LAND USE IN EUROPE

A METHODOLOGY FOR POLICY-ORIENTED FUTURE STUDIES

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STELLINGEN

1 Het voorspellen van toekomstige ontwikkelingen is uiterst moeizaam omdat de cyclus van verwondering, hypothesevorming en toetsing niet kan worden toegepast op de toekomst. Toekomstonderzoek kent dan ook meer getuigenissen dan bewijsvoeringen.

2 Het achterhalen van toekomstige onmogelijkheden biedt meer houvast dan het trachten te voorspellen van de meest waarschijnlijke ontwikkeling.

3 Pragmatisme en het vermijden van politieke keuzen heeft het Gemeenschappelijk Landbouw Beleid gemaakt tot een ingewikkelde legitimering van achterhaalde financiële steunregelingen.

4 Wetenschap en beleid kunnen niet gescheiden zijn door een kloof omdat ze niet in een vlak liggen. Het bouwen van een brug is dan ook een zinloze bezigheid.

5 De term 'expert-system' verhult het gebrek aan kennis op het desbetreffende gebied. De term 'best-guess system' geeft de essentie beter weer.

6 'Duurzame ontwikkeling' duidt op een na te streven ideale situatie, te vergelijken met 'geluk voor allen' en 'sociale rechtvaardigheid'. Operationalisering van dit type idealen in vastomlijnde leefregels bewerkstelligt meestal het tegenovergestelde.

7 Ecologie is een wetenschappelijke discipline, geen keurmerk.

8 Met de wet in de hand is nog nooit een volksgezondheidsprobleem opgelost maar wel een probleem van rechtshandhaving gecreëerd. Met de afschaffing van de Opiumwet wordt dan ook geen volksgezondheidsprobleem gecreëerd maar een rechtshandhavingsprobleem opgelost.

9 De wens om belanghebbenden medeverantwoordelijk te maken voor het ontwikkelen van beleid in de zogenoemde 'stakeholderplanning' staat op gespannen voet met de verantwoordelijkheidsverdeling in onze representatieve democratie.

10 Met de invoering van het gekozen burgemeesterschap komt een einde aan de riante afvloeiingsmogelijkheden voor ex-bewindslieden, mislukte bestuurders en afgeschreven kamerleden.

Behorende bij het proefschrift

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PREFACE

Writing a PhD thesis as a sideline activity is a perilous undertaking, a general notion certainly reconfirmed by this study. When I originally took up the challenge I was all too easily convinced by my supervisor Rudy Rabbinge that it was merely a matter of carefully writing down what we had already been discussing for some time. It would simply be an extension of the study that had led to the report 'Ground for choices; Four perspectives for the rural area in the European Community', an undertaking that at that moment we had just finished. However, the truth turned out to be a bit more complicated. On the one hand a lot more thinking and discussing appeared to be necessary than we had anticipated to come to a balance between the methodological aspects of future studies and the particular case of land-use in Europe. On the other hand an intensification of my main occupational activities, resulting from a change in position, made the sideline more marginal than ever. If Rudy Rabbinge would not have insisted on finishing the job, I seriously doubt whether this preface would ever have been written.

As with almost everything, this dissertation could not have been completed without the help and efforts of numerous other people. First of all the group of (former) colleagues at the Netherlands Scientific Council for Government Policy with whom I compiled the report 'Ground for choices' deserve to be mentioned: Rudy Rabbinge, Marina van Damme, Frans Bletz, Dirk Scheele, Yvonne Starrenburg, Huib Hengsdijk and Emmy Bolsius. Although this group carried out all the core activities, we would never have succeeded without the input of numerous other scientists: Henny van Lanen, Kees van Diepen, Fre de Koning, Henk Janssen, Herman van Keulen, Arnold Brecht, Kees Hendriks, Jan-Dirk Bulens, Nicole Bischoff, Rob Jongman, Diana van der Stelt-Scheele and Marcel Wijermans, a list far from complete. I will certainly have forgotten somebody, so to whom it concerns, please accept my apologies in advance.

Three people need special attention though. First of all I would like to thank Jan Schoonenboom, my co-supervisor, who through the years proved to be the ideal sparring partner. We tested all sorts of ideas and deductions and we never seemed to run out of new ones. For me these discussions were indispensable, not only for improving the line of reasoning in this dissertation, but also for keeping up spirits in my daily working environment. Secondly I wish to express my thanks to Simone Langeweg, who managed to uncover all sorts of flaws in the consecutive versions of the texts. If it weren't for her perseverance, I would certainly have grown accustomed to my own mistakes. If there are still errors or weaknesses in this text, the blame is fully on me. Finally, I want to express my thanks to Rudy Rabbinge, whose never failing optimism proved to be a strong source of inspiration.

Henk van Latesteijn

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SUMMARY

The common agricultural policy (CAP) is going through a phase of significant restructuring. The original goals of the policy – already stated in 1957 – were primarily aimed at improving agricultural production and reducing consumer prices for agricultural products. The success of the CAP in achieving these goals led to a considerable increase in agricultural productivity within the EU. However, with this rapid development a number of negative external effects of agricultural production activities have also become apparent. The original CAP goals, then, no longer suffice when it comes to facing the problems encountered in present-day agriculture. Effects on social structure, on nature and landscape and on the environment have led to the identification of new policy goals to deal with these drawbacks. With the steadily increasing claim on the budget of the EU, the call for restructuring the CAP has become even more prominent.

The call for new objectives alone was not enough to facilitate the process of restructuring. Many of the actual proposals to change the CAP are restricted to relatively minor changes to the instruments used. Nobody is really willing to give up policies that have led to a healthy agricultural sector with reasonable incomes for the farmers, reasonably stable internal markets, a guaranteed food supply and reasonable consumer prices. Furthermore, the questions whether these instruments were used to attain preferred policies and whether it was possible to achieve certain combinations of compatible policy goals were never addressed. However, recent history shows that much of the new intentions within the CAP have been frustrated as a result of ongoing growth in productivity.

In this study the proposition is put forward that the problem with restructuring the CAP concerns the CAP's relative ignorance of future possibilities. To overcome this lack of information the possibilities are investigated to set up a future study that brings to light a conceivable and feasible mix of policy goals. Methods from future studies research are critically surveyed so as to develop an adequate methodology for this purpose. It is concluded that an explorative approach based on the description of the properties of the agricultural production system combined with additional information about the external conditions of the system might indicate the technical feasibilities of this system. However, if the consequences of different policy goals for future developments in land-based agriculture are to be identified, the exploration should also incorporate the identification of these policy factors in the guise of an optimisation exercise. This combination of a technical exploration of feasibilities and a political optimisation of goals is denoted as a 'pragmatic' methodology to underline the observation that it is neither the technical possibilities that shape the future, nor the political aims, but a mixture of the two.

This methodology is then applied to the case of future land-use in the EU. The technical possibilities for land-based agriculture in the EU are quantified by combining agronomic information on the relation between plant properties and

production potentials, information on soil properties and historical observations of the weather. First, a crop growth simulation model is used to assess the potential yield of various indicator crops. This simulation model uses information on crop characteristics, on quality of the soil and on properties of the climate as its inputs. Next, 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. This translation requires information on possible farming systems and cultivation methods as additional inputs and is based on an expert judgement. Finally, the technical possibilities are confronted with political wishes regarding the performance of the agricultural system. Requirements for various policy goals related to land-use together with alternative cropping systems and a demand for agricultural produce are used to construct the linear programming model GOAL (General Optimal Allocation of Land-use).

With this model four contrasting scenarios of future land-use in the EU are developed, based on four different political philosophies: free trade and free market, regional development, nature and landscape conservation and environmental protection. To that end eight policy goals have been incorporated in the model: maximisation of yield per hectare, maximisation of total labour, minimisation of deviation from current regional distribution of labour, minimisation of total pesticide use, minimisation of pesticide use per hectare, minimisation of total N-fertiliser use, minimisation of N-fertiliser use per hectare, minimisation of total costs. In a stepwise procedure, the individual policy goals are optimised alternately to allow for a constant feedback of the results and thus constructing different future scenarios. In this procedure choices have to be made, so the scenarios will be normative by definition. The combined scenarios reflect certain preferences in policy goals and the consequences of these preferences for agricultural land-use in the EU. These results comprise the limits to the options available to the agricultural system.

The model calculations point to dramatic differences between the four scenarios. When it comes to land-use the highest value is some three times higher than the lowest. The difference is twofold as far as employment and use of nitrogen (total and per hectare) are concerned. Highest values for use of crop protection agents per hectare are 4 times the lowest, while the totals differ by a factor of 7.

All four scenarios lead to a considerable reduction in agricultural area. At present about 127 million hectares are used for land-based agriculture. In the nature and landscape scenario only 26 million hectares are needed. The other scenarios also lead to a sharp reduction in the area of land required, ranging from 42 million hectares in free trade and free market scenario to 76 million hectares in the regional development scenario. These results indicate that policies that aim to maintain the area of agricultural land at the current level will have to fight an increasingly fierce battle to withstand the overall trend. Similar conclusions can be drawn for the other policy goals.

The results of this study can be evaluated at three different levels. First, a comparison can be made between the stated demands for a method to explore future possibilities in agriculture and the method that has evolved in this study.
The scenarios constructed with the aid of the GOAL model explore technical possibilities to attain a set of well-founded policy objectives. These possibilities are explored by investigating the technical limitations that restrict the potentials of the agricultural sector based on well-known quantitative data. The limitations form the 'hard facts' that are needed to convince policymakers. Although some of the assumptions can be brought under discussion, any adaptation would lead to a more pronounced result in terms of the scenarios. The combination of a technical assessment with a subjective optimisation has indeed given us scientifically underpinned description of limits to the growth of agricultural production and a politically retraceable optimisation of goals.

Second, the results of the exercise reveal that model calculations like these can act as a more or less unimpeachable authority that may discipline the discussion. The optimisations of relevant policy goals obtained with the GOAL model cannot be used to bridge a perceived gap between science and policy, but the outcomes can fulfil a functional role in the way in which the political issues are brought under discussion. If this is the ambition of scientific analysis in a policy context, it will be very difficult to trace the precise impact of any scientific finding in the policy debate. It can be illustrated, though, that there are numerous issues that may benefit from this type of information.

Thirdly, the question arises whether the methodology developed in this study may be transferred to other issues and policy domains. The basic assumption in the general approach is that it is the political process that is sovereign with respect to political choices and it is the scientific community that is sovereign with respect to analyses of order and regularity in nature (and society).
This approach is truly pragmatic in the sense that it is fully understood that the analysis must provide policymakers with the best available information to facilitate an informed decision, while at the same time not forgetting that 'political efficiency' will ultimately be the decisive force. Both scientific facts and political goals thus retain their identity throughout the process of analysis, as appeared from our study of the future possibilities for land-based agriculture in the EU.
It is in this very respect that the methodology developed in this study differs from other approaches. In other areas of research and policy, however, it may prove much more difficult to make this distinction between scientific analysis and political optimisation. It should be considered a challenging task for policy-oriented science then to develop a similar functional distinction by trial-and-error, thus opening up new possibilities. This requires, as a first step, that in all policy-oriented future studies facts that are prone to scientific analysis be systematically separated from more subjective assumptions and goals.

1 INTRODUCTION

1.1 THE POLICY DILEMMA: GOALS OF AGRICULTURAL PRODUCTION

The Common Agricultural Policy (CAP) has proven to be very successful in attaining its primary objective of ensuring food security within the European Union (EU). Its policy measures stimulated a tremendous growth in agricultural production. Improving production conditions, increasing knowledge of cultivation techniques and high-yielding varieties have led to this period of growth whose end is not yet in sight. Biotechnological innovations may even lead to a more pronounced productivity rise in the future.

However, this increase in production has also brought about undesired side effects. To date, the CAP has lacked a feedback mechanism. It virtually is an open-ended regulatory system, which ultimately results in an accelerating situation of surplus production for several products. Farmers receive aid through an intervention system. In this system, the EU sets a floor price at which it buys surplus production of a limited number of agricultural commodities. Next, these surpluses are sold on the world market, which again requires EU financing to overcome the price differences. To be able to keep up this policy the EU budget has had to rise every year, which in turn has led to political strain within the Union. EU member states argue about the maximum level of support that should be observed. There is a tradition of conflicts with important trading partners over the 'subsidised dumping' of EU surpluses on the world market. Moreover, this market is distorted mainly to the detriment of developing countries. Finally, current production methods give rise to an increasing environmental problem.

Some measures have been taken to limit production, i.e. notably a system of quotas for some products and a set-aside scheme in arable farming, by which land is taken out of production. However, these measures do not fully recognise the problem at hand. In fact, the perception as to which is the most relevant problem differs with the stakeholder that is involved and the level of scale that is observed. Individual farmers, regional authorities, national governments and European politicians will all have their own opinion about quotas or set-aside schemes. This makes it difficult to come up with adequate policies. At the level of the EU the budget problem prevails, but at regional levels other problems draw much more attention. These regional problems range from consequences of overexploitation in areas where agriculture is booming to consequences of land abandonment in areas where agriculture is no longer viable.

The effects of overexploitation became apparent in the guise of detrimental effects to surface and groundwater. In high yielding production environments the costs of inputs were almost negligible compared to the potential profits. In some cases, especially in The Netherlands, this resulted in a considerable overuse of nutrients. Since the crop did not take up the superfluous nutrients, these polluted the environment through processes like run-off and leaching. The same holds true for the use of pesticides. Farmers were inclined to use pesticides in a preventive mode, since the costs of application were much lower than the potential costs of harvest losses. Taken together, these developments settled the opinion that agriculture was primarily threatening to the environment.

Other regions could not keep up with the rapid changes and consequently agricultural production came to a standstill in these areas. Abandonment of the land resulted and with that the function of agriculture as caretaker of the landscape also vanished. Especially in mountainous regions this formed a tangible threat, since vegetation forms defence against erosion on slopes. If the vegetation is no longer maintained, landslides might result. The desertion of former agricultural areas even led to speculations about 'chemical time bombs': the sudden withdrawal from especially arable lands might lead to an increased leaching of the chemicals (both nutrients and pesticides) that remained in the soil (Stigliani et al. 1991).

Next to possible effects on the environment, deterioration of the rural society may become apparent. With a decreasing number of farmers, the foundation for a rural social structure may weaken, given the fact that a great deal of services such as public transport, schools and postal delivery can exist only if a minimum number of people inhabit an area (OECD 1986).

In the early nineties a general feeling arose that the problems would become intractable if the sector would carry on this way. New policy objectives were formulated in answer to the emerging problems. This development may be attributed to the side effects of the CAP, but for a large part these new objectives can also be regarded as new signs of modern times. Especially the increasing environmental problems triggered a new public awareness of the dangers that accompany modern society. In all sectors, the possible effects of production on the environment initially led to the introduction of measures to abate environmental pollution. Next, production processes were critically assessed, sometimes leading to major restructuring. The same development can be observed in the agricultural production sector. Production was no longer considered the single objective, but also concern for the common environment should have an influence on developments in agriculture. In its 1985 Green Paper, the European Commission stressed the importance of environmental goals as an inseparable part of agricultural policies and these new objectives should be put to practice (CEC 1985). However, most of these objectives call for formerly unexplored pathways of (agricultural) development. The normal routine was to set up policies that would speed up the productivity growth of the sector, almost irrespective of the long-term consequences. Through the years, the list of wishes with respect to environmental and social conditions had grown, but information on how to accomplish these could not be derived from practice.

The continuing success of the CAP with respect to its primary goals combined with the continuing call for policies to mitigate the adverse effects of agricultural production constitutes a policy dilemma. On the one hand the benefits of present policies for some of the stakeholders are evident, while on the other the need for changing present policies to address public interests is also apparent. This leads to the situation that any policy proposal that aims to enhance any of the new public objectives in agriculture is likely to meet massive opposition from a number of stakeholders. At the same time, continuation of the present policies will meet an increased public debate since the conflicts with perceived public goals are becoming more and more visible.

Rausser (1992) illustrated this policy dilemma using data from the US. He analysed US agricultural policies and discerned between 'redistributive' and 'productive' policies. Generally speaking, public interest is served by redistributive policies that comprise instruments such as deficiency payments, price support, trade barriers, storage subsidies, input subsidies and subsidised credit. All these measures aim at redistributing wealth from one group to another and thereby restoring the balance in such a way that public interest is served best. Of course, the precise definition of 'public interest' is crucial to the outcome of these redistributive policies. Productive policies, conversely, aim to enhance the rate of economic growth, without giving much attention to the distributional side effects that will accompany any targeted growth effort. The measures here consist of an array of different things such as correcting market failures using public good expenditures, information and market services, and inspection of standards and support to public research. Because these policies exist side by side and because they serve such different goals, it is inevitable that in the design and implementation of agricultural policies conflicts emerge between public and special interests. As mentioned, public interests are served mainly by redistributive policies, but special interests are served best by productive policies that are very sensitive to political lobbying to safeguard the interests of stakeholders. In the debate on agricultural policies, this dichotomy between public interest and the interests of farmers and the agricultural production sector is highly visible. Acreage premiums, for example, may come into conflict with the principals of general social support policies. These premiums are meant to support arable farming in a given area but in practice they present a special title for social support based on the ownership of agricultural land. This special title for support founded in the productive policy of an acreage premium can disrupt the balance that was achieved with a set of carefully designed redistributive social support policies. Levies on environmental hazardous emissions from agriculture are another example. These levies are meant to redress the societal costs and sectoral benefits of using the environment as a free production factor to agriculture. However, in a situation where governments are also aiming at supporting the agricultural sector for strategic reasons, the redistributive policy of a levy comes into direct conflict with all the productive policies to enforce the sector. The list of conflicts can be extended almost indefinitely.

