SUSTAINABLE LAND USE IN THE EC: AN INDEX OF POSSIBILITIES

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ABSTRACT

The Netherlands Scientific Council for Government Policy has developed a methodology to explore long-term options for land use in relation to policy objectives. The core of the methodology consists of a linear programming model that can be used to demonstrate the influence of various policy preferences on future land use changes within the European Community. In the model agricultural activities are defined according to best technical means that can be used to approximate intentional sustainable agriculture. The model calculates optimal allocations of land use that can be used to approximate locational sustainable (agricultural) land use. Different optimizations result from different priorities on policy objectives. These results can be regarded as illustrations of the subjective nature of sustainable land use.

In this paper different notions related to sustainable land use planning are illustrated using the methodology adopted by the Council.

1. INTRODUCTION

The Netherlands Scientific Council for Government Policy recently produced a report on options for future land use in the European Community (EC) (WRR 1992). In the report four scenarios focused on strategic options for agriculture and forestry are given that demonstrate the importance of objectives of, and not just the instruments for implementing, European agricultural policy. The scenarios provide information on the interactions between the allocation of different types of land use and several policy aims that are to be considered simultaneously in relation to land use (Rabbinge and Van Latesteijn, 1992). Hence, these scenarios show the conflicts arising from increasing productivity, market saturation, uneven distribution of production within the EC and increasing concern for regional employment, sustainable protection of the environment, nature and landscapes. The scenarios are used to explore options that materialize when different priorities are given to the policy aims involved.

The results can be used to illustrate some of the questions that emerge with respect to sustainable land use planning. Firstly, it can be illustrated that the concept of sustainability comprises many dimensions. A coarse classification distinguishes between environmental, economic and social sustainability. But even if one limits his attention to environmental sustainability it can be shown that definitions are ample. Secondly, the study shows that sustainability to a large extend is a subjective notion. This implies that different sustainable scenarios can be set up, each with its own validation. Thirdly, the difference between intentional and locational sustainability is illustrated. Especially in land use planning this distinction is important: an activity might be sustainable by its intentions, but the location of the activity might completely obscure this intention.

2. SUSTAINABLE LAND USE ACTIVITIES

The future land use possibilities are explored in a quantitative fashion with the aid of a computer model that calculates optimal allocations of types of land use given a set of preconditions. With this approach it is imperative to formulate types of land use in quantitative terms. The results must be significant for the future, so current agricultural practice should not be used as a reference. This would only freeze current inefficiencies and regional differences. Instead, types of land use that can be envisaged over a longer period of time are defined, without any regional restrictions. This is approached by using the concept of best technical means: agriculture is defined according to the results that are currently obtained in plant testing stations and experimental farms under optimal conditions. These forerunners are used as a reference for future developments. Because in the model these types of land use can be used in all regions, the results of the model calculations are not biased by the current differences in (agricultural) regional development.
Best technical means can be regarded as sustainable agriculture put into practice. In sustainable agriculture emissions to the environment should be minimized. Ideally agriculture should be performed in a closed cycle. However, this is impossible. Inputs are inevitable, because the gist of agriculture is harvesting useful products at a rate higher than attainable under natural conditions. Next to that the efficiency of inputs being transformed into outputs will never be 100%. This means that losses will be inevitable. Best technical means implies that the efficiency of the inputs will be maximized, leading to minimal losses of necessary inputs per unit of output. This leads to a maximal 'leakproof' agricultural system, which by itself is optimally sustainable. This can be denoted as intentional sustainability.

In figure 1 the procedure to define these types of land use is illustrated. The procedure can be divided into three major stages (Van Latesteijn, 1992).

