THE EXTENSIFICATION DEBATE IN EUROPEAN AGRICULTURE

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1 INTRODUCTION

Within Europe and in the General Agreements on Tariffs and Trade (GATT) negotiations, Common Agricultural Policies (CAP) have been criticised because of a series of problems they have created. Within the GATT talks, issues related to over-production and trade inhibition have played the major role. In the European debate, the CAP budget development and environmentally detrimental CAP implications have provided equally strong impetus for policy change. Farmers' lobby groups are rather suspicious of any potential policy changes for fear of income losses to the farming community.

This paper investigates the impacts of "extensification" policies that are primarily targeted at changing environmentally unsustainable production methods which are currently predominant. Focussing on a region in South-West Germany, a range of policies are analysed with respect to their implications on soil erosion, nutrient leaching, pesticide intensity and the biodiversity of agro-ecosystems. An environmental index of regional agricultural production is established which provides the basis for policy comparison with respect to environmental sustainability of applied production methods. In order to investigate the trade-off relationship between environmental sustainability and financial viability of given farming structures, a regional scoring model further combines the environmental index with an economic index for each policy scenario.

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2 BACKGROUND OF THE "EXTENSIFICATION" DEBATE

2.1 CAP and surplus production

Common Agricultural Policies (CAP) were developed after the Treaty of Rome was signed in 1957 by the six founding states of the European Community (EC). The broad objectives were to increase agricultural productivity, to ensure a fair standard of living for farmers, to stabilise food markets, to secure the availability of supplies, and to guarantee reasonable prices for consumers. The fundamental principals of CAP have remained the same while the community increased to 12 member states. They are:

1) a Common Market,
2) Community Preference, and
3) Common Financing.

Within 30 years, the market-policy dominated framework of price subsidies, import barriers and export enhancement has created a range of problems. Production well above self-sufficiency in a number of commodities is a financial burden on society twofold. First, there are the costs of purchasing the subsidised products, of storing them, of disposing of surpluses on the world markets, and of having the market control system administered by an extensive bureaucracy. The cost of the CAP have been escalating and account for the largest section of the EC budget. Second, the Community's consumers pay higher prices for agricultural products than they would without the system.

Sales of surpluses on international markets at dumping prices distort the mechanism of free trade in that this action forces world market prices to fall below a free-trade-equilibrium, affecting the export incomes of traditional exporting nations and a fall in commodity prices for their producers.

Price subsidies provoke structural effects and intra-sectoral distortions within the community, as it is estimated that 20 % producers, who account for 80 % of the production, receive the equivalent share of subsidies, while the remaining 80 % small properties share 20 % of the payments. Ironically, the system hampers structural adjustment at the same time because it keeps small farm businesses profitable and it indirectly increases land values, affecting land transactions for both purchase and lease.

CAP has responded to the fundamental issue of commodity surpluses by introducing a range of market-related regulations. They include production quota, 'set-aside' and 'extensification'. It can be said that neither of these programs has solved the problem. The political definition of "extensification" relates to a program, where farmers can claim direct payments when they agree to reduce their output of surplus products by at least 20 % for at least 5 years (Commission of the European Communities, 1988).

2.2 Environmental aspects of agricultural production

In the processes of intensification and specialisation of agricultural production, which technical progress has initiated and CAP have promoted, traditional forms of agricultural land use have largely disappeared in central Europe. In the 'cultural landscapes' these locally adapted land use systems were not only a living embodiment of history and tradition and an economic resource to the population. They were also of crucial importance for other recreational and regeneration functions of the landscapes and for the floral diversity and associated fauna within the traditional agro-ecosystems (Baldock 1990).

The agricultural revolution in the past four decades has seen a development where agriculture has become not only the major cause of habitat loss and species extinction. Also, massive inputs of fertilisers and pesticides have caused pollution of ground and surface water, thus imposing increasing external costs on the densely populated European countries that rely on these major drinking water sources (de Haen *et al.* 1991).

Increasing environmental awareness of the societies has resulted in the petition for more environmentally sustainable agricultural practices and in some countries there is increasing willingness to develop and finance regionalised programs where farmers receive income transfers when they stay with or re-establish environmentally sound and culturally attractive production practices which remain at an extensive production level.

2.3 Extensification of agricultural production

Farmers' lobby groups have been opposing the concepts of extensification, in both the political and the environmental sense, for fear of income losses as well as for aversion against loss in entrepreneurial freedom. A quantitative analysis is needed to argue the expected trade-off relationship between environmental achievements from extensification and income losses for the farming community.

The term "extensification" will not be used in its CAP-sense but is defined as a reduction of factor inputs, both fixed and variable, per unit of land under production and the adoption of soil and biodiversity conserving and less water polluting landuse practices. This definition is a reversal of the original sense of the term, which meant the increase of area under production (from lat. extendere) with the same aim as intensifying. From an environmental viewpoint, extensification is the antonym to intensification with the aim of achieving long-term sustainable agricultural production.

A range of policy measures can be expected to reduce production intensities. In order to provide quantitative insight into their implications both environmentally and farm financially, a hierarchical model was established and applied for a region in South-West Germany.

3 QUANTIFYING EXTENSIFICATION EFFECTS

3.1 Regional Analysis for the Kraichgau

Most environmental problems are of a regional rather than a site-specific character, particularly they relate to non-point source pollution and when bio-physical processes, for example in the case of nitrate-pollution of groundwater, incur external effects. Hence, the extensification issue is investigated on a regional level.

The study area is the Kraichgau, an area of 1750 square kilometres in the Rhine Neckar Basin in South West Germany. It is a landscape famous for its highly productive loess soils in a rolling hill landscape. 50 % of the region is under agricultural production, 80 % of which is cropped after extensive land consolidation programs in the 1960s. Severe soil erosion and water quality hazards as well as loss of remaining semi-natural habitats are urgent environmental problems.