This study aims to provide information that can help to decide what type of policy should be prioritised given the multiplicity of possible goals. The route to that information is not sought after in the policy goals themselves, but in the possibilities that the agricultural sector possesses for achieving these goals. To that end the (technical) possibilities for European agriculture in the future will be explored and these possibilities will be confronted with the (political) wishes that play a part in the current policy debate. These wishes are both redistributive and productive by nature and stem from the different perceptions of the policy problems that should be addressed by the CAP. To fully understand these perceptions the following paragraphs will deal with the developments in the policy debate in agriculture.

1.2 THE ORIGINS OF THE AGRICULTURAL POLICY DEBATE

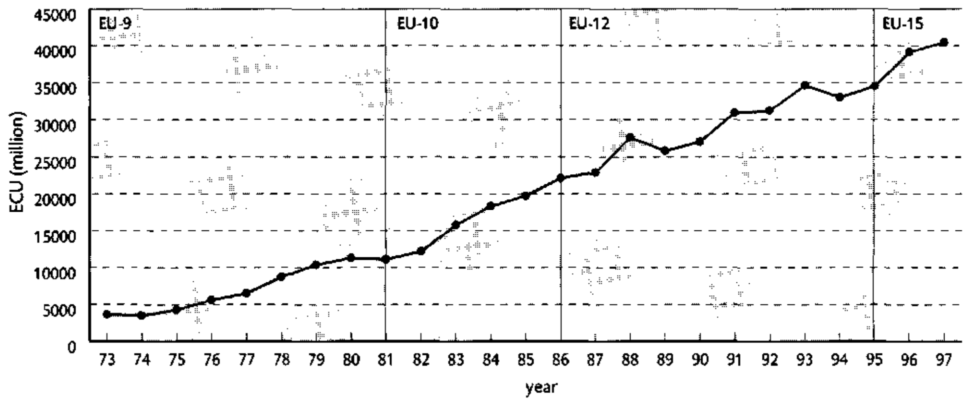
1.2.1 HISTORICAL DEVELOPMENTS

The CAP finds its roots in Article 39 of the Treaty of Rome of 1957 that stated the following goals for agricultural policy at Union level:

1 stimulate productivity growth of agriculture by speeding up technological progress and by ensuring rational development of production and optimal use of production factors, especially labour;
2 guarantee a reasonable standard of living for the agricultural population, especially by rising the per capita income of those working within the agricultural sector;
3 stabilise agricultural markets;
4 safeguard food supply;
5 realise reasonable consumer prices.

A system of intervention and protection at the borders of the EU was devised to shelter the internal production from the influence of the world market. Where protection at the border was impossible, a system of deficiency payments was set up to insure an internal price well above the world price. These price supports and export subsidies were financed through a fund at the community level. Effectively, this combined price support and export subsidy led to a guaranteed minimum price for any volume produced of certain commodities. Not surprisingly, this led to a situation of stable internal prices for these commodities. National structural policies and extension systems to stimulate innovations in the different branches and disseminate these innovations to all regions accompanied the measures at community level. In less than three decades after its conception, the various policy instruments of the CAP led to a considerable growth in productivity. Therefore, the EU is now more than self-sufficient in almost all indigenous products (Meester and Strijker 1985). Most farmers earn an acceptable income and stable markets guarantee the supply of foodstuffs.

Figure 1.1 **Expenditures of the European Agricultural Guidance and Guarantee Fund (EAGGF), 1973-1997**



Although individual farmers and the trade balance benefited from the policy measures, there was a price to be paid. From 1975 to 1987 agricultural production increased by 25 percent in the EU, but total agricultural income and employment in the sector decreased with almost the same percentage (Von Meijer 1989). This relatively beneficial situation for a smaller number of farmers could only sustain at increasing costs for the community. Agricultural production rose well above the market's absorption capacity. Between 1973 and 1988, the volume of agricultural production in the EEG increased by 2 percent per annum whereas internal consumption grew by only 0.5 percent per annum. A situation of over-production for certain commodities (especially cereals, milk and beef) resulted.

Because of increasing price support and export subsidies expenditures of the European Agricultural Guidance and Guarantee Fund (EAGGF) increased from 5×10^9 ECU in the mid seventies to some 40×10^9 ECU in 1997 (CEC 1998). The growth of the EU from nine to fifteen member states undoubtedly had an influence on this increase. If only the period of the EU-12 from 1986 to 1995 is considered, then the budget for this fund still reveals almost a doubling in a period of only nine years (Figure 1.1).

Subsequent price-cuttings to control this source of public expenditure have endangered the profitability of agriculture in less endowed regions. Since the second goal of the CAP is a profitable agricultural sector in all regions, compensatory measures were taken to adverse the regional effects of decreasing prices. EU funding to strengthen the structure of regional economies and regional agriculture increased. Decisions on the use of these funds were taken without much awareness of the cost-effectiveness of regional investments. Often investments in agricultural development may not only be ineffective, but also counter-productive: the intent to dam agricultural surpluses on a general level can be obstructed by measures to improve regional production facilities (Van der Stelt-Scheele 1990).

1.2.2 EMERGING CONFLICTS BETWEEN OBJECTIVES

From the outset, agricultural policies have been aimed at a profusion of objectives. These objectives form the core of most of the political debates that surround the policy planning in agriculture. Moreover, some objectives have a strong ideological component that further complicates the discussions.
A long-standing debate deals with the question whether agriculture should operate under (politically) controlled market conditions or that agriculture could prosper in a free market. In recent years, the call for free market conditions has been heard more often. This argument was enhanced by the growing tension in the relations of the EU with important trading partners. In the so-called Uruguay-Round in the GATT discussions trading partners of the EU were irritated by the perceived impact of EU subsidised exports on their world market share and the world price. Triggered by this debate on trade liberalisation, a strong lobby in the agricultural policy arena advocated the free market and free trade philosophy.

Historically, agricultural policies have been primarily concerned with socio-economic objectives such as lowering the costs of production, rising productivity and ensuring reasonable incomes to the farmers. Simultaneously electoral pressure has led to several conflicts in the objectives to be pursued. The CAP was formulated by representatives from different EU member states with different backgrounds and sometimes with strong roots in the various regions of the Union. This has led to a policy practice of defending the status quo of constituencies. When decisions had to be made that may have a detrimental effect on the regional labour force in agriculture, the *Common* Agricultural Policy is easily forgotten. Rather, politicians tend to defend the interests of their voters, without many scruples with regard to the collective outcome of this process. Indeed, redistributive policies are not very popular if negative effects on the regional stakeholder community are evident.

The productive regional policy goals aimed at strengthening the local agricultural sector were endangered further by the success of the sector itself. The ever-increasing yields coincided with a very moderate growth in demand within the EU. In such a situation the competition between producers inevitably leads to cost reduction at the farm, since there is no way of opening up new markets. This cost reduction was achieved mostly by replacing labour with machines. Moreover, in land-based agriculture production will shift to regions that can produce most efficiently. Often, these efficiently producing regions are not primarily interested in keeping up their agricultural labour force since these regions already are on economic efficient labour input levels. In some producing regions in France that still employ a substantial fraction of the rural population, these developments have regularly led to serious conflicts between farmers and government. In most cases farmers demanded a floor price that would cover their expenses. At the same time, the market prices for agricultural products showed a decline because total factor costs were considerably lower in other regions as a result of better-endowed agricultural land. Stated in economic terms: the fierce competition on a saturated market sharpened the regional distinction in competitive advantages and disadvantages. This illustrates that not all socio-economic goals point into the same direction of development. It all depends on the emphasis that is put on the public interests (thus the Community interests at the level of the EU) versus the special interest of regional or local stakeholders.

Next to that, the increasing attention for the negative external effects of agriculture on the environment has stimulated the call for environmental goals at the level of the EU. Especially problems related to the pollution of groundwater have urged a call for policy responses. This raw material for drinking water is affected by nitrate leaching and pesticide use. The call for conservation of natural values is also important for the developments in agriculture. As agriculture is by far the largest user of land, any development in agriculture will have a major influence on the possibilities of conserving natural areas.

The causes for the negative external effects are manifold. In agriculturally less-endowed regions, nature and landscape values are under stress. In areas where natural conditions have so far hampered agricultural developments older farming systems have survived. Although most of these systems are not very profitable, the farmers still carry on in the old tradition. Since in most regions there is a tendency to maintain the status quo, it can be argued that a general crisis in the agricultural sector forced farmers to maintain their ways of production in those areas *in spite of* the very poor quality of the land (Laurent 1992).
Although economically not very feasible, those systems are sometimes considered very beneficial to the natural environment. The ways of production are claimed to be in harmony with local nature values. Consequently, these systems are sometimes referred to as HNV (high nature value) farming systems (Baldock and Beaufoy 1993). The value of nature measured in terms of species diversity or the proportion of rare species is well above average in many areas where the economic viability of agriculture can be questioned.

The CAP forms a threat to these HNV farming systems; either by subsidising restructuring of the agricultural system or by forcing abandonment of the area. This bimodal development is caused by contradictions within the CAP itself. Certain areas have been formally designated as 'less-favoured areas' and this entitles them to support from the structural funds financed by the EU.
The programs developed within the framework of these funds are highly production-oriented. Investments in infrastructure (roads, irrigation works) and agribusiness are all aimed at creating more favourable production circumstances in the region. This implies a drastic rupture from traditional ways of production. For example: the agro-forestry systems that have been evolved over centuries in the *dehesas* of Extramadura are threatened with destruction as a result of combined funding from the Social Fund, the Agricultural Guidance Fund and the Regional Development Fund adding up to 55 million ECU'S (CEPA 1992).

Other areas do not fall into the supported category and suffer from the general EU policy regarding production control. Eventually there is no future for the HNV farming systems in these regions, because most of them cannot withstand the competition with higher yielding systems in other regions. An unmitigated development in either direction may lead to unwanted effects. On the one hand restructuring marginal land may result in an overuse of marginal farmlands, possibly leading to the degradation of the natural environment. On the other hand market forces may drive economic marginal farmers out of production in areas where for other reasons the presence of a farming community is wanted. These examples show that farming typically is a *conditio sine qua non* for many environmental, spatial and socio-economic objectives that may sometimes come into conflict with the original objective of producing directly marketable products.

On the other side of the scale, well-endowed regions may also experience conflicting policy goals. Spatial concentration of agricultural production in these regions may lead to pollution problems because of overuse of fertilisers and pesticides. The changes in agricultural structure can also have an impact on the amenity of rural areas in many ways. Concentration of dairy farming and intensive livestock production may cause stench problems. Large monocropping farms, functional farm buildings and the elimination of old landscape elements such as hedgerows and small bushes may greatly affect the amenity of rural landscapes, and thus the recreational value of rural areas. Another important negative effect is the reduction of natural and semi-natural wildlife habitats mainly due to structural adjustments in agriculture and to expanding infrastructure. For example, in the intensively managed pastureland of the Netherlands the number of meadow bird species is declining as a result of drainage, high nutrient levels and restructuring of the land.

1.2.3 INITIAL POLICY REACTIONS

In 1985, the European Commission agreed upon the so-called 'Green Paper' that concluded that the agricultural sector should be subject to reasonable public prescriptions and controls to avoid the deterioration of the environment (CEC 1985). The Commission also stated that agriculture is an important means to conserve the rural environment. This notion suggested an emerging need for the CAP to change and to eliminate the conflicts between market policy and structural policies. Thus, in a later paper the Commission proposed to reform structural policies (CEC 1988c). The Commission recognised that objectives of structural measures cannot be restricted solely to the enhancement of agricultural production. These measures should not come into conflict with the general policies concerning agricultural markets and prices in the EU. An important consideration was formed by the staggering budgets needed to pay for the increasing surplus production. To reduce this surplus production the following measures were proposed:

1 adjustment of the prices for agricultural products within the EU to bring them in line with those in the world market, and
2 limiting production in the EU to self-sufficiency, while guaranteeing farmers an acceptable level of income.

The CAP should be steadily transformed to encompass environmental and social objectives. Measures should be directed towards an improvement of the regional economic structure as a whole, including the regional environment (CEC 1988a).

In the paper 'The future of rural society' the Commission sketched the outline for a policy based on restructuring the agricultural sector, considering the responsibility of agriculture for the management of the rural areas (CEC 1988b). The next step was to develop an integral concept that would combine the various objectives. This concept should be flexible enough to allow for the specific properties of the various regions in the EU. In short the main properties of this rural management policy are:

- continuation of the 'old' objectives that relate to food supply and agricultural income by means of market stabilisation;
- elimination of the huge claims on the Union budget;
- incorporation of socio-economic, environmental and spatial objectives;
- elimination of inconsistencies resulting from piecemeal legislation.

1.2.4 THE MACSHARRY REFORMS

After long debates, the Council of ministers finally agreed upon a series of measures commonly known as the 'MacSharry proposals' in June 1992 (CEC 1991). The reforms were hailed as a breakthrough, because it was the first sign of EU policy shifting from price support towards more market-oriented strategies. The measures comprised a substantial fall in guaranteed prices in the arable and beef sector (e.g. minus 29 percent for cereals and minus 15 percent for beef). Farmers were compensated for their loss in income through a system of compensatory payments coupled to a 'set-aside' program (withdrawal of land from production). The payments were made on a per area basis and regional differences were accounted for by considering historical yield data from the region.

Especially the revisions of the price support schemes for arable farming have had a positive effect on some of the problems in the sector. The enormous stocks of cereals almost disappeared. The new price policies played an important role in achieving the Uruguay Round GATT Agreement in 1994. In this agreement considerable reductions in domestic support for agriculture and in export subsidies were written down that were only possible after the initial one-sided measures taken up by the EU. The 'new' position of the EU even contributed to the agreement on setting up the World Trade Organisation (WTO) as a continuation of the GATT.

Although the lowering of the guaranteed prices brought EU prices more in line with those on the world market, the compensation schemes that replaced the old price support (obligatory set-aside and acreage payments) leaves the basic problem untouched. After the reforms, the support mechanisms in the arable sector were still a mixture of old intervention-style policies and new direct payments to farmers. The list of policies in effect after 1992 reveals this ambivalent strategy (Baldock and Mitchell 1995):

- import tariffs on cereals, oilseeds etc;
- export subsidies on a range of crops;
- intervention purchase and crop storage arrangements;
- fixed areas for oilseed production;
- compensatory payments for cereals, oilseeds and protein crops per hectare, related to fixed regional base area;
- area payments for farmers participating in the quasi-voluntary set-aside scheme;
- supplementary area payments for durum wheat in traditional areas;
- aid for industrial use of starch from maize, wheat and potatoes;
- quotas for sugar beet production.

The list shows that several instruments are still based on the paradoxical combination of stimulating production and reducing the volume produced. Even the new measures suffer from the same ambiguity. To receive area payments a farmer must keep all of his land under agricultural production, even in the case of set-aside. He is not allowed to put some different non-agricultural use to part of his land. Moreover, the set-aside must be rotational which even adds to the environmental burden of agricultural production because nitrogen leaching will increase due to insufficient land cover (Dubgaard 1993). So, area payments conditional to set-aside do not only ignore the structural overproduction of some commodities, they even may aggravate the environmental risks of arable farming. This negative verdict for set-aside schemes and area payments may change if set-aside can have a more structural character. In the Netherlands the province of Groningen expanded the possibilities within the CAP framework at the regional level by using the set-aside scheme as one of the drivers to permanently withdraw land from the agricultural area. This resulted in a reconstruction plan for the Oldambt region in which agricultural, recreational and residential land-use is located along the shores of an artificial lake.
This, however, is an exception and set-aside at the level of the EU is only used to temporarily reduce the area of arable land.

The 1992 reforms added a new element to the CAP in the guise of accompanying measures. Three sets of measures can be discerned. The first set of measures was aimed at improving environmental conditions by supporting production techniques that were thought to be favourable to the environment, the landscape and natural resources. A second set of measures was aimed at encouraging afforestation within the EU as an alternative for traditional agricultural use of the land. Finally, a third set of measures provided an early retirement scheme for farmers that enabled Member States to subsidise the retirement of farmers from the age of 55. From these three sets of measures only the second relates directly to the use of agricultural area. The other two are efforts to incorporate elements from environmental and social security policies into the CAP.

Especially the first set of measures, the so-called agri-environmental program, gave rise to a discourse on the possibilities of incorporating environmental goals into agricultural policies. This combination is also known as 'cross-compliance', i.e. the attachment of environmental conditions to agricultural support policies (Baldock and Mitchell 1995). Understandably environmentalists were very keen on expanding the potentials of these measures, since they addressed the problems identified earlier with HNV farming systems and other related issues. Indeed, although this scheme is provided under the umbrella of agricultural policies, cross-compliance basically deals with an extension of environmental polices. The original concept of cross-compliance stems from agricultural policies in the United States. In that context it initially denoted that eligibility for a given support scheme was made conditional to accepting similar schemes for other commodities grown by the farmer. However, in the context of the CAP cross-compliance is equivalent to attaching environmental conditions to agricultural support payments. Thus, agricultural support payments are made instrumental to achieving given environmental goals.

Although some mixing of environmental and agricultural goals did take place, from the measures that were taken it can be concluded that there has been no fundamental debate on the aims of the policy. Changes are exclusively limited to the instruments used. The real problem of combining incompatible goals in a situation where the conditions over time aggravate the incompatibilities was not addressed. Policymakers did not invoke the discussion to which extent their goals were incompatible. An assessment of these emerging conflicts might have given the impetus for a fundamental discussion about the goals that should be pursued in future policies. The call for elimination of piecemeal legislation apparently was not strong enough.