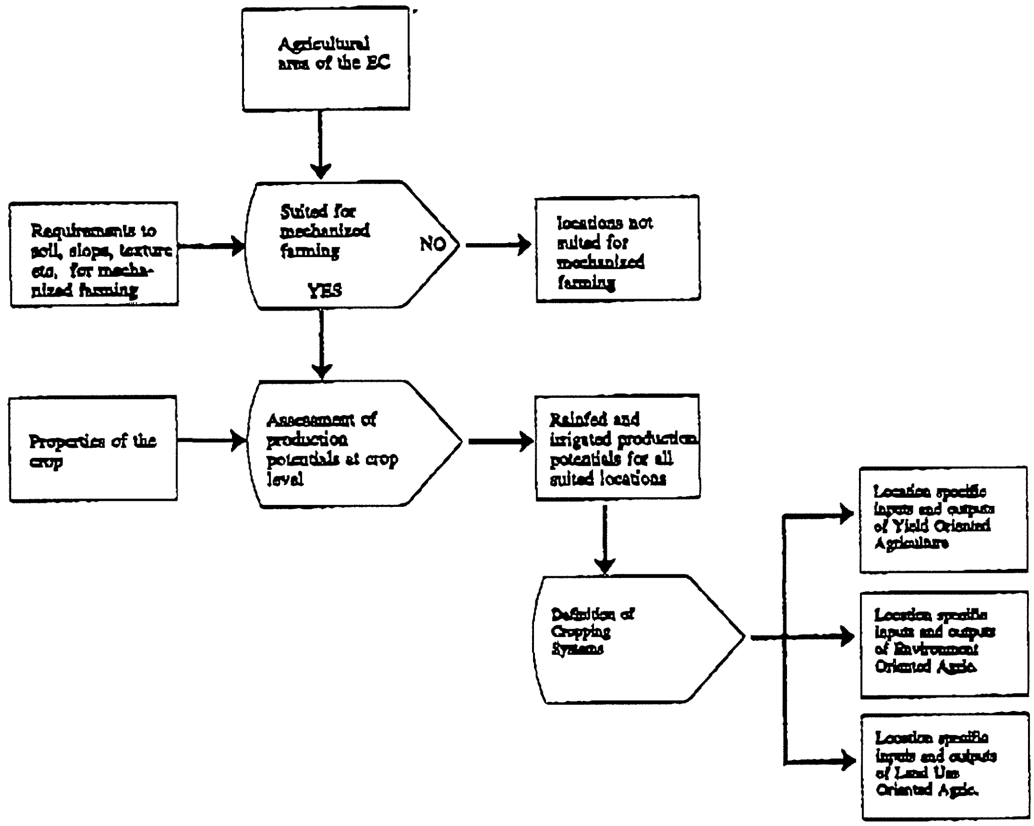


Figure 1
Definition of location specific inputs and outputs for agricultural activities in the EC based on the adoption of best technical means

In the first stage a qualitative land evaluation the suitability of the area of the EC for (mechanized) farming of a certain crop is assessed. This is accomplished through the use of a Geographical Information System (GIS) combined with a decision support system ALES (Automated Land Evaluation System) (Van Diepen et al, 1990). The evaluation is executed at the level of Land Evaluation Units (LEUs), a combination of soil and climate conditions that is considered to be homogeneous. For the EC some 22.000 units are necessary to cover the total area (Reinds et al, 1992). By looking at factors like steepness, salinity, and stoniness of the soil the suitability for mechanised farming of grass, cereals and root crops as well as the suitability for rough grazings and perennial crops (including forestry) is assessed (Van Lanen et al, 1992). As an example in figure 2 the total areas suitable for grass, cereals and root crops per EC member state are given. The results clearly reflect the differences in soil quality throughout the EC. In each country the suitable area for grass production exceeds that for cereals, and that for root crops is still smaller. This is caused by the inclining demands to soil quality of these crops.

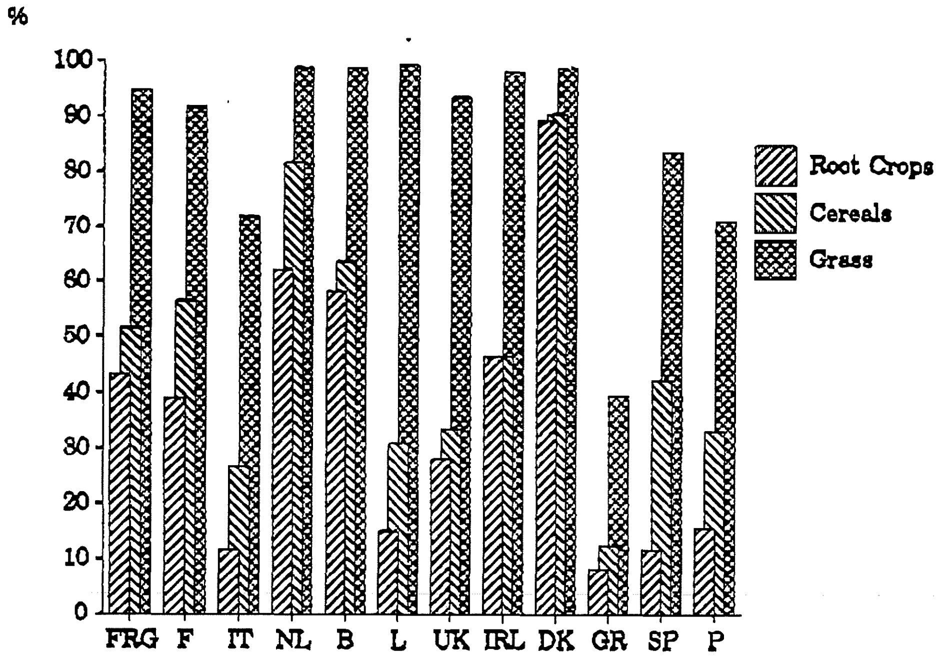


Figure 2
Suited area for mechanized farming of Root Crops, Cereals and Grass in the 12 EC member states

In the second stage production potentials for suited locations are calculated by means of a simulation model. This can be denoted as quantitative land evaluation (Van Lanen, 1990). The quantitative land evaluation is accomplished through the use of the WOFOST crop growth simulation model (Van Keulen and Wolf, 1986). The simulation model uses as its inputs: technical information on regional soil (such as water holding capacity) and climate properties and relevant properties of the crop (such as phenological development, light interception, assimilation, respiration, partitioning of dry-matter increase over plant organs and transpiration). Using this input information the rainfed and irrigated yields of winter wheat, maize, sugarbeet, potato, and grass are assessed. In the rainfed situation maximum yields can be limited by the availability of water at any point during the growing season. In that case the model simulation gives an indication of the attainable yields when no irrigation is applied. In the irrigated situation there are no limitations to crop growth other than those impeded by climate and soil conditions and properties of the crop. In that case the model simulation gives an indication of the maximum attainable yield at a given location.

