

Planning consequences of long term land use scenario's in the European Union

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Abstract

Agriculture in the European Union (EU) is going through a phase of accelerating changes that calls for major decisions. The continued increase in production per unit of land area and per unit of livestock, due to improved production circumstances, better cultivation methods and external inputs, has led to significant increases in agricultural productivity.

Abundant use of fertilizers and pesticides in some regions have created considerable negative environmental side effects, whereas in other regions, under-use of external inputs has created environmental problems of another nature, such as erosion. Increase in productivity per unit of area will continue during the coming decades as the gap between potential and actual yields is still very big and in general external inputs are used more efficiently at higher levels of production. However, the production surpluses in the EU create budgetary problems for the EU and distortions of the world market. Decreasing prices of agricultural products within the EU may lead to the abandonment of marginal agricultural areas, but due to income subsidies such a threat may be less pronounced maintaining the mentioned problems. This calls for reorientation of the Common Agriculture Policy. For this reorientation a clear and explicit formulation of options and a study of the possibilities and ways to achieve them is necessary for the rural areas. The Netherlands Scientific Council for Government Policy initiated such a study and developed various options for rural policy in which different preferences are given to a number of objectives related to agriculture and rural development. The consequences for land use are shown in the guise of different scenarios.

Key words: Land use scenario, European Union, Common Agricultural Policy

Land use changes in Europe

Land use changes are of all ages. Under the influence of changes in food demand, caused by demographic events, the cultivated area of Europe has shown considerable fluctuations (Figure 1). Periods of expansion and periods of contraction of cultivated area occurred all over the world. The idea that we may be facing a new period of contraction is therefore not exceptional and to some extent supported by the characteristics of the present situation.

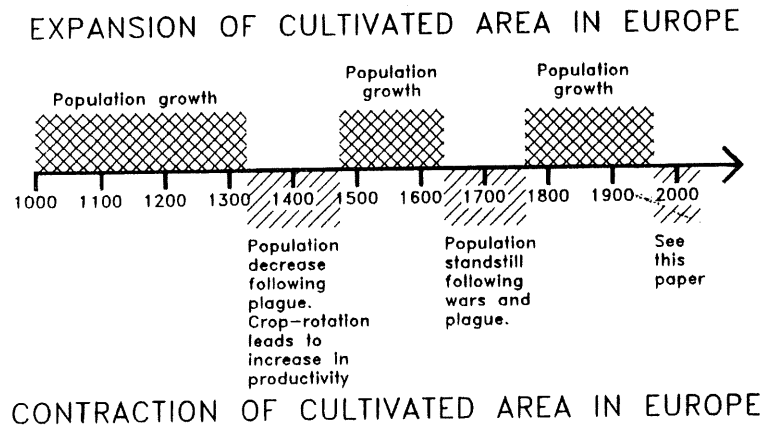


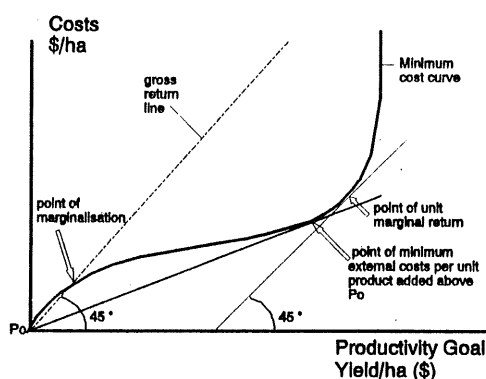
Figure 1. Periods of expansion and periods of contraction of cultivated area occurred all over the world.

The productivity in EU agriculture measured in kg of dry matter per unit of acreage continues to rise thanks to ongoing advancements in agronomic knowledge and by the built-in incentive to increase productivity. The use of variable inputs (nutrients, pesticides) per unit of output decreases when higher yields per hectare are realized. When growing conditions are improved by various types of measures, such as soil improvement, irrigation, sowing bed preparation, fertilization etc. the crop shows a much better response to variable inputs. So, proper agronomical measures lead to a situation where the efficiency of resource use will rise. A detailed analysis of this resource use efficiency in agriculture is given by De Wit (1992) (See box). Such principles were applied in the identification of agricultural production possibilities for the various production situations within the European Union (De Koning et al., 1995). These figures were used as input for the computer model described in this paper.

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A clear position in the debate on intensification or extensification has always been taken by the late Professor De Wit, an agronomist. Basic in his theory is a sigmoid curve representing the relationship between costs of production and yield. Two points are of interest in the economic sense:

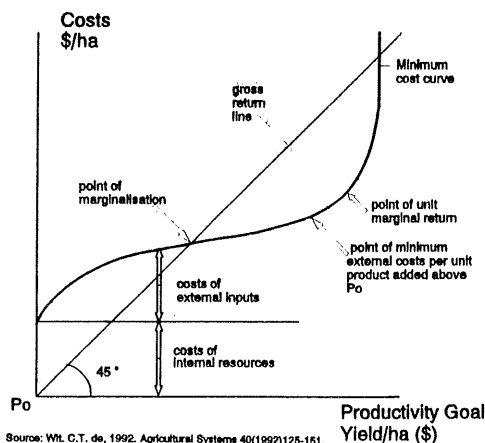
The first is the intersection between the minimum cost-curve and the so called gross return line. It represents the point of marginalisation. Below this point, no profitable production systems exist at the available level of knowledge and prices. The second is the point of unit marginal return has a tangent of 45 degrees. This point represents the economic optimum. The point, where the line through P_0 , being the intersection of the minimum cost curve and the vertical axis, touches the minimal cost curve, is the point of minimum external costs per unit product. This is the environmental optimum.