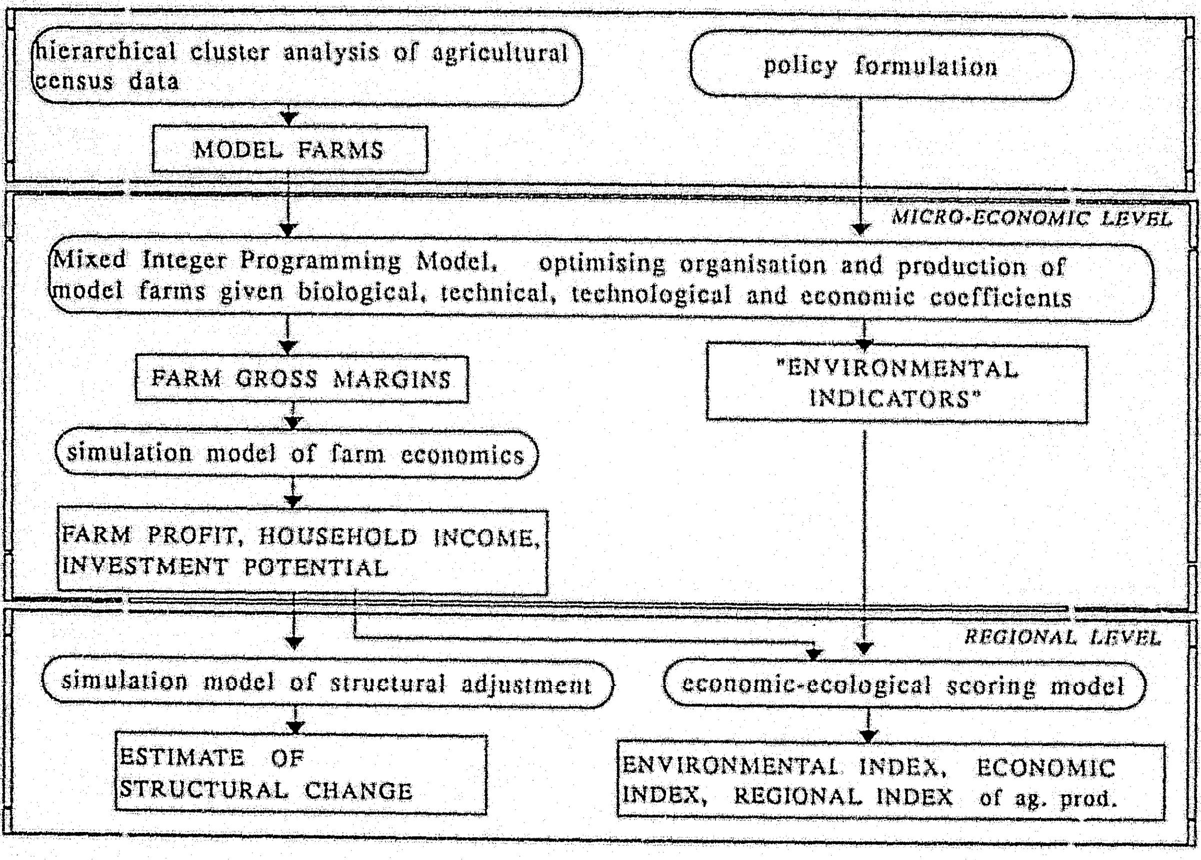
Farming structures in the region are extremely heterogenous. Regarding production specialisation, cash cropping is the predominant income source of more than half of the farm enterprises. A quarter specialises in dairy and beef production, with pig/poultry enterprises, mixed farms and viticulture enterprises making up the remaining 25 per cent. With respect to the income structure, only one third of the farms are classified as full time farms, generating more than fifty per cent of the household income on-farm. They average a farm size of 31.6 hectares. Structural adjustment happens rapidly. Between 1979 and 1987, the number of farms had declined by 27 %. With a good choice of off-farm employment available in the region, the proportion of part-time farms to full-time farms has shifted from 1:1 to 2:1 in the same period. The region has seen extensive land consolidation in the 1960s and 70s. Agriculture in the Kraichgau currently employs 3.4 % of the working population and earns 2.1 % of the regional gross income.

On the fertile loess soils, production intensity is high with sugar beets, maize and high-protein wheat being the major crops. Per hectare of agricultural area, 185 kilograms of nitrogen are purchased annually- an increase of 150 % since the early 1960s. If the nitrogen from animal manure is taken into consideration, there is a total 230 kg N applied per hectare and year. Given the requirements of the predominant crops concerning pesticide regimes, this land use accounts for a high risk of nitrate leaching into the groundwater system and soil erosion and pesticide pollution. Erosion levels between 10 and 60 tonnes of top soil per year have been measured in different rotations (Quist 1984; Clemens *et al.* 1989). Extensification seems a necessity - but the question remains how the financial viability of farming and structural adjustment will be affected.

3.2 The hierarchical model concept

In order to investigate environmental and farm financial effects of a range of policy options on the region and present them in a readily understandable format for all stakeholders, a hierarchical model was developed. It is outlined in Figure 1.

Figure 1: Hierarchical model approach



The farming structure of the area is represented in 29 model farms which are derived from cluster analysis of agricultural census data. The characteristics of each model farm feed into a mixed integer programming farm model which maximises gross margin and calculates parameters which characterise the environmental sustainability of the production practices applied. Parameters that determine financial viability of farming are estimated separately in a simulation model.

The farm-level model results are subsequently transferred into the regional model level. First, the impacts of the policy scenarios on structural adjustment are estimated. Second a regional scoring model. captures the environmental and financial sustainability of farming through an indexing procedure and produces a regional index of production as the ultimate basis for policy comparison. A detailed description of the model can be found in Greiner (1993).

3.3 The concept of environmental indexing

Environmental indexing has become an important means of monitoring the state of the environment and at the same time interpreting them with respect to a question asked. The approach is of major political relevance in the attempt to include environmental consideration into policy making. In Canada, for example, a Green Plan has been proposed, with one aspect of the Plan being to report the state of Canada's environment on a continuing basis. The report has four components: 1) National State of the Environment Reporting and products, 2) Integrated monitoring, 3) Environmental components of National Accounts and 4) Environmental indicators (Hirvonen 1992). Environmental indicators in this context would be analogous to economic and social indicators, such as employment indicators and the consumer price index, used daily by governments and policy makers.

Indices are a means of representing a comprehensive set of parameters in a single number. They are a tool for summarising, and interpreting complex relationships. An index is therefore a way of reducing large volumes of data provided into a more useable and user-friendly form. As is the case with any simplification process, information is lost during the procedure of creating the index. With a carefully designed index however, the data is tailored in such a way that it retains only the essential meaning for the questions being asked of it (Ott 1978).

Environmental indices can be an accurate means of continual assessment of the state of the environment and of monitoring changes in environmental conditions. With respect to agricultural land use, Meyer *et al* (1992) emphasise the potential of environmental indices to reliably and accurately assess the ecological condition of agro-ecosystems which is critical to efforts to achieve productive sustainable agriculture. The development of environmental indices is orientated at achieving a precise description of the (regional) state of soils and water resources, of species development, erosion and food quality (Young 1991). Their usefulness is not restricted to provide a useful source of information to policy makers for decision taking. Through aggregating the results of constant monitoring in the follow-up stage, essential feedback information on the impact that governmental regulations and policies have on the environment can be obtained.