1.2.5 FUTURE EXPECTATIONS

The combination of incremental policies in response to growing conflicts over goals will enhance future conflicts. Diverging socio-economic and environmental goals will certainly lead to very different consequences for future developments in agriculture. Striving for a free-market situation through elimination of protective policies will be difficult to combine with policies aimed at maintaining the regional labour force in agriculture. Still, these matters are all taken evenly serious in any proposed policy reform. For tactical reasons, politicians frequently state that all goals are of equal importance. In this setting, it will be very difficult to come up with initiatives that touch upon the priority setting between the different policy objectives. This may be illustrated with the repeated efforts of the Ministers of Finance to bind the expenditures within the CAP to an upper limit.

This financial priority melted away in the following discussions between the Minister of Agriculture that persisted in the unmodified continuation of all other goals of the CAP. In general, any attempt to prioritise will inevitably lead to a reaction that consolidates the present situation. What is needed then is a mechanism to shift attention from the *means* to the *ends* of policy.

1.3 THE NEED FOR METHODOLOGICAL CONSIDERATIONS

1.3.1 FUTURE STUDIES

The CAP is thus faced with a policy dilemma. On the one hand, it is becoming apparent that the earlier success of the CAP in promoting productivity growth has led to a prosperous sector. On the other hand, this success has also increased the conflicts between socio-economic and environmental goals. This dilemma has resulted in incremental policy responses. Political conflicts were resolved by extending or ameliorating existing measures. Hence, at a very general level the emerging new policy objectives call for a drastic reform of policies, but in day-to-day policymaking these reforms are obstructed by the relative success of current polices. Nobody is really willing to give up policies that have led to a healthy agricultural sector with reasonable incomes for the farmers, reasonably stable internal markets, a guaranteed food supply and reasonable consumer prices.

There are two different ways to explain this deadlock. The first is to blame it on the limited ability to make decisions at the level of the EU. If this explanation is adhered to, the solution may be a sudden sense of decisiveness stemming from political debate, diplomacy or power play. If policymakers agree upon the relative importance of the different policy goals, they could take a unanimous stand and overcome the battle of special interests. However, this is not a very likely chain of events. The second explanation is to blame it on the lack of information. If policymakers are not well informed about possibilities for and consequences of the political goals under discussion, they will inevitably fall back on a line of reasoning based on preconceived notions. The least that can be done in this situation is to increase the level of information to enable an informed consensus building process in the policy arena. If information is brought in from an unimpeachable authority, then there is a chance that the debate will shift from a battle between special interests to the construction of a public or Community interest.

In this study the second explanation is taken as a point of departure. The proposition is put forward that the problem with the CAP concerns its relative ignorance of future possibilities. In all debates on policy reforms so far, the question whether an increasing productivity could be brought in line with the various demands from policy was hardly ever tabled. But precisely this type of discussion is needed to enable a debate on the desirability of the policy goals. The potentials for a further growth in productivity will be crucial to the possibilities of achieving certain specified policy goals. In retrospect, 'ignorance' is no overstatement, because it appeared time and again to be the major factor for the problems

within the CAP. All expectations regarding the results of policy measures aimed at increasing productivity have been overshadowed by the final realisations. Without exception, the production per hectare showed a much higher growth than had been anticipated. Due to a persistent technological development productivity growth in agriculture was constantly underestimated.
The enormous surplus production would not have existed if productivity rise had stayed within the margins expected beforehand.

What is needed then is an idea about the future possibilities within the agricultural sector. Here science can lend a helping hand. The scientific discipline of *future studies* explicitly aims at illuminating situations like these. By analysing the future in one way or the other, some light may be shed on the complex problems of the present. The idea is that information about future possibilities may help to better understand the interconnectedness of the problem at hand. These insights may help to identify the room to manoeuvre in the political debate. Information about possible future developments can help to opt for the preferred alternative.

The ambitions of the CAP are relatively clear, be it that there is no way of telling whether these ambitions are attainable or compatible. If the current debate is to benefit from a future study, the results of a future study should shed some light on the attainability and compatibility of the different ambitions. In that case, these results can act as a frame of reference for future possibilities. As long as this frame of reference is lacking, all political ambitions will be defendable by themselves and the only option for a policy debate will be to defy the ambitions altogether. This forms a challenge to the way in which the future study is executed. Usually the core of a future study is formed by an elaborate description of the current conditions and ambitions that may shape the future. Current conditions and developments are then extrapolated to paint a picture of the future. However, the problem with earlier attempts to describe these developments for agriculture was the structural underestimation of productivity growth.
Time and again it proved virtually impossible to come up with a reliable estimate. If the attainability of a given policy goal is of primary interest, then a more sensible route may be the assessment of the potentials for productivity growth. For a first approximation of these questions it may be very informative to find out the potentials for a further growth in productivity. Ultimately these potentials define whether a policy goal can be attained. Whether the goal will be attained within a given time span is another question. In this case, however, information is needed on future conditions that may limit current aspirations. This requires an adapted method of future research.

This study investigates the possibilities of delivering scientifically based information that may help to find a way out of this dilemma. The challenge is to find a firm basis for assessing the conditions that may determine the future possibilities for the agricultural sector. What is needed is an exploration of the future that brings to light a conceivable and feasible mix of policy goals.

Is it possible to assess boundaries for the continuous developments in agriculture? Moreover, can these boundaries be linked to the current political discussion? This is what lacks the current debate on reforms of the CAP. If a future study could come up with this type of information, there would even be a benchmark for all ongoing discussions on relatively minor changes in policy instruments. Now these discussions can go on endlessly, and the outcome is solely dependent on the prevailing political stance.

Whether an exploration of this nature can generate limits to future developments from current structures remains to be seen. There is no easy answer to this question, since we have to deal with different opinions about inertia in the system. For example, several development theories start from the assumption that agribusiness complexes or current levels of investment in infrastructure and management skills put a restriction to future developments. This assumption leans heavily on the observation of slowly changing structural features of economic production systems. Indeed, for short-range explorations some of these structural constraints may be very important. However, there is ample evidence that apparent inertia can suddenly change at a much higher rate than was ever expected. The diffusion of knowledge in the economic sector is a classical example. Especially in the Netherlands, the period of restoration after World War II is characterised by a combined effort to modernise the agricultural community. Research, education and extension services worked closely together to realise a shift in the level of education and training. The emphasis on structural development of the agricultural sector within the EU may well have a similar effect at the level of the EU. A second example comes from the restructuring of the Dutch dairy sector. Of course, this capital-intensive agribusiness complex reveals inertia, merely from the fact that capital investment is involved. However, changing economic conditions will also have a dramatic effect on the movement of capital. The increasing international competition has urged Dutch co-operative dairy corporations to merge. These new mega-institutions shift their activities to international markets and optimise their financial result by closing down dairy factories and setting up new added value enterprises elsewhere. These developments modify the image of a mature and stable economic sector that is relatively insensitive to exogenous influences.

Therefore, the incorporation of a *priori* restrictions to the future that stem from current structures may limit the scope of perceived possibilities. The structure that reveals itself today is to a certain extent the result of policy decisions in recent history. Consequently, the structure of the future will partly be the result of policy decisions that lie in the near future. Since the future dimension was meant to inform the polity on possibilities, the incorporation of this type of boundaries in the study would lead to circular reasoning. Therefore another basis is needed to assess information about future possibilities.

1.3.2 IN SEARCH OF CONSTRAINTS

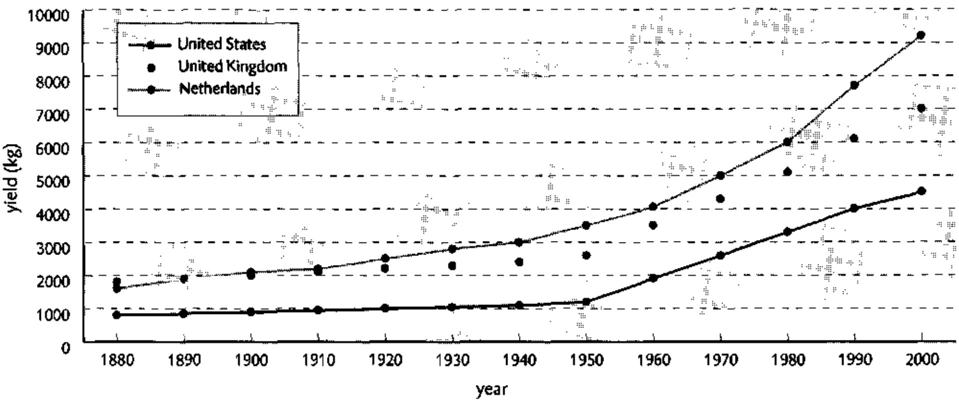
Several potential candidates for logical or technical boundaries present themselves in respect to the land-based portion of agriculture. A most promising candidate to focus investigations on is *land-use*. Land is the one factor that plays a role in all agricultural policy goals that have been discussed earlier. The possibilities to attain some or all of these different policy goals will depend on the future performance of the agricultural sector. An adequate yardstick to measure this performance is agricultural land-use, because this relates directly to the productivity per hectare, an agreed figure to measure the physical performance. Since land-use determines the agricultural production at a given location, it is also an indication for the economic performance. Land-use also indicates the type of production and thus the level of other input factors involved, such as labour, energy, capital and outputs such as production, emissions and waste products. This description of local activity can give a first estimate of the possible impact on the environment. Finally, all developments in agriculture – be it as a result of the introduction of new techniques and technologies or as a result of new policies – will have an effect on the type and location of land-use throughout the EU. The most promising feature of land-use in this respect is its definiteness. Only a limited number of hectares are both available and suited for agricultural purposes. Any policy that does not fit in with this 'constraint' promises more than it can account for. Although it may seem trivial, this feature is hardly ever considered in policy analyses.

Following the previous section, the obvious second candidate for a constraint is production per hectare or *productivity*. Although changes in land-use have up to now always led to an increase in production per hectare, the prime question is whether this development will continue in future. Still, an assessment of the likelihood of this ongoing rise in productivity is very relevant to almost all policy proposals. This can be illustrated by the following example.

A historic evaluation of the yield of wheat in the United Kingdom and the United States reveals remarkable similarities in the development of soil productivity growth (De Wit et al. 1987). As can be seen in Figure 1.2 both countries show a sharp increase in productivity growth shortly after the Second World War. The introduction of modern farming techniques such as improved nitrogen application, the use of herbicides and new forms of mechanisation and the synergetic effect of improving on plural inputs simultaneously can explain this bend in the curve. Together these changes resulted in a 'green revolution'.
The results of this revolution were overwhelming: productivity growth boomed from less than 5 kg ha^{-1} $year^{-1}$ to around 50 and 80 kg ha^{-1} $year^{-1}$ in respectively the United States and the United Kingdom. In the Netherlands the situation is not very different, although modern agriculture seems to have started earlier.

Although the starting position did not differ much from the United Kingdom around 1880, in the Netherlands productivity rose with more than 20 kg ha^{-1} $year^{-1}$ between 1880 and 1940. After that productivity growth went up to over 100 kg ha^{-1} $year^{-1}$ (Figure 1.2).

Figure 1.2 The trends in the average yield of wheat in the United States, the United Kingdom and the Netherlands over the last 100 years



Source: Based on De Wit et al. (1987), Knibbe (1993) and LEI-DLO (1999)

It is only a matter of logic to see that this continuing rise in productivity cannot go on endlessly. As with most developments in nature a levelling off might be expected. The real question then is at what levels this will occur. Policymaking could benefit enormously if an independent estimate about the levels at which the productivity rise would saturate was available. If there is still a very long way to go before the boundaries of productivity growth are reached, the current policies of the CAP will be exposed to ever expanding pressures. Surpluses will continue to rise and with that all payments related to these surpluses. If, on the other hand, the level of saturation is almost reached, then productivity will become a major constraint to achieve new policy goals.

Hence, the most important question is whether this rise in productivity will be levelling off, and if so, whether this level differs much from the levels that are found today? All other problems are related to this primary question.
Ultimately, if the limits to the productivity growth can be identified, the future limits to the land-based agricultural production system will also be identified.
If these limits are known, other questions that are strongly related to the reform of the CAP may find an answer. Does the system allow for a continuation in agricultural employment? Does the system allow for a certain level of protection of the environment? Does the system allow for a sustained generation in agricultural income? These questions illustrate that a decision on political objectives demands at least some information on options for future developments.
An exploration of possible future caveats and potentials for the different goals related to agriculture might give the information needed to clarify the

discussion on preferable policies. Just generating this information cannot solve all problems that underlie the debate. However, at least all parties can then be informed of the different interests at stake, public and private, and the consequences of alternate policies can be illuminated. Moreover, showing the consequences of the individual policy goals may provide a framework within which a discussion on the desired optimal policy mix can be started. Thus, exploring the possibility of setting limits to the productivity growth in agriculture could be the first step in a way out of the policy dilemma.

1.4 THE STRUCTURE OF THE STUDY

1.4.1 RESEARCH QUESTIONS

This study analyses the conditions that must be met and the methodology that can be used to explore possibilities for future land-use in the EU. All decisions regarding the future of agricultural land-use should consider the potentials and constraints of the agricultural system itself. Therefore, the first set of questions to be answered focus on the potential developments of the agricultural system:

- *Is it possible to define upper limits to the potential productivity rise in land-based agriculture?*

This question deliberately does not include a reference to the time dimension. The exploration should be aimed at identifying the ultimate limits of the production system. From an analytical point of view, the question whether these boundaries will be encountered on short notice is secondary. Rather, a scientific exploration must focus on the limits of the system that are relevant to any future development.

From a political point of view, the time frame is of utmost importance. If the calculated boundaries are still far ahead, some first conclusions with as to the magnitude of the potential overproduction within the EU can be drawn. This information points into the direction of a political limitation to the acreage to be used for agricultural purposes. If, on the other hand, the calculated boundaries are near the saturation point, the political relevance of the observation is evident. Policies that implicitly reckon with an ongoing rise in productivity will fail. Moreover, if there is a regional difference in potentials, the sheer distribution is a political issue in itself. This implies that the boundaries of productivity rise should be assessed at a regional level. The current differences in productivity between countries and between regions are evident. Most probably, the potentials of different regions will also show considerable differences. Regions where the scope for a further rise in productivity is limited will have fewer options for future developments than regions that still have a long way to go.

Once the regional potentials are known, the next set of questions can be focused on the options for attaining various policy goals that are at stake.

- *If limitations to agricultural production can be assessed, what are the consequences of different policy goals for future developments in land-based agriculture?*

Given the potentials for agricultural production in the different regions of the EU, the possibilities for attaining policy goals related to land-use can be assessed. These possibilities illustrate the consequences of choices policymakers now make for specific policy goals. If the exploration indicates that the consequences are not very favourable, some numbers can even be put to the 'price' of the specific policy choice. This type of policy-oriented future research informs the policymakers of the trade-offs that are present in the policy arena on land-use issues. Especially this type of information is lacking in the current debate. Most discussions on policy reforms either are non-committal or shift away from the aims to the means by focusing on policy measures.

1.4.2 METHODS

In this study, methodologies from the realm of future research will be tested for their applicability to these types of questions. It is argued that the methodologies used in future research are dependent on the role that is ascribed to policy-oriented future studies. If a future study is meant to support the process of policymaking, it must be clear what type of information the study generates. The use a policymaker can make of this information must be unambiguous from the outset. This implies that attention must be given to the different views on the responsibilities and possibilities of future research and to the different views on the responsibilities of policy making.

It is not clear from the outset that existing methods for future research can deliver these qualities. Most future studies comprise some type of extrapolation of current trends or practices, even if this is not very obvious. An analysis of a number of policy oriented future studies revealed that most of these studies give more information about the time they were set up than about the future they try to describe (Scientific Council for Government Policy 1988).
Most future researchers are fully aware of the limitations of future studies based on extrapolations of observed trends. As a rule, they try to improve on the results by increasing the level of 'reality' of the model. However, this adaptation ties the description of the future even stronger to the appraisal of the present. No other methodological revisions have been developed to overcome this drawback. This implies that methodologies only relevant to a (small) part of possible future developments are used as proxies for all future developments. For the present study such an approach will not be sufficient. Using current performances so as to assess future possibilities will obscure a host of potential developments that may be crucial to the political debate. Therefore a careful examination of methodologies will be necessary to address the question that is raised in this study.

1.4.3 STRUCTURE

This study builds on the experiences that were collected in preparing the report 'Ground for choices. Four perspectives for the rural areas in the European Community' by the Netherlands Scientific Council for Government Policy (Dutch abbreviation WRR) to the Dutch Government (Scientific Council for Government Policy 1992) and related publications (Van Ittersum et al. 1998; Van Latesteijn 1991; Van Latesteijn 1993; Van Latesteijn 1994; Van Latesteijn 1995a; Van Latesteijn 1995b; Van Latesteijn 1998; Van Latesteijn and Rabbinge 1994; Van Latesteijn et al. 1990; Rabbinge et al. 1994a; Rabbinge and Van Latesteijn 1992; Rabbinge et al. 1996; Rabbinge et al. 1994b). Much attention will be paid to the selection of methods, the application of these methods at different levels of scale and the interaction between the consecutive steps in the analysis. Against this methodological background, the results of the analysis will be discussed and some attention will be given to the way in which different groups in society received the results of the original report.

The study is set up as follows. In Chapter 2 the focus will be on methodological issues. What type of method is needed for the research question at hand? Is there a method available in the field of future research and if so, what are the peculiarities of precisely this method? In Chapter 3 the general methodology of explorative future research is specified for application to the question of future possibilities of European agriculture. What is the knowledge base that can be used to set up a model and what are the specifications of the model that is needed? Chapter 4 specifies the construction of the model in more detail. All the information that is necessary to construct a model that can be used to confront technical possibilities with political wishes is presented. For a large part the specification of the model can be seen as a result of the research effort. The results obtained with the model are described in Chapter 5. These results comprise scenarios of possible future land-use in the EU based on the technical boundaries that are specified by the agricultural activity and the wishes that are formulated at present in the political debate. Finally in Chapter 6 the research, its results and application will be discussed.