Source: Wit, C.T. de, 1992. *Agricultural Systems* 40(1992)125-151.

For a more realistic representation the costs of internal resources (costs of machinery, buildings, interest etc.) have to be added. The higher these costs are the more the point of marginalisation shifts to the right. Two conclusions can now be drawn:

First, the point of minimum external costs per unit product is always at a lower productivity level than the point of unit marginal return. The move towards the direction of a more efficient use of external inputs is at the expense of net profits.



Source: Wit, C.T. de, 1992. *Agricultural Systems* 40(1992)125-151.

Second, in the whole area between the gross return line and the minimum cost curve, farming is a lucrative business. Different types of farming are possible within this area. But the farmer who is closest to the point of unit marginal return, earns the most money, and the farmer who is closest to the point of minimal production costs, charges the least to the environment.

And there is a third conclusion: Both the point of minimum external costs per unit product and the point of unit marginal return occur at a relative high level of intensity.

Inputs in the model are technical information about various aspects of agricultural production and policy views that indicate a desired (thus a subjective) priority between different goals and the levels to which these goals should be fulfilled. To make these views operational a set of explicit goals is formulated that can be used in the model. The relative priority for each of the goals is different for each of the policy views.

The continuing rise in productivity can be seen in all parts of the world. The discontinuity after World War II is due to innovations from various disciplines, better known as the first green revolution (Rabbinge, 1986) that was followed by a second, 20 years later in many developing countries. Independent of political system or economic conditions the rate of increase of productivity reached very high levels. Technological improvement was the major drive for this change.

In the EU the continuing rise in productivity has led to a considerable change in the level of self-sufficiency for major agricultural food products. In less than 25 years the EU transformed from a net importer of agricultural products into a net exporter of food.

After self-sufficiency was reached, productivity growth continued to rise as a result of the Common Agricultural Policy (CAP) of the EU. Until the latest reforms in 1992/93 the CAP consisted of a system of guaranteed prices that creates a seemingly infinite demand. If supply is ample the guaranteed prices impede a price signal to the producers to diminish their production. This led to a situation of surplus production with major budgetary consequences. The system of guaranteed prices required an ever increasing amount of money from the European tax payer to finance.

Unfortunately the discussion on instruments and objectives in the EU concentrates on price subsidies. From the very start the CAP was dominated by guaranteed prices, leading to a system of import levies and export subsidies. Instruments to promote the regional agricultural production circumstances through structural improvements such as land reclamation and irrigation were added much later. Such structural policies were already present in many countries at the national level. In The Netherlands a long standing tradition exists to support the development of the agricultural sector through a combination of agricultural research, education and extension. This combination of public management and private entrepreneurship has helped the development of the agricultural sector considerably. The success of agricultural development was overwhelming and in spite of the increasing surplus production there is no tendency to reduce the structural improvement programs. On the contrary: more and more EU-subsidies are used for structural strengthening of the production circumstances in the less endowed regions that will lead to a further rise of productivity.

At the same time attention has grown for other goals than agricultural production. It is recognized that environment, employment and farmers income are tightly linked to developments in agriculture, and thus to agricultural policy. The deterioration of landscape and the decrease of nature has resulted in much criticism of agriculture. Another important point is the considerable overuse of pesticides and plant nutrients partly due to extremely low prices, which has created immense

environmental problems in some parts of the EU.

Limitations to growth in productivity

The study by the Netherlands Scientific Council for Government Policy aimed at exploring the options for future land use in the EU by looking at the limitations to the growth in productivity. Ultimately those limitations will define the possibilities of agriculture in the Community. In the study three types of limitations were distinguished:

1. Technical limitations: there is a well defined yield maximum for each crop, given the properties of the crop, the properties of the soil and the actual climatic conditions. This determines how much useful product can be produced when plants grow under optimal conditions.
2. Demand limitations: now that population growth in the EU has come to a stand-still, a further rise in consumption will be very limited. Moreover, the possibilities for a structural export position for food products appear to be limited. The same holds true for the potentials of non-food use of agricultural produce (agrification). Although there is an enormous acreage available, the value added per unit of acreage is very low for bulk production of energy and fibre crops. Farmers will only be able to generate a fair income in a far future through these types of production on energy farms of considerable size.
3. Limitations that stem from policy-goals: objectives in the field of nature conservation, recreation and the like will set limits to the location and nature of agricultural production. Because policy goals are subjective by nature these limitations will be controversial to a large extent.

The study reported in this paper was focused on the effects of policy choices in relation to the technically possible productivity growth, i.e. the study tries to assess the consequences for future land use in the EU of limitations that stem from policy goals.

