources can not be efficiently controlled only at the farm level but have to be additionally curbed by management of the landscape diversity:

- decrease of water shortage
- increase of pollution from non-point sources
- soil erosion
- impoverishment of plant and animal communities.

The protective activities within farm can only moderate the generation of those threats (e.g. by reasonable use of fertilizers, regardless if organic or industrial origin ones are applied). Because of interconnectivity of water fluxes in phreatic aquifer of the whole watershed, widespread ground water migration of chemicals leached out from soil of one farm will appear. Due to large ranges of biota dispersion, the protective activities within small farm are not sufficient to achieve protection of living resources in agricultural landscape. Thus protection activities carried out at the landscape level should enhance environmentally friendly technologies applied on farm level.

The higher control efficiency of environmental threats evoked by agriculture could be achieved therefore by structuring landscape with various non-productive components like shelterbelts, hedges, stretches of meadows, riparian vegetation strips, small mid-field ponds or wetlands and so on. That is by management of total landscape.

It was shown that biogeochemical barriers effectively control diffuse pollution (see for example HAYCOCK et al. 1997, RYSZKOWSKI et al. 1990, 1996, 1997) and protect biodiversity (e.g. RYSZKOWSKI and KARG 1997, RYSZKOWSKI et al. 1998) as well as influence water storing capacities in the landscape (RYSZKOWSKI and KĘDZIORA 1996, KĘDZIORA and OLEJNIK 2002).

Diversification of the agricultural landscapes by introduction of biogeochemical barriers should be implemented in new Common Agricultural Policy of the EU. The emphasis on the landscape management programmes should be therefore considered as very important element of the CAP.

2 Examples of landscape research in Western Poland

2.1 Heat and water balances

The shortage of water in rural areas is very serious environmental threat in Poland. The threats caused by water deficits are not as spectacular as air pollution impacts nevertheless they produce real menace during warm and especially dry plant growing seasons. In dry years water deficits evoke problems in many farms located in the Central Lowlands of which western part is the corn-belt of Poland (Wielkopolska – Kujawy region). The problem is all the more urgent as water shortage is not adequately recognised in the environment protection programs. Presently emphasis is given on engineering aspects of water management by building large water reservoirs or digging small ponds storing water in the countryside. Beside that the drainage programme under development is mainly aiming at fast removal of water from fields after spring thaws or heavy rains. The options for slowing down fluxes of precipitated water by structuring plant cover in agricultural landscapes are practically neglected despite the fact that such possibilities were indicated by scientists.

The new developments in micrometeorological technology enabled scientists to develop new methods for estimation of heat and water balances under field conditions (KĘDZIORA et al. 1989, OLEJNIK and KĘDZIORA 1991, RYSZKOWSKI and KĘDZIORA 1993, KĘDZIORA and RYSZKOWSKI 1999). The studies carried out at the Research Centre for Agricultural and Forest Environment and at the Chair of Agrometeorology of Agricultural University in Poznań led to the elaboration of a model estimating the heat balance for a large area. Empirically estimated balance fluxes (energy use for evapotranspiration, air and soil heating) were correlated with meteorological characteristics and the parametrization of plant cover structure. Use of the model makes it possible to estimate for a given habitat the effect of plant cover structure on real evapotranspiration as well as on air and soil heating for a particular meteorological regime in the course of the year.

It was shown that shelterbelts use nearly 3 times less energy for air heating than cultivated fields. Thus cultivated field can be called the landscapes “ovens”. At the same time shelterbelts or forests used about 50 per cent more energy for evapotranspiration than cultivated fields. Grasslands show intermediate values. So trees function as "water pumps" in respect to water cycling in the landscape. According to estimations obtained for agricultural landscape during the plant growth season (20 March till 31 October) evaporated water from coniferous forest patch was more than 200 litter per 1 m^2 higher than in wheat field. For mid-field shelterbelt this difference was almost 180 litters per 1 m^2 (Table 1). Almost in all studied situations evaporation during plant growth season in Wielkopolska region is higher than precipitation. Thus the storage of winter precipitation importantly contributes to soil moisture during summer season. The building up of water storage capacities in the landscapes of the region therefore plays an important role in the sustainable management of the Wielkopolska countryside.

Tab. 1: Real evapotranspiration rates in mm (litters per 1 m^2) during the plant growth season in various ecosystems of agricultural landscape in Wielkopolska region

Ecosystem	Evapotranspiration (E)	Precipitation (P)	(E:P) x 100
Coniferous forest	616	440	140
Deciduous forest patch	552	440	125
Shelterbelt	578	400	144
Meadow	460	400	115
Rape seed	430	400	107
Sugar beet	418	400	104
Wheat	400	400	100
Bare soil	319	400	79

The introduction of shelterbelts into uniform agricultural landscape composed mainly by cultivated fields is one of the best tools for managing heat balance and water regime in the landscape. The evapotranspiration rates, surface runoff and percolation of the water across the soil profile are quite efficiently controlled by the plant cover. High infiltration capacity of soil under permanent vegetation strips and resistance to flowing water effected by plants significantly reduces surface runoff. In landscapes with shelterbelts or strips of meadows the runoff is low excluding events of very intensive rainstorms. In these areas the subsurface outflow is relatively high in comparisons with surface runoff and is very stable over the time. In contrast the surface runoff in row crop fields or in grain crop fields is intensive and rapid. In uniform agricultural landscape the surface runoff is born quickly, lasts short time and often effects erosion. So introduction of diversified plant cover structures affects both evapotranspiration as well as runoff fluxes of water in the landscape.

These long-term studies have shown that plant cover structure is a factor which channelling solar energy increases the diversity and variability of energy and water fluxes within various ecosystems of the landscape. One of the interesting result of the studies is disclosed fact that air heat fluxes induced by the different rates of solar energy conversion into air heating (for example over cultivated fields and shelterbelts) form thermal gradients which influence on air movement. Air movement forced by these gradients could transport energy from cultivated field to shelterbelt. This effects is documented by very high rates of evapotranspiration in shelterbelts. Such influx of additional heat energy can enhance transpiration rates in shelterbelts. Thus, the heat balance of the entire landscape will not be a simple sum of heat balance components of all ecosystems treated separately but must be considered as a result of various interactions.

The methods as well as models reported above can be useful for appraisal of plant cover structure in landscapes for management of water resources.

2.2 Scientific grounds for diffuse pollution control

The cleansing effect of vegetation on subsurface and overland fluxes of chemical compounds carried by water was first shown in the case of riparian vegetation strips (e.g. PETERJOHN and CORRELL 1984, LOWRANCE et al. 1985, HILLBRICHT-ILKOWSKA et al. 1995, CORRELL 1997, HAYCOCK et al. 1997). Those and many other publications showed, that ground water passing through the riparian buffer zones was cleansed of chemical compounds due to biostorage, soil sorption capacities, denitrification in the case of nitrogen compounds, and filtration of suspended particles in a case of oversurface flows.

Long-term studies carried out in the Research Centre for Agricultural and Forest Environment in Poznan, Poland indicated that shelterbelts (mid-field rows or patches of trees), stretches of meadows and small mid-field water reservoirs located in upland parts of watersheds also impact on the chemistry of water passing by (BARTOSZEWICZ 1990, 1994, BARTOSZEWICZ and RYSZKOWSKI 1996, RYSZKOWSKI and BARTOSZEWICZ 1989, RYSZKOWSKI et al. 1997, 1999). Because of their impact on ground water chemistry those landscape structures are called the biogeochemical barriers. Presented below results capitalize on the vast amount of information obtained during the studies carried out in the Research Centre for Agricultural and Forest Environment in Poznań, Poland.

It was observed that nitrate concentrations were decreasing substantially when ground water carrying them from under fields passed under biogeochemical barriers. Both shelterbelts or small mid-field forests could decrease concentrations of incoming $N\text{-}NO_3$ from fields in range of 63% to 98%. In meadows the detected decrease of nitrate concentrations was similar and ranged from 79% to 98% of the input (RYSZKOWSKI 2000).

The decrease of phosphate concentration under the biological barriers is also clearly evident although not in cases when plant residues underwent rapid decomposition and release phosphorus compounds (BARTOSZEWICZ 1990, HILLBRICHT-ILKOWSKA et al. 1995, KĘDZIORA et al. 1995).