2 IN SEARCH OF APT METHODOLOGIES

2.1 INTRODUCTION

The exploration of options for future land-use in the EU requires a methodology that addresses the scientific assessment of the potential increase in productivity and the assessment of the effects of the multiple goals attributed to land-use. The method of future research then should both make use of scientific information and provide information that is useful in the process of policy planning. In this chapter the role of future research in policymaking will be examined and different methods of policy-oriented future research will be scrutinised for their applicability.

First, the peculiarities of policymakers and future researchers will be described to set the scene. Next, a description of policy-oriented future research will be given to identify the role of research in policy planning. Different methods will be described that have been used in policy-oriented surveys of the future.

The survey of possible methods leads to the conclusion that an explorative approach will be the most appropriate choice. In such an exploration, the scientifically assessed properties of the system and the value-driven desires regarding the performance of the system can be confronted with each other. At the end of this chapter the basic lay-out and demands of the method will be given and the data requirements will be sketched.

2.2 FUTURE RESEARCH IN A POLICY ENVIRONMENT

2.2.1 ABOUT SCIENTIFIC 'FACTS' AND POLITICAL 'BELIEFS'

Future research deals with realities that do not yet exist. All results of future research, no matter the shape in which they are presented, are always constructions of the mind, never representations of an observable reality. This conflicts with the traditional opinion that science is to produce irrefutable facts (Rip 1992). In this respect, future research holds a weaker position than empirical science, although even there difficulties arise in producing the wanted 'hard facts'. These facts will always be completely out of reach for future research. At best, future research can provide information on possible future realities, but not on reality itself.

Policymaking, on the other hand, is part of everyday reality and it has a hard time in coping with that. The dynamics in society lead to an increasing burden on policymaking because every change in the societal context will ask for a policy reaction. This results in a situation where policymakers rush from one fire to the next trying to extinguish it. Short-term issues therefore absorb policymakers, dealing with competing interests from amongst others the public, the political arena and the media. In such a situation, there is not much room to contemplate the long-term issues and alternative strategies that future research has to offer. The primary attention of a policymaker will be focused on obtaining information that enables him to stick to his own theories, carefully constructed to find a balance between the conflicting interests of all participants (Van Latesteijn and Schoonenboom 1998).

Whenever there is room, policymaking also deals with constructing a desired image of the future and translating these views into political statements. Usually these manoeuvres can be observed during election campaigns and at the beginning of a new term of office of the administration. In those instances, political parties or governments express their ambitions regarding the way in which they wish to shape our future society. Normally they will not be interested in all the uncertainties that surround any account of future developments, but are primarily concerned with delivering a clear political statement. This statement tries to demonstrate that future developments result from activities we should undertake now. In that way, the policymaker can contribute actively to the realisation of the image presented in a policy plan.

However, in the process of setting up policies political authorities always did and probably also always will use the services of future researchers to shed some light on the future. Apparently policymakers are not entirely confident in the plans that they set up themselves. They are in need of a scientific expert opinion to legitimise their ambitions. This leads to a contradictory situation.
Future research has become an integral part of public policymaking, although policymaking primarily deals with the here and now and future research is engaged in setting up constructions about the then and there. This implies that institutionalised future research is carried out by government agencies and other institutions using advanced statistical methods to painfully come to grips with describing future events. However, governments use these predictions to their own benefit. If a prediction is in line with the envisaged policies, it will be used to persuade opponents. If, on the other hand, the research shows that future developments are not very favourable to the formulated policies, the results of the study are likely to be ignored. This interdependency may easily mix the roles and responsibilities of policymakers and future researchers. It becomes hard to discern between the scientific activity of future research and the subjective activity of policymaking. The ideal situation, where future research delivers scientific 'facts' and policy deals with beliefs, is easily corrupted. The coalition between policymaking and future research diffuses the distinction between facts and beliefs. Underneath this coalition, a clear danger is present.

In democratic societies much attention is given to the process of policy planning. Much of the debate among interest groups and stakeholders is aimed at the respective priorities that governments should use in the planning process. Especially if the policy debate involves considerable stakes and the uncertainties are evident, a mixture of scientific 'facts' and political ideologies can be misused to influence the outcome of the debate.

Therefore, the role of future research and its relation to political opinion forming is very important. If the relation is not clear, then decisions might be taken on wrong 'facts' and assumptions. Eventually, recognition of these mishaps can lead to serious questions about the legitimacy of the policy.

The societal problem that forms the background of this study indicates that all potential pitfalls of mixing facts and beliefs are present. The research questions that were stated in Chapter 1 involve both technical/scientific aspects (the scope for growth in agricultural productivity) and more value-driven/political aspects (policy goals and their consequences). The first research question is aimed at assessing scientific facts: is there a scientific way of determining the upper limits of productivity growth in land-based agriculture? Various scientific methodologies are crafted for questions like these. The second research question deals with assessing the impacts of goals: can the pursuit of policy goals be described in terms of consequences for land-based agriculture? This type of question touches upon the implicit beliefs that underlie policy goals. By itself the research question is clear, since the goals are taken as given. However, the exact specification and selection of goals is not a scientific activity. Also the assessment of the consequences of these goals requires a non-neutral selection of a mix of policy goals that should be attained simultaneously. Hence, with the introduction of subjective policy goals the world of facts is crossed with the world of beliefs.
The design of the research should therefore be carefully crafted to fully acknowledge the differences between the two domains. A closer look on policymaking and future research may help to clarify the elements of an apt methodology.

2.2.2 A POLICYMAKERS' PERSPECTIVE

Policymakers, not only from government but also from interest groups, constitute the target group for policy-oriented future studies. This seems a trivial remark, but to formulate the right research questions and set up an adequate research design it is essential to clearly identify the target group. When the relationship between policy-oriented future research and its presupposed target group is contemplated, a number of questions arise. How do policymakers use information resulting from future research? Are they willing to review their opinions on the basis of the results of such an enterprise? Under what conditions are they open to apply these results? For the design of the future research the answers to these questions are very important. If the assumptions and methodologies do not correspond with the culture that is dominant among policymakers, it is very likely that the impact of the research will be next to zero.

What then is the dominant culture of policymakers? A large body of literature is devoted to this question. For this study, two observations seem relevant.
The first is the notion that policymakers, like almost any group in society, are driven primarily by risk avoidance. The second is the existence of distinct views in the relationship between policymakers and the scientific community: technocratic, pragmatic or decisionistic.

Risk-avoiding strategies

There is a general tendency in society towards risk-avoiding behaviour. If individuals reveal risk-avoiding strategies, it is generally acknowledged as cautiousness or wise behaviour. Risk seeking is for daredevils or mavericks, not for the common man. One way of consolidating risk-avoiding strategies is to form institutions. In this way people create their own 'risk-less' environment. Instead of the unknown and the hazardous, an institution creates rule, order and standard procedures. In turn, institutions will even have a stronger urge to adopt a risk-avoiding conduct. Governments, as prototype institutions, will most certainly avoid risks, because they have to reflect the common interest of their constituencies. They have been set up to eliminate unexpected and risk-bearing situations and therefore will not show any behaviour that may lead to unease and disruption.

Downs (1967) describes the mechanism that may explain the risk-avoiding behaviour of bureaucrats that populate governmental institutions. According to his analysis bureaucrats are at least partly trying to satisfy their self-interest. Therefore a bureaucrat tries to maximise his utility by performing at such a level that his own achievements are satisfactory. This 'satisficing' behaviour is responsible for the relatively low attention for new and potential disturbing facts. If new information is acquired, the level of satisfaction may drop, so it is in the self-interest of the bureaucrat to operate at the level of his present level of knowledge. In the event that new information (facts or ambitions) leads to an unsatisfactory performance of the bureaucrat, he is willing to invest in new activities, but these activities will only differ slightly from the actions that are part of his repertoire.

At the level of the institution this behaviour becomes visible in the careful 'trial-and-error' approach of administrations. Whenever policies give rise to criticism from the public, the almost natural administrative reaction is to expand the rules. Sometimes rules are added to include certain groups or situations within the scope of the policy, in other instances extra rules are set up to identify exceptions to the rules. Only in very few cases the rules themselves are withdrawn or replaced by completely new ones. Preserving existing rules forms the basic motivation of satisficing behaviour of bureaucrats. With that they form the cement of the institution. Abolishment or replacement of any rule would almost inevitably lead to new problems. For that matter, satisficing behaviour can be regarded as a survival strategy: if the institution is to survive, it has to adapt almost fluently to changing opinions and new circumstances.

Another trait of institutions is the anticipating behaviour with which an institution tries to get clues on the necessity of institutional adaptation so as to avoid sudden changes. At first glance this may seem in conflict with the trial-and error approach, but a closer look reveals that again the basic motivation can be traced back to satisficing behaviour. Anticipating behaviour makes that institutions are interested in future results of present actions.

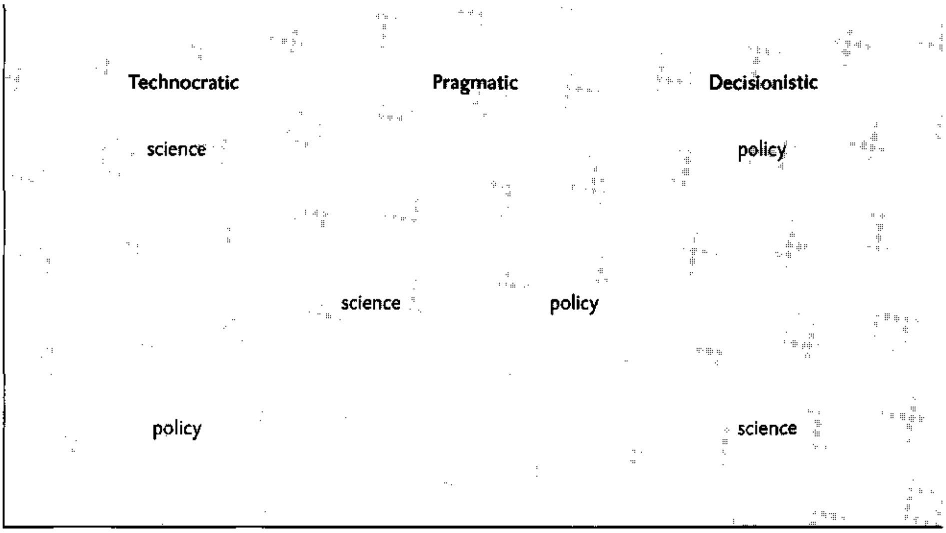
The ultimate aim of this activity is to develop the most 'balanced' decision. To this end, all sorts of methods are used to obtain information about the future. The need for future studies observed by governments can be explained from this type of behaviour. For governments anticipating behaviour would encompass an assessment of long-range developments to avoid political problems in the (near) future and to restrict adaptation to the least adventurous steps. Hence, short-range and long-range future research can be regarded complementary for policymaking if the assumption holds that both sources of information are instrumental to the same mechanism of satisficing behaviour.

The net results of these two characteristics can be denoted as incrementalism. The dominant behaviour of governments will be the 'little steps' approach. The policies will be incrementally adjusted, whenever the effects of policies give rise to amendments. Consequently, a relatively slow evolving set of rules, regulations and even institutions will result.

Technocrats versus decisionists

Identification of the target group alone is not sufficient to produce a useful future research. The question has to be clearly defined and it has to enable the right format of the research. Many problems and disputes find their common denominator in the violation of this prerequisite. The specification of the question, however, is linked to the way in which people look upon the role of policy and the role of science in the process. A longstanding debate within planning theory concerns the role of scientific information in the process of policy planning. According to Habermas (1968), two extremes and a middle position can be discerned in a typology of the relation between policy and science. They are presented in Figure 2.1. In the decisionistic view, policymakers use scientific research as a means to attain their pre-defined policy goals. Thus, politics have the prerogative to define and decide upon the goals for society as a whole. The outcome of the political debate defines the policy goals, but even more, the discussion about the goals is restricted to the political domain. Scientific research or scientific models are purely instrumental to these goals. In a decisionistic planning perspective policymakers would pose questions to researchers aimed at obtaining adequate technologies: "We know exactly what we want to achieve, just tell us how we can do it".

Figure 2.1 Three different views on the relation between science and policy according to Habermas



Source: Habermas (1968)

In the technocratic view the results of scientific research prescribe the policy goals. Scientific research, through the use of models, shows what is feasible and these feasibilities determine the policy goals. Once scientists have understood the way in which things work, the policy goals can be easily deducted from that knowledge. A political debate is no longer necessary. At best policies are used to 'sell' the goals to the public and are thus instrumental to the scientific dominance.

Next to the two extremes a third model is conceivable, according to which there is a continuous interaction between science and policymaking. This intermediate model is referred to as the pragmatic planning perspective: science can never be neutral to values, nor can policymakers be considered as entirely immune to scientific information concerning their goals or values. In this model it is also possible to use explorations to the full. If the options for choice are described extensively, then it is possible to concentrate the political debate on the real political (thus subjective) issues. In this pragmatic middle position, there is no clear supremacy of science or politics. Political goals are tested against the available means described by science, but at the same time information on these means can be used to adapt policy goals. In practice this pragmatic position will lead to a periodic shift in priorities. At one moment the political supremacy will be evident and characteristics of the decisionistic view will be apparent in the relation between science and policy. The next moment science may take over the lead and dictate the possibilities to the political arena. This implies that the pragmatic position requires a mix of technocratic, or better: technical and decisionistic approaches.

Hence, according to these three views, policymakers will judge the role of science very differently. In the decisionistic view, science is purely instrumental to the a priori goals of the policymaker. Scientific methods are used to solve puzzles, so that efficient and effective policies may be executed to attain the political objectives. In the technocratic view, the results of scientific analyses prevail. In this view, policymakers have a strong belief in the explanatory power of scientific research. Once the analyses show the logical relationships, the direction of the policies to be pursued is evident. In the pragmatic view, the role models of policymakers and scientists are not clearly separated. Policymaking as well as scientific research relies on an interaction between scientific findings and political beliefs. None of the parties can claim full sovereignty.

The conclusion of these observations must be that policymakers are not the easiest audience for a future researcher. Because of their risk-avoiding strategy, they are inclined to adhere to their earlier policies. New ideas or revolutionary information from future research will not automatically find a willing ear among such an audience. This is very much related to the quality of the information that future research provides. Uncertain predictions or speculative stories will usually not be sufficient to overcome the risk-avoiding nature of the average policymaker. Generally, a policy-oriented future study that renders uncertain or speculative results will lead to benign neglect: of course there will be a polite response but in effect the results will be ignored. The only way in which future research can break through the risk-avoiding defence is to bring about convincing 'facts' regarding the future. In some cases, a persuasive story may suffice, but it is more likely that unchallenged facts on future developments are required to influence the behaviour of policymakers. If decisionistic planning prevails, policymakers will have a purely instrumental view on future research. In their view, results of future research have to be in line with the propositions made in the political arena. If not, they will be neglected. In a technocratic relation between science and policy policymakers, on the other hand, will want to use the results of future research as a guide for their ambitions. In their view, results of future research must point into the right directions for consecutive policy actions.
This puts a very severe claim on the robustness of the research findings.
The question is whether future researchers can live up to those demanding expectations. In this study I will try to fulfil the requirements of the pragmatic model which respects the autonomy of science and policymaking, but at the same time tries to optimise the relations between both realms.

2.2.3 A FUTURE RESEARCHERS' PERSPECTIVE

Future research entails the study of trends, both technical and social, with the aim of seeking understanding of the future and gaining the ability to deal with the future. Usually, future research consists of a mixture of demographic studies, technology assessment and forecasting, policy assessment and projection, trends and needs analysis and many more related activities. Performing these techniques will not be sufficient, however. Next to the regression lines that these techniques will bring, a more imaginative element has to be added as well. A future researcher must also use his minds' eye to arrive at the desired constructions of the future. The difficulty lies in suggesting where the regression line starts to curve, changes direction, or perhaps even ends. This requires an uncomfortable logical leap. Therefore, equally critical to this area of study are softer skills such as formulating intentions towards the future, synthesising new 'facts' from gathered data, abstracting from the observed trends, and conceptualising potential new pathways.

However, even with these additions, future research in essence forms a scientific discipline that needs unifying concepts in order to survive. This implies that future researchers seek for common guidelines to restrict the creative elements. It all has to be scientifically correct and must obey the peer review community. This is not without risk, because the strict rules of the scientific paradigm do not really correspond with the creative freedom that is needed. In this case, the rules may easily lead to a scientific elite group, to expert futurologists, that claim dominance. In 'normal science', as Kuhn (1962) noted, paradigms are devised by craftsmen that carry over a tradition of methods and procedures. The creative element in future research makes it partly an art and partly a science, resulting in a tense relationship with the Kuhnian notion of normal science. This contradictory character of future research was first noticed in the late seventies. It became clear that the optimistic views on the future that had been produced so far were all based on the positive economic and social growth conditions of the fifties and sixties. With the changing of the tide in the seventies, the questions for future research also changed. People were no longer interested in know-how questions (how can we keep up growth) but wanted answer on know-why questions (why are we encountering such problems). It dawned upon future researchers that they had "painted the future in single colours, those handed down to us by the dominant paradigm preservers" (Linstone 1977).

This observation bears a strong resemblance to the classification of scientific research as proposed by Funtowicz and Ravetz (1991) and their accompanying plea for the development of methods for what they call 'post-normal science'. They reason that from the outset of scientific research the problems that were addressed could be characterised as having a low level of uncertainty and furthermore, relatively low interests were at stake when solving these problems. The quality of scientific research was safeguarded by a system of peer review, which is sufficient under those conditions.