In the third stage the potential yields of indicator crops are translated into cropping systems that comprise a certain rotation scheme, certain management decisions and a certain use of inputs.

Based on results of field experiments and on expert knowledge a limited set of rotation schemes is set up and consequently the input and output coefficients are deduced (De Koning et al, 1992). It is assumed that cropping systems with excessive input of labour are excluded. This means that all cropping systems are mechanized (e.g.: no manual weed control). For a given level of production (the rainfed and irrigated production levels) the minimal input of resources can be assessed. The theoretical background of this optimization is dealt with extensively by De Wit (1992) . He describes this optimum as the situation where each variable production resource is minimized to such a level that all other production resources are used to their maximum. This defines the technical optimum for that particular production situation and will be used as a reference.
To arrive at feasible field systems expert knowledge is used to define cropping systems that are acceptable from both an economic and agronomic point of view. This set of systems is called Yield Oriented Agriculture (YOA). Another set can be defined when more account is taken of environmental hazards related to agriculture. This implies that less environmentally hazardous inputs (such as pesticides and fertilizers) are used, even if this means a slight decrease in yield. Here again the criteria are still rather subjective. This set of systems is called Environment Oriented Agriculture (EOA). A third set is based on land use concerns. Under all circumstances it can be foreseen that the agricultural area within the EC will diminish. This can be detrimental to the maintenance of the countryside in some regions. So a set of cropping systems is be defined that is characterized by a relatively low soil productivity. This set of systems is called Land use Oriented Agriculture (LOA).

3. CONSTRUCTING SCENARIOS

To construct the scenarios a Linear Programming (LP) model is used in conjunction with a procedure called 'Interactive Multiple Goal Programming' (IMGP). A LP-model is generally used to optimize a single objective function. The IMGP procedure enables the optimization of a set of objective functions in an iterative process. This reveals the trade-offs between different goals that are modelled by the objective functions. The procedure to construct the scenarios is illustrated in figure 3.