The biogeochemical barriers change concentrations as well as composition of dissolved organic compounds (DOC) migrating with water (SZPAKOWSKA and ŻYCZYŃSKA-BAŁONIAK 1996, ŻYCZYŃSKA-BAŁONIAK et al. 1996). On the average the concentration of DOC was lower under studied meadows and shelterbelts than in water under cultivated fields. But on some dates (e.g. after heavy rainfall) DOC leached from decomposing plant residues in the biogeochemical barrier increased concentrations of organic compounds in ground water. DOC due to the richness in functional groups are able to complex and chelate mineral substances, particularly heavy metals. It was estimated that more than 50% of the ions of Mg, Fe, Zn and over 30% of Ca was transported in water reservoirs in form of complexes fixed with DOC (ŻYCZYŃSKA-BAŁONIAK et al. 1996a). The amount of metals bound to the DOC depends on their chemical composition (ŻYCZYŃSKA-BAŁONIAK and SZPAKOWSKA 1989, ŻYCZYŃSKA-BAŁONIAK et al. 1996a). Thus the biogeochemical barriers influencing the chemical composition of DOC indirectly influence water migration of heavy metals.

The great influence of plant cover structure on output of elements from watersheds was shown by BARTOSZEWICZ (1994). The studies were carried out in two small watersheds located nearby. The first one covered in 99% by cultivated fields was called uniform and the second one (mosaic) was composed by 83% of cultivated fields while the rest of terrain was covered by meadows (14%) and shelterbelt (3%). The mean annual precipitation for both watersheds was the same and amounted to 514 mm. On the average annual water output during three years studies from mosaic watershed was lower by 32 mm than from the uniform one. Because the water input (precipitation) was the same in both watersheds the observed differences in water runoff rates, should be attributed to differences in evapotranspiration rates between cultivated fields and meadows or shelterbelts (RYSZKOWSKI and KEDZIORA 1987). When the waterborn migration of mineral compounds from the mosaic watershed was compared with their outputs from uniform drainage basin then more than tenfold lower outputs of inorganic ions were detected.

2.3 Landscape diversity and biodiversity

It was found in long-term studies on animal communities in agricultural landscape that mean biomass of total above ground insects is almost four times higher in perennial crops and meadows than in spring cereals, while in winter cereals and row crops it assumes intermediate values.

Grasslands and tree patches show also the highest biomass of herbivores and predators and perennial crops like alfalfa show intermediary level of biomass in comparison to cultivation of cereals. Estimations of insect larvae biomass in soil also showed the highest biomass in the stretches of meadows, moderate values in alfalfa and the lowest ones in the cereal cultivations (KARG and RYSZKOWSKI 1996).

Quantitative analyses indicate that both, invertebrates and vertebrates as well as plants and fungi communities are considerably richer in the mosaic landscapes of Wielkopolska than in uniform ones composed only of cultivated fields. During ten years studies carried on in mosaic landscapes the occurrence of 60 insect taxonomic families with mean density of 61.9 indiv$\cdot$m^{-2} and biomass 55.0 mg d.w.$\cdot$m^{-2} were reported in fields located between shelterbelts. In the uniform landscapes 49 taxonomic families with mean density of 40.7 ind.$\cdot$m^{-2} and biomass 40.3 mg$\cdot$m^{-2} were detected in the fields with the same crops like in mosaic landscape. The studies on the above-ground insect fauna in uniform and mosaic landscapes carried out simultaneously in Poland and in Romania showed similar results (KARG et al. 1985, RYSZKOWSKI et al. 1993).

Animal species of the Turew mosaic agricultural landscape form a considerable percent of faunistic list of the total Wielkopolska region. For instance, despite relatively poor water network in the studied area occurrence of 36 dragon fly species (Odonata) were found, that is 50% of recorded species in the whole country, 40 species of water bugs (Heteroptera) were detected which constitute 80% of the species number known in the Wielkopolska. More than 90 species of water beetles were found which makes 62% of total species list for the region (S. MIELEWCZYK – personal communication). Among terrestrial invertebrates the high species diversity was found in mites (Acarina), Macrolepidoptera, Apoidea (Table 2).

Tab. 2: Number of invertebrate species reported from Turew agricultural landscape. Personal information if year of publication is not indicated.

Taxa or group	Number of species	References
Nematoda	40	WASILEWSKA 1979
Enchytraeidae	16	RYL 1977, RYL and KASPRZAK 1978
Lumbricidae	7	RYL 1984
Acarina	216	KACZMAREK 1988, 1993
Subcortical and wood inhabiting insects	~190	BAŁAZY
Macrolepidoptera	~500	KARG
Thysanoptera	39	SZEFLIŃSKA 1992
Apoidea	260	BANASZAK 1983

Among vertebrates 12 species of amphibia were found which represents the complete list of those animals appearing in the lowland areas of Poland (BERGER 1987). Differentiation of the Turew's agricultural landscape by mosaic of shelterbelts, small ponds and wetlands provides good breeding sites for birds. In the breeding season about 100 bird species appear. Inclusion of about 40 migratory species during autumn and winter increases the total list of species up to nearly 140. This indicates very high diversity of the bird species (KUJAWA 1990, 1992). The structure of mid-field afforestation has influence on the bird's species diversity. In mid-field small patches of forests and shelterbelts composed of several parallel rows of trees the highest number of species was detected and the lowest one was found in one rows alleys.

Mammal community is composed of 47 species which is approximately almost the total number of species which can be found in the region (RYSZKOWSKI 1982).

The similar situation was observed in plant communities. About 200 vascular plant species could be detected only in cultivated fields (Table 3). When the survey of the total mosaic landscape is carried out including grasslands, afforestations, and water reservoirs then more than 800 species were identified. The stretches of grasslands present the highest diversity (Table 3). As many as 14 totally protected and 9 partially protected species exist in the studied mosaic landscape. Beside that 44 threatened species according to the red book list was found. The highest number of protected and threatened species appeared in small patches of grasslands and in water bodies.

Tab. 3: Number of vascular plant species in various habitats of the Turew agricultural landscape (updated data of RYSZKOWSKI, GOŁDYN and ARCZYŃSKA 1998).

Habitat	Grass-lands	Shelterbelts and afforestations	Manor's park	Road - sides	Water reservoirs	Cultivated fields	Total landscap e
Number of species	321	266	306	220	211	193	805

The studies carried out by SIEMINIAK et al. (1992) recorded 61 species of soil algae. The number of algae species that occur in the Turew landscape is similar to some deciduous and mixed forests (NOVICHKOVA-IVANOVA 1980).

The presented results of the long-term, complex studies clearly indicate that impoverishment of the biota caused by agriculture could be modified if diversified landscape patterns are maintained or introduced. It seems that conservation of the biota depends on the presence of refuge sites providing better conditions for their survival. The less habitats are disturbed by tillage activities the better conditions for survival exist. The soils of the spring crops with the most frequent impacts of tillage activities usually show lower abundance of animals than it is observed in overwintering and perennial crops, while the highest abundance is detected in meadows, shelterbelts and mid-field forest patches. When a new shelterbelt is planted in cultivated field the mobile animals like insects very fastly populate those newly created refuge sites.

In old as well as in new planted sheterbelts from 12 to 15 times more insects overwinter than in soils of cultivated fields. Thus by introduction of refuge sites like hedges, shelterbelts, stretches of meadows, small mid-field wetlands or water reservoirs the negative effects of agricultural intensification could be to some extend mitigated. The fields where animals were eliminated could be recolonized quite fastly by mobile animal groups from unaffected refuges in a mosaic landscape. Thus one can suppose that the main factors counteracting biodiversity decline – are the maintenance or development of mosaic structure of agricultural landscape and dispersal properties of species both among plants and animals. The size of refuges and their distribution should match the requirements for breeding, food or nutrient acquisition, dispersion abilities and others fulfilment of existence of species in question. Mosaic plant cover structure is of special interest not only for survival of animal species in the agricultural landscape but also for enrichment of plant communities themselves.

3 Landscape ecology contribution into development of the Common Agricultural Policy of the EU

The European Commission's Progress Report on the review of the Fifth Action Programme for the Environment (5EAP) published in 1996 indicated needs for more comprehensive approaches to environmental issues. The growing concern on environment protection was strongly highlighted by the report published by the European Environment Agency on the State of European Environment (STANNERS and BOURDEAU 1995) and by the Europe's Environment: the second assessment (EUROPEAN ENVIRONMENT AGENCY 1998). In those documents it was shown that "the European Union is making progress in reducing certain pressures on the environment, though this is not enough to improve the general quality of the environment and even less to progress towards sustainability".

The European Commission identified a clear need to tackle growing problems of groundwater pollution and depletion. The groundwater pollution from diffuse agricultural sources was recognised as a problem in most Member States. The other crucial problem is protection of biodiversity. Although the Habitats Directive came into effect in 1994 the success of its implementation seems to be small. Many plant and animal species are still threatened.