4 METHOLOGICAL ASPECTS OF ENVIRONMENTAL INDEXING

4.1 Choice of Indicators

The components of environmental indices are environmental indicators. Environmental indicators are measurable attributes of the environment which can be monitored (Meyer *et al.* 1992). Three major stages to environmental index formulation can be identified. First, the user group and purpose for the index need to be defined and stated. Second, following carefully prepared selection criteria, appropriate environmental indicators are chosen, and third, indicators are aggregated into a multivariate index where the index provides accurate information to the designated user group(s).

In the choice of indicators three criteria are applied which are, that the indicator should be responsive/sensitive to environmental stress, that it be relevant to a stated application or goal and that it should be easy to monitor. The two fundamental steps which follow are, first, the calculation of subindices and, second, the aggregation of the subindices into the overall index (Ott 1978). While subindices aggregate the indicators related to different environmental aspects, the overall index provides the final assessment. The procedure may also be referred to as scoring model.

4.2 Aggregation

Both aggregation stages face the problems of establishing an aggregation function and assigning weights to the variables involved. While subindex functions show a range of functional relationships including simple multipliers or the variable raised to a power, the main index is generally generated in a summation or a multiplication operation which can incorporate a standardisation formula (Ott, 1978).

The process inevitably leads to simplification and information reduction and caution in establishing the aggregation functions is required to minimise distortion: Assigning weights to the variables in every aggregation stage determines the level of influence that single indicators have on the overall index. While additive aggregation functions bear a risk of eclipsing (ie. the overall index does not show poor environmental quality, even though one of the component subindices does), multiplying tends to over-emphasise extreme index values.

Given the value laden nature of weights, the question of how to obtain weights which accurately reflect the relative influence of the components of an index on the overall index is central to index formulation. Hope and Parker (1992) used a public opinion poll to assign weights to the components of an environmental index. The question remains, whether public knowledge about crucial facts and relationships is sufficient to rely on this opinion. Expert opinion is another method of weighting component subindices, however problems with consistency, repeatability and subjectivity are possible sources of error. However, a structured methodology for deriving weights can be applied which produces consistent results. Using pairwise comparison, informed individuals are able to compare like objects in relation to a set criterion (Saaty 1982, Saaty and Alexander 1981).

4.3 The importance of scale

The scale for which an environmental index is designed and the scale at which it is applied are of crucial importance. Every stage in the procedure is affected, namely the choice of indicators and the way the information is aggregated, particularly which relevance is assessed to single aspects and hence how the weights are assigned. It is equally important to mention that misinterpretation occurs if the index is not interpreted at the appropriate scale, be it the local, regional, national or global level. While abuse of the results of environmental indexing cannot be excluded, it is inevitable to display and explain the scoring process and data limits and to provide interpretations on the appropriate scale and limit extrapolation. The fact that regional and higher scale indicators are derived from collation and synthesis of detailed data and not measured directly makes them useful tools at the policy and program evaluation level, but sets limits to their applicability at the operational or research level (Hirvonen 1992).

5 AN ENVIRONMENTAL INDEX (ENI) OF AGRICULTURAL PRODUCTION

5.1 Concept and choice of indicators

The aim of the analysis outlined in the introductory chapters is one of policy analysis at a regional level, which has been shown to be a major field of application of environmental indices. However, unlike the cases stated as examples, no experimental or observation data are available as indicators. Instead, the results provided from runs of the programming model of regional agricultural production (Figure 1) offer a variety of environmental parameters which characterise regional production practices and respond well to changes in the policy framework of agriculture.

In order to develop a regional environmental index of agricultural production, the following steps were undertaken. The environmentally most relevant parameters were chosen as variables and hence basis for a regional scoring model of agricultural production. They were aggregated and standardised against what was defined "environmentally sustainable" which resulted in a number of sub-indices. These were subsequently aggregated to an environmental index as measure of the sustainability of agricultural production.

The following environmental parameters were obtained from the MIP model results. Determining the general land use intensity are the percentages of cropping and pasture land. For cropping, the percentages of erosion enhancing crops (ie. sugarbeet, maize and sunflower), cereal crops, legumes, and fallow on cropping area. With respect to soil erosion the soil cover during autumn, winter and spring. Fertilisation is captured in the application of nitrogen, phosphorus and potassium per hectare and the nutrient balance for these macro-elements. Pesticide application is measured in d-marks per hectare and the average number of pesticide applications per hectare. The intensity of husbandry production is reflected in the term DE/hectare. DE stands for "Dungeinheiten", which is a similar measure to DSE (dry sheep equivalent), based on 500 kg liveweight.

5.2 Aggregation of sub-indices

Four sub-indices, which are referred to as partial indices (PI) in the following explanations, reflect major aspects of the status of environmental sustainability of agricultural production. They deal with the relevant environmental problems in the area which relate to soil erosion, nitrate leaching, pesticide contamination and decline in the bio-diversity of agro-ecosystems.

Partial Index 1 (PI_1) deals with soil erosion control. The results of the programming model applied at model-farm level record soil cover in autumn, winter and spring (SC_{awc}) under the paddock rotations applied, and the percentage of erosion-enhancing crops (EEC) grown in summer. They do not directly estimate tillage intensity and hence no full estimate of the C-factor within the Universal Soil Loss Equation (USLE) (Wishmeier 1978) is possible. The highest danger of soil erosion is given for bare soil during the high-rainfall early summer months and is associated with the growing of erosion enhancing crops (Schwertman *et al.* 1987). The following formula determines PI_1:

$$PI\_1 \quad = \quad 1/2\ (SC_{awc} + (1 - EEC)).$$

In doing so, it standardises the value of the index to the range zero to one, with one representing environmentally sustainable or "extensive" production and values towards zero reflecting environmentally detrimental production practices. This condition applies to all partial indices:

$$0 \quad \leq \quad PI \quad \leq \quad 1.$$

Given the nature of cropping, only pasture can provide total soil cover and protection from soil erosion and hence only pastoral farms can receive a value of $PI\_1 = 1$.

The second partial index (PI_2) deals with the general production intensity which is of relevance for the bio-diversity within agro-ecosystems. This is a landscape-specific factor which is determined by the natural fertility and relief of the region. Nitrogen is an input factor for both pastoral land use and cropping and for the Kraichgau, an application intensity of nitrogen (N_{tot}) up to 80 kg $N^*ha^{-1}*a^{-1}$ can be tolerated for sustainable production (Lünzer et al 1988). Fertilisation above this threshold sacrifices sustainability. The standardisation formula then becomes

PI_2 = $80 / N_{tot}$ for all $N_{tot} > 80$ kg $N^*ha^{-1}*a^{-1}$; and
PI_2 = 1 for all $N_{tot} < 80$ kg $N^*ha^{-1}*a^{-1}$.