Methodology

A computer model GOAL (General Optimal Allocation of Land use) was developed, which calculates *optimal* land use in the EU of the twelve member-states (the territory of the former GDR has not been included). The optimal allocation of land use is calculated by considering the possibilities of different types of land use driven by varying policy views to produce an exogenous given demand. This is illustrated in Figure 2.

The scenarios are formulated at the level of political administrative units

(NUTS-1) because decisions and policy implementation take place at these higher levels of aggregation. The NUTS-1 level (the EU-12 divided into 64 regions) was an arbitrary choice compromising the detail dictated by land evaluation and physical production circumstances and the more general level dictated by policy making. Policy-makers can now see how their priorities will affect land use at the level of NUTS-1 regions and how these effects are distributed over the EU.

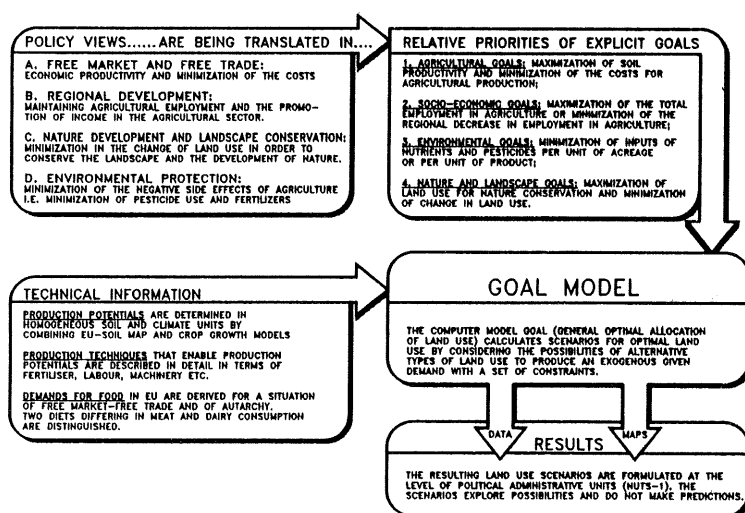


Figure 2. The computer model GOAL (General Optimal Allocation of Land use) calculates optimal land use by considering the possibilities of alternative types of land use to produce an exogenous given demand and a set of constraints.

It is assumed that farmers use the best technical means and that farming activities are located where soil and climate conditions are suitable for a well defined cropping system. In this way the scenarios indeed give an indication of the 'ceiling' of the growth in the productivity of land based agriculture.

Results

The qualitative and quantitative land evaluation of the EU showed where crops

could be grown and what attainable crop-yields are at a given location. Two situations were distinguished: an attainable yield, using only the available water (rain-fed agriculture), the "water limited yield" and a potential yield when irrigation or drainage removes water limitation (the "potential yield", because it shows the maxima for the next decades).

Taking wheat as an example Figure 3 shows five classes of maximum attainable water-limited yield per hectare within each region given the quality of the soil and the local climate characteristics, for the NUTS-1 regions in the EU. The given results are averages: parts of the regions indicated are in fact not suitable for wheat farming. The aggregation from detailed land evaluation studies to the NUTS-1 level was done by using weighted averages (Van Lanen 1990).

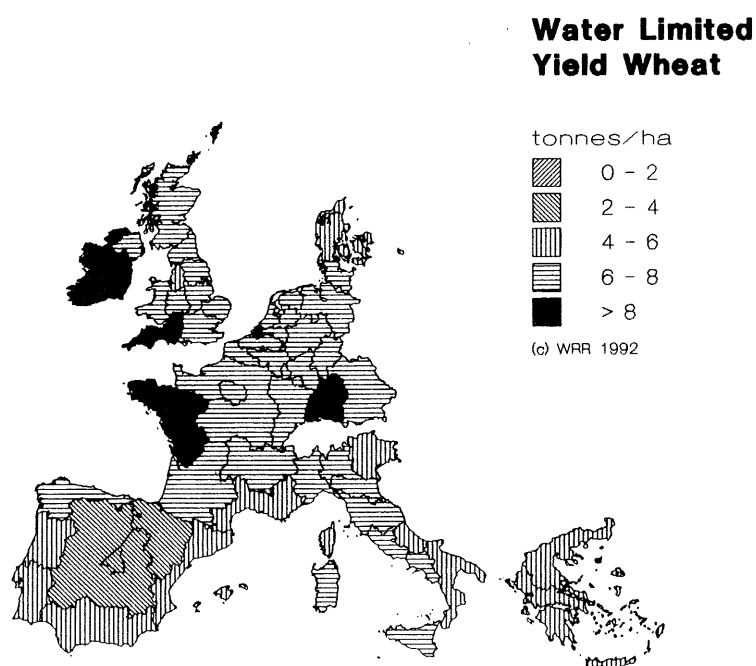


Figure 3. Five classes of maximum attainable water-limited yield of wheat per hectare within each NUTS-1 region under optimal conditions.