It was indicated in preceding section that both water quality and quantity protection as well as conservation of biodiversity can be more successfully achieved if on-farm activities are combined with diversification of the landscape plant cover structure. The value of landscape approach to environmental problems was recently recognised in communication from the European Commission on "Directions towards sustainable agriculture" as well as in Agenda 2000 designed to implement "environmental consideration aiming to assure farming practices, necessary to safeguard the environment and preserve the countryside". But it seems that appreciation of advantages of landscape approach to environment problems is not fully acknowledged in formulation of the new CAP. The main focus is put on protection activities within farm. The understanding that landscape diversification will generally increase the resistance of production systems to threats and minimise risks is not sufficiently apprehended.

Thus, for example, the set aside programme proposed in the new CAP in order to limit production is not linked with the use of withdrawn parcels for control of diffuse pollution. But if set aside parcels were properly located in respect to directions of ground water movement or prevailing winds then plants growing on strips withdrawn from production would control wind erosion or ground water pollution. That activity could therefore enhance effectiveness of Nitrates Directive issued by the Commission of the European Communities (CEC). Elaboration of the new recommendation by the CEC needed for implementation of such approach to set aside parcels should strongly rely on landscape achievements. The same can be said about small progress in a biodiversity protection in rural areas. The main focus is directed to conserve wild plants or animals in protected areas. Using the recent achievements in agricultural landscape ecology one can preserve many species introducing suitable pattern of refuge sites in the rural areas outside of protected areas.

Forest, shelterbelts, strip of grasslands or cultivated fields influence strongly on evapotranspiration rates, heat convection to atmosphere or modify climatic conditions. Thus the change in land-use forms of the landscape can moderate to some extent the impacts of the global climate change (RYSZKOWSKI and KĘDZIORA 1995, KEDZIORA and RYSZKOWSKI 1999). The influences of the different plant cover structures in agricultural landscapes on the exchange of heat energy and water between ecosystems and atmosphere are almost completely neglected in the new CAP as well as in mitigation programs of global climate changes.

It seems therefore that in the next future landscape ecology will have quite important bearing on of the transformation of the Common Agricultural Policy of the E.U.

On more aspect of the importance of landscape ecology for the future development of the Europe is linked to the problems of spatial planning. At the 1999 Potsdam conference of Council of Ministers responsible for spatial planning in the E.U. the document called the European Spatial Development Perspective was issued (ESDP 1999). This document recognises the importance of the spatial dimension in reconciliation of economic, social and nature protection issues. While the intensive agriculture can lead to pollution problems and destructure of cultural landscapes those negative impacts can be counteracted through suitable regional planning. Diversification of economic activities in space can increase efficient and sustainable use of infrastructure. It is also stated in this document that spatial planning can play an important role in the conservation of biodiversity. One can add that spatial planning enriched by modern achievements of landscape ecology can lead to more successful preservation of natural and cultural heritage.

In conclusion it can be stated that creation of the network of co-operating institutions having knowledge and expertise in landscape management issues could facilitate successful transmission of achievement of landscape ecology to the Common Agricultural Policy.

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Managing Interactions between Agriculture, Nature and Economy

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Abstract

Scenario studies, visualised in geographical information systems, are useful to evaluate possible future landscape developments, and to identify potentials and limitations in combining multiple landscape functions. Here we describe the development of a scenario system that focusses on exploring interactions between landscape functions – e.g. the interactions between farm management, economy, nutrient losses, fauna population dynamics, plant community development etc. A scenario for drinking water protection via afforestation is presented. It shows benefits from subsidies targeted to areas with special interests in protection of drinking waters from nitrate pollution differ from non-targeted subsidies.

Experience has shown that working with scenarios and involving potential users at an early stage in development are important ways of focussing the work effort and ensuring that relevant tools are developed. Developments in data collection and collation at the EU level will allow similar systems to be developed elsewhere.

Keywords: Scenarios, Multidisciplinarity, Geographical Information systems (GIS), Water Framework Directive, Multifunctionality

A new perception of European landscapes

Today's demand for sustainability is not limited to agricultural production and profit but includes other aspects of rural life such as the environment and landscape. Proper utilisation of the future landscape requires a holistic approach where consequences of various different land uses are assessed and management adjusted. At the same time, regulatory authorities in member states have the task of implementing a range of EU directives that target specific policy areas e.g. the Nitrates Directive, National Emissions Ceilings Directive, Habitat Directive and the Water Framework Directive. If policy initiatives directed towards implementation are developed in isolation, there is a tendency for the resulting regulations to become antagonistic. For example, as part of the implementation of the Nitrates Directive in Denmark, farmers were obliged to plant more winter cereal crops. This has resulted in an increase in the frequency of pesticide applications, a development that threatens wildlife and conflicts with the objectives of the Habitat Directive.

The ARLAS scenario system

In 1997, the project "Land use and landscape development, illustrated by scenarios - Interactions between nature, agriculture, environment and land management" (ARLAS) was initiated under the Danish research programme: Land use - the farmer as landscape manager. The project finishes in 2002.

The project is multi-disciplinary and involves collaboration between the Danish Institute of Agricultural Sciences, The National Environmental Research Institute, Geological Survey of Denmark and Greenland, University of Aarhus, Viborg County, The Danish Agricultural Advisory Centre, and Danish Institute of Agricultural and Fisheries Economics.

The focus of the project is the farm as an integrated part of the rural landscape. The objective is to develop methods to enable interactions between policy areas to be identified and quantified. In this way, policy makers can seek to avoid antagonistic interactions and promote those that are synergistic.

The policy areas currently targeted in the ARLAS scenario system are agricultural production, nutrient losses, landscape, and nature conservation. The process involved when investigating a policy initiative is as follows. The policy objective is defined and one or more policy measures are formulated. Often, these policy measures are in the form of regulations or economic incentives to achieve a certain change in land use or land management e.g. planting of woodland or extensification of livestock farming. These measures are then applied to the target area, either using an economic model or a decision tree or a combination of the two, using a GIS. The results are spatially explicit changes in land use or land management. The GIS is then used to generate input files for a number of models. The models currently available to the ARLAS scenario system concern agricultural production and losses of nitrogen, hydrology and plant and animal wildlife (Figure 1).

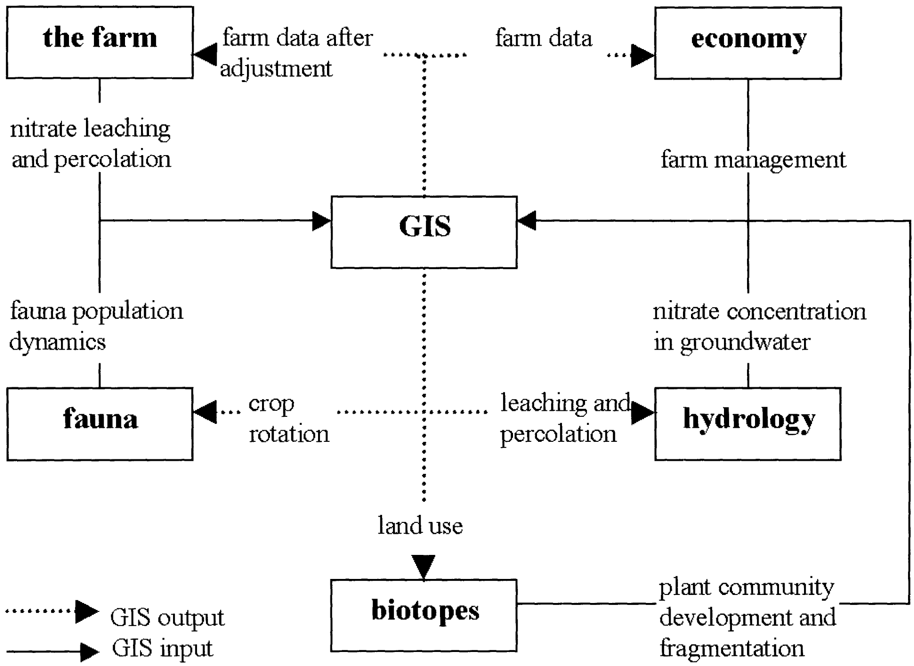

Fig. 1: A simplified illustration of the scenario system in ARLAS (HANSEN et al. 2002)

The main data sources for the ARLAS scenario system are the national databases for cropping (GLR), livestock holdings (CHR), soil types and climate. The main function of these databases is to support Denmark's compliance with EU support schemes and directives.

Examples

Test site

The test site for the ARLAS scenarios is an area of 100 km^2 in Viborg County, Denmark, Figure 2. The area has been the focus for an intensive campaign of data collection, including a detailed mapping of the soil, geology, biotopes and even of small landscape features such as ditches and field boundaries. The detailed data were collected to enable the importance of the scale of available data on scenario outcomes to be investigated. Data are digitised and stored in a Geographical Information System (GIS), which is the basis for the subsequent analyses.