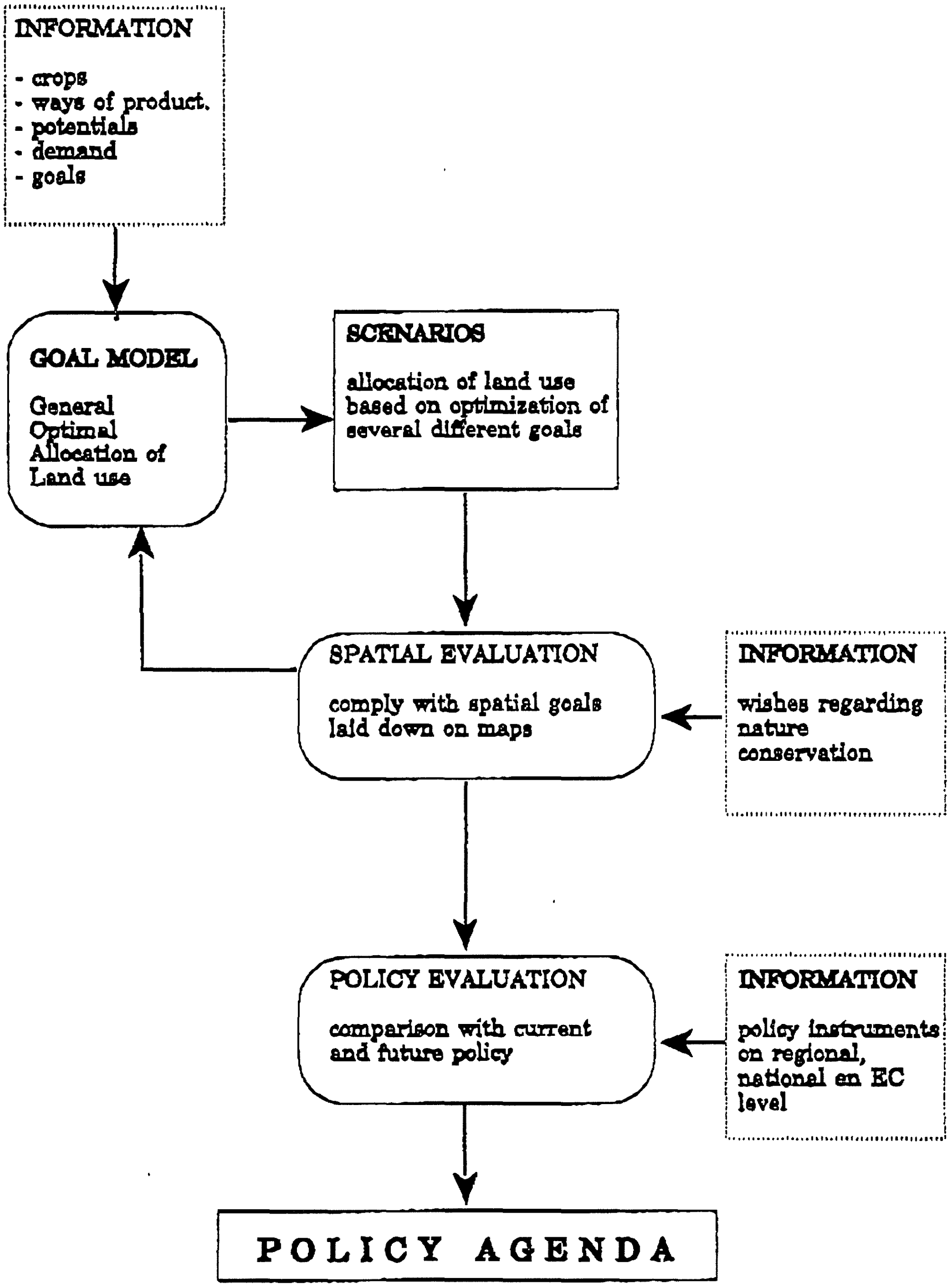


Figure 3
Procedure to generate land use scenarios with the GOAL model

The core of the procedure is formed by a LP-model of (agricultural) land use in the EC which has been named GOAL (= General Optimal Allocation of Land Use). The model can choose from a limitative set of types of land use (YOA, EOA and LOA) to meet an exogenously defined demand for agricultural and forestry products. A number of policy aims are coupled to types of land use in the form of objective functions. These aims indicate the variety of notions that are considered essential for future land use.

In the GOAL model the following obejctive functions are formulated:

1. maximization of yield per hectare;
2. maximization of total labour;
3. maximization of regional labour;
4. minimization of total pesticide use;
5. minimization of pesticide use per hectare;
6. minimization of total N-fertilizer use;
7. minimization of N-fertilizer use per hectare;
8. minimization of total costs.

These aims reflect the classification into environmental, economic and social sustainability. For environmental sustainability the minimization of pesticide and fertilizer use is essential. Economic sustainability is more or less guaranteed if total costs are minimized combined with an ongoing rise in soil productivity. Social sustainability can only be achieved if labour within the agricultural sector is insured, or if the available labour is evenly distributed over the regions.

Distinct policy views can be fed into the model by assigning different preferences to these aims. Within the GOAL model this is done interactively in an IMGP-procedure by restricting the objective functions to a certain domain, e.g.: total labour is not allowed to drop below 6 million manpower units (MPUs). In this way scenarios can be constructed that show the effects of policy priorities, e.g.: to maintain the labour force the model will have to select types of land use with a relatively high input of labour.
Four scenarios have been drawn up to illustrate four contrasting political philosophies about desired policy on land-dependent agriculture and forestry in the EC. A philosophy can be defined in this context as a cohesive set of preferences with regard to a number of aims. All philosophies are based on the assumptions that their preferences should be used to sustain agriculture and its environment in the rural areas. However, what exactly must be sustained differs considerably between the philosophies. This in a clear indication of the subjective nature of the concept of sustainability. The four scenarios all represent a view on sustainable land use, be it from a different point of view.
We distinguish:
a - free market;
b - regional development;
c - nature and landscape;
d - environmental protection.

The scenarios are expressed in the GOAL model by setting different preconditions to the objective functions and by varying the demand. Two examples can illustrate this:
In the free market scenario the costs of agricultural production are minimized and no other preconditions are put to the objectives. Moreover, free trade implies that import and export is allowed, so the demand for agriculture produce from within the EC is modified according to expectations regarding new market

balances. The model will now choose the most cost-efficient types of land use and allocate them in the most productive regions.
In the environmental protection scenario friendly view again the costs of agricultural production are minimized, but here strict limitations are put to the objective functions that represent the use of fertilizers and pesticides. Next to that the demand for agricultural produce is fitted to self-sufficiency. The model will now choose for types of land use and allocations that agree with the imposed preconditions.

With these data the model calculates four different scenarios for land use. Policy-makers can now see how their priorities will affect land use and how the effects are distributed over the EC. However, aims relating to nature and landscape cannot be expressed in figures in such a way that the model can interpret them. To remedy this situatioin a spatial evaluation is build into the procedure. A map has been drawn up which represent the best division of land from the point of view of wildlife protection (Bischoff and Jongman, 1992). This map is matched with the regional allocation of types of land use generated by the GOAL model to identify potential problematic areas with respect to competing land use. In could be that the results produced by the model will have to be amended as new space requirements arise. Finally in a policy evaluation the outcomes are used to determine to what extent current and future policy can cope with the developments which occur in the scenarios. An estimation can be made of the effort required to achieve aims, depending on the question of whether we will have to 'go against the tide' or simply go with it. In this way the scenarios produced by the model can serve as guidelines for policy. If the outcomes all point in the same direction, there is clearly conflict between the technical possibilities and a policy which seeks to achieve something else. Policy, then, 'goes against the tide'. If the outcomes of the scenarios are very varied, there is clearly greater scope for policy.

4. RESULTS

The scenarios contain an overwhelming load of information. In this paper this is reduced to four maps that show the regional allocation of land use and four graphs that show the relative values of the objective functions in the four scenarios (figures 4 to 7).
The maps show the percentage of UAA (Utilized Agricultural Area) per region that is used for land-dependent agriculture (exluding forestry). In the free market scenario (figure 4) agriculture is confined mainly to Germany, France, The Netherlands and Belgium. In the regional development scenario (figure 5) agricultural activities are distributed fairly evenly throughout the EC. The regional allocation in the nature and landscape scenario (figure 6) is almost an inverse image of figure 4. Here agriculture is almost exclusively restricted to the mediterranean countries. The environmental protection scenario (figure 7), like the regional development scenario, results in a fairly even spread of agricultural activities over the whole of the EC. However, a

striking difference is the relative absence of agriculture in the northwest (United Kingdom, Ireland, The Netherlands and large parts of France).