Figure 4 shows the very spectacular result if the water limitation is removed. High yields can then be accomplished almost anywhere because most of the physical comparative advantages are eliminated. However this requires in many cases high costs for land reclamation. This result indicates an extreme, showing what is technically possible. No account is taken of the possibilities or impossibilities of irrigation in real life. However, in the GOAL model irrigation costs and availability of water are incorporated to prevent such unfeasible outcomes. This quantitative land evaluation is done for cereals, grassland, oilseed crops, protein crops and root crops and also for forestry. The resulting possibilities show that areas favourable to forestry coincide with the higher yielding arable farmlands, even in the case of low demanding tree species.

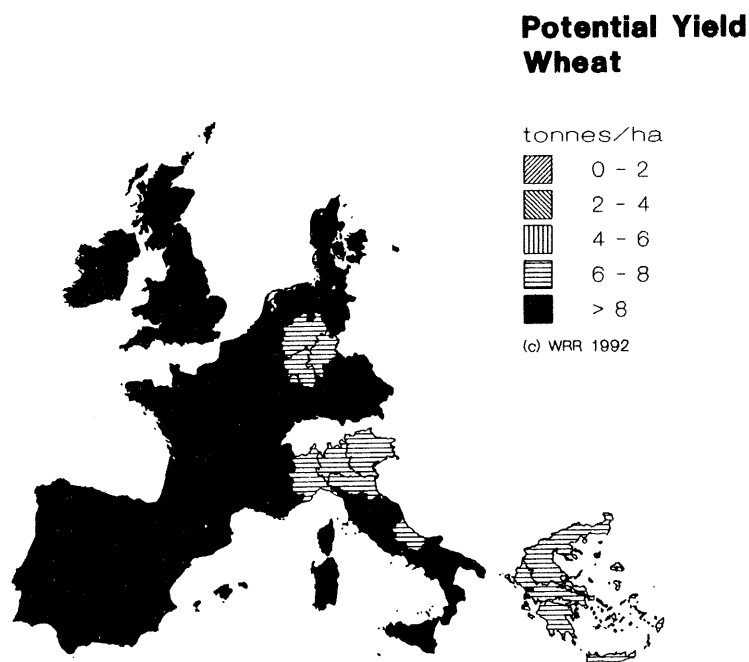


Figure 4. Five classes of maximum attainable yield of wheat per ha within each NUTS-1 region under optimal conditions if the water limitation is removed.

The category of nature and landscape goals turned out to be very difficult to implement in GOAL. Objectives related to nature and landscape are site specific. This makes it virtually impossible to define a general rule that models these objectives. Therefore some ex-post analyses were performed to render information on the fulfilment of these goals. The resulting map shows the preferred locations for nature conservation and development. The criteria used to determine where nature conservation or development should be promoted include, amongst others, species diversity and protection of rare ecosystems that are necessary for the survival of some species. The resulting 'European Ecological Network' is based on information gathered from all member states (Bischoff & Jongman, 1993)

To quantify the demand for food a study was done that evaluated the results of many econometric general equilibrium models of world trade of agricultural products. The outcomes of these models were summarized in terms of probable demand for various product groups in a situation of free trade - free market. In the case of autarchy the present maximum for the demand is used for the present diet and a changed diet. The technical information described above was collected by various research groups. All this information was brought together in the GOAL model, where technical information and policy views meet, resulting in various scenario's.

Calculation of scenarios

GOAL was used to calculate scenarios on the basis of alternative policy views. Each policy view results in a different scenario, but there are also general results that may be of interest to policy makers.

A first result shows that all options imply a radically diminished use of land for agricultural purposes (Figure 5). At present in the EU, about 130×10^6 ha are used as farmland. All scenarios show a spectacular decline to roughly $30-60 \times 10^6$ ha. Even if labour is maximized within agriculture and extensive land use oriented production techniques are accepted, not more than 90×10^6 ha will be needed for production. This should be considered as a technical maximum.

There are three reasons for this considerable difference between the scenario results and the present situation:

1. The production achieved in the scenario's is in many regions much higher than the actual values. Due to the use of the best land and a relatively high level of production on that land the area in use for this highly efficient agriculture is very small.
2. The cropping systems used in the scenario's are highly technical efficient, so that limitations or reductions due to sub-optimal production techniques or inadequate use of input are eliminated; and

3. Production takes place mainly in the best locations, so that marginal areas where only relatively low production is achieved have only a limited effect on the average.

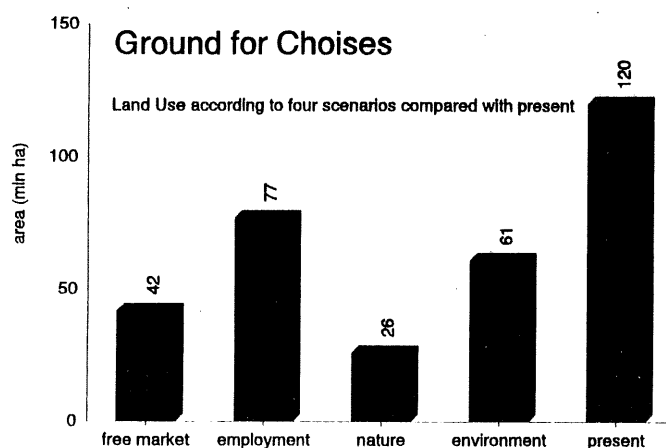


Figure 5. Land use according to four scenario's compared with present. See text for further explanation.