Fig. 2: Land Use in the 10 x 10 km^2 study area, situated around the city of Bjerringbro in the midwest of Denmark. The ESA's are environmentally sensitive areas with respect to groundwater quality (DALGAARD et al. 2001c).

A scenario for drinking water protection

This scenario illustrates the use of the ARLAS system to investigate measures for drinking water protection. Investigations have shown that spreading of livestock manure is closely related to N-losses (DALGAARD et al. 2002a), and the distribution of livestock manure and fertilisers is the main driving factor for nitrogen (N) leaching to ground- and surface waters. A model for the geographical distribution of N between fields within each farm and between farms within the study area was developed (DALGAARD et al. 2001c). In this model, the N-distribution within and between farms is simulated from number and types of animals on each farm, the crop rotation and the choice of cash and roughage crops for feeding livestock, soil types, distances to neighbouring farms and the N-need for fertilisation of the crops on these farms. Figure 3 pictures an example of simulated distribution of N in manure and fertilisers on agricultural land within the ARLAS study area.

In the scenario, the effect of drinking water protection via afforestation or set-aside in the groundwater protection areas (ESAs) is investigated. This scenario is especially relevant in the context of the EU Nitrate and Water Framework Directives.

According to EU legislation, necessary measures should be implemented in order to protect drinking water quality in designated areas i.e. the ESA's in figure 3. Two options for reducing nutrient inputs to such water sources are afforestation and set-aside. When fields in the ESA's are afforested or turned into permanent set-aside, the areas are taken out of agricultural production. In the ARLAS scenario system, each farmer's reaction to these measures, in form of changed animal and crop production, is decided from a set of rules, and the resulting change in fertilisation practice is decided from the model described above. In this way, the effect on N-leaching is estimated and interactions with other economic and ecological functions in the landscape assessed. As will be described in the following, these interactions are often non-linear and crucial to include in analysis of possibilities in creating multifunctional landscapes.

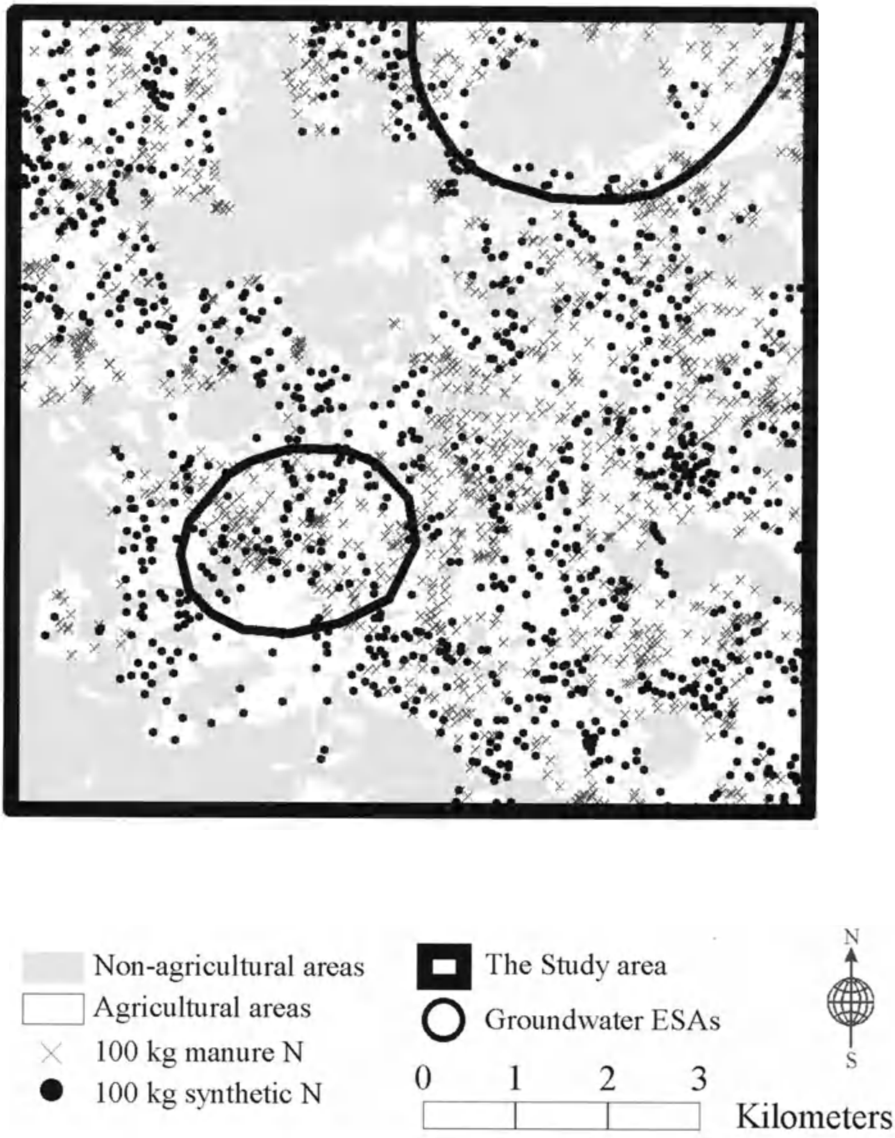

Fig. 3: Example of simulated distribution of nitrogen (N) in manure and fertiliser on agricultural land inside and outside ground water protection areas in the project area. Especially manure N is a good indicator for N-losses, and drives the models for N-leaching to ground and surface waters (DALGAARD et al. 2001c).

Interactions between multiple functions

Here, we will show an example of the interactions between landscape functions, which the ARLAS scenario system can help disentangling. The two functions included in the example are the economic benefit from farm production, given by the average farm level gross margin, and the reduction in nitrogen losses resulting from the introduction of afforestation on former agricultural land (see the drinking water protection scenario described above, and RYGNESTAD et. al. 2001, 2002). The policy measure investigated were two different auctions based measures, with an equal, total afforestation subsidy of 2.7 mio. DKK used (Figure 4). In the targeted measure, only farms within ground water protection areas (i.e. farms with most of their fields within the ESAs in figure 2 and figure 3) are invited to tender. In the uniform measure all farms in the study area are invited to tender, and in both the uniform and the targeted situation it is assumed that farmers choose afforestation, if the afforestation subsidy per ha is higher than the average farm level gross margin per ha.

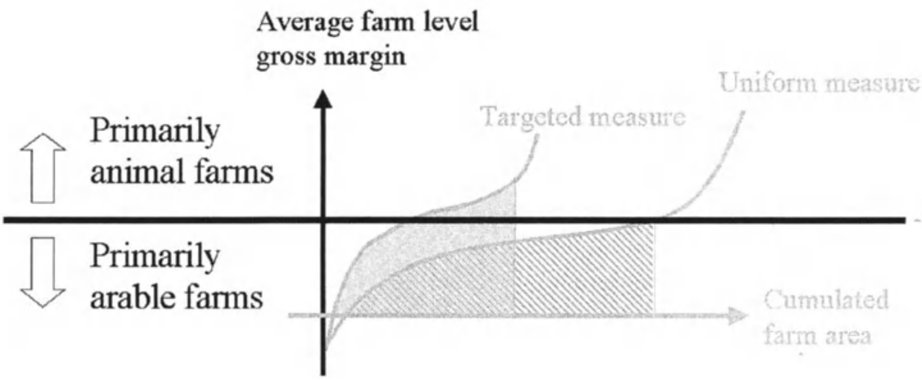

Fig. 4: Example of interactions between farm income and drinking water protection via auction based afforestation. In the uniform measure all farms are invited to tender and the hatched area is afforested. In the targeted measure only farms within designated areas are invited to tender and a smaller area is afforested. However, the total protection effect of the targeted measure is equal to that of the uniform measure, because the targeted measure affects more of the animal farms that have a higher impact on N-pollution than the mainly arable farms affected by the uniform measure.

As illustrated in figure 4, the uniform measure leads to the largest area afforested (the hatched area). This is because the marginal subsidy needed to make farmers plant woodland increases faster in the targeted than in the uniform measure. However, the farms with low average farm level gross margins which plant woodland as a result of the uniform measure, are primarily arable. In contrast, the targeted measure results in more animal farms, which typically have higher gross margins than arable farms, also planting woodland. Because N-losses are closely related to high livestock density, the groundwater protection effect of the targeted measure will be as high as the effect of the uniform measure, even though the area included by the targeted measure is much smaller (DALGAARD 2001).

Conclusions and perspectives

The methods developed in ARLAS are applicable at a range of scales, from small areas, in which each individual farm is considered as a separate entity, to larger scales, in which standard farm types are used.