Nitrogen also plays the key role in groundwater pollution from agricultural production because it easily leaches through the soil profile in the form of nitrate (NO_3^-). The potential for nitrate leaching is a function of the nitrogen balance rather than the absolute amount of fertilisation applied. Given the climatically and geological and soil conditions in the Kraichgau, a nitrogen balance surplus (N_+) of 23 kg $N^*ha^{-1}*a^{-1}$ can be tolerated. Given the conditions of 200 mm annual recharge, constant organic soil matter and no nitrate reduction in the groundwater, the threshold of 50 mg nitrate per litre of water, which is the legal contamination threshold for drinking water quality, will not be exceeded (Werner 1989). The standardisation formula for PI_3 which represents the potential threat for water quality is

PI_3 = $23 / N_+$ for all $N_+ > 23$ kg $N^*ha^{-1}*a^{-1}$; and
PI_3 = 1 for all $N_+ < 23$ kg $N^*ha^{-1}*a^{-1}$.

It is difficult to capture the intensity of pesticide regimes. The monetary term is limited because modern systemic and highly specific chemicals are more expensive than general formulae. A change in the legal framework (e.g. prohibition of atrazin) may increase the costs of plant control while decreasing the potential dangers associated with it. The intensity of pesticide regimes may also be measured as pesticide applications per hectare and year (PA). Again, it does not account for the potential threat of each application but it is easy to record. With a maximum of six applications found in sugar beet and canola growing, the standardisation formula for PI_4 is

PI_4 = $1 - (PA / 6)$.

This means, that any pesticide application is considered environmentally unsound. Only farms with alternative production methods or pastoral properties can be expected to operate environmentally sustainable in this respect.

These four partial indices or sub-indices capture directly of indirectly the environmental significance of agricultural production methods as applied by the model farms in the region. They relate to cropping versus pasture, paddock rotations, tillage practices, fertilising and pesticide regimes.

5.3 Aggregating the sub-indices to an environmental index (ENI)

After choosing the variables for the scoring model and aggregating and standardising them into partial indices, the partial indices must be aggregated into the environmental index. This involves the issue of weighting them in the aggregation procedure. All four indices represent important environmental aspects of agricultural production. They are partially interdependent. For example, increased soil cover not only reduces the potential threat of soil erosion, it also a means of reducing potential nitrate leaching. Or a high percentage of sugar beets decreases environmental sustainability of production not only in terms of increased potential erosion but also as a crop that demands intensive chemical care. Consequently it is decided to equally weight the four partial indices into the environmental index (ENI) of agricultural production.

$$ENI \quad = \quad 1/4\ (PI_1 + PI_2 + PI_3 + PI_4)$$

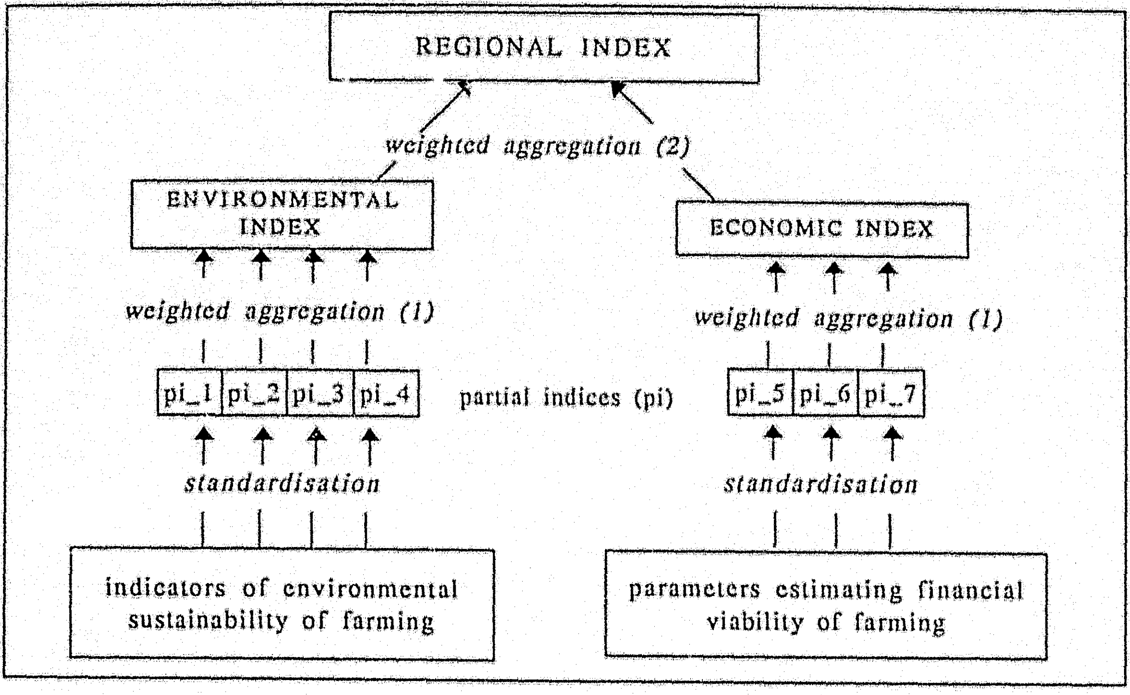
with

$$0 \leq \quad ENI \quad \leq \quad 1$$

where "1" represents sustainable extensive land use and decreasing values reveal environmental hazards of the production methods applied.

By displaying not only the value for ENI but also its composition of the four partial indices, an "environmental sustainability profile" of agricultural production in obtained which shows the significance of each aspect considered in the value of the ENI. The procedure of obtaining ENI is displayed in the left hand side of Figure 2, which reveals that this index is only part of a larger-scale scoring model.

Figure 2: Scoring model of regional agricultural production



6 ECONOMIC INDEX (ECI) OF AGRICULTURAL PRODUCTION

6.1 Concept of the Economic Index

Equivalent to the Environmental Index, an Economic Index (ECI) is created to judge the efficiency of current agricultural production structures. Its variables consist of the outcomes of the farm-financial simulation model which are profit from farming (P), available household income (HI) and the household's investment capacity (IC).

Again, the values are standardised. This is achieved by dividing them by the highest value found amongst the model farms. Hence, the economic index is displaying the relative viability of farming structures given the currently prevailing price conditions and legal framework relevant for agricultural production. The three partial indices are

$PI\_5 = P/P_{max};$

$PI\_6 = HI/HI_{max};$

$PI\_7 = IC/IC_{max}.$

6.2 Defining weights for the aggregation process

Their different relevance for the continuation of a farming enterprise has to be reflected in the weighting factors in the aggregation towards an ECI. Weighting is an intrinsically subjective act, however, the Saaty-procedure can help to minimise the error.