The difference in location of agricultural activities in the scenarios is naturally also connected to differences in land use objectives. For instance, in the nature and landscape scenario the distribution of employment over the regions is extremely uneven. To get in impression of these differences a comparison can be made between the value of the objectives in the scenarios and the value that is obtained if no precondition is put to any of the objectives. The latter gives an estimate of the upper limit of the objective function. For example: if no preconditions are put to any of the objective functions minimization of land use renders a value of 21 million hectares. In the free market scenario land use adds up to more than 42 million hectares. In figure 4 this is denoted in the bar graph with a value of 2. The land use in this scenario is twice as high as the limit value. So can be regarded 'better' if the graph shows low values for all objective functions. However, note that by presenting the results in this way a weighing factor of one is applied to all objectives. The differences between the scenarios are based on different perceptions of adequate weighing factors.

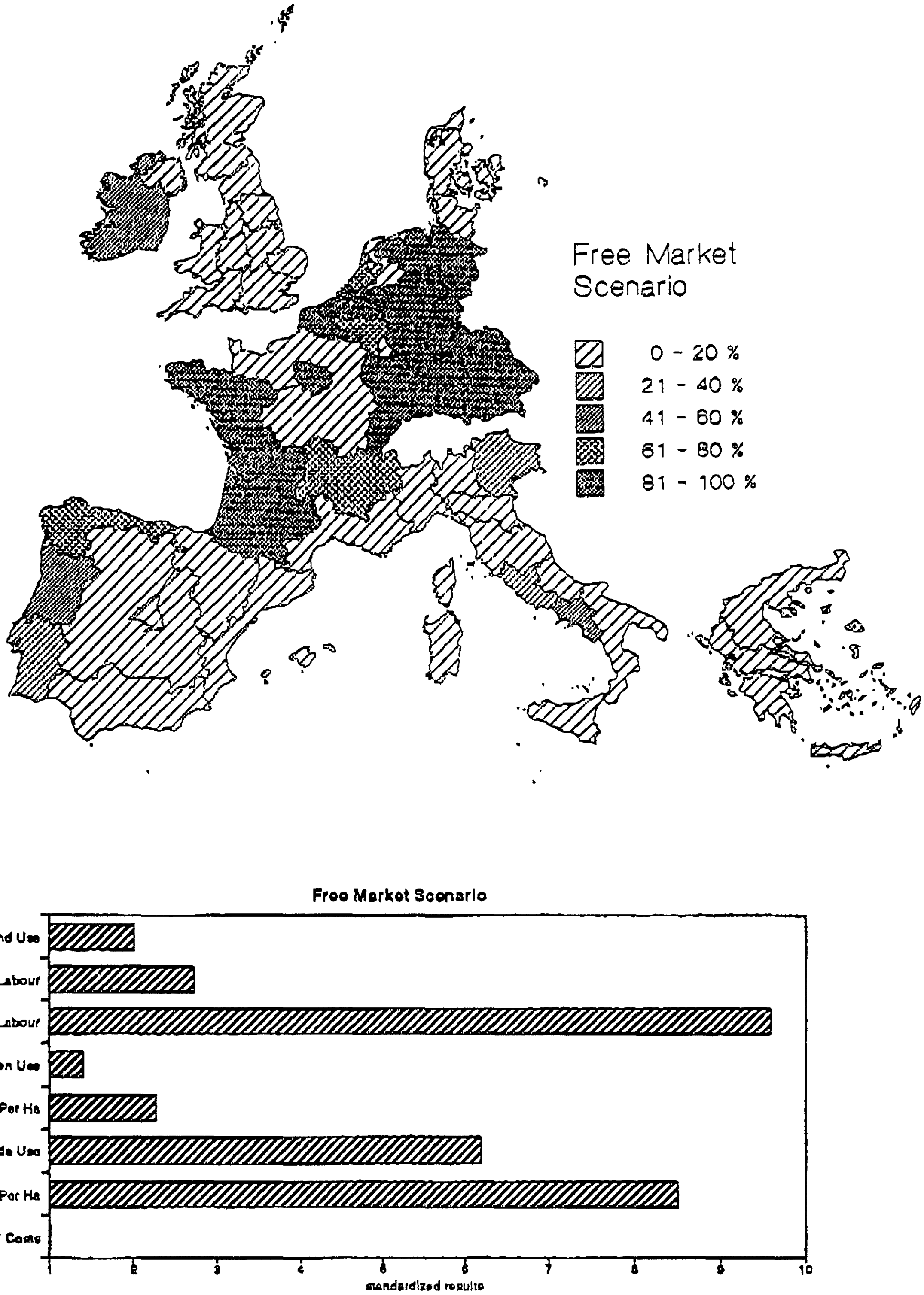
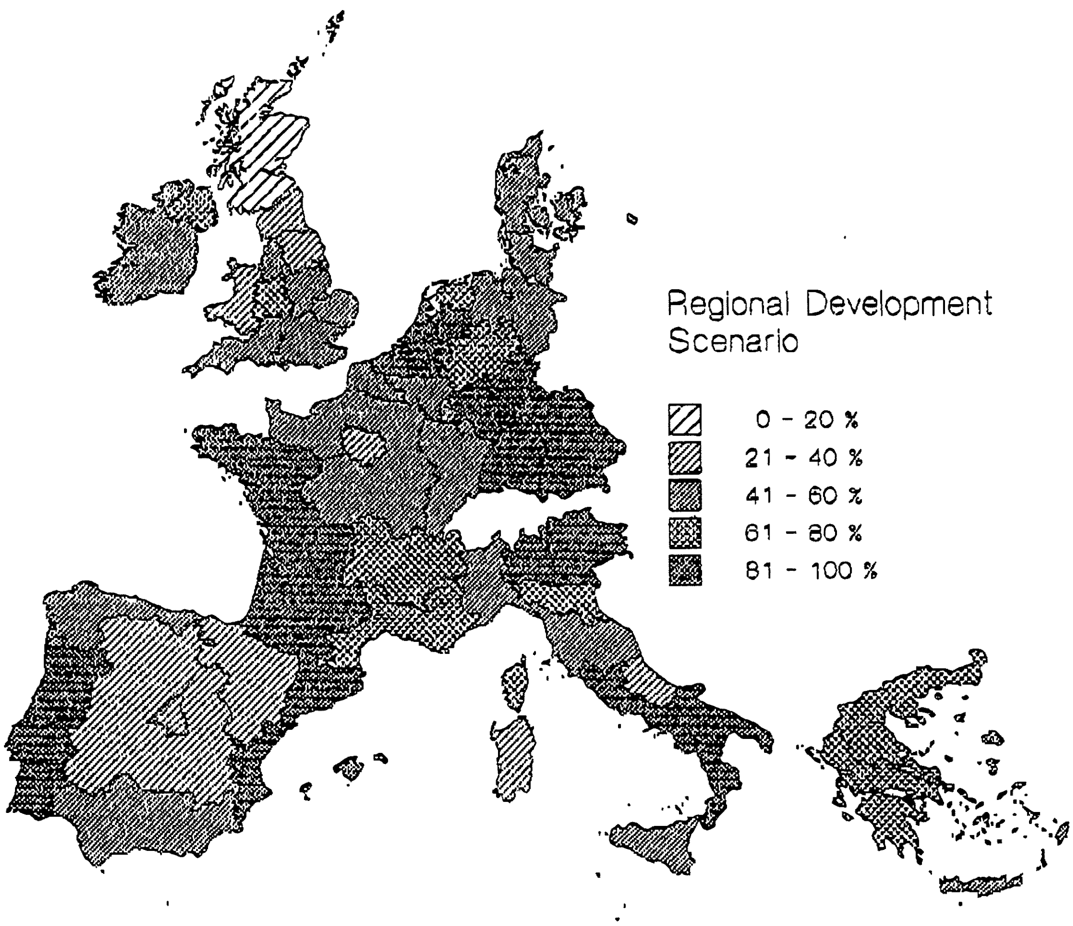