Denmark has been in the forefront in the collection of digital farm data in national databases and in the development of methods to combine these data with other data types (DALGAARD et al. 2002b). Soon, similar data will be available in all EU countries e.g. from national censuses, the EUROSTAT Farm Accountancy Data Network (FADN) or area support scheme databases. There will then be opportunities to develop methods to combine these data, in scenarios for landscape development in the different regions of Europe.

The ecological, economic, wildlife and visual functions of landscape within a modern society are determined by processes that operate over a range of scales in space and time. Integrating knowledge of these processes into tools that can be used by people who have stewardship over the land, such as farmers and regulators, requires an interdisciplinary approach. Such an approach demands significant effort as it must work against the trend of specialisation and fragmentation of knowledge that has occurred over the recent centuries. It also requires substantial technical developments, relating to data collation from disparate sources, data manipulation and data management. Our experience from the ARLAS project is that working with scenarios and involving potential users at an early stage in development are important ways of focussing the work effort and ensuring that relevant tools are developed.

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Sustainable Management of Wood and Timber Fluxes in the Region Ostprignitz-Ruppin

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Abstract

The regional fluxes of wood and timber were analysed in the region Ostprignitz-Ruppin in the Land of Brandenburg, Germany. An evaluation scheme was applied using a combination of top down and bottom up strategies, which included global and regional aspects. A set of indicators reflecting the main economic, ecological and social processes in the region was established and applied for the analysis. Specific target values for the indicators were defined using natural laws as well as technological and political items. The best solution under the aspect of sustainability was calculated. Priority activities for a sustainable regional development were formulated.

Keywords: Regional material flux, indicators, sustainable management, wood and timber

Introduction

Sustainable industrial production requires a change of the raw material base from fossil towards renewable resources of material and energy, as biomass and solar energy, the closing of the material cycles, and the reduction of wastes in mass and toxicity. Since the landscape will be the main source of raw materials and energy, and a sink for the production residues and the municipal solid waste, it will play an important role in the said change of the industrial society. On the other hand, landscape has important functions in the natural household, and is an economic factor for the region.

Most activities depend on the material fluxes, which influence the natural system as well as economic and social activities. Hence, the fluxes have to be controlled in such a way, that the natural performance of the landscape is guaranteed, and the needs of the production processes for raw material and waste deposition as well as social needs are satisfied simultaneously.

In the last decade, the needs for a sustainable material flux management were described by many authors (THRÄN 2001), especially for industrialised regions. There, main demands are a general reduction of the material fluxes, e.g. by a "Factor 10" (SCHMIDT-BLEEK 1994), or a considerable increase of the forest area (BMU 1995).

For the development of rural regions, which are characterised by a low material turnover at a very low level of economic activities, as well as a high proportion of natural forests, the results of such studies cannot be applied directly. But suitable evaluation schemes for the rational management of the material fluxes for a sustainable regional development are missing. They must be developed and applied stepwise by use of examples and their generalisation. The establishment of a sufficient date base is also urgently needed.

The paper contributes to that goal by (i.) an analysis of the wood and timber fluxes in the rural region of Ostprignitz-Ruppin, Germany, (ii.) the development of a reasonable evaluation scheme including a set of indicators prescribing sustainable regional development, (iii.) the definition of target values and the (iv.) optimisation of the fluxes.

Material fluxes in the exemplary region

Short description of the region

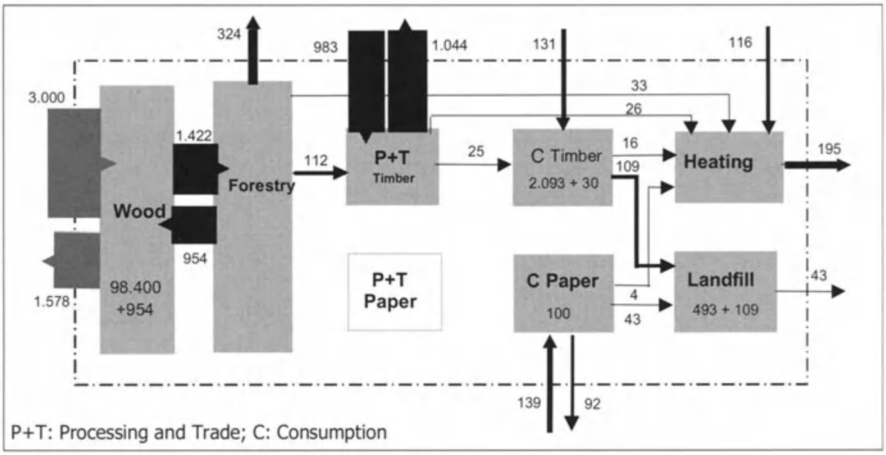
The region under study is the district Ostprignitz-Ruppin, located in the North-West of the Land of Brandenburg, Germany, 80 km far form Berlin. It is a typical poor structured rural region, characterised by (THRÄN and SOYEZ 2000)

- a high proportion of the total area (268.293 ha) used for agriculture (52%) and forestry (32%),
- dominance of very small enterprises, no real industry (only 4 % of the firms have more than 20, no enterprise more than 500 employees),
- high unemployment rate (17,7%),
- low population density (42 inh/km^2; in comparison: Germany 223, Brandenburg 88) and
- decreasing population figures (1989: 120.271; 2001: 112.386, -6,7%).

This situation is a result of the political changes in Germany after 1989, which were accompanied with a collapse of the regional economy due to its structural deficits and low developed productivity, but is also a consequence of lacking of regional markets and the missing use of regional resources. In contrast to the economic situation, the environmental situation is very favourable, especially the quality of waters in lakes and rivers is high - but sadly not by active measures as the application of ecological technologies! Improved use of the regional resources seem to be the key approach to a promising development.

Regional fluxes of wood and timber

The portfolio of the rural material fluxes indicates (THRÄN and SOYEZ 2000), that biomass is of high importance. In the case of food, the production is 10 to 30 times higher than the private consumption. Only 15 % of the wood biomass available is used for timber production. A massive import of fossil fuels for heating and transportation is reported. The concrete regional analysis of the wood and timber balances comes down with the results given in figure 1.



Legend: Storage in kg dry mass/inh, change in storage and fluxes in kg dm/inh/yr

Fig. 1: Actual biomass fluxes in the region studied (THRÄN 2001)

"Wood and forestry" comprises the regional wood and its cultivation with reference to the wooden components, without leafs and needles. "P+T timer" means processing of wood (without fibres for paper processing) and the trade with wood, half products, and products. "P+T paper" means paper related processes, which actually are but not found in the region. "C paper and C timer" describes the consumption of wooden and paper products. "Heating" comprises the energetic use of wood and paper residues as well as the combustion of firewood. "Deposition" means the deposition on regional landfills of wood and timber as well as paper residues. By landfill processes, it is assumed, that the fibres will be metabolised and leave the system; lignin remains unchanged in the landfill.

Currently, the largest regional material fluxes are related to the growth of the forests, i.e. the resource potential. The natural wood production is in the range of 3 Mg/inhabitant/year. This tenfold exceeds the anthropogene wood and timber fluxes. 50% of the renewable wood mass may be used under the aspects of a sustainable wood processing. The other part remains for natural or touristical forest services, until it is destroyed by natural processes and thus leave the wood as emissions. At the moment, the potential available is used at a rate of 500 kg/inh/yr; 954 kg remain unused see also table 3). Thus, the natural stock increases. It actually amounts to about 50 Mg/inh/yr, that means about 50 times more than the anthropogene stock, which exists especially as timber wood in buildings.

It is to be pronounced that the anthropogene wood fluxes actually have only low regional meaning, since raw material is mostly imported (986 kg dm/inh/yr), and the products are mainly exported (1044 kg). Timber, which is consumed in the region, is also imported (121 kg). With respect to the deposition, there are differences between waste paper and waste wood fluxes. Waste paper is processed for recycling, but outside the region, due to missing processing capacities inside, and residual wood is deposited in regional landfills. The relatively low use of wood from the region itself, as well as the deposition of wood in landfills, underline that there are high potentials for a change towards sustainability.

An evaluation scheme for sustainable regional fluxes

A generally accepted evaluation scheme of material fluxes is missing until now; the following suggestion (THRÄN 2000a) was developed for the regional management of material fluxes and was proven as suitable. The whole scheme is given in figure 2.

It consists of four levels. On the first level, "sustainable material management" is operationalised for use in a rural regions. As a base for that, the specific functions of the rural space (RSU 1996), are applied:

1. supply of (renewable) resources
2. sink for the wastes of industry and business, and municipal solid waste
3. providing of ecological space to protect the living area of animals and plants
4. providing living area for the inhabitants and recreation areas for urban people.