First, priorities between the three variables are established through pairwise comparison using a matrix. The matrix offers a framework for testing consistency, for testing all possible comparisons and for establishing the sensitivity of the overall priorities to changes in judgement. The variables are arranged in a matrix as set out in Table 1. To fill out the matrix, the questions asked are for example: How much more important for the continuation of a farming enterprise is the available income of the farming household in comparison to the profit made in the farming enterprise? On a scale of 1 to 9, where "1" stands for parity and "9" represents complete dominance, the greater importance of IC may be expressed in a "4" in the cross section of the two variables above the diagonal and the corresponding "1/4" in the field below. Available household income is considered the key measure for financial sustainability of a farming enterprise. The estimation of the investment potential of the household has to be considered rather vague, as its estimation includes only an estimate for household consumption, which can be determined securely on a single-farm basis. Profit from farming is an important factor, because only enterprises yielding profit are likely to receive both replacement and new investment.

Table 1 : Basic Saaty matrix

	AI	P	IC
available household income (AI)	1	4	5
profit from farming (P)	1/4	1	3
investment capacity (IC)	1/5	1/3	1
Σ vertical	1.45	5.33	9

Next, the matrix (Table 2) is normalised by dividing each value assessed by the vertical sum of each column. The values in the first three columns of the following matrix evolve.

Table 2 : Standardised Saaty matrix and weighting factors

	AI	P	PI	Σhoriz.	weight
IA	0.69	0.75	0.56	1.99	0.67
P	0.17	0.19	0.33	0.69	0.23
IC	0.14	0.06	0.11	0.31	0.10

The row sums divided by the number of columns (3) determine the relative priority of each variable which becomes the weighting factor in the aggregation for the economic index so that we obtain the following weighting formula:

$$ECI = 0.23 * PI\_5 + 0.67 * PI\_6 + 0.10 * PI\_7$$

with

$$0 \leq ECI \leq 1.$$

6.3 Integrating of the environmental and the economic indices into a regional index (RI) of agricultural production

The scoring model can be taken one step further by aggregating the economic and the environmental indices of agricultural production into a regional index of sustainability of agricultural production. Again, weighting is the crucial factor in creating this regional scoring value. The whole scoring model is presented in Figure 2.

This last step of aggregation again bears the vital question of weighting the two variables. Weighting in this instance clearly requires a political decision. It depends on whether priority is set on creating the framework for an environmentally more sustainable agricultural land use or whether the political power of the farming community and sympathising sectors outweighs environmental concerns. As this question cannot be answered within this analysis, the weights in this final aggregation step are sensitivity-tested. Instead of one index per policy an index-band is obtained and displayed which shows the relative superiority of the tested policy conditions given different priorities.

7 SELECTED RESULTS

7.1 Policy Scenarios

Amongst the policies under consideration for generating extensification of agricultural production are the reduction of price subsidy levels, imposing a levy on potentially environmentally hazardous inputs, and enforcing a compulsory set aside program.

Amongst the farming lobbyists, price reductions are the least favoured policy. It can be expected to create an extensification effect by reducing the marginal income per unit of factor input and consequently creating a lower optimal level of variable inputs. A significant tax on nitrogen as the key input factor in terms of production intensity will increase the marginal costs of production, again leading to a decrease in optimal factor input. Imposing a compulsory set aside program involving 25 per cent of the cropping area of a farm whilst compensating farmers with a close-to-average-gross-margin premium reduces the production intensity on these areas to zero with no economic effect on the production intensity on the remaining 75 % of cropping land.

7.2 Environmental Sustainability Profiles on the Farm Level

On the farm-level, MIP results and environmental and economic indices are generated for 29 model farms. Farms of different specialisation are subsequently looked at with respect of the extensification effects of the policy scenarios as reflected in the environmental sustainability profiles (ESP).

Figure 3: Environmental Sustainability Profiles of selected model farms in the reference situation