A second result from the scenarios is that by using best technical means under optimal conditions only $1.5-3 \times 10^6$ man years are needed for the total agricultural production. In 1987 about 7×10^6 were involved in primary production. The considerable decline in man years needed in land based agriculture is caused by the elimination of hidden unemployment and efficient use of labour. An analysis of hidden unemployment in agriculture in the EU showed that in 1987 there was already an enormous surplus of labour in agriculture.

A third interesting feature of all scenarios is the dramatic decrease in the use of pesticides. Under optimal conditions only $40-80 \times 10^6$ kg active ingredient is needed throughout the EU. In 1987 more than 400×10^6 kg is used.

A fourth result concerns the input of nutrients. In 1987 8.5×10^6 tons of nitrogen fertilizer were used. In the model calculations the minimum amount is about 2×10^6 ton fertilizer. The limited amount of land where high production

levels are achieved does require a less than proportional use of inputs. Therefore pesticide use efficiency and fertilizer use efficiency are very high. This also holds for energy and labour use efficiency (De Wit *et al*, 1987).

Maps derived with GOAL further demonstrate also the optimal location of land use and production techniques given different policy views. Four alternative policy views have been elaborated. The first policy view concerns "Free market - Free trade" (Scenario FF). In this scenario costs of production should be as low as possible. The second policy view concerns stimulation of regional development "(Scenario RD)" in a situation of autarchy in the EU. Regional employment is maximized in this scenario. The third scenario concerns "Nature and Landscape". (Scenario NL). In this scenario the greatest possible effort is made to conserve natural habitats, creating zones which divide them from agricultural areas. This is the scenario in which agriculture will take place on the smallest possible area. In the fourth scenario, concerning "Environmental protection" (Scenario EP), the primary policy aim is to keep alien substances from entering the environment.

In Figure 6 the regional distribution of land use in the four scenarios is represented. In scenario "Free market - Free trade" (Figure 6a) agriculture is confined mainly to the northwest of the EU; in scenario "Regional Development" (Figure 6b) agricultural activities are distributed fairly evenly throughout the EU; in scenario "Nature and Landscape" (Figure 6c) many agricultural activities shift to the southern regions and in scenario "Environmental Protection" (Figure 6d) agricultural activities are again fairly evenly spread over the EU. These differences in spatial distribution of agricultural activities are the result of differences in policy goals.

The significant differences among the scenarios show that regions have different potentials for productivity increases. 'Weak' regions that are almost out of production in scenario "Free market - Free trade" show a strong increase in scenario "Nature and Landscape". In the latter scenario, which seeks to minimize the area of agricultural land in favour of large nature areas, land-based agricultural activities virtually disappear in a number of regions with a strong position at present. In this scenario, production on a limited area of land is given preference over production at minimum costs. This shows the relative value of the term 'weak' and the importance of policy objectives for the future of rural areas in the EU. Development of highly productive, irrigated agriculture in southern Europe may cause problems in the northern member states with respect to agricultural land use and employment.