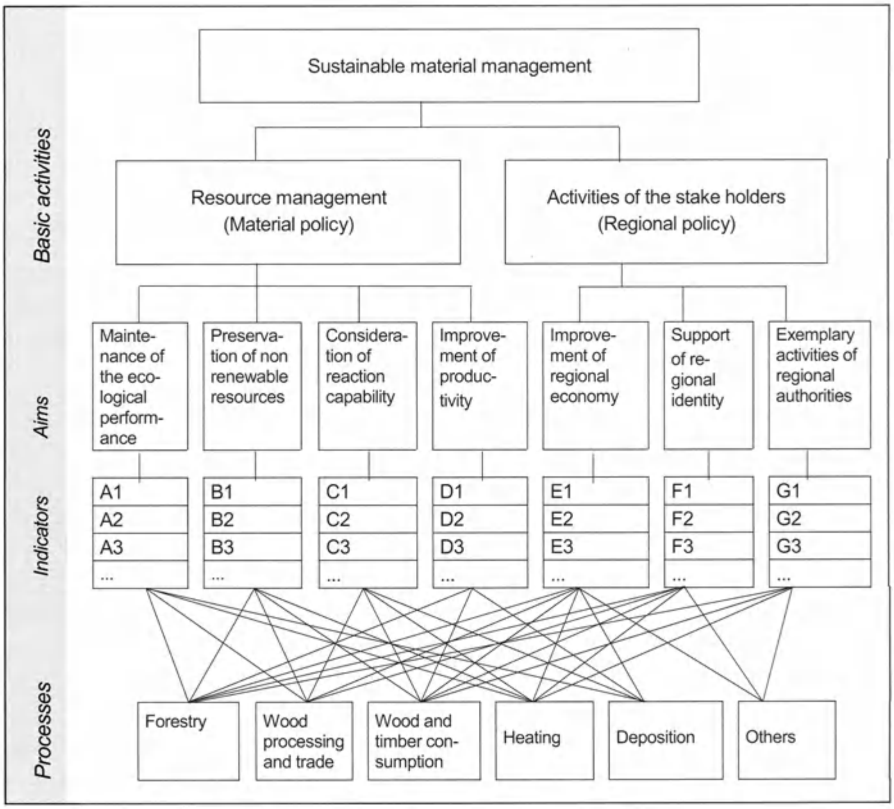


Fig. 2: Evaluation system for sustainable rural regions (THRÄN 2000a)

Two kinds of basic activities are defined from that set of functions. Item 1 and 2 are mainly related to the management of the resources, which is to be organised by an appropriate "material policy"; item 3 and 4 more or less reflect the needs of the stake holders on the regional level, thus are influenced by "regional policies". It is to be mentioned, that the "classical" separation of sustainability aims into economic, ecological and social aims is not used, since the processes are strongly interconnected and all three aims are included in the two kinds of basic activities given in figure 1.

On a <u>second level</u>, specific aims with respect to sustainable activities are defined. Two approaches are possible: the top-down and the bottom-up procedure. According to the top-down approach, the rules of the global material policies (ENQUETE KOMISSION 1994) are applied. They comprise four aims, (a) the maintenance of the ecological performance, (b) the preservation of non renewable resources, (c) the consideration of the natural reaction capability, and (d) the improvement of the productivity.

According to the regional policy (bottom-up approach), specific aims have to be formulated after a precise analysis of the situation given in the region considered. Three aims are estimated as of high relevance for the regional development, and are suggested for use (THRÄN 2001):

The improvement of the regional economy (e), which is crucial for the development, is based on the resources of the region, as wood and other bio-resources. Other economic effects are the regionally related private ownership of forests and the energetic use of wood and timber from regional forests by regional companies, and tourism.

The support of the regional identity (f), may directly influence the life of the people including their understanding of their "own" nature or landscape. Exemplary activities of the public authorities (g) may support the use of ecologically acceptable material and regional products, e.g. wood and timber in public buildings. Thus, seven aims were formulated.

On the third level, these aims must be specified and indicators be found for their evaluation.

As an example, for the specification of the "Maintenance of the ecological performance" (aim a), may be discussed: The regional biomass stock has to be constant in quantitative and qualitative respect. The anthropogene material input into the environment must not adversely influence the regional environmental situation. All ecological functions have to be preserved, and the material input may not exceed the local assimilation capacities, particularly of soil. Furthermore, sufficient area were no industrial activities and no material input take place, is necessary for wildlife and plant preservation.

For the first aim (a), seven indicators are suggested (see also later table°1): (A_1) total wood mass, (A_2) the share of natural forests in the landscape (GIEGRICH 1996), (A_3) ecological priority areas in the forest, (A_4) the re-forestation (with special respect to nitrogen-balance, due to advantages of forests prior to energy plantation (MÜLLER 1995), (A_5) the emissions by wood processing, (A_6) the input of pollutants and (A_7) the deposition of waste wood.

In analogy, indicators are to be formulated for the other six aims (b - g). In the case studied, this procedure resulted in a set of 48 indicators (THRÄN 2001) - see table 1. After the elimination of redundant and/or inconsistent indicators, a set of 27 decisive indicators remained.

Tab. 1: Number of indicators chosen per aim

Aims	No of indicators
(a) maintenance of the ecological performance	7
(b) preservation of non renewable resources	5
(c) consideration of the natural reaction rates	8
(d) enhancement of the productivity	4
(e) improvement of the regional economy	12
(f) support of the regional identity	6
(g) exemplary activities of the public authorities	6

On the fourth level of the evaluation scheme, the set of indicators has to be related with the key regional processes, as presented in figure 1: Forestry, wood production and trade, wood and timber consumption, heating, and deposition. Every single indicator, defined for describing the aims (a - g), may be related to one or more of the key processes, and visa versa, the processes are prescribed by a set of indicators of different origin (see table 2, left column). As table 2 shows, most indicators refer to the process “Wood processing and trade” due to the strong interactions in these processes. Deposition, as a non sustainable process, is described by one indicator only.

Tab. 2: Selected Indicators and suggested target values (after THRÄN 2001)

Indicator	suggestions for the target value of the indicator
Process: Forestry (5)	
Ecological priority areas in the forest [A_3]	5% of the forest (BMU 1995)
Excess of re-forestation [A_4]	>50 ha/a (BMU 1995)
Growth and harvest of wood [A_1,B]	complete sustainable use of wood
Process: Wood processing and trade (13)	
Energy use for wood processing [C]	50% of the actual value (BMU 1998)
Quota for re-use of residual or used wood [C]	>7,5 % of timber processed (BMU 1998)
Participation on wood processing of small enterprises [E]	rising
Trade with regional wood and timber [E]	in 90% of regional property markets
Processing of the regionally produced timber [F]	50% in the region
Process: Wood consumption and disposal (4)	
Timber constructed buildings [F,G]	rising, esp. in public construction
Process: Heating (4)	
Contribution of wood to total heating energy [C]	>5% of the actual energy need (MARKERT 1996)
Process Deposition (1)	
Deposition of wood with and without contamination [A_7/C]	0 (BMU 2001)

Legend: in brackets (n): total number of indicators describing the processes, in brackets [A...G] affiliation of the indicator to the aims (a-g)

Application of the indicators in the evaluation system

The indicators can be used for the monitoring of the region with reference to wood and timber balances, after calculation the actual values. Table 3 represents some values for selected indicators, which were calculated after given statistical data or by questioning the parties involved, as forestry offices, or companies.

Tab. 3: Actual values and targets for selected indicators

Indicator	actual value kg dm/inh/yr	target value*	actual/ target value (%)
Growth and harvest of wood [A1]	384 (MELF 1996)	>1422	27
Regional wood processing capacities [C]	1095 (LDS 1995)	>980	112
Waste wood processing capacities [B]	142 (THRÄN 2001)	>230	62
Regional wood use [B]	156 (THRÄN 2001)	>245	24
Production of wood for heating use [B]	37 (THRÄN 2001)	>442	8
Deposition [A,C]	152 (THRÄN 2001)	0	-

Legend: * calculated after suggested principal values (see table 2)

For a rational interpretation of the results and for the establishment of useful scenarios, there target values of the indicators must be defined. Basic suggestions for such target values are given in Table 2 (right column) (THRÄN 2001). They were mostly defined as a result of a societal process, in a few cases as a consequence of natural laws. In several cases, target values cannot be described precisely due to unclear consequences of measures, or political and technological uncertainties, so that only tendencies ("rising") can be formulated and no indicator target value can be suggested. Some concrete target values for the situation in the district Ostprignitz-Ruppin are given in table 3 (3rd column).

A comparison on the base of the quotient of the actual and the target values makes clear, that the current situation is far from the sustainable state (in %, see table 3, 4th column). With respect to energetic use of regional wood, e.g., only 8% of the target value are reached.