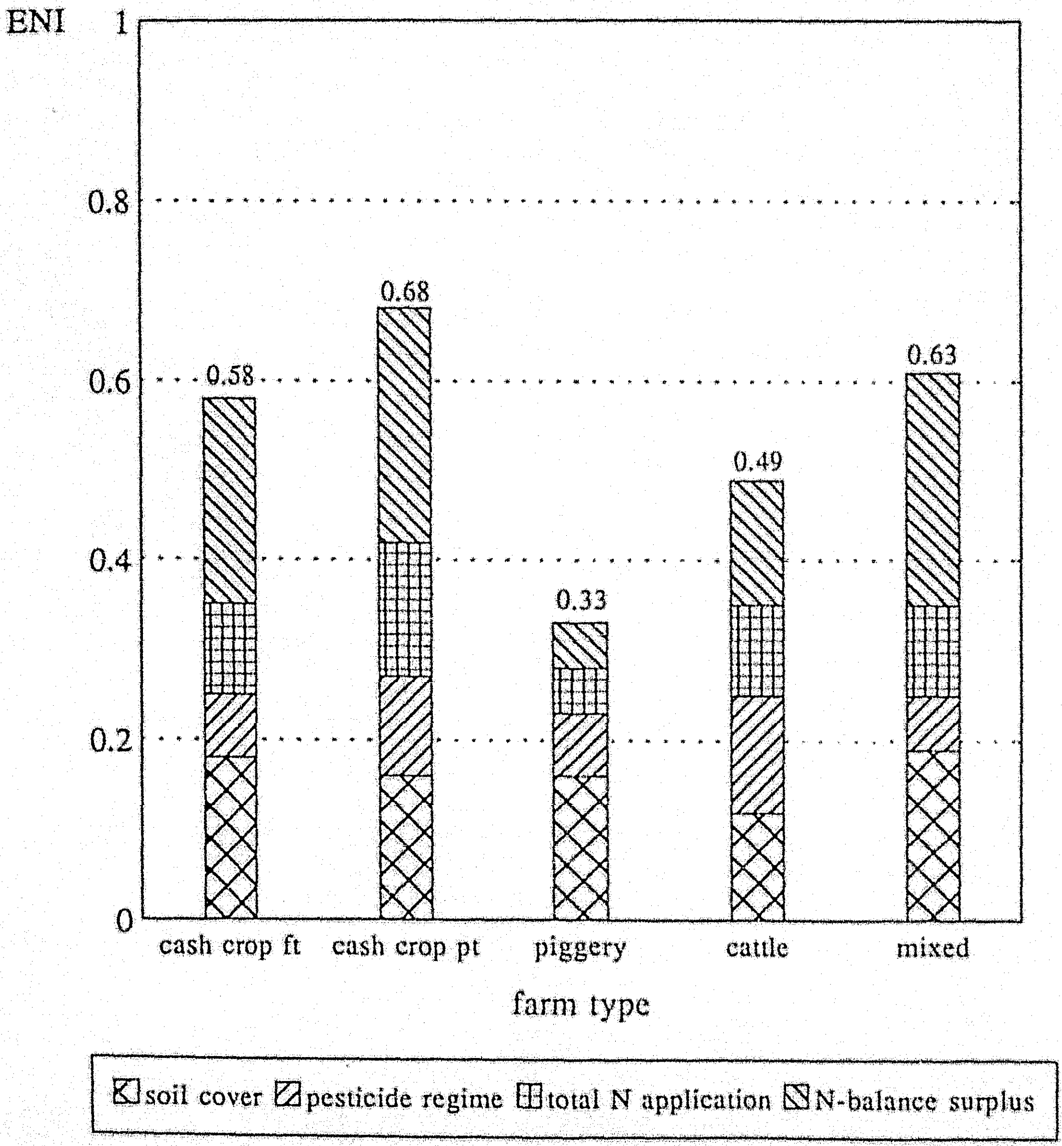
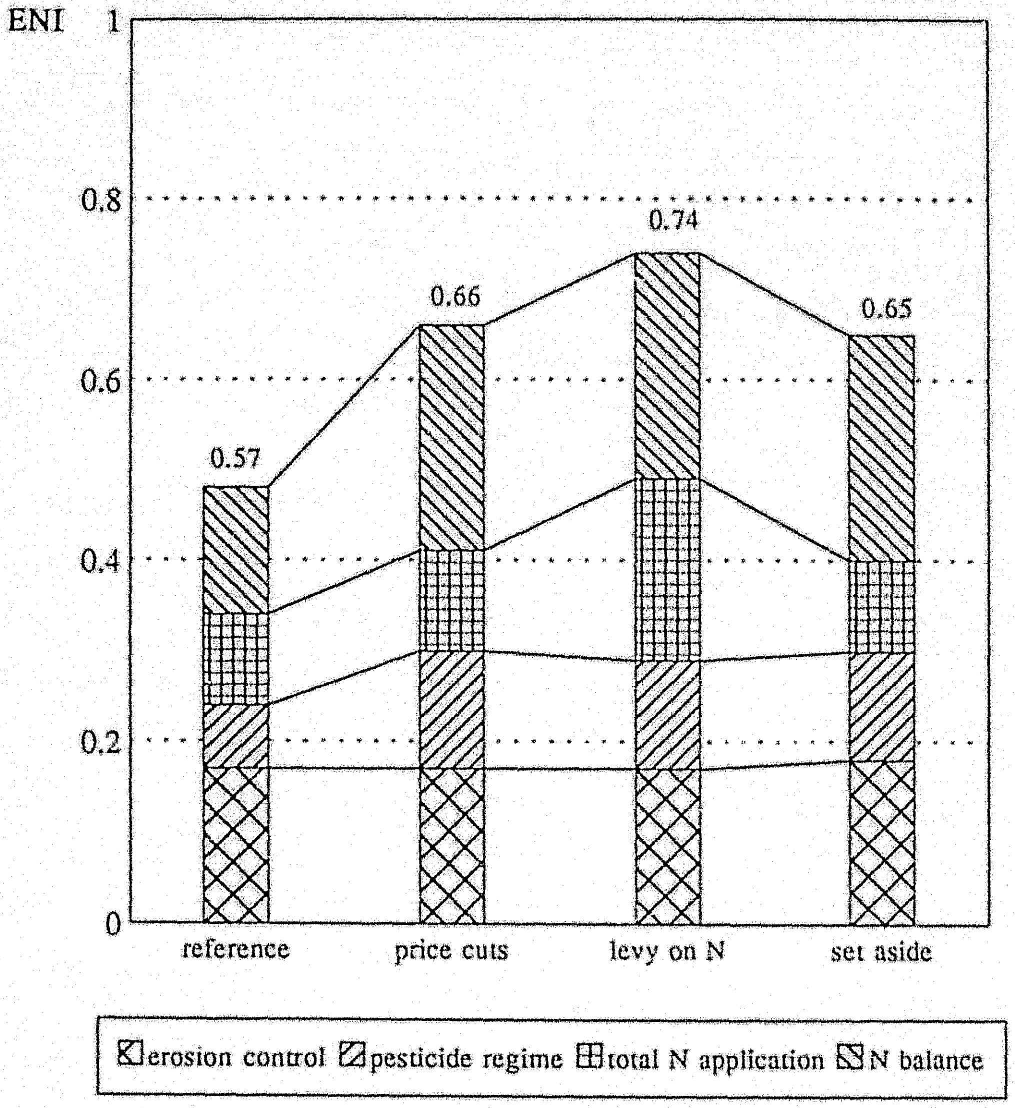


Figure 3 compares the environmental indices of the farms in the reference situation. The highest ENI score is 0.68 for a cropping farm with major off-farm income. A moderate application intensity of agro-chemicals results in nitrogen balance that raises no environmental concern. There is scope for improving erosion control through increased soil cover. The ENI 0.63 which is achieved by the mixed farm, closely followed by the cropping farm (0.58). Both farms show high values in the partial indices for soil cover and nitrogen balance. However, their total production intensity and pesticide regime are of environmental concern. The ESP of the cattle farm displays problems with the nitrogen balance on a high application level at a value of 0.49. Of extreme environmental concern are the production practices of the piggery. At a value of 0.33, the only positive aspect is a high degree of soil erosion protection. Nitrogen application from manure is very high, accompanied by a potentially disastrous nitrogen balance and an intensive pesticide regime to ensure a yield from the crops.

Figure 4 shows the implications of above policy scenarios on the environmental sustainability profiles of a full-time cropping farm. Price reductions achieve a conceivable extensification effect with ENI increased from 0.57 to 0.65. This improvement is based mainly on a reduction of pesticide application. The reason lies in the voluntary adoption of the set-aside program on a third of the cropping area at the expense of growing winter cereals. Even though the production intensity on the remaining area remains the same. A levy on nitrogen-purchases achieves an improvement of ENI of +0.17. Again, the pesticide intensity drops significantly and also nitrogen application drops to half the initial level. This policy achieves a reduction of production intensities over the whole cropping area without attracting a participation in set-aside. Legumes are incorporated into the cropping mix. Compulsory set aside shows the same effect as its voluntary adoption in the price-cut-scenario.