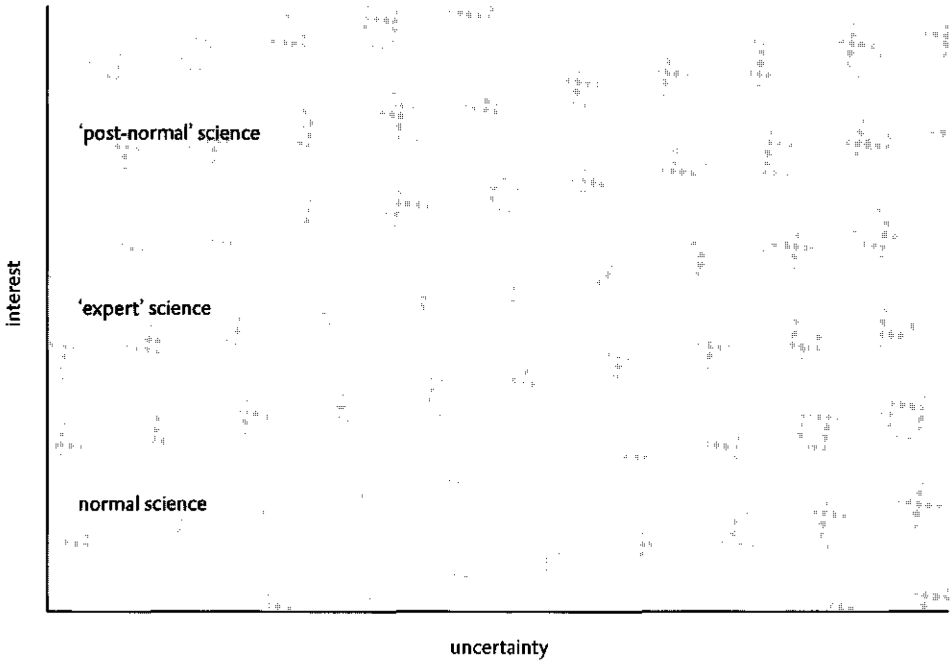
However, if the problems become more complex and more stakeholders do get an interest in the outcome of the research, the system of 'puzzle-solving' science in a peer review community is no longer satisfying. We then enter the domain of expert opinions. Most policy-related scientific problems could be categorised in this group. Experts are defined as scientists that have proven their abilities in the domain of normal science. From this achievement they are trusted to decide upon matters that are sometimes way beyond their original field of reference.

A good example is the development of standards for environmental policies. In almost all cases groups of experts decide upon the crucial safety factors that are incorporated in the standards. Therefore, the experts set the standards for society as a whole. The same holds for future researchers. Their status as experts in the field gives them the opportunity to come forward with results and ideas that cannot be judged by peers, because their methods do not comply with the standard scientific paradigms.

For a number of policy problems, even this expert approach can no longer keep up its legitimacy. If the uncertainties and interests involved become larger, there is a good chance that stakeholders do not accept the judgements of experts if the outcome is unfavourable to them. Experts are being 'exposed' by underlining that in questionable situations the opinion of a layman is of equal importance as the opinion of the expert. This mechanism can be seen in all evolved democracies. Not only do stakeholders refute the opinion of experts, they also employ their own experts to perform scientific assessments and draw conclusions that may be totally contrary to the conclusions of the 'other' experts. If this action-reaction process continues, the result might be that all research results are questioned and the context for an informed decision disappears. Decisions on large-scale infrastructure investments such as airports and railways are good examples. In the Netherlands the debate on the expansion and relocation of Schiphol Airport is a point in case. All scientific information that is produced is weighed and filtered by the various stakeholders leading to a reconfirmation of earlier positions. Hardly ever does a new scientific finding lead to convergence.

In a situation of high (scientific) uncertainty and huge (societal) interests the normal quality control of scientific research is no longer sufficient. Hence, the normal practice of peer review is hardly applicable if the general public (or the relevant stakeholders) do not accept the authority of the scientific peers. This implies that in such a situation the traditional or normal way of doing scientific research can be disputed. This phenomenon is called 'post-normal science' by Funtowicz and Ravetz (1991), who represent their ideas with a simple graph given in Figure 2.2. In the graph it is shown that the normal science is restricted to problems with a moderate level of uncertainty and a moderate level of societal interests involved. The quality of this 'puzzle-solving' is guarded by a system of peer review. With most policy problems, however, the scientific uncertainties increase, leading to debates about the 'right' theory. This is combined with a real societal interest that is connected to the outcome of the debate. In normal science it will be relevant to the scientists involved which theory wins, but with policy problems the outcome of the debate will always lead to a redistribution of profits and burdens. As long as 'experts' can function as acknowledged middlemen, the situation is manageable. However, if the stakes get higher and the uncertainties also, experts are no longer taken for granted. Stakeholders themselves will dominate the debate and there is no way of setting up a system of quality control for research in these situations.

Figure 2.2 Classification of scientific research based on the level of uncertainty and the level of interest that is affected by the research results



Source: Funtowicz and Ravetz (1991)

From this classification, it can be concluded that uncertainties in research and the accompanying risks for stakeholders are of crucial importance. Uncertainties and risks influence the way in which research is executed as well as the use that will be made of the results.

Future research has to deal with these peculiarities. Unlike normal science, future research is not a matter of mobilising and organising our knowledge to the best advantage. It is a matter of coming to grips with the unknown (Holling 1977). Although this observation is not a new one, it has not been resolved even partly. A substantial part of all future studies still follow the familiar paradigmatic roads of scientific analysis and keep painting the future in single colours. In policy-oriented future research this tendency is increased by the bias of policymakers towards results that legitimise current policy. If a future research is set up to act as an early warning system or as a sensitising mechanism to stimulate the political debate on objectives, the inclination towards oversimplification as means to deal with uncertainty must not be overlooked.

2.2.4 THE NEED FOR INTERACTION

The problem addressed in this study deals with the relation between technical possibilities that are potentially present in the agricultural sector and different value-driven policy preferences that are put to the sector. The uncertainties related to future possibilities for land-use in the EU are ample. There is a lot of discussion going on concerning the factors that are relevant to rural and regional development. What role does the infrastructure play? Is the current level of investment in industry and in agribusiness really important? Are the natural conditions of an area the key factors for future developments? All these questions deal with observable facts. The uncertainties stem from the difficulty or even impossibility to reliably predict these facts.

Next to these empirical uncertainties, a number of uncertainties can be registered at the level of policymaking too. These uncertainties are related to the subjective nature of policy issues and therefore have a normative character.
Is economic efficiency of land-based agriculture the first priority? Or should the safeguarding of the environment be at the top of the list? Maybe both these goals should be of minor importance compared to the level and distribution of employment in the sector? It is clear that in these discussions both the uncertainties and the stakes are very high. The result of this may well be that opportunistic alliances will be formed between different groups of stakeholders that find common ground in a given policy debate. In that case the outcome of the policy debate will most likely be based on the outcome of a negotiation process without a clear role for substantive arguments.

All these observations point to the conclusion that for this study a very specific methodology must be found. This methodology should take into account the specific demands of 'post-normal' science and be in line with the pragmatic approach towards the relation between science and policy. These demands will not be easy to comply with. In practice, there seems to be a strong drive towards either technocratic policy planning and 'normal science' based future research to underpin this process, or a decisionistic selection of policy-oriented future research aimed at a direct usefulness to the process of policy planning and implementation. This suggests that research results should either be driving the policy debate or be fully instrumental to policy. This dichotomy fits in well with established ways of doing scientific research.

In a pragmatic view, research results should clarify the problems at hand, without overruling the responsibilities of the politicians. The selection of methods needed in this study should reflect this seeming ambiguity in the approach to a scientific problem. An inventory of available techniques could help to identify promising methods.

2.3 METHODS OF FUTURE RESEARCH

2.3.1 ORIGINS AND TYPOLOGY

Scientific future research finds its origins in military activities that were started during World War II. The brains of generals alone were not sufficient to develop the complex strategies needed in modern warfare. Technological developments proved to be a decisive factor and information on the progress of these developments was crucial to devise appropriate strategic decisions. Within this context scientific activities were deployed to reveal some of the secrets that the future was safeguarding.

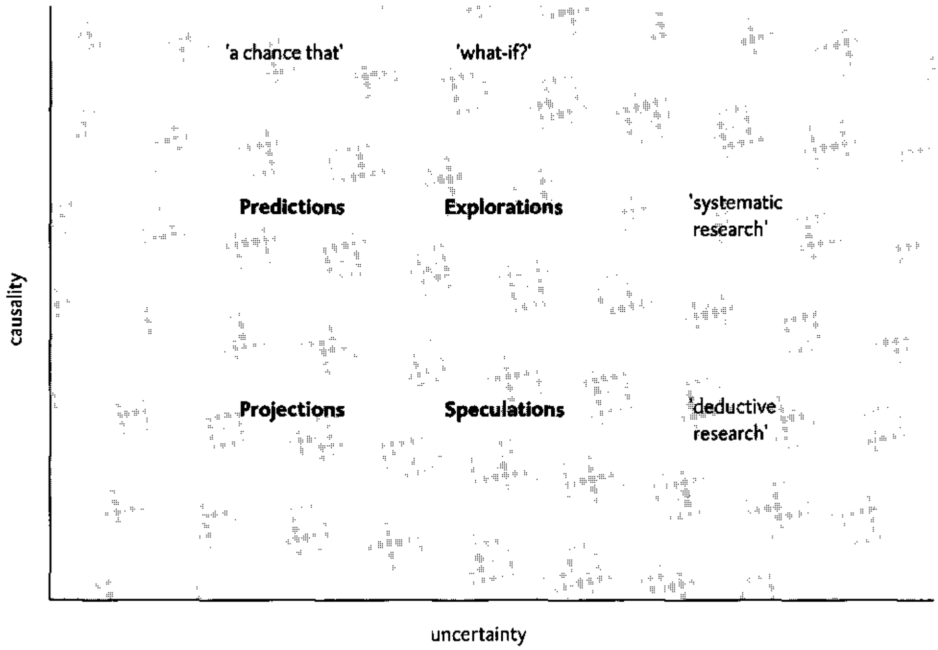
The successes of this new scientific activity were not unnoticed and outside the military others copied the approach. In the first decade after World War II, several new methodologies were applied in all sorts of studies. Institutions like the Rand-corporation and the Hudson Institute in the US acted as a catalyst in the development of new approaches like Delphi-rounds and scenario studies. These new methodologies were used to assess future needs and problems in all sectors of society. Gradually the understanding grew that not all future studies rendered the same type of information. More research effort put into improving forecasting techniques led to the recognition of many shortcomings of predictions. The reliability of predictions was discussed vigorously. If a prediction was unreliable, how could sound policy proposals be deduced from those predictions? In reaction to that, forecasters started working with 'conditional predictions' or scenarios that could give information on future developments, if certain prerequisites were met.

At present the activities within the field of future studies can be grouped into four categories based on two criteria. The first criterion is the level of uncertainty that has to be dealt with. This uncertainty can have very different origins, such as the collected historical data, the parameters built into the model or exogenous developments that are to be assessed and statistical error terms. The second criterion is the level of causality used to arrive at a forecast. Models can be built on information on causes of certain developments or on statistical regressions that have been found. If this type of information is available, then the causal underpinning of the future research is relatively strong. In other cases, only an untested theory or a verbal model is at hand. This constitutes a much weaker causal foundation for a conclusion about future developments. The four categories of future research are presented in Figure 2.3, which is based on a classification given by Becker and Dewulf (1989).

Projections and predictions are both characterised by a relatively low level of uncertainty but they differ in causality. A projection uses relatively certain estimates but has no clear causal model with which an assessment of future developments can be made. There is no information available on feedbacks or other mechanisms that will influence future developments.

For example: there is confidence that the number of people on earth will rise. This is a relatively certain estimate of things to come. But, when we only assume a straightforward continuation of current growth levels, we are merely producing a projection of population numbers for, say, the year 2010. In this case, the information that is available about certain topics in the present is used as a yardstick for the future by mere projection.

Figure 2.3 **Typology of future research. If uncertainties in data and models are apparent, only 'what-if'-type questions can be addressed. If the uncertainties are small the likeliness of future events can be assessed. Systematic future research is possible if causality of the models is prominent. If causality is lacking, only regressive or deductive methods are available leading to projections or speculations of future events.**



Source: after Becker and Dewulf (1989)

A projection may evolve into a prediction if more information is available on the possible relations. Of course, the distinction between the two categories is rather arbitrary. However, a prediction claims a certain degree of predictability based on a model of the described developments, whereas a projection merely transplants current knowledge and information into the future with nothing more to support it than a tentative theory. For example: suppose we know how the number of people in a region will influence economic development. Suppose next that we have a model on how this can influence both natality and mortality rates. Together, this information on causalities enables us to predict instead of project population numbers for the year 2010. In reality the prediction of future population will be a daunting task because this prediction will always be based on assumptions about the relevant relations. Only if we are dealing with a repeating system like a chemical reaction or an individual farm field, the causal relations within the system can be described with more confidence. A prediction of a unique system like the weather or regional economic development will always be based on partly assumed causalities.

If there is little information about the causal relationships and the level of uncertainty is relatively high, we are left with speculations about the future. For example: if we know that current natality and mortality rates will not hold for the future, but there is no information on how these matters could change over time, we can only speculate about the world population in the year 2010. There is not much persuasive power in a speculation, but for certain situations it might be the best we can obtain.

If more information is available about how different developments are related, a speculation changes into an exploration of the future. In our example: if we have information on how economic developments might influence both natality and mortality, but different theories exist alongside each other, we can set up an exploration of how the world population might develop. So this type of forecast aims to give a range of possibilities for the future. Given certain assumptions about uncertain developments an exploration may shed some light on possible developments.

In practise, the four categories cannot be distinguished very sharply. The two criteria (level of uncertainty and of causality) are prone to very subjective interpretations. Therefore the distinction between the categories is subjective as well. For the sake of clarity the four categories will be used to describe the differences in methodology. The term 'forecast' will be reserved for referring to a general future research activity.

For the questions raised in this study a methodology is needed that produces facts that are 'hard' enough to convince policymakers of the need to take them into consideration. This points into the direction of methods that are based on causality. A future study will also be more convincing if there are not too many uncertainties involved that can be contested in consecutive policy debates. This points into the directions on methods that lead to outcomes in the guise of 'what-if' statements instead of methods that produce arguable results with a predictive nature. This first quick scan will be elaborated by a more detailed description of the four types of methods. Before that a few key notions in the methodological discussion of future studies must be introduced. These key notions can then be used to scrutinise the four types of future research with respect to the use in this particular research.

2.3.2 ON PROBABILITY, PLAUSIBILITY AND FEASIBILITY

Three keywords keep coming back in the description of future research: probability, plausibility and feasibility. For the rest of this survey of methodologies for future research, a clear understanding of these three words is essential. They indicate subtle differences between different future studies that can not adequately be described by the typology given earlier.

Probability is a scientific concept. It can be used to express the fact that there are no observable certainties, but that all measurements contain a stochastic element. In future studies probabilities are used to denote the (un)certainty of a result. The probability states that a certain event or development has a given chance of occurring. This chance can be calculated from the probabilistic properties of the variables that are considered and from the probabilistic properties of the parameters in the model that is used.

Plausibility denotes a completely different concept. It has nothing to do with scientific methodologies or conventions but reflects the opinion of an individual or a group about the level of realism. Is it conceivable that a certain event or development will occur? Can we imagine the situation that emerges from the results of a future study? It will be obvious that the answers to questions like these can never stem from scientific analysis. It is a matter of personal judgement or consensus within a group whether we label something as plausible or not. Also in the political domain plausibility plays an important role next to desirability in generating policy goals. Of course this labelling can be informed by information stemming from a scientific analysis. In that sense plausibility can act as a liaison between scientific assessment and political judgement.

Feasibility has yet another meaning. It expresses whether something is attainable or practicable. This, however, has nothing to do with a subjective notion like plausibility. The decision whether something is feasible or not is based on information about constraints and confinements that can be assessed with the aid of scientific methods. So, 'plausible' is a notion that stems from subjective experience and 'feasible' is a notion that stems from observation and scientific analysis.

In combination with the earlier discussion on the dominant policymakers' requirements to future research, it will be clear that these three concepts play a crucial role. The 'hard facts' that policymakers prefer will be very difficult to distil from research since most future studies are biased in the direction of describing plausible future developments. A future study aimed at obtaining probabilistic results is much more in line with the political preference for undisputed facts. An estimation that indicates the chance that a certain event might occur is much less debatable than a study that describes several plausible pathways into the future. The same holds for studies that indicate the feasibility of a future event. A feasibility study about the future at least gives policymakers information about what cannot be attained. Although negatively stated, precisely this type of information provides 'hard facts' about what might be a realistic ambition and what will prove to be an effort in vain.

2.3.3 SCENARIOS AND POLICYMAKING

It was already stated earlier that future research is hampered by a fundamental drawback. No single future study can generate objective, undisputed facts about future developments. At best some conditional information on probable pathways of development can be provided. In some cases this can be extended with information on the causality between current decisions and these possible future developments. Especially if information on long-term problems is required, this drawback may cause a lot of controversy. On the one hand, this has to do with the role that is attributed to scientific research in policymaking. Should wishes that stem from political choices guide scientific research or should the outcome of scientific research lead policies? In the first case future studies that result in probabilities will be most applicable. They can legitimise the political preferences and point to necessary (additional) measures. In the second case future research is used as a tool for goal seeking. This asks for future research that illustrates plausible developments, that stresses the uncertainties that the future has in stall for us.