Figure 4
Regional allocation of agricultural activities (in percentage of current Utilized Agricultural Area) and standardized values of the object functions in the free market scenario (WRR, 1992).



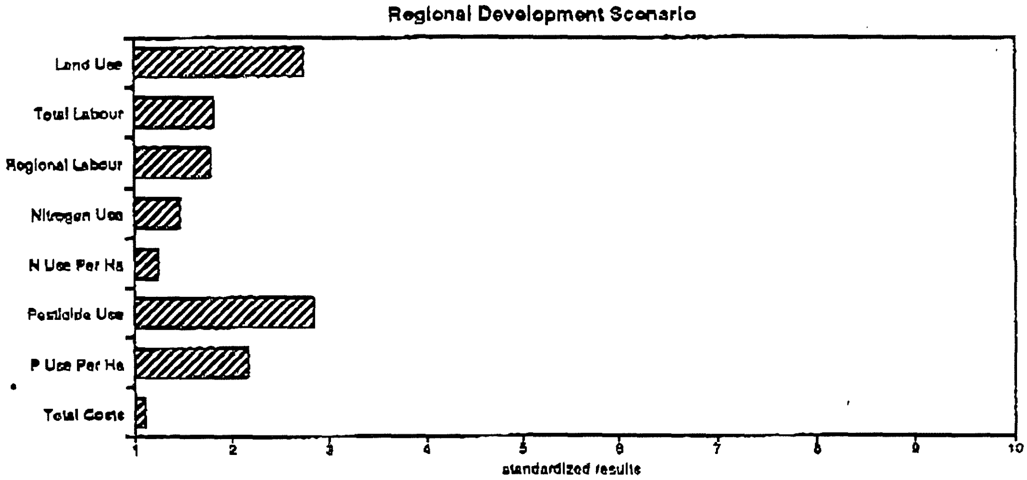
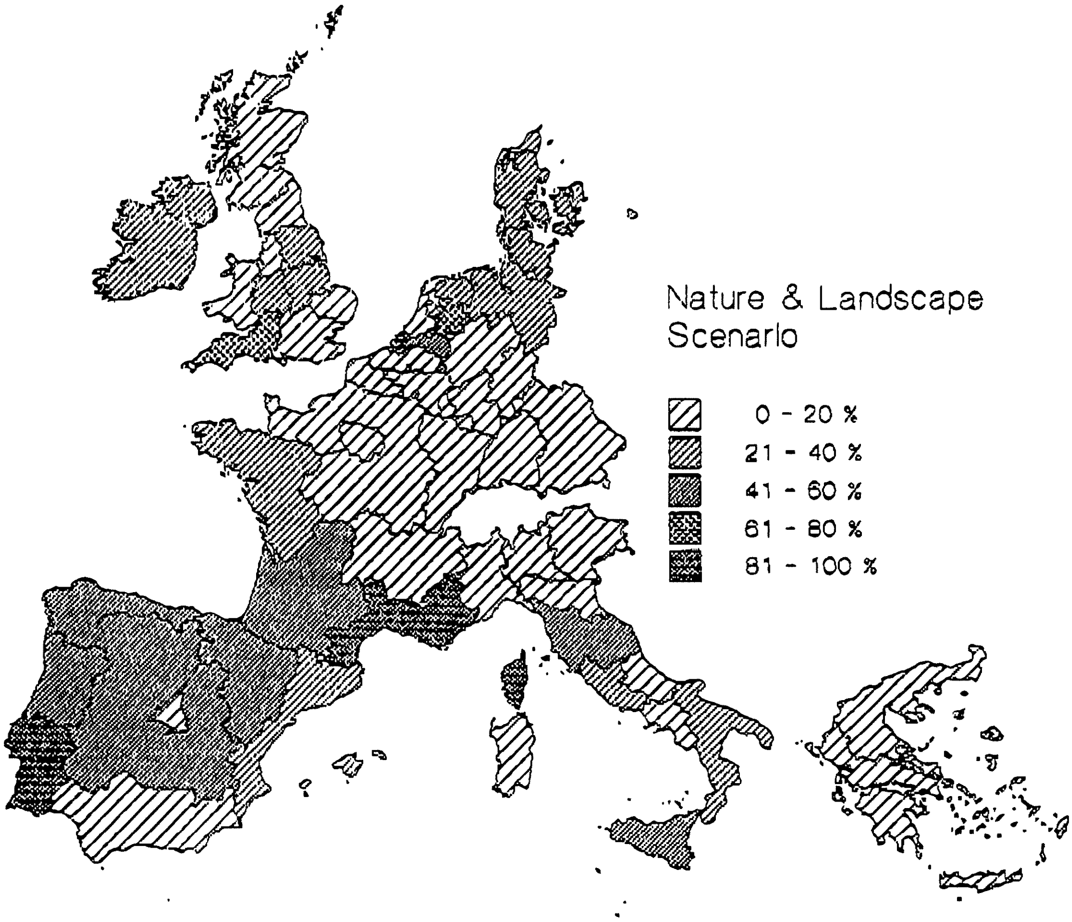


Figure 5