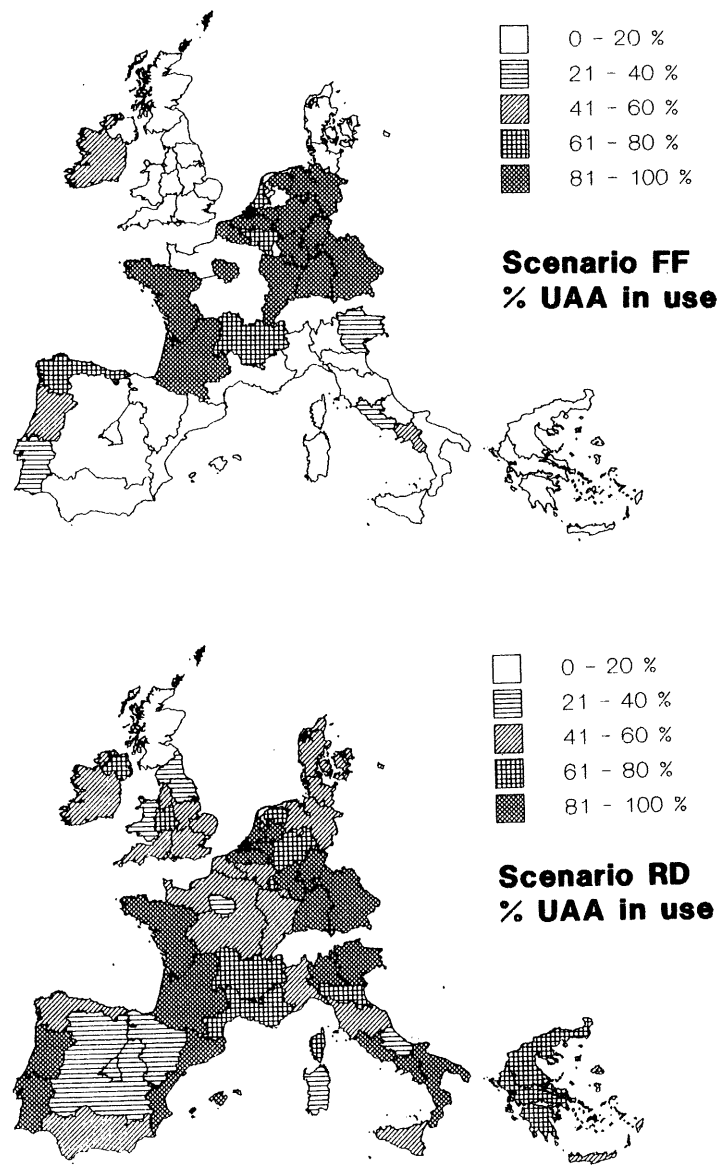


Figure 6 (a,b). The percentage of currently used agricultural area that is still in use in the four scenario's (%UAA in use).

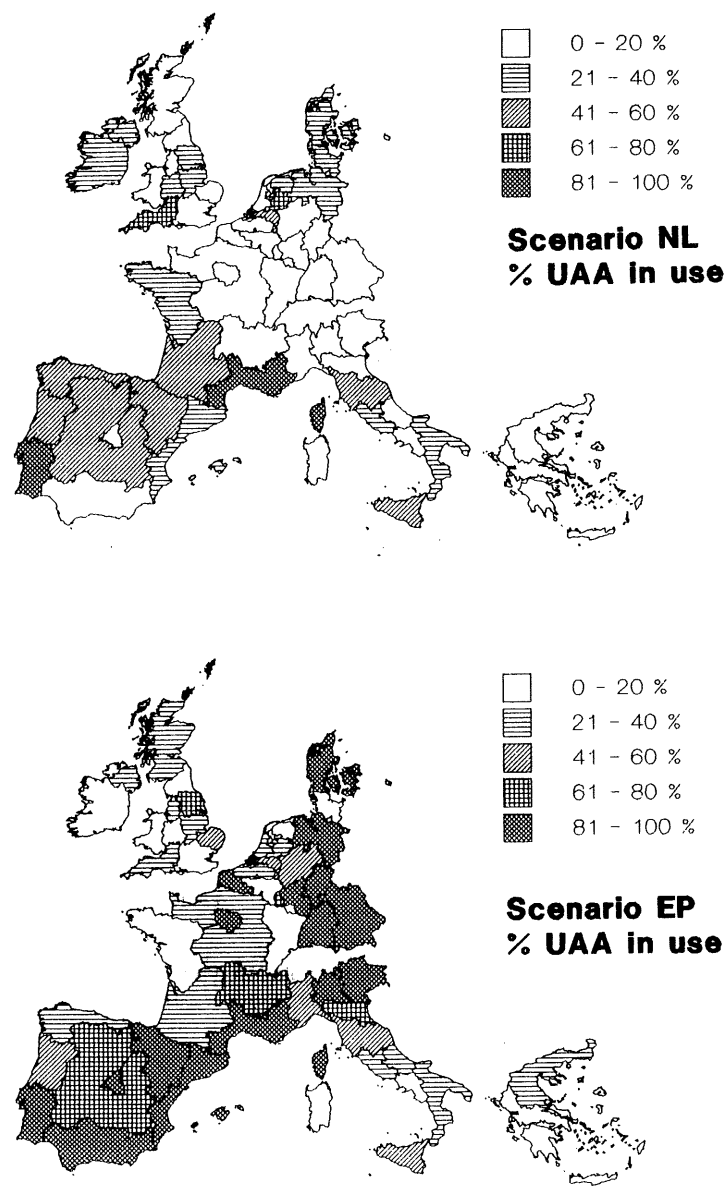


Figure 6 (c,d). The percentage of currently used agricultural area that is still in use in the four scenario's (%UAA in use).

Ecological and landscape consequences of land use change

Scenarios "Regional Development" and "Environmental Protection" reveal a more uniform distribution of agricultural land use throughout the EU. In scenario "Regional Development" this is a result of the policy objective that maximum employment must be retained in all regions, which results in 29% of the current level of agricultural employment in all regions. Since the same percentage of employment is maintained in all regions, those with a high level of employment at present (such as the Mediterranean regions) enjoy a relative advantage. The policy objective in scenario "Environmental Protection" is attained by exploiting the longer growing season in southern regions. As in scenario "Regional Development" this results in a shift of agricultural activities to southern Europe, but it with a different distribution over the regions.

These examples illustrate that not only can information on important macro policy indicators be provided by GOAL, but also that an optimal allocation of land use may be derived.