On the other hand, the nature of future studies themselves adds to the discussion. There is not a real one-on-one relationship between type of research and the anticipated results. Predictions and speculations are easiest to classify. Predictions are generally concerned with probability. A prediction must provide information about the chance of occurrence to be convincing. A speculation deals with matters of plausibility, because it is the only means of keeping the exercise within acceptable boundaries. For projections and explorations, it is much more difficult to classify the type of results that are foreseen.
Projections lack causality, so there must be a reasoning of plausibility attached to the exercise. However, projections also deal with extending current observations to the future and therefore with probabilistic properties. Explorations will rely heavily on plausible reasoning. In an exploration, the imaginative powers of the future researcher will be needed, but plausibility will be necessary to come up with convincing results. However, explorations may also aim at gathering information on feasibilities. In that case, independent information is needed to assess these feasibilities and this leads to a completely different research design.

As was shown in paragraph 2.2.2. policymakers are by nature more interested in questions of tactics: what should we do to alleviate the problem that we are faced with now? These questions are best helped with predictive future studies, because they give direct information on what might be expected in the near future. However, an increasing number of policy problems deal with strategies: what should we aim for if we want to avoid or solve the problem that we face? Information on probable developments will not be sufficient to answer this question, since a strategic policy debate does not deal with the direction of current trends but with the destination that we might be heading for. This asks for future studies that have a more 'goal-seeking' character. Information on future possibilities can help this goal-seeking process by extending the degrees of freedom for policy. This will be a difficult task for future researchers, because the demands from the policy domain are contradictory. The research must be convincing (and therefore fact-based) and indicating towards new possibilities (and therefore value-loaded) at the same time.

At first glance, scenarios serve this requirement well since they are explicitly meant to paint the future in many colours. Schwartz (1991) defines scenarios as plausible and consistent images of the future based on realistic estimations about external factors. The narrative element of scenarios is underlined by Kahn and Wiener (1967): scenarios are appealing stories about the future that serve to broaden the mind. These descriptions indicate the explorative character of scenarios, but also the restriction to the plausible, consistent and realistic. Kahn used the term 'surprise-free scenarios' to indicate the plausibility and consistency of the scenarios that he constructed. In practice, very different types of scenario studies can be encountered. There will be predictive, probabilistic elements, for example to sketch a baseline scenario. Often this will be mixed with projections too. The description of the scenarios, or more precisely the selection and detail of the external factors that will be included in the study, forms the speculative or explorative part of the study. The result will depend on the emphasis that is given to any of the elements of the scenario study (Van der Heijden 1996).

Different sets of assumptions can be used to generate a number of conditional predictions. Taken together these predictions can provide information on the scope of probable future developments. Another way is to construct explorations instead of predictions. The main difference between these two approaches is that conditional predictions underline the probability of the results, whereas explorations merely need a plausible or logical foundation. The results of an exploration are therefore different from the results of a prediction and they should be treated likewise. Still, the expression 'scenario' is used for both approaches, which at times can be very confusing.

In the next two paragraphs the methods that are used to generate predictive or explorative scenarios are looked upon in greater detail. It has already been suggested that predictive scenarios will not be sufficient to provide the information needed in this study. Predictive scenarios contain a probabilistic assessment of future developments. Precisely this characteristic hampers the reliable estimation of future productivity growth. A more systematic description of the peculiarities of these predictive methods might shed some light on the grounds for this relatively bad performance. An inspection of the properties of explorative methods might give some clues on how to go about in this study. If an explorative approach is needed, what different types of methods are available to choose from? The strengths and weaknesses of both the predictive and explorative approaches will be illustrated with a number of examples.

2.3.4 PREDICTIONS AND PROJECTIONS AIM AT PROBABILITY

Predictive policy-oriented future studies are based on the assumption that this type of study can facilitate policymaking by narrowing down the uncertainties that are inherent to policy decisions. In this view, a future study generates information about the future with a certain degree of accuracy. If all the information that is available on a certain topic is fed into some kind of extrapolating technique, the future will reveal some of its secrets to us. If the future can be predicted in this sense, some of the uncertainties of the future will be eliminated.
For policymakers this means that the chances of making a wrong decision would be narrowed down a little.

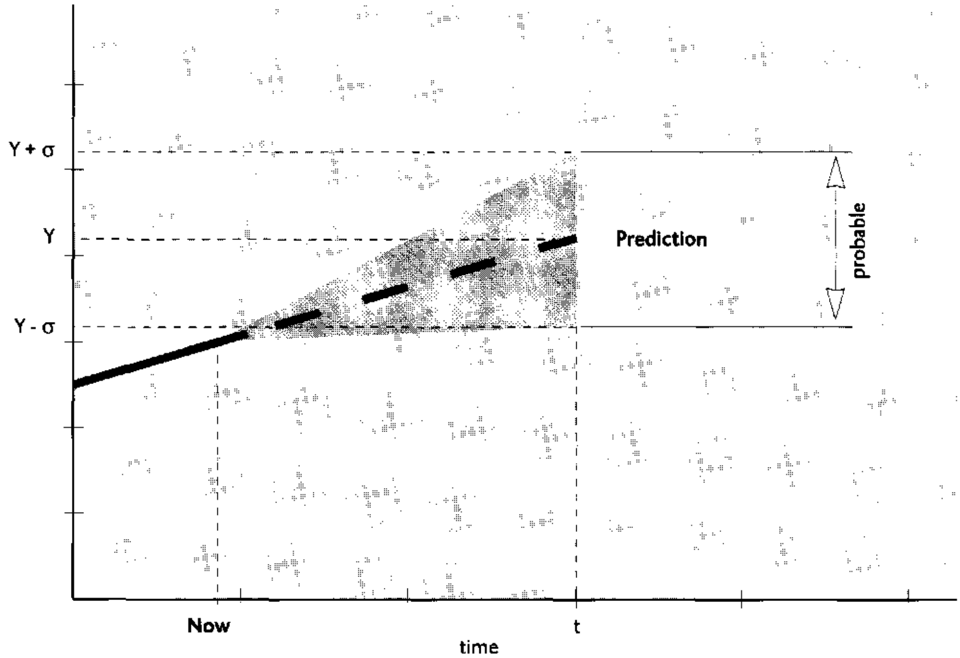
This bias towards reduction of uncertainty has played an important role in future research. The 'demand-side' wants useful results from future research and the 'supply-side' has reacted by focusing on precisely that type of future research. This inclination is clearly present in the working definition that Van der Staal (1989) uses in his survey of methodologies of future research

Scientific future research can be described as the study of facts and knowledge on relevant developments in nature, society and science, with the ultimate aim to reduce uncertainties in future oriented activities. To this end, the information is processed with pre-defined methods and expertise to generate plausible and controllable findings, sometimes subject to further restrictions with a defined probability on possible developments that may occur on a defined moment in future.

According to this description, future research will always be concerned with the probabilities of future events. Current facts and knowledge are extrapolated into the future, leading to an estimate with an accompanying interval of confidence. A generally accepted way of assessing this interval is to calculate the standard deviation s of the prediction and consider all values between plus and minus σ. Although the methodologies can differ substantially, the outcome of this procedure will take the form of the graph given in Figure 2.4.

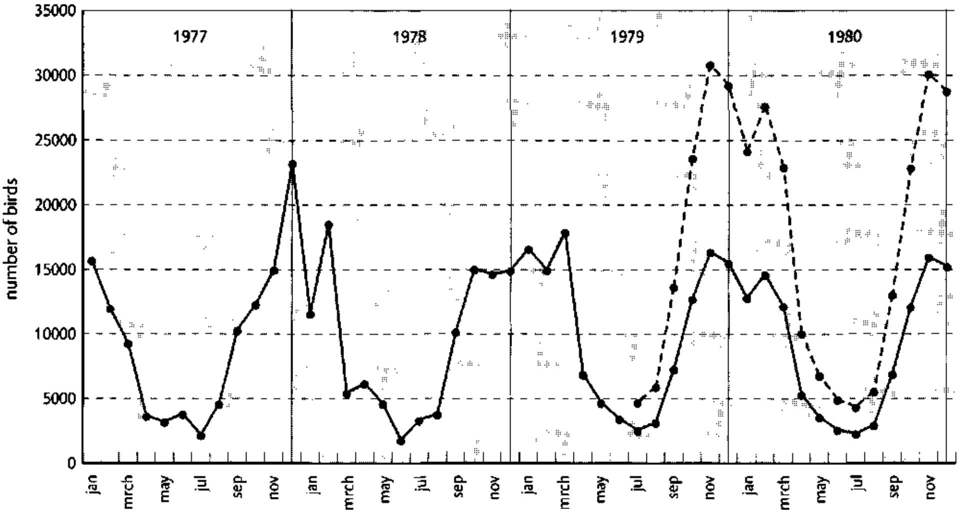
A prediction is meant to give information on the probable development of an observed phenomenon over a limited period of time in the future. By definition, predictions and projections are based on information gathered in the past and the present. In a prediction additional information on causality between the observed input and output of the system is used to calculate future values. Projections are completely based on historical time-series. There is no way to assess the relation of future developments with those in the past and present. In all developments, however, a certain inertia cannot be denied and therefore the notion of continuity is widely adhered to in this line of research. Of course, this presumption can be debated and thus it is inevitable that there is a great deal of uncertainty to this type of future research.

Figure 2.4 **Predicting the future: historic data is extrapolated which leads to a predicted value with a confidence interval. Y is the calculated value for time t. Y+σ and Y-σ denote the boundaries of the distribution of possible outcomes of the prediction due to statistical errors in the calculation of the predicted values.**



There are numerous methods to extrapolate historic data. If there is not much information on causality, mathematical methods can be used to describe the observed data and construct a projection into the future. An example of this approach is the ARIMA-modelling (auto-regressive integrated moving average) proposed by Box and Jenkins (1976). Although these models do not contain any additional empirical information, they can very accurately describe a given time series. This is illustrated for example in an analysis of time-series data of Oystercatcher (*Haematopus ostralegus*) counts (Van Latesteijn and Lambeck 1986). With the aid of ARIMA-modelling it proved possible to accurately describe the observed monthly number of foraging birds and track back the impact of the closure of a nearby estuary in the southwestern part of The Netherlands. However, this ARIMA-modelling is merely used to describe an empirical time-series. If this type of modelling is used to generate a projection, the drawbacks of the methodology become visible. The accuracy of the projection is very poor due to considerable and unavoidable statistical errors in the estimation of the parameters of the model. As an example, Figure 2.5 shows the original Oystercatcher counts together with a prediction of the series over 18 monthly periods. As can be seen in the graph the confidence interval of the predicted values very quickly exceeds practicable limits. Especially in winter months, when the number of birds is relatively high, the projection of bird numbers is of no practical use.

Figure 2.5 **Observed (Jan 1977-May 1979) and predicted (June 1979-Nov 1980) numbers of foraging Oystercatchers (Haematopus ostralegus) on refuges along the coastline of Schouwen, an island in the southwestern part of The Netherlands (solid line) together with the upper and lower limits of the prediction (dotted lines). Due to statistical errors in the model specification the predictions show a large spreading in upper and lower limits, proportional to the number of birds.**



Source: Van Latesteijn and Lambeck (1986)

Predictive methods involve the construction of a complex model of which the parameters are estimated using independent empirical data. Although an abstraction, the model is meant to reflect the real world to a certain degree. In constructing the model a balance must be found between copying the real world situation as closely as possible and limiting the number of parameters in the model. Therefore, the modeller only incorporates parts of the real world that appear to be essential for the process that he wishes to describe. There are no rules on how to discern between essential and non-essential elements, so a large variety of models can be encountered that claim to address the same topic.

Throughout the years, various principles have been adopted to diminish the number of problems and caveats in model building. These principles include procedures to specify, validate and test the model thoroughly. However, these procedures cannot avoid that most parameters in a model are estimates, which are inevitably characterised by some degree of unreliability. This unreliability can stem from lack of data or from the existence of conflicting sets of data. Estimating procedures generally are highly sensitive to the number of observations. The statistical variance in the estimation can only be lowered if large numbers of observations are available. If these large numbers cannot be produced due to a lack of data, statistically unreliable estimates will result. If different sets of data are available, different estimates may result from the estimations. In most cases there is no additional information available that allows for a selection between the different estimates. In that case the modeller is stuck with more than one specification of the model.

So a prediction generated with the aid of an explicit model will always be based on partial knowledge about the system. This implies that for the rest of the system assumptions are needed. Therefore, all models incorporate a number of exogenous variables that describe the 'environment'. Exogenous variables can account for a number of differences between the results of future studies on the same topic. Cole and Miles (1978) conclude that the differences in exogenous variables are critical to the debate and can be traced back to differences of opinion in:

1 the available resources and speed of technical change;
2 the desirable political objectives and norms for society;
3 the social and political processes whereby society evolves and changes.

In a survey of future studies, the WRR concluded that the role of these exogenous variables must not be underestimated (Scientific Council for Government Policy 1988). It can even be demonstrated that these assumptions are dominant for the results obtained. The outcome of future research has to do more with the selection of 'relevant exogenous variables' than with the specification of the model itself. These exogenous variables generally comprise a prediction by itself. For example: a study of future educational needs may use a prediction of the developments in international trade as one of its exogenous inputs.

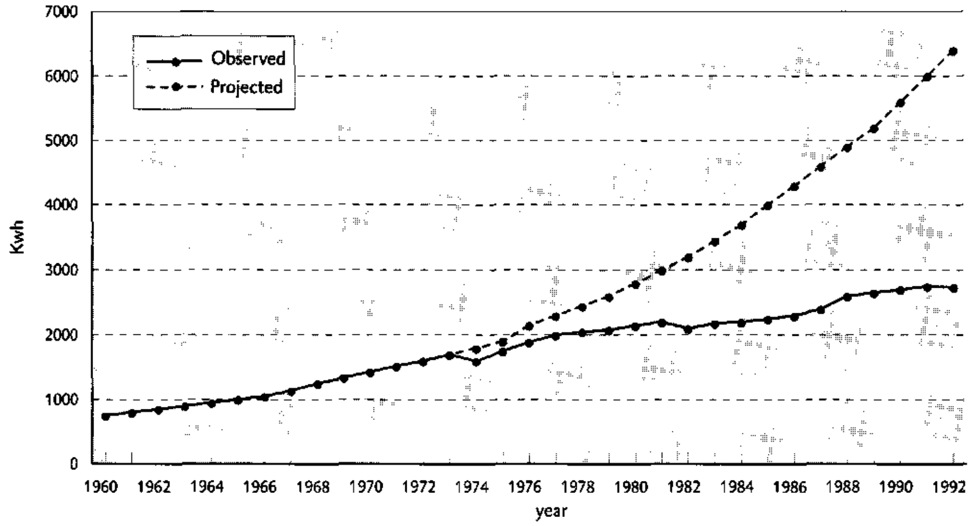
However, there are several conflicting theories, based on other types of future research, on the developments in international trade that might be expected. The selection of one of these conflicting forecasts of future international trade can have a decisive impact on the results of the study of future educational needs. In conclusion: the difference between the 'objective' information from the prediction and the 'subjective' information put into the assumptions regarding the exogenous variables is hard to assess.

The discussion on the accuracy of the estimated parameters has always troubled the users and critiques of predictive models. As an example: it is generally acknowledged that the operation of the economic process and the decisive factors in its dynamics are improperly understood. This means that caution is needed when it comes to the use of models in which the behaviour of the various economic actors is specified in some detail. In a review article several economists stated that "no economic theory tells you exactly what the equations should look like" resulting in 'fiddle and fit' operations until the model seems to be working well on data from the past (Koala 1986).

Models of the behaviour of economic actors have steadily become more refined, without, however, doing much to solve questions surrounding the instability of the relationships and the potentially varying interpretations of the observations. The difficulty of specifying expectations – a crucial factor in the explanation of not only investment and consumption behaviour but also labour market behaviour – is illustrative in this respect. Particularly when there are numerous feedback mechanisms in the specification of the reaction equations, the model can become 'policy resistant', meaning that the results obtained by the model are barely susceptible to influence by the instrument variables. The margins for policy then appear very narrow: whatever policy options are examined, the problems remain unsolved.

A nice example can be seen from the ten-year projections of electricity consumption by the US Department of Energy in 1975, analysed by Bohi and Darmstadter (1994). The projections showed an enormous overestimation of electricity consumption, as is illustrated in Figure 2.6. This overestimation was not due to an incorrect assumption on economic growth, but to the inability to assess reliable estimates for elasticities of energy demand in a situation of sharply higher prices. If a policymaker is confronted with these types of predictions, the incentive to devise new policies to counteract the observed trends will be marginal.