Regional allocation of agricultural activities (in percentage of current Utilized Agricultural Area) in and standardized values of the object functions in the regional development scenario (WRR, 1992).



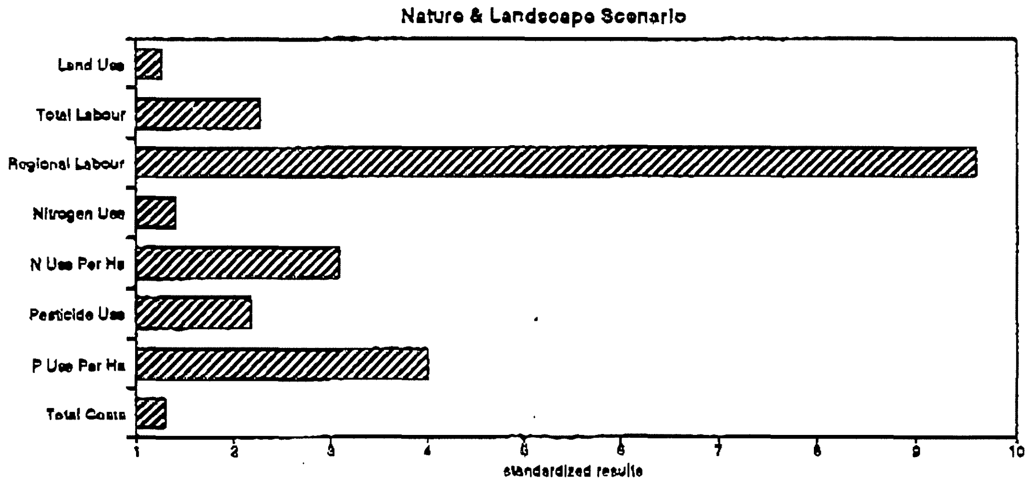
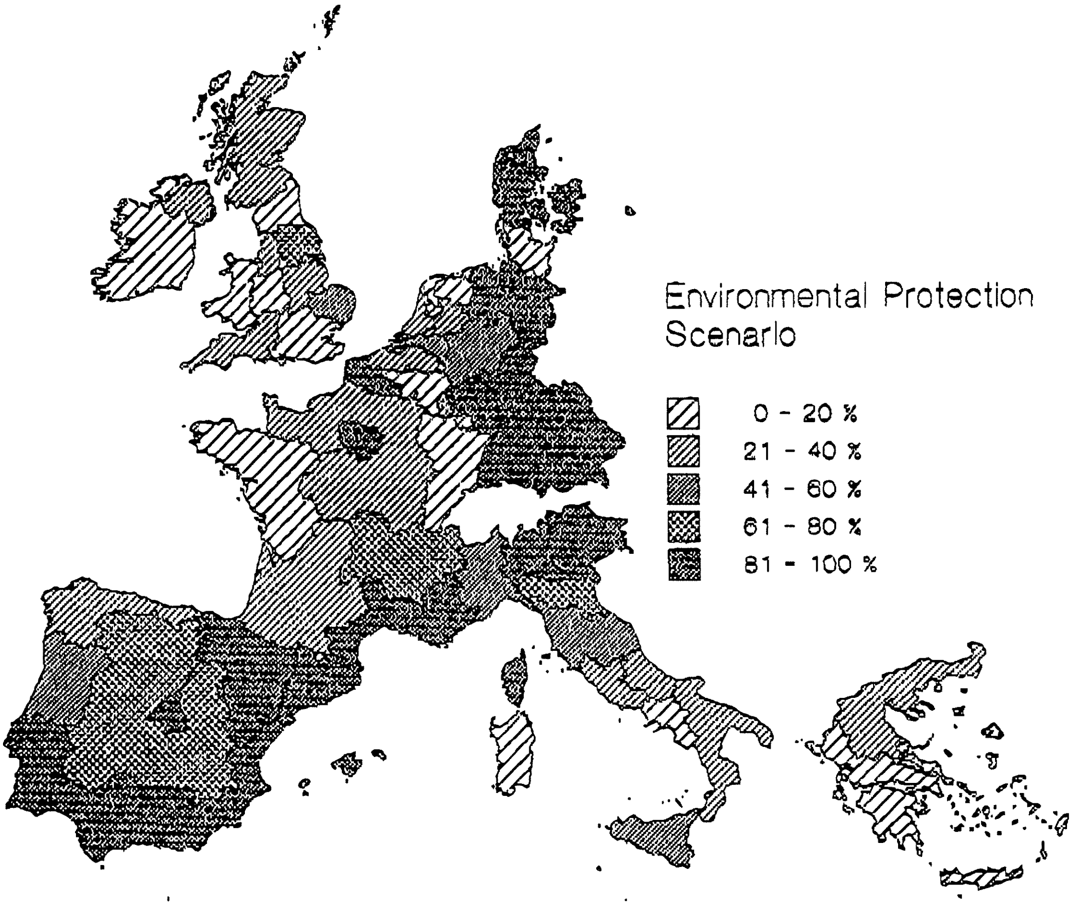