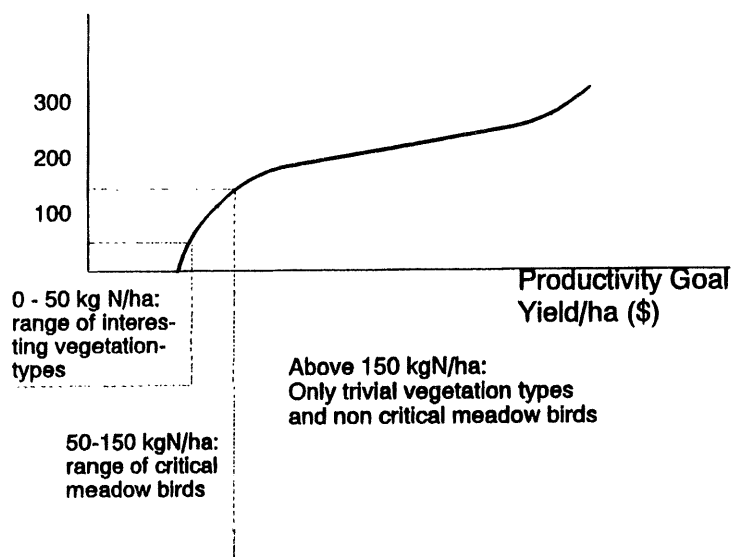


Figure 7. Position of several goals of nature protection on the nitrogen curve of Van der Meer.

Agriculture and the management of nature and landscape

The results of the scenario studie are extremely important regarding agricultural management of nature and landscape. All forms of modern agriculture based on intensive soil use, either being driven towards an environmental optimum or towards an economical optimum, only can have a limited meaning for nature and landscape.

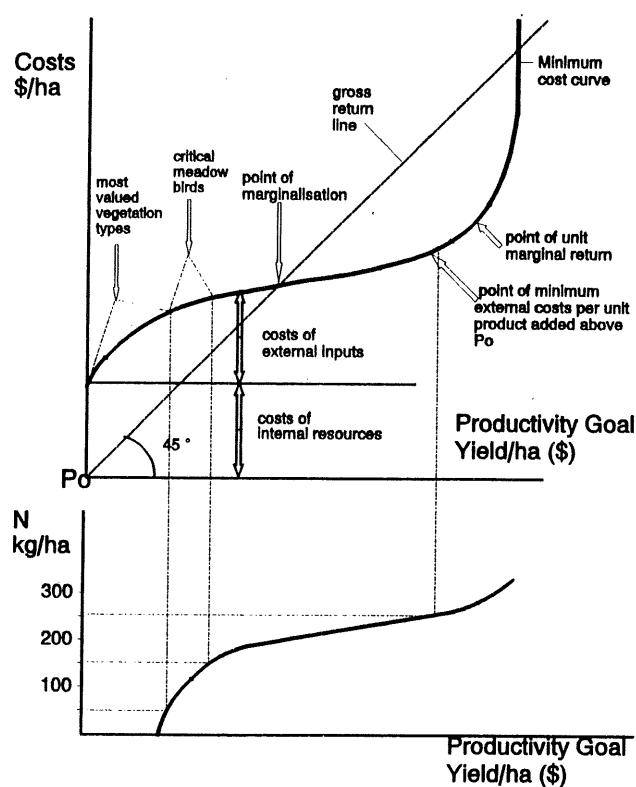


Figure 8. Integration of the curves of De Wit and Van der Meer shows the marginal position of nature oriented agricultural management in modern agriculture

This can be demonstrated in an example in which the Curve of de Wit is elaborated for dairy farming systems on peat soils in the Netherlands. Van der Meer (1993) indicates the position of the point of minimum external costs in terms of total nitrogen gift at present best practical means at a level of 230 - 280 kg/ha.

Van Rabenswaaij *et al.* (1991) searched for correlations between the agricultural use of several hundreds of grassland parcels and their results in terms of nature protection. All parcels belonged to farms which were subsidised in the context of the Netherlands Environmental Sensitive Areas programme. The outcome of this search can be summarised in a Nitrogen curve that was drawn up by van der Meer (1993). The result is Figure 7 and this shows that all vegetation types that are considered as being of great importance, are found in the traject of 0 to 50 kg N/ha. Above 50 kg N/ha only the low valued vegetation types and plant species (in terms of nature conservation) are found.

The optimum path for the presence of very critical and critical meadow birds turned out to be the zone between 50 - 150 kg N/ha. If these figures are combined into Figure 8 then it becomes clear that modern agriculture either being driven towards an environmental optimum or being driven towards an economical optimum only can have a meaning for the lower valued vegetation types and non-critical meadow birds.

It should be clear however that this conclusion holds for the type of grassland described above, that is purely used for fodder production and has therefore all characteristics of a "crop". Rough grazing with cattle and for meat production is possible at grassland that is in crop terms relatively poor, but in terms of labour productivity high. The scale and structure of farms using these technologies is however very different from pure forage producers such as the common dairy farms in The Netherlands.

All this is nothing new regarding the economic push factor. But what is worse is that this analysis shows that environmental goals and goals of nature and landscape diversity are no longer pointing in the same direction. The "traditional" synergy between the environmental movement and nature protection organisations can no longer be taken for granted.

The end of the synergy between nature and landscape conservation on the one hand and strategies aiming at reducing agricultural emissions into the environment on the other hand gives rise to new questions for landscape ecology and planning. Also new perspectives for spatial planning can be derived.