Sustainable biomass flux in the region

A sustainable biomass flux in the region is realised, if the target values of all 27 indicators are fully met. Using the balance equations, the individual fluxes under this condition can be calculated. In the concrete case, 49 variables and systems equations were formulated. The boundaries of the system were chosen by the environmental compartments, as water, soil, and atmosphere, as well as the neighbouring regions (details see THRÄN 2001). The results are given in figure 3.

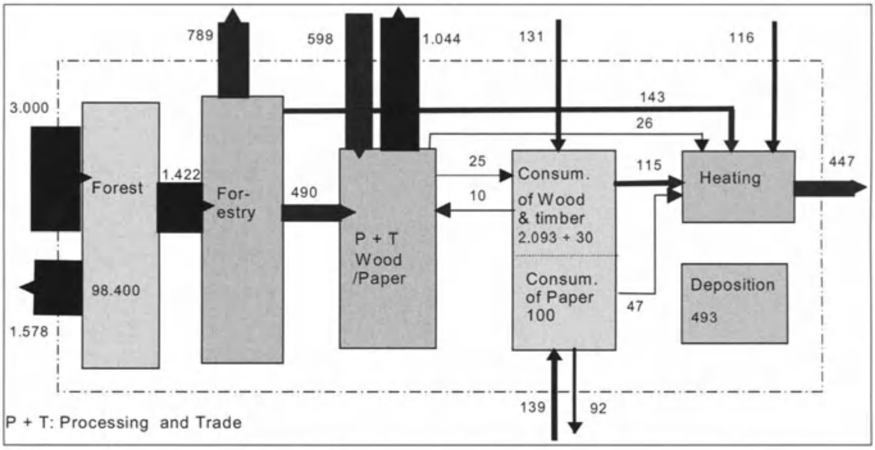


Fig 3: Optimised biomass fluxes in the region studied (THRÄN 2001)

Compared with the fluxes given in figure 1, there considerable differences are evident: a much larger part of the wood from forestry is exported (by 240%), and much more timber for processing is taken from the regional forests, so that the imports can be considerably reduced (by about 40%). The residues from wood and timber consumption no longer are deposited in a landfill, but are used as heating material in the region.

Consequences for the regional development

To achieve sustainable material fluxes, a set of measures is needed in the region. Improved use of regional wood products has highest priority. Most relevant is the use of firewood in private households and public institutions. This implies the development of a regional firewood market and information on modern heating systems. Another important factor is the use of timber wood for the construction of buildings. This can be influenced by the administration by own examples of use of wooden material in their buildings, but also by regulations. No relevance was seen for the source separated collection of used wood and timber material, which is often seen as a sustainability supporting measure..

With respect to the development of the landscape, no change in the forest area is necessary and the character of the landscape will remain unchanged under the more sustainable regional conditions.

Conclusion

The evaluation schema for a sustainable wood and timber household was successfully applied to establish sustainable regional material fluxes in the region Ostprignitz-Ruppin. The results indicate, that a higher use of regional wood for heating values and construction is necessary. But no increase in the forest area is needed, which is partly in contrary to the situation in industrialised regions. The approach can be adopted to other regions and to solve special problems. In the future, more examples are necessary to compare different regions and to generalise the development potentials. An application is possible also for the planning of landscape functions as a special aspect of regional development.

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Landscape Tomorrow: A Research Network for Sustainable Development of Multifunctional Landscapes www.landscape-tomorrow.net

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Abstract

Global change and EU enlargement affect the driving forces of ecosystem functioning, land use decision-making and rural development. New demands on landscapes and natural resources call for multifunctional approaches to land development. Tools are required to (i) identify the effects of land management on landscape sustainability and (ii) support the decision-making process of the multipurpose utilisation of landscape resources. These requirements call for major scientific efforts on a European level including both, interdisciplinary research and coverage of all Europe.

Scientists from across Europe installed the **Landscape Tomorrow** research network to prepare themselves for challenges to research on sustainable land development in a European perspective. The network research will (i) analyse general principles of landscape multifunctionality, (ii) develop methods to assess the sustainability of agricultural and forestry land management, and (iii) identify strategies of sustainable land management and rural development. With this, **Landscape Tomorrow** provides a scientific basis for future land development strategies and offers strategic co-operation with land use decision makers on the political, planning and management level.

Keywords: research network, European integration, Landscape Tomorrow, 6th framework programme

Rationale

Landscapes are spatial systems in which diverse uses such as agriculture, fishery and forestry, water management, settlement, recreation, production and traffic are combined with natural and cultural factors including economic, ecologic and social concerns. In the past, the multifunctional utilisation of landscapes related to spatially distinct natural and cultural settings has led to an overwhelming variety of European landscapes, each containing unique characteristics.

Nowadays, a developing world economy and the EU enlargement bring about pressures to change European landscape uses as consequences of shifting driving forces such as market conditions, globalisation and climate change. In the medium term perspective, the role of food and primary production will decrease in favour of alternative utilisations supporting specific but multifaceted demands of urban and rural population. In the long-term perspective, the priority list of landscape demands is difficult to foresee. However, the limited area of most European countries requires the consideration of many demands and landscape functions both, **in space and time simultaneously**. All social groups, including science, involved in land use decision making are challenged to co-operate and find solutions to the multifunctional utilisation of landscapes which meet the requirements of sustainability in land development as expressed in the documents of international organisations and the European Commission (COM. 1999, OECD 1995).

The characteristic features of sustainable land development might considerably vary from region to region as do their natural, political and social characteristics. However, the question of whether or not certain land use options are sustainable or not, depends not only on the specific characteristics of the respective region, but also on land use options in other regions. If for example, many regions took the same measure of sustainable development, on a larger scale, some key elements of sustainability might vanish due to interrelations between the system components. Therefore, **sustainable land development requires a regional approach , but needs to be embedded in a European structure**.

The initiation of sustainability trends for tomorrow's landscapes requires a joint effort between different interest groups. On the scientific part, insight understanding of global and regional processes of landscape functioning, management and rural development is required in many disciplines representing the environmental, social and economic aspects of land development. On the one hand, regional knowledge has to be provided for the entire area of Europe in a serviceable way, which implies its transference into a unifying and comprehensive system. On the other hand, the many patches of disciplinary knowledge on landscape and land use processes have to be combined to a multidisciplinary and comprehensive pattern of sustainable land development.

In order to be prepared for the challenges to research on sustainable land development in a European perspective, scientists from across Europe installed the **Landscape Tomorrow** research network for the sustainable development of multifunctional landscapes. **Landscape Tomorrow** provides a scientific basis for future land development strategies.

Aims and Objectives

Being a European Network of Excellence, **Landscape Tomorrow** brings together European expertise in the fields of agriculture, forestry, landscape science and rural development to integrate research, education and training and to disseminate knowledge on key issues of the sustainable development of multifunctional landscapes. The research will

<u>analyse:</u>

- regional specific characteristics of landscapes and sustainable land use,
- multifunctionality of landscapes with respect to rural development,
- positive and negative externalities under different production systems,
- rural-urban interactions and implications for land use decision-making;

<u>identify:</u>

- strategies to integrate soil, water and biodiversity issues in land use management,
- thresholds of landscape processes and functional interactions,
- demands of the society for green or yet unknown future services,
- actors, institutions and instruments of land use decision-making,
- land use conflicts and prospects of solutions and implementations,
- potentials for rural development;

<u>develop:</u>

- methods for environmental monitoring and forecasting including extreme and catastrophic events,
- operational forecasting and decision support tools for sustainable land use and landscape management,
- concepts for the multipurpose utilisation of agricultural and forest resources.

achieve:

- transparency and comparability of methods for monitoring landscape and land use systems including the environmental, social and economic dimension,
- consensus of the use of databases and indicator systems of key land use properties.

The results of the network activities will include contributions to the scientific community as well as products for practical application and policy making. The **key deliverables** of the research efforts will include:

- a European database of regional specific landscape and land use characteristics,
- a European list of methods and indicators for impact assessment of land use combinations,
- a European monitoring network for landscape and land use changes,
- a European research platform for land use and landscape research,
- a European knowledge and communication base for the exchange of information between researchers, policy makers, planners and land use managers,
- a European education and training network for sustainability aspects of multifunctional land uses.

Clients

In a time period, where pressures to change land use is increasing due to shifts and driving forces such as market conditions, globalisation and climate change, Landscape Tomorrow elaborates scientific expertise concerning the economic and environmental effects of different land use options. As such, the network will be a valuable partner for organisations involved in land use decision making, including the scientific community, policy makers on EU, national and regional level, societal bodies, advisory bodies and land managers.