Figure 6
Regional allocation of agricultural activities (in percentage of current Utilized Agricultural Area) and standardized values of the object functions in the nature and landscape scenario (WRR, 1992).



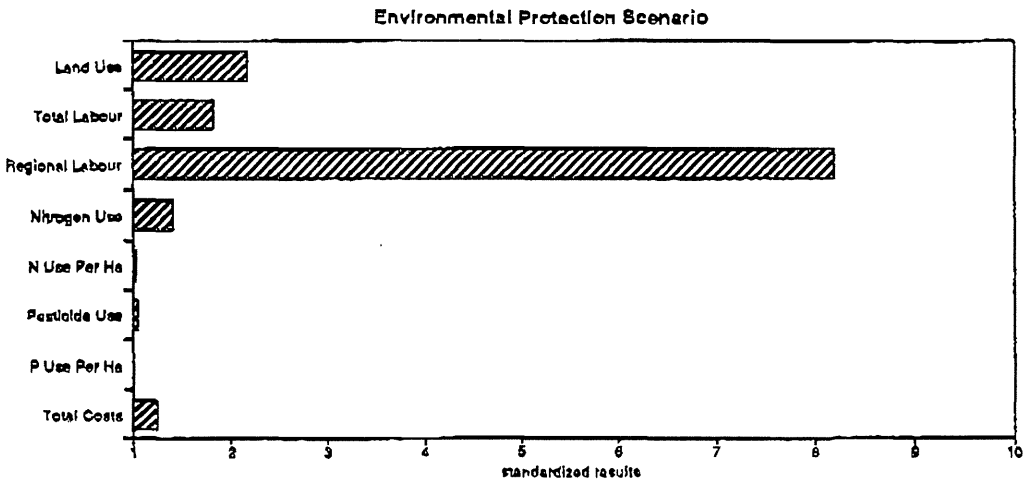


Figure 7
Regional allocation of agricultural activities (in percentage of current Utilized Agricultural Area) and standardized values of the object functions in the environmental protection scenario (WRR, 1992).

Bearing in mind these limitations a comparison of the results shows that the regional development scenario and the environmental protection scenario show the lowest values. An exception is found for regional labour. Only in the regional development scenario this objective shows a low value. In all other scenarios a value of about 9 is found. This is due to the fact that this objective function does not indicate a mean value, but a limit value based on the highest attainable employment in one region. Apart from the regional development scenario the precondition set to this objective function is arbitrarily kept very low, leading to these figures.

5. CONCLUSION

With the methodological framework described in this paper we have been able to produce scenarios that, given a set of policy aims, describe optimal land use across the EC. At different levels these scenarios comply with the notion of sustainability. The results indicate that a range of possibilities emerges when then preconditions are put to the scenarios. Sustainable land use planning appears lead to an index of possibilities, each of them sustainable in its own right. The study does not provide a blueprint for agricultural policy leading to sustainability. Instead it presents a set of scenarios that explore possibilities of future land use in the EC. For strategic policy planning this approach can be very useful.

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