Spatial planning is not only necessary in order to allocate the most suitable landscapes for high intensive sustainable agriculture. A more clear distinction is needed between agricultural production zones and zones for nature protection now that the functional synergy between the two has such low perspectives. New production landscapes have to be designed in which intensive agricultural production without severe environmental burdens is in synthesis with a framework

of other functions. Apart from nature development promising functions are recreation, housing and water production (Van Os *et al.*, 1995)

This spatial planning of intensive agricultural production zones, of new rural functions and of large areas for nature (re-)development should be based on an European framework but it has to be elaborated in national and regional plans because of the earlier mentioned site-specific character of nature and landscape.

If land, that has been intensively used and polluted, falls fallow, it is not virgin land but land that not necessarily has a natural suitability for nature development. In first instance it loses its agricultural function because it is no longer suited to agriculture. Here lies the other great challenge for landscape-planners: the development of sanitation-schemes that aim at the re-development of nature and of sustainable landscape structures without its traditional manager - agriculture - longer being present.

Conclusions

In this paper a combination of various techniques and disciplines is presented. GIS and crop growth simulation studies were used for qualitative and quantitative land evaluation. Detailed agronomical analysis and detailed crop growth studies have led to the definition of production techniques that indicate the relationship between various inputs and outputs. Analysis of econometric studies on world trade markets of agricultural products helped to formulate the demand for food produced within the EU.

The combination of all this technical information with policy views has led to the assessment of options for future land use in the EU. This range of options may help in strategic policy planning and may set ultimate aims for mitigating policy instruments.

From the results of the study it may be concluded that major changes in land use are inevitable in all policy options. All scenarios point to a dramatic decrease in farmland. About one third of the present area under cultivation will be sufficient once productivity in the EU reaches the optimum. It should be noted, however, that the scenario's explore possibilities, and do not make predictions.

The differences between the scenario results indicate that there is room for policy change, but the possibilities of mitigate effects are severely limited. As already illustrated in Figure 5, present land use of 130×10^6 ha may eventually come down to the range that was mentioned, although these figures are extremes. Technical development can bring about a maximum decrease of 100×10^6 ha, if the best technical means are used for agricultural production. Through policy intervention it may be possible to opt for either the lowest area of 30×10^6 ha or the highest area of 60×10^6 ha. However, acceptance of extensive types of agricul-

ture may increase the area with 50×10^6 ha. So policy will have an effect, but compared to the decrease brought about by technical improvements this effect will be limited. The present study has demonstrated that the scope for strategic decisions is limited and any reform of the CAP should consider these limitations.

Policy goals, however, can have a major influence on the distribution of agricultural production locations in the member states, as shown by the maps generated in the study.

Agriculture that produces according to best technical means is not only responding to economical but also to environmental demands. For nature and landscape management a synthesis with modern agriculture can no longer be taken for granted. The problem of huge areas of land falling out of agricultural use and without the perspective of management as an agriculture by-product is a new challenge for spatial planning and the protection of nature and landscape.

References

- Bischoff, N.T. & R.H.G. Jongman. 1993. *Development of rural areas in Europe: The claim for nature*. Preliminary and background studies no. V79. Netherlands Scientific Council for Government Policy. SDU Publishers, The Hague. The Netherlands.
- De Koning, G.H.J., H. van Keulen, R. Rabbinge & H. Janssen. 1995. Determination of input and output coefficients of cropping systems in the European Community. *Agricultural Systems* 48: 485-502.
- De Wit, C. T., Huisman, H., Rabbinge, R. 1987. Agriculture and its environment: Are there other ways? *Agricultural Systems* 23, pp. 211 - 236.
- De Wit, C. T. 1992. Resource use efficiency in agriculture. *Agricultural Systems* 40(1992):125-151
- Netherlands Scientific Council for Government Policy. 1992. *Ground for Choices: Four perspectives for the rural areas in the European Community*. Reports to the Government no. 42. SDU Publishers, The Hague. The Netherlands.
- Rabbinge, R. 1986. The bridge function of crop ecology. *Netherlands Journal of Agricultural Science* 34. pp. 239 - 251
- Van der Meer. H.G. 1993. Intensiveren of Extensiveren, een doelloze discussie. In: *Intensiveren of extensiveren*. Themagroep Landbouw en Milieu. LU. Wageningen.
- Van Lanen, H. A. J. 1990. *Qualitative and quantitative physical land evaluation: an operational approach* (Thesis) Landbouw Universiteit, Wageningen, The Netherlands. 195 p.
- Van Latesteijn, H. C. 1992. A methodological framework to explore long-term options for land use. In: *Systems Approaches for Agricultural Development*, eds. F. W. T. Penning de Vries, P. S. Teng & K. Metselaar. Kluwer Publishers, The Netherlands.
- Van Os, J., A.f. van de Klundert & A.G.J. Dietvorst. 1995. Back to the Future. New functions for rural areas in Europe. In: *Scenario studies for the rural environment*, eds. Job F. Th. Schoute, Peter A. Finke, Frank R. Veeneklaas, henk P. Wolfert. Kluwer

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Academic Publishers. The Netherlands. pp. 611-616.
Van Rabenswaaij, C.W., L.A.F. Reyrink, P.J.A.M. Smeets & J.T.C.M. Sprangers 1991.
Ecologische effecten van aangepaste landbouw. Rapport Centrum voor
Agrobiologisch Onderzoek, Wageningen.