The cattle enterprise and mixed farm react in a similar fashion to the policies. Price reduction favour voluntary set-aside, a levy on nitrogen reduces nitrogen purchases and lowers pesticide intensity. Soil erosion control remains unaffected. The environmentally detrimental land use practices of the piggery remain unaffected by any of the policies. Masses of pesticides are needed for phytosanitary reasons in over-fertilised crops. The massive nitrogen balance surplus is an extreme hazard for groundwater quality. The problem of disposing of the waste product "manure" on a small area is exacerbated by the compulsory set-aside scenario, where the manure is dumped on an even smaller area which sends nitrogen-balance-surpluses sky-rocketing. It is obvious, that different policies are needed to address the environmental dangers associated with intensive livestock production.

Figure 4: **Environmental Sustainability Profiles of a full-time cropping farm under different policy scenarios**



7.3 Extensification Effects on the Regional Level

Through aggregation of the farm-level results, environmental sustainability profiles can be obtained on the regional scale. The environmental index values in the policy scenarios are summarised in Table 3. Besides to overall regional figure, a distinction between households with predominant income from farming versus households with predominant off-farm income has been made. The calculations show that the latter would favour sustainable production under the price reduction conditions. This is explained through a large-scale adoption of the set-aside program which offers farms with below-average productivity a highly attractive premium for not-producing. The only policy achieving a "true" extensification effect is the levy on nitrogen purchases, where the actual production intensity in crop production is significantly reduced.

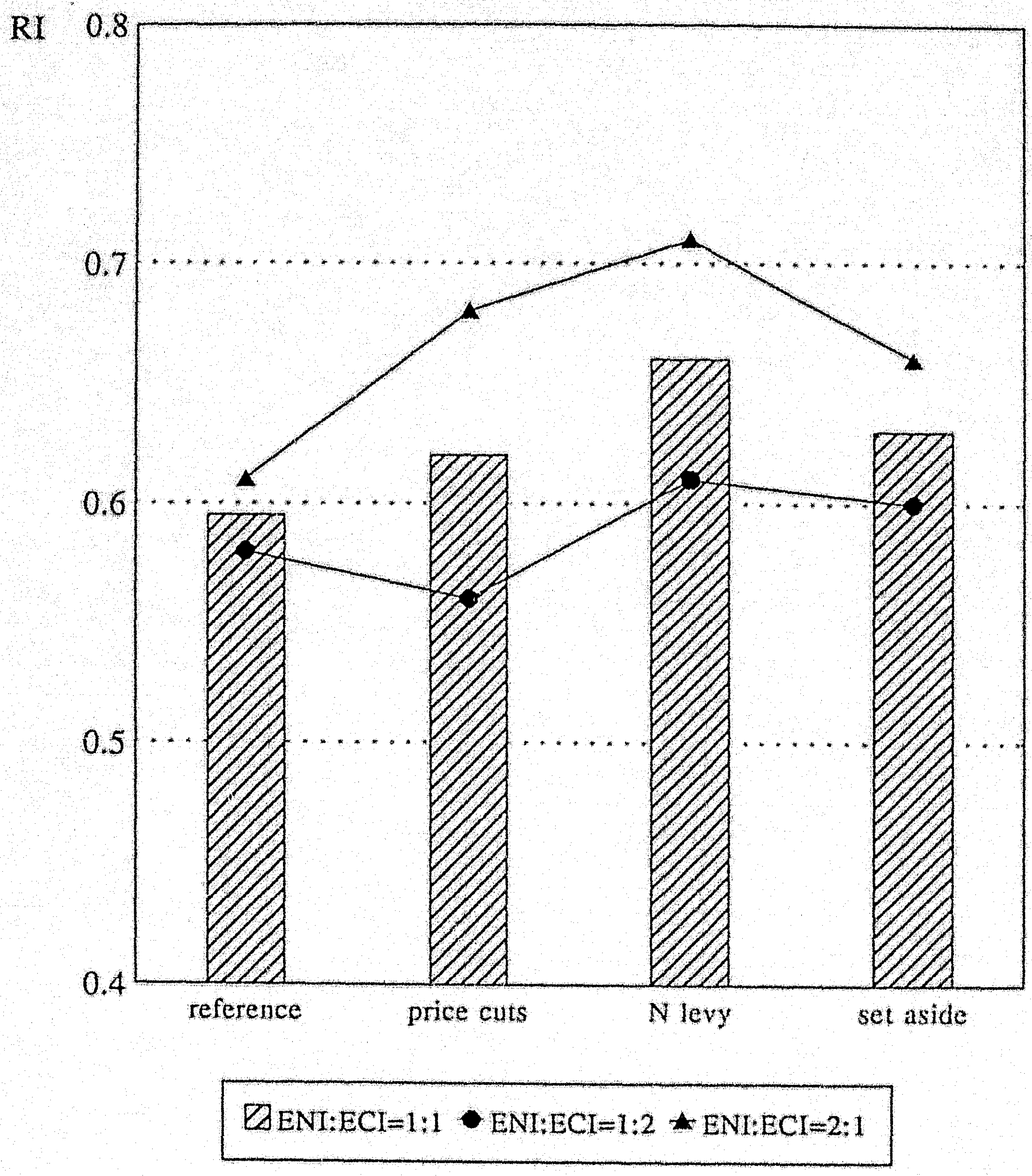
Table 3 : The regional environmental index in the policy scenarios

	Total Region	Full-time farms	Part-time farms
Reference	0.63	0.60	0.69
Price reductions	0.80	0.78	0.88
Levy on nitrogen	0.82	0.82	0.83
Compulsory set-aside	0.73	0.72	0.75

If we take these results one step further and aggregate the environmental index with the economic index calculated for the scenarios, we receive a total regional scoring value (RI) which will reflect the trade-off between extensification of production and financial viability of farming according to the weight assigned to ENI and ECI. Figure 5 shows, however, that within a range between 1:2 and 2:1 of assessing relative importance to financial aspects of extensification aspects, a levy on nitrogen still remains the most favourable policy under investigation.

This regional index as are the environmental and the economic indices are region-specific constructions and should not be extrapolated to other areas of different climatic, geological and structural conditions. Also, it has to be emphasised once more that the evaluation of these policies is restricted to an environmental-economic sustainability space. If other aspects of policy implications such as production quantities were to be incorporated, the approach would need to be extended by this dimension.