General Approach

The Network co-operation will be based on jointly executed research projects that integrate existing knowledge at regional or national level towards the European scale. The projects will be based on a comprehensive analysis of regional specific landscape functions and the identification of the various demands on land use. Following that, the landscape performance has to be analysed with respect to these functions and demands. On the basis of adequate indicator systems (COM 2000 (20), OECD 2001) landscape assessment and monitoring strategies will lead to the delineation of conflicts within land use combinations and the identification of sensitive areas where land uses contradict with environmental, economic or social targets of land development. A proper problem definition will then lead to research activities designed to support decisions on land use policy and management which will optimise land use combinations and minimise negative effects on economic, social and environmental level. Those research activities might include the development and implementation of adequate assessment and decision support tools (DALGAARD et al. 2002, WERNER and ZANDER 2002). The research process will be of iterative character and involves land use decision makers on both, the political and management level. The sketch in figure 1 illustrates the general concept of problem oriented research used in **Landscape Tomorrow** projects.

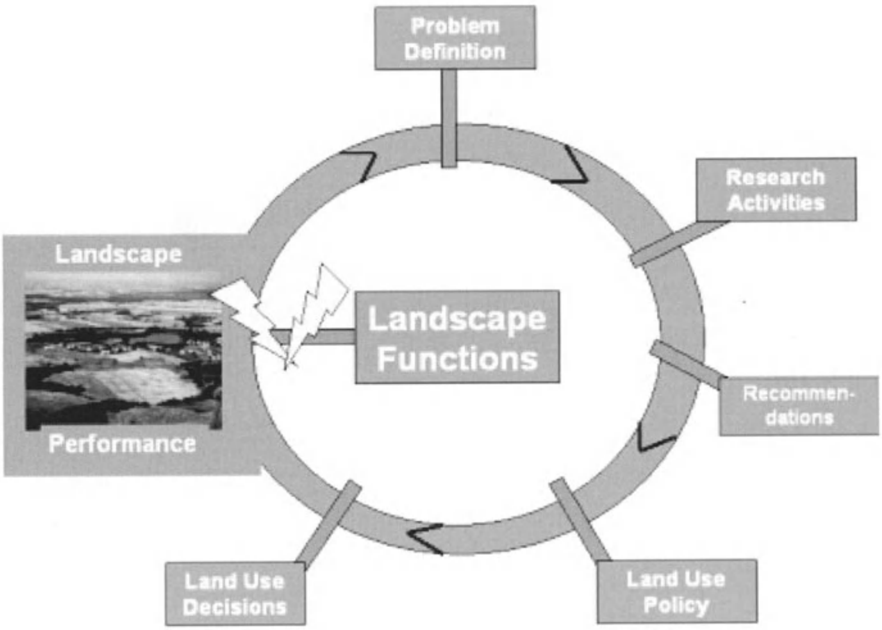

Fig. 1: General Concept of problem oriented research used in **Landscape Tomorrow** projects

According to the general concept described above, three parameters will be characteristic for **Landscape Tomorrow** research: (i) problem oriented objectives, (ii) interdisciplinary approaches and (iii) the promotion of European integration. It is anticipated that considerable knowledge of land use development will be gained through joint approaches which consider all important disciplines simultaneously, thus finding realisable solutions. Whilst many research topics (i.e. common data bases, comparability of assessment tools, indicator systems) need full European coverage, some problems (desertification and salinisation, urbanisation problems) are rather specific and refer to only a certain set of landscapes. The analysis of driving forces and key actors however always has to consider the European perspective.

Research integration

One challenge of integrating landscape research across Europe is the apparent conflict between the need to harmonise landscape research tools and methods, and the need to consider and support regional distinctions of European landscapes. Finding solutions to this situation will be one of the most challenging and rewarding tasks of the **Landscape Tomorrow** Network .

The Network will integrate the activities of national institutes into its jointly executed research, through the development of a **library of scientific knowledge**, research facilities and scientific infrastructure. Knowledge will be brought together in workshops, conferences and think tank events supplemented by frequent internal newsletters and bulletins. The web-site (www.landscape-tomorrow.net) serves two purposes (i) informing the public about activities and achievements of the Network and (ii) supporting internal information, communication, data transfer and knowledge management with an intelligent **common database** accessible through the web-site.

Research facilities and infrastructure, including laboratory equipment, field stations, GIS and bibliographic systems, will be available to Network partners in **a single virtual research platform**. This research platform will overcome research fragmentation and mitigate the current under financing of research through a concerted and efficient use of facilities. Synergetic effects are anticipated when each participating institution will make its specific set of research equipment available to the other network partners. Moreover, the mutual utilisation of research facilities will serve as a basis for **scientific exchange and training programmes** including jointly executed PhD courses and programmes. An interdisciplinary study course on sustainable development of landscapes is also foreseen.

The spreading of excellence will be guaranteed through the organisation of bridging meetings with stakeholders and policy makers and the organisation of outreach activities involving extension services, administration and the media. Specific activities such as summer courses and 'training on the job' will facilitate the dissemination of knowledge. A strong collaboration with teachers and colleges will support the evolution of an environmentally conscious society as a pre-requisite for sustainable land development.

Partnership Structure

The **Landscape Tomorrow** research network was initiated in 2001. In April 2002, a scientific workshop with more than 50 scientists from 13 European countries resulted in the agreement about the network structure, the identification of aims and objectives and a draft of the joint programme of activities. This publication on **Sustainable Development of Multifunctional Landscapes** at hand is the first result of the network cooperation.

The **Landscape Tomorrow** partnership is based on existing co-operations between major research centres dedicated to interdisciplinary landscape research. By combining these research groups, the Network generates a Europe-wide consortium that integrates environmental, social and economic expertise. To date, around 30 research institutions have signed the partnership agreement of the **Landscape Tomorrow** network (Fig. 2). The partnership includes institutions with a focus on basic research as well as those dedicated to applied research, landscape planning and land use management in the field of agriculture and forestry. Most of the institutions disseminate their knowledge through scientific education, transdisciplinary projects and policy support.

Most of the aims and objectives of the network require comprehensive expertise in all European landscapes. However, specific emphasis is put on the landscapes of EU accession countries since highest dynamics of land use changes and related environmental, social and economic developments are anticipated in those regions. The partnership structure of the network reflects this specific situation.

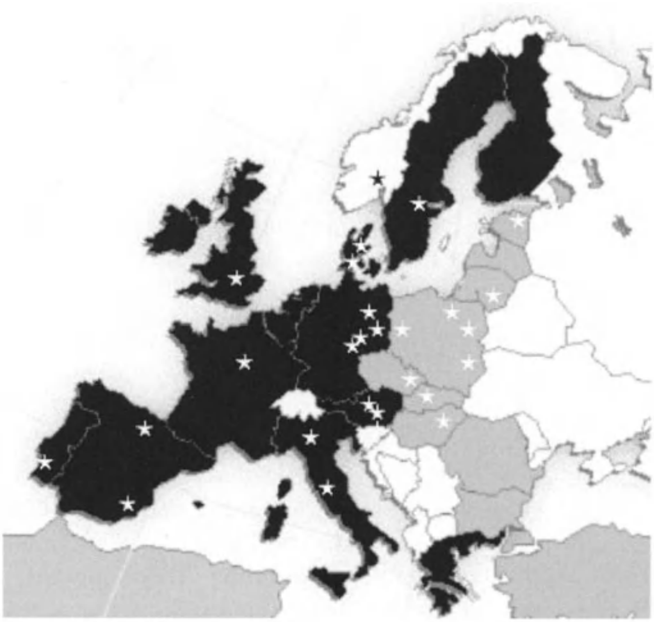

Fig. 2: Landscape Tomorrow partnership structure (stars refer to partner institutions)

The wider perspective: towards a European research area

In January 2000, the European Commission launched the conceptual framework for a consistent European research area (COM 2002 (6)). The concept was developed to contribute to improved framework conditions for research in Europe, to promote competitiveness of European research and overcome research fragmentation. In this concept, the major measures to achieve this ambitious goal were outlined as (i) the creation of a frontier-free area for research in Europe, (ii) a better use of financial instruments and resources, and (iii) the promotion of human resource mobility and research. On the basis of this conceptual framework, the "sixth framework programme for research, technological development and demonstration activities" was developed and decided upon by the European Parliament and the Council in January 2002 (PE-CONS 3635/02). Sustainable land management is one key issue within its seven priority thematic areas of research. Therefore, the scientific objectives and research approaches of the **Landscape Tomorrow** network are fully in line with the research needs expressed in the sixth framework programme. Through its integrating and structuring activities, **Landscape Tomorrow** will also have a strong impact on the integration and consistency of the

European research area in the field of landscape science and sustainable land development. With its continuously consolidating network structure being supported by a strong management, **Landscape Tomorrow** is understood to meet the requirement of *Networks of Excellence* as one important instrument to implement the required activities described in the sixth framework programme.

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