Figure 2.6 **Observed and projected US electricity consumption in kilowatt-hours x 10^9, 1960-1992. The difference in projected values and actual developments can be ascribed to a wrong estimation of the elasticity of electricity demand at higher prices.**

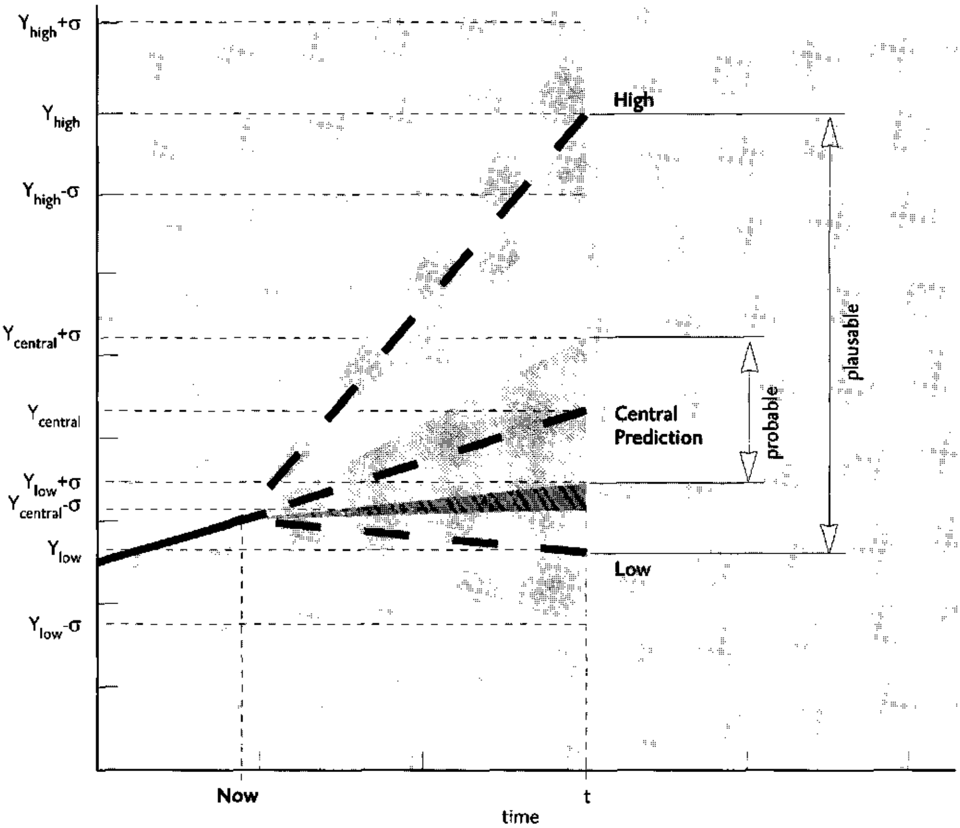


Source: Bohi and Darmstadter (1994)

One way to get round the problem of decreasing reliability of model specifications is to distinguish several alternative sets of exogenous variables. In this way the same model can generate different predictions depending on the exact specification of the model parameters and/or the exogenous variables.
This is illustrated in Figure 2.7. On the basis of different estimations of the model parameters or other estimates of exogenous variables, a high and a low prediction can be calculated next to the original or central prediction. Because the high and low predictions imply different assumptions regarding the model parameters and/or the exogenous variables, the three varying predictions are generally indicated as scenarios. Given the assumptions regarding the model that is used to obtain the prediction, a scenario therefore represents a prediction of future development with some accuracy. For each of the scenarios (Central, High and Low) an interval denotes the accuracy of the prediction. Hence, the probability of a prediction is a consequence of the statistical uncertainty in the output of the model that is used to generate the prediction. The different plausible predictions are results of varying assumptions regarding the input of the model. Each of these inputs by itself is considered equally plausible, so no ranking can be made in the plausibility of the scenarios.

If a prediction is calculated for a longer period of time (so-called mid-term or long-term forecasts) the confidence intervals of the different scenarios will tend to overlap. Of course, this overlap complicates the interpretation of the results, especially since each of the scenarios must be regarded equally plausible.
Still, most of the contemporary policy-oriented forecasts fall into this category (United Nations demographic forecasts, FAO world food scenarios, OECD economic outlooks and many others). The reason for this popularity can be found in the predictive aspirations that appeal to policymakers and the causal modelling that relates to the established paradigms of normal science.

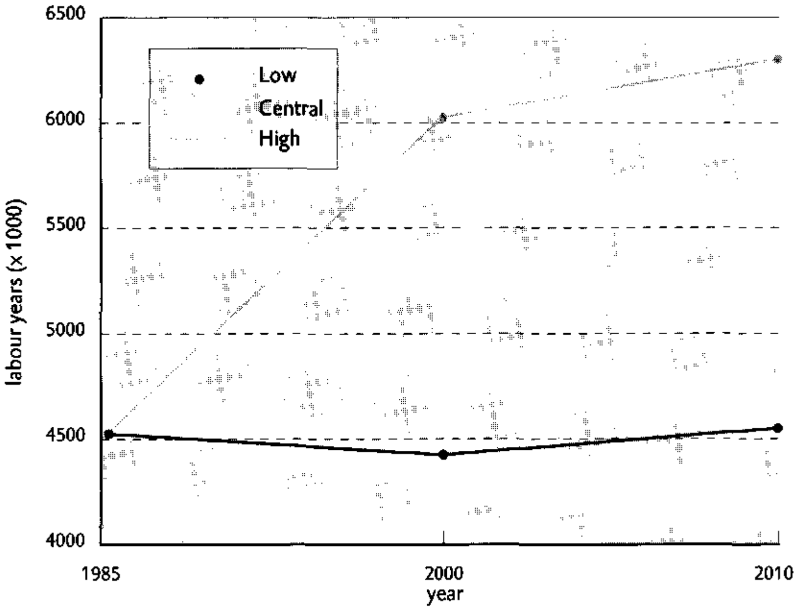
Figure 2.7 **Alternate predictions (Central, High and Low) result from different assumptions regarding the specification of the model**



Not always the consequences of this proliferation of probable and plausible outcomes of conditional predictions are accounted for. All econometric models that aim at long-term forecasts have to deal with these problems. As an example, Figure 2.8 presents the results of such a model. The graph shows the calculated development in total employment in The Netherlands. This example is taken from a study of the prospects for the Dutch economy up to the year 2010 that was produced by the Netherlands Central Planning Bureau in 1985 (CPB 1985). In the report the Bureau carefully explains that three scenarios have been assembled, because it is impossible to generate a most probable prediction over a period of twenty-five years with an econometric model. Therefore, it is stated that the three conditional predictions together should be looked upon as a survey of future threats and possibilities to the Dutch economy. The three predictions (High, Central and Low) are based on varying assumptions on global trade, prices of imported goods and the international rate of interest.

The study does not indicate error levels in the three individual predictions. Given the fact that a number of exogenous inputs partly stem from tentative guesses the statistical errors will probably be considerable.

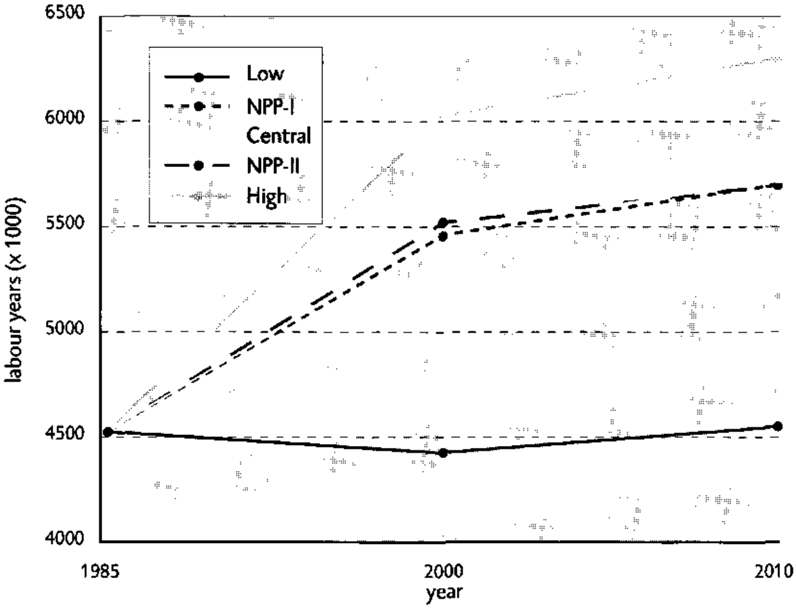
Figure 2.8 **The Central, Low and High predictions of the total volume of labour under different assumptions regarding international trade, import prices and the international rate of interest, 1985-2010**



Source: CPB (1985)

In a later report the Netherlands Central Planning Bureau used the Central prediction as a reference to assess the impact of three scenarios for environmental policy (CPB 1989). This study concludes that two of these scenarios show distinct effects on the Dutch economy when compared to the baseline scenario. This last addition is crucial. The baseline scenario in this study is the Central prediction in the earlier study. Among other things the study indicates that a scenario that aims at the maximum input of end-of-pipe measures will lead to a loss of 49,000 jobs by 2010. A scenario that includes more structural adjustments of the economy in order to attain a sustainable development will result in a loss of 20,000 jobs. However, when these deviations from the Central projection are compared to the High and Low predictions in the earlier study, the effects of the environmental policy scenarios disappear in the background noise. Although the study indicates that the results in the form of deviations from a central projection can lead to false interpretations, the figures of the earlier study are not presented by the CPB. As can be seen in Figure 2.9, the graph of the calculated effects on the total labour volume of the environmental policy scenarios together with the three projections stresses the negligible effects that environmental policy has. Still, the alleged effects of those environmental policy scenarios on the economy played an important role in the discussions following the presentation of the National Environmental Policy Plan that contained the policy proposals. In an annex to this policy plan the results of the assessment were presented as the economic consequences of the policy plan.

Figure 2.9 **The effects of two scenarios of environmental policy (NPP-I and NPP-II) compared to the baseline scenario (Central projection) and the two other projections of possible long-term developments, 1985-2010**



This example shows that a clear understanding of the concepts of probability and plausibility is very important. In the case of the environmental policy plan, the three original conditional predictions had been based on assumptions of plausibility. Thus, each of the three developments would have an equal chance of becoming reality. In the follow-up study, the effects of environmental policies on employment were stated in terms of probability. A logical combination of the two studies would have indicated that given the plausibility of the three original scenarios, the effect of the environmental policies is insignificant. Mixing the two categories without further explanation can easily lead to misunderstanding or even misuse of the results. In this case the policymakers were misinformed. It looked as if the environmental policy did inevitably lead to sacrifices in the field of employment. The combined information from the two studies would have shown that no real sacrifices were involved.

A provisional conclusion from this brief description of predictive future studies reveals a number of weaknesses with respect to the accuracy and therefore the usefulness of these methods in the present study. First of all prediction can only be based on observed historical dynamics of the system. It is virtually impossible to obtain independent information that can be used to adapt the model to a more 'realistic' description of future dynamics. At best the future researcher can use his intuition to generate assumptions about the future dynamics of the system. Applied to the question of this study we would need an estimate on the level of acceleration or deceleration of productivity growth in land-based agriculture in the future. Any assumption in this direction would be highly speculative and thus undermine the persuasiveness of the results. Secondly, all predictions and projections tend to over-emphasise the current or most recent developments and mould future developments on this rather shortsighted impression of reality. This leads to either a systematic underestimation or overestimation of future events. The CAP seems to have suffered from a constant underestimation of the potentials within the sector. This indicates that predictive future studies in agriculture give a semblance of truth that impairs the use of these studies to underpin a debate on policy reforms. It is really the question whether predicting future productivity growth is the best we can do. Therefore, the search for alternative methods will continue in the next paragraph by examining explorative types of future studies.

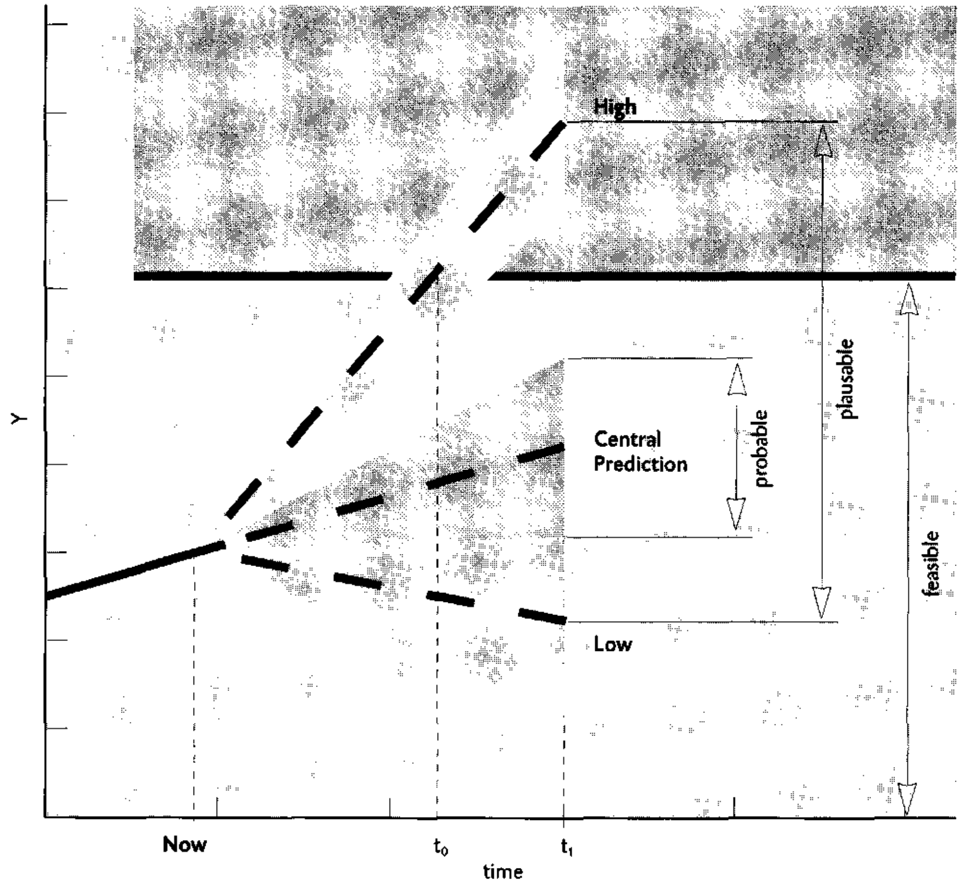
2.3.5 EXPLORATIONS AND SPECULATIONS AIM AT FEASIBILITY

When it comes to investigating developments over the longer term, the danger arises that predictive research may prematurely leave out alternative developments and policy options. Moreover, detailed behavioural models are less suitable for evaluating the consequences of policies expressly aimed at altering behavioural patterns. If one's concern is to survey long-term prospects and if breaks in the trend are not to be ruled out in advance, it is likely that explorations in the guise of conditional predictions might not render the desired information.

An exploration of future feasibilities will then render more satisfactory results. In such an exploration, the concept of continuity that underpins predictions is put aside. Once these constraints of continuity are dismissed, anything is possible. Time series need not be extrapolated and breaks in the observed trends can perfectly well take place within an exploration. However, if all is open for discussion, any outcome is thinkable, unless some foothold can be derived from the characteristics of the system under investigation. Properties of the system might point to the limits of what is feasible within the system itself. All other options are then brought within the limits that the system puts to any future development, thereby opening up the full scope of possibilities that the future has in store for us.

Of course, there is a price to be paid for obtaining this type of information. Exploring feasibilities does not allow any conclusions with respect to probability or plausibility. This type of exploration merely tries to identify the borders of future developments that are present in the system itself. The information on feasibilities obtained in such an exploration clearly differs from probabilities and plausibilities. This is illustrated in Figure 2.10.

Figure 2.10 Explorations with conditional predictions compared to explorations of feasibility: the conditional prediction results in three different scenarios with their corresponding confidence interval. The exploration of feasibility indicates the feasible scope for future developments. It can be concluded from the example that scenario High will not be feasible. After t_1 the prediction exceeds the feasibility bounds.



With explorations of this type, the focus of research is no longer on developments that might be expected, but on developments that might be feasible.
If no other information is available, only the fantasy of the future researcher and his perception of what might be possible restrict the domain of feasibility. If the system itself reveals properties that can act as an independent source of information on the extent to which the domain of feasibility reaches, the exploration becomes much more convincing, especially to policymakers. Hence, the question arises whether it is possible to generate hard scientific arguments on properties of the system. If an exploration can trade the principle of continuity for an analysis of boundaries inherent to the system, two benefits are obvious. First, abandonment of the continuity principle enables a truly 'goal seeking' exercise. Second, rational scientific analysis of boundaries meets the demands from policymakers for 'hard facts'.

The loss of predictive power in this type of exploration may seem a step backwards. However, the usefulness of a well-founded assessment relating to the borders of future possibilities might be more relevant to policymaking than a disputable assessment of the probability of a given development. The identification of boundaries on the one hand enables a debate on the possibilities that are present and on the other confines the debate to the domain of technical possibilities. Thus, the aim of an exploration of the future is partly to reduce uncertainty to a predefined domain, and partly to expand the feasibilities to their maximum. Here, it is important to search for the boundaries of future developments, not to reduce the uncertainty for those who have to decide on policy issues, but to show them the realm of possibilities that the future has in store.

Once an indication of boundaries for the future is obtained, the next step may be to evaluate the goals addressed in the 'goal seeking' exercise. New questions can now be raised. Is there ample room for development? Alternatively, do the assessed boundaries prevent certain goals from being realised? Are certain combinations of policy goals possible if the boundaries of the system are considered? When compared to the working definition of Van der Staal (1989) that was cited earlier, this constitutes an expansion of the definition of future research. Therefore, a working definition of future research that also encompasses explorations of the future might be phrased as follows:

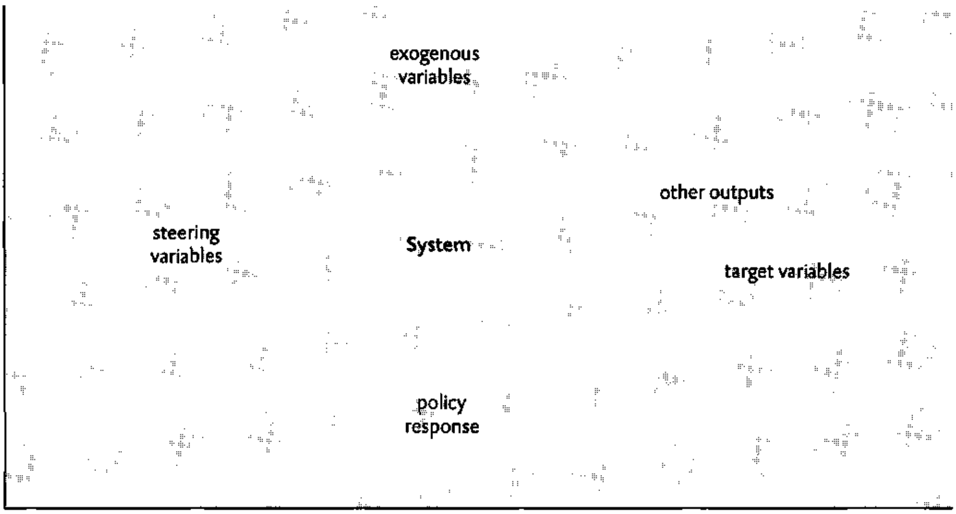
Scientific future research can be described as the study of facts and knowledge on relevant properties in nature, society and science, and the processing of this information with pre-defined methods and expertise to generate verifiable findings on possible developments of the system under investigation, with the ultimate aim of gaining a better insight in the factors that shape our future.