Figure 5: The Regional Index of Agricultural Production



8 SUMMARY

This paper presents the concept of establishing an environmental index as a means for measuring extensification effects of potential policy action. Environmental indices provide a pragmatic and operational approach to summarising a range of aspects and simplifying complex relationships. Unlike in the standard approach of capturing the essence of observations of environmental relevance, the procedure presented in this paper aims at condensing the complex results of a hierarchical programming model into a form which is digestible to user groups such as farmers, lobby groups and policy takers, all stakeholders involved in the attempt to promote and enhance environmentally sustainable and financially viable agricultural production practices.

The stratification applied is designed to address the specific need of the two-dimensional approach. The regional environmental index of agricultural production provides the basis for comparing policy options with respect to a range of ecologically relevant aspects, while the economic index of agricultural production assesses the economic implications for the regional farming community. Both aspects are combined into a regional index which has to be seen as a tool to investigate and evaluate the trade-off between environmental friendliness and economic persistence of the production structures and land use practices of the specific region under investigation.

The results of the scoring model indicate that there are basically two policies available that show significant extensification effects, these are (1) significant reduction in price subsidies, and (2) imposing a levy on the purchase of nitrogen fertilisers. Price cuts result in very high income losses despite the fact, that a voluntary set-aside program with a high per-hectare-premium is available. Production intensity on the remaining area remains unchanged. A nitrogen-tax achieves an extensive reduction in production intensity over the whole cropping area. The results also indicate, that the environmental hazards associated with high-intensity husbandry cannot be addressed by any of the policies under investigation.

Recent years have already seen a significant reduction in price subsidy levels for EC-financial reasons. Particularly in Germany, the resulting negative income effects for the farming community have been (partially) off-balanced by an increase in programs, where farmers can voluntarily join ecologically motivated initiatives at a local and regional level and are paid to do "landscape gardening". Other policy schemes offer financial aid for structural adjustment eg. in case of early retirement. According to the model results presented, this policy development can be expected to enhance environmentally sustainable agricultural production practices on a broad acre scale while a change in legal conditions will be necessary to address the environmental problems associated with intensive animal production.

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9 REFERENCES

Baldock, D.; 1990; The Common Agricultural Policy and the environment. WWF International CAP discussion paper number 2, Gland, Switzerland.

Commission of the European Communities; 1988; Regulations 1094/88 and AB1.L/88.

Constanza, R.; 1992; Ecological Economic Issues and Consideration in Indicator Development, Selection and Use: Towards an Operational Definition of System Health. In, D.H. McKenzie, D.E. Hyatt and V.J. McDonald (eds), *Ecological Indicators*, Elsevier Applied Science, London and New York, 1491-1502.

de Haen, H., H.F. Fink, C. Thoroe a. W. Wahmhoff; 1991; Impact of German intensive crop production and agricultural chemical policies in Hildesheimer Börde and Rhein-Pfalz. In: M.D. Young (ed.) *Towards Sustainable Agricultural Development*, Belhaven Press, London and New York, 9-49.

Dixon, J.A. and M.M. Hufschmidt; 1986; *Economic Valuation Techniques for the Environment*. The Johns Hopkins University Press, Baltimore and London.

Greiner, R.; 1993a; Estimating Ecological and Economic Impacts of Selected Agricultural Policies in South-West Germany. In, M. McAleer and A. Jakeman (eds), *International Congress on Modelling and Simulation*, Proceedings, 1307-1312.

Greiner, R.; 1993b; Differentiation between Model Farms on a Scarce Regional Data Basis. In, M. McAleer and A. Jakeman (eds), *International Congress on Modelling and Simulation Proceedings*, 1401-1406.

Greiner, R.; 1992; *Art und Umfang der Extensivierung landwirtschaftlicher Bodennutzung in Abhängigkeit von agrarpolitischen Massnahmen*. Landwirtschaft und Umwelt, Vol. 7, Wissenschaftsverlag Vauk, Kiel.

Hirvonen, H.; 1992; The Development of Regional Scale Ecological Indicators: A Canadian Approach. In, D.H. McKenzie, D.E. Hyatt and V.J. McDonald (eds), *Ecological Indicators*, Elsevier Applied Science, London and New York, 901-915.

Hope, C.W., Parker, J.D.E.; 1992; An Environmental index for the UK. In D.H McKenzie, D.E. Hyatt and V.J. McDonald (eds), *Ecological Indicators*, Elsevier Applied Science, London and New York, 1536-1540.

Lünzer, J., Padel, S. u. H. Vogtmann; 1988; *Ökologischer Landbau: Daten-Fakten-Zusammenhänge*. Stiftung Ökologischer Landbau (Hrsg.), Kaiserslautern.

Meyer, J.R., D.L. Campbell, T.J. Moser, G.R. Hess, J.O. Rawlings, S. Peck and W.W. Heck; 1992; Indicators of the Ecological Status of Agroecosystems. In, D.H. McKenzie, D.E. Hyatt and V.J. McDonald (eds), *Ecological Indicators*, Elsevier Applied Science, London and New York, 629-658.

Nip, M.I., J.B. Latour, F. Klijn, P.K. Koster, C.L.G. Groen, H.A.U. de Haes and H.A.M. de Kruijf; 1992; Environmental Quality Assessment of Ecodistricts: A Comprehensive Method for

Environmental Policy. In, D.H. McKenzie, D.E. Hyatt and V.J. McDonald (eds), *Ecological Indicators*, Elsevier Applied Science, London and New York, 865-882.

Ott, W.R.; 1978; *Environmental Indices - Theory and Practice*. Ann Arbor Science Publishers, Ann Arbor.

Quist,D.; 1984; *Zur Bodenerosion im Zuckerrübenanbau des Kraichgaus*. Dissertation, Fakultät für Biologie, Heidelberg.

Saaty, T.L.; 1982; *Decision Making for Leaders*. Lifetime Learning Publications, Belmont, California.

Saaty, T.L. and J.M. Alexander; 1981; *Thinking With Models*. Pergamon Press, Oxford.

Schwertmann, U.; Vogl, W. u. M. Kainz; 1987; *Bodenersion durch Wasser*. Ulmer Verlag, Stuttgart.

Werner, R.; 1989; *Methoden und Modelle zur Optimierung der Intensität der Landschaftsnutzung durch Lanwirtschaft und erste Ergebnisse*. Landwirtschaft und Umwelt, Band 4, Vauk, Kiel.

Wishmeier, W.H. u. D.D. Smith; 1978; *Predicting Rainfall Erosion Losses*. Agriculture Handbook, No. 282, Washington.

Young, M.D.; 1991; Overview: the integration of agriculture and environmental policies. In, M.D. Young (ed), *Towards Sustainable Agricultural Development*. Belhaven Press, London and New York. 337-342.