This definition does also encompass the questions that have been raised in this study. The aim of the study is to identify the limits of productivity growth in agriculture to get a better understanding of the possibilities to realise a number of potentially conflicting policy goals. The analysis of methods of future study has provided an overall idea of the type of future research that the research questions call for. An explorative future study might generate just the type of information that is needed to inform the debate on restructuring the CAP.
An assessment of the feasibilities of the agricultural system can be the first step in an elucidation of the attainability and compatibility of competing policy goals. What is still not very clear is the way in which the results of the research have to be targeted on policymakers to be effective. This will be dealt with in the next section by looking into a number of earlier examples of such policy-oriented studies.

2.3.6 POLICY-ORIENTED PREDICTIONS VERSUS EXPLORATIONS

For policymakers it will be of interest to have a consistent analysis of the various policy options that are available. However, most economic models calculate the response of target groups to single policy measures or single sets of measures, and most ecological models calculate the single effect of an intervention on a subset of the ecosystem. Both types of information are insufficient to policy-making. Information on responses to single inputs cannot be used to decide upon available or imaginable policy options. If a future research is to be used for policy purposes, it should contain target variables that indicate the output of the system relevant to policy. Furthermore, it should entail the relevant inputs of the system that are amenable to policy. These inputs are often referred to as the steering variables of the system. Next to these, other input variables operate on the system but these are hardly influenced by policy. Finally, the properties of the system are influenced by exogenous variables. The values of these variables determine how the system will change its reaction on a given input. In Figure 2.11 a schematic representation of the relations between steering variables, other inputs, target variables, other outputs and the exogenous variables is given.

Figure 2.11 **Schematic representation of a policy-oriented future study. Of primary importance is the identification of the target and steering variables of the system. These are the outputs and inputs of the system that are amenable to policy. Exogenous variables together with the properties of the system define the response of the system to input.**

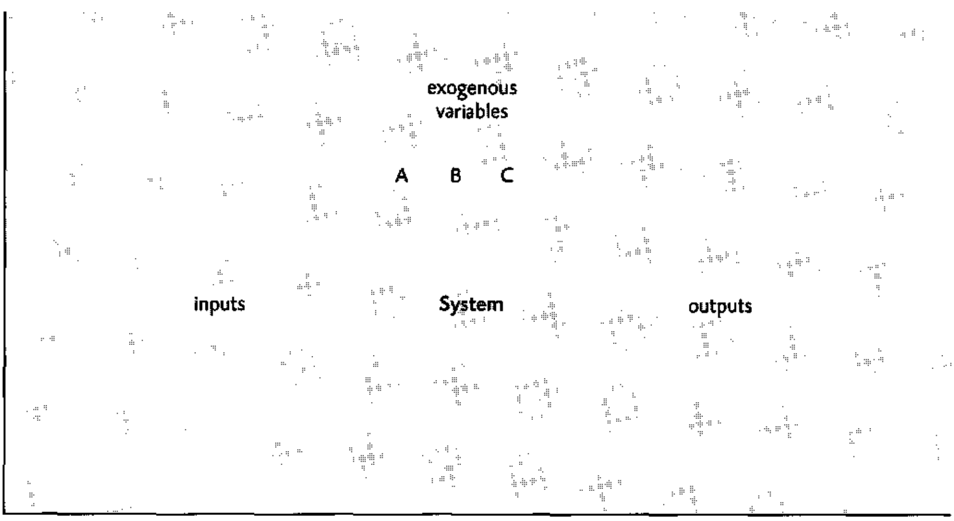


A policymaker can benefit from future research that explicitly addresses the relationship between steering variables and outputs of the system, because he is confronted with the consequences of his own actions. This type of study shows how policymakers can respond to undesired changes in target variables and how this response operates through the steering variables of the system.
However, the majority of future studies that claim to be policy-oriented lack these indispensable features. They are generally restricted to the single response case, expanded with a set of different values for the exogenous variables.

A good example of such a study was presented by the Netherlands Council for Agricultural Research (NRLO)(Kamminga et al. 1993). In this study the prospects for future developments of rural land-use in the Netherlands are examined with the explicit aim to generate policy-oriented recommendations regarding agricultural research. The model underlying this study, however, is best represented by the scheme in Figure 2.12. Policy responses to an undesired output of the system are absent. What is presented is a sensitivity analysis of a single forecast to changing exogenous variables. These exogenous variables had been deducted from a study by the Netherlands Central Planning Bureau that explores alternative future environments for the Dutch economy (CPB 1992). To that end three different economic theories have been translated into paradigms (referred to as 'European Renaissance', 'Global Shift' and 'Balanced Growth') that control future achievements of economic blocks in the world and future trade relations on the world market.

For a first exploration of the boundaries of economic development, such an approach can be sensible. If, however, those paradigms are used as input for a policy-oriented forecast of rural land-use, two basic errors will be made. These errors also appear from a comparison of Figure 2.11 with Figure 2.12. The first error is that inputs and outputs are not divided into variables that are relevant for (output) or amenable by (input) policies. The second error is the lack of description of (potential) policy responses, which makes it impossible for a policymaker to derive any action perspective from the research. He can only be sensitised to the relative importance of certain exogenous variables. However, information of this type cannot lead to a prioritisation of goals or another policy response.

Figure 2.12 Schematic representation of a policy resistant future study. The system is fed with different assumption (A, B and C) regarding the exogenous variables. The output of such a study reflects the sensitivity of the system to changes in the external conditions.



From this it can be concluded that a policy-oriented future study should first of all be very explicit in the policy goals or responses that are to be investigated. The scenarios that are drawn up should be more than a narrative on the possible differences in the exogenous variables. Especially in explorative studies, this leads to non-operational results. In most cases, these scenarios are magnifications of current positions in the debate. For example: business-as-usual, increased industrial production and ecological awareness. These types of scenarios are very often produced with respect to physical planning and they faithfully follow the guidelines laid out by Schwartz (1991). In a two-by-two diagram four scenarios are constructed along two axes that represent major uncertainties. Numerous scenario studies are constructed in this way. Just a few examples to show the systematic approach:

- The City of Rotterdam used the axes global versus local orientation and responsive versus bureaucratic administration to paint the four pictures of the city Chained, World-wide, Decoupled and Talented (Anonymus 1996).
- After the fall of the Berlin Wall all sorts of ideas emerged about the possible development of Europe. In a scenario study Hyde-Price illustrates the different possibilities for the year 2010 in four scenarios based on international relations and internal coherence: (1) NATO and an 'Atlanticist' Europe, (2) a West European Defence Community, (3) the CSCE and a Pan-European Collective Security System, (4) Europe des États (Hyde-Price 1991).
- The debate on future developments within the Dutch spatial planning formed the starting point for the scenario study 'The Netherlands 2030'. Although six major uncertainties were identified (urbanisation, mobility, ecology versus economy, social divergence, land-use policies and nature conservation), four scenarios were identified: Palet (= Palette; free settlement for individuals and companies), Parklandschap (= Parkscape; extended landscaping in-between cities), Stromenland (= Streamland; streams and rivers form the backbone of developments) and Stedenland (= Cityscape; strong division between high quality urban and rural areas) (VROM 1997).

The drawback of this type of scenario study is that the policymakers are left empty-handed. At best the scenarios describe what the range of possibilities for the exogenous developments might be and on rare occasions this may render such stirring results that there will be a policy reaction. More likely, the scenarios will be translated into appealing metaphors that can be used in the ongoing policy debate. Given the risk-avoiding nature of policy, one of the metaphors will probably be selected as the dominant 'reference' to avoid discussion and confusion about the differences between the scenarios. For example: in the Netherlands the Ministry of Housing, Physical Planning and Environment selected a slightly altered Cityscape scenario as the reference for further policy development. What the relevance of such a selection might be for strategic and tactical policymaking remains unclear.

Hence, the basis for this selection is a number of different scenarios that describe different sets of assumptions with regard to exogenous conditions mixed with ideas on policy reactions that are consistent with these exogenous conditions.

The question remains as to what these scenarios might inspire. What can I do with the information that there are multiple ways of looking at the future if I have to decide on huge investments this year? In the scenarios no distinction is made between truly exogenous developments that just might occur and policy reactions that may be adequate. The scenarios are not driven by political goals and do not encompass steering variables that might inspire to policy reactions. The scenarios depict the consequences of a maximised orientation based on a singular policy reaction such as a complete embrace of the market (the Worldwide scenario in the Rotterdam study) or unbridled urbanisation (the Palette scenario in the Netherlands 2030 study) in an arbitrarily chosen context. Because of this politically highly incredible exaggeration they can only inspire to think of the future as full of possibilities that are sometimes not very apparent. If a clear distinction had been made between external context and possible policy reactions given that context, then it would have been possible to answer 'what-if' type questions with these scenarios that might be relevant to policy. This relevancy can only be achieved when the 'if' part of the question is stated in more or less conceivable policy reactions. This emphasises the necessity of the incorporation of a feedback mechanism as displayed in Figure 2.11 into a policy-oriented future study so as to help identify some handles for policymakers. Policy does not deal with the maximisation of a single policy goal, but with the optimisation of sets of sometimes-conflicting goals. This calls for scenarios that do not maximise a single policy goal, but optimise a set of policy goals that are relevant to the ongoing debate. So policy-oriented scenarios should encompass relevant goals in the form of variables and illustrate the possibilities of combining these goals given a certain context.

2.4 CONCLUSION: A POLICY-ORIENTED EXPLORATIVE APPROACH TO THE FUTURE

The brief survey of methods for future research leads to the conclusion that for the questions raised in this study an explorative approach is the most promising way to go about. Predictions may generate information that is relevant to day-to-day policymaking. As the accuracy of predictions declines rapidly with the time horizon, long-term issues can seldom be served with information stemming from these predictive studies. Predictive future studies give rise to rather speculative conclusions about expected future developments. Especially in the case of developments within land-based agriculture it turns out that the assessments of future productivity growth can hardly be based on historical data. However, this is the only source of information available.

If an explorative approach is chosen, the attention can be diverted to the properties of the agricultural system as a source of information. A targeted description of the properties of the agricultural production system may indicate the feasibilities of this system. Combined with additional information about the external conditions of the system this may result in a description of the utmost possibilities of land-based agriculture. In theory this leads to the answer of the first research question as to what may be the upper bounds of the potential productivity rise in land-based agriculture.

However, an additional condition is required to enable an answer to the second research question. If the consequences of different policy goals for future developments in land-based agriculture are to be identified, then the exploration must not only be driven by exogenous variables but also by endogenous policy factors. In earlier studies by the Netherlands Scientific Council for Government Policy there have been attempts to incorporate these factors. In 1987 a report was published wherein the Council explored the potential impact of divergent trends on the economic development of the Netherlands (Scientific Council for Government Policy 1987). This study targeted on the identification of obstructions for further (economic) development by checking the feasibility of several policy goals under different assumptions with regard to the technical possibilities. The incorporation of different types of environmental measures and the ability to 'play' with different policy options were useful additions to the existing tools for analysis (Van Latesteijn and Veeneklaas 1987). This type of (technical) exploration combined with (political) goal-seeking also reflects the pragmatic middle position of Habermas (see Figure 2.1). It is neither the technical possibilities that shape the future, nor the political aims, but a mixture of the two. The importance of policies in the guise of variables in a scientific analysis is accentuated by this equal status of technical and political restrictions. If absent, future explorations may easily degenerate into a haphazard collection of sketches of alternative futures. The ties of predefined policy goals should bind a policy-oriented future study. Only then an instrumental link exists between the scientific exercise and the political decision process.

As was shown in section 2.3.5 an exploration is aimed at assessing the limits to future developments. In a policy-oriented exploration these limits can be confronted with policy goals that are pursued. The exploration can shed some light on the question whether certain combinations of policy goals can be attained. The outcome of such an exercise is only relevant to policy if these combinations are more or less plausible from a policy perspective. Scenarios that describe maximised single goals or unimaginable combinations of goals will not easily find an audience in the policy arena. It should be borne in mind, however, that by using this type of methodology the results are restricted to statements on feasibilities. An exploration along these lines does not imply a judgement with respect to the plausibility of a certain development. Accordingly, any suggestion as to the probability of the course of things is lacking. What can be inferred is the feasibility of a given policy goal or a combination of policy goals given the properties of the land-based agricultural production system. The application of this methodology will be discussed in the next chapter.

3 A PRAGMATIC METHOD TO EXPLORE OPTIONS FOR LAND-USE

3.1 INTRODUCTION

A pragmatic exploration of future possibilities requires that both the properties of the system under investigation and the value-driven preferences that are related to the system be identified. In the case of exploring future possibilities for the land-based agricultural production system in the EU it is therefore necessary to identify the constraints on future developments that are contained within the agricultural system itself. This constitutes the 'technocratic' part of the pragmatic methodology. Using scientific analysis the properties of the system can be assessed. These properties define the technical boundaries of the agricultural production system. Next, those constraints can be confronted with policy goals related to the performance of land based agriculture. This constitutes the 'decisionistic' part of the methodology. An optimisation of partly conflicting policy goals can yield information about the scope for policy reforms or adaptations. The combination of technical boundaries and political optimisations is the essential characteristic of a pragmatic approach.

In the case of agricultural production the technical limitations of the system are well known. In the agricultural sector, commercial use is made of biological processes, which must obey physical, chemical and biological principles or laws. These inevitabilities allow us to perform an exploration according to the guidelines for the agricultural system set out in Chapter 2. Ultimately, the technological possibilities determine the economic possibilities of the sector. This approach is not a new one. Already in 1955 Sir George Thomas wrote (Thomas 1955):

> Technology is governed by scientific principles, some of which are understood. (...)
> I have supposed that developments which do not contradict known principles and which have an obvious utility will in fact be made.

This idea of a technology-driven future can be applied to land-based agriculture as well. In this case not to formulate a prediction, but to estimate the ultimate potential of the sector. For other areas, a similar approach seems much more troublesome, because a basic understanding of governing principles is still lacking. Especially social systems do not obey general 'laws' and therefore are very hard to characterise. Or, to use the words of Sir George Thomas: "sociology still has to find its Newton".

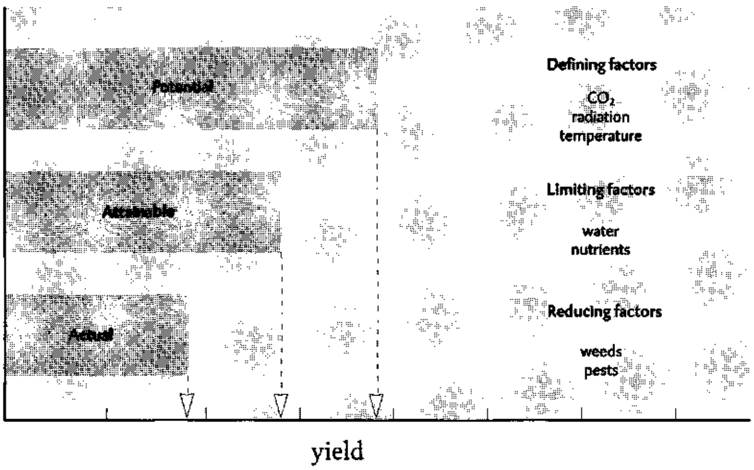
In this chapter the principles that govern land-based agriculture will be clarified. These principles can be used to describe the properties of the system, usually at the level of biological processes and individual plants, the traditional level of scientific research. However, the goals that are related to land-based agriculture play a role at much higher levels of scale. Therefore, a stepwise methodology will be developed to bridge the gap between these levels. Each of the steps requires its own method and model. The different steps and methods used will be explained in the following paragraphs.

3.1.1 THE BIOLOGICAL LIMITATIONS TO AGRICULTURE

The most crucial step in setting up an explorative model is the identification of the system. Any system has its own properties and is fed with information from exogenous variables that can influence its performance. This implies that first a division must be made between properties of the system itself and properties that the system adopts from the exogenous variables. The concepts of *yield-defining, yield-limiting and yield-reducing* factors can help to discern between 'inherent' and 'adopted' properties of the agricultural system (Van Ittersum and Rabbinge 1997; Ivens et al. 1992).

The relations between these three types of factors are presented in Figure 3.1. Under normal conditions, man cannot influence yield-defining factors like CO_2, radiation and temperature. They are the natural conditions at a given location that define the potentials for agricultural production. Of course, it is possible to influence the amount of radiation and the temperature at a given location, but this implies building a greenhouse. The temperature in this greenhouse will be significantly higher than the ambient temperature. If assimilation lights are installed in the greenhouse (as is done with cut flowers), even the radiation can be increased. However, this modification would transform land-based agriculture into footloose production. The characteristics of the crop, the other yield-defining factor, may also be influenced if cultivars with truly new features would be developed. However, in the foreseeable future new cultivars at best entail a slight improvement of the fraction of the crop that has economic value.

Figure 3.1 Yield-defining, -limiting and -reducing factors and their influence on crop yield. Invariable crop properties and climate conditions define yield-defining factors. Yield-limiting and -reducing factors can be influenced by management decisions.



Source: Rabbinge (1993)

Both other categories – yield-limiting and yield-reducing – are objects of deliberate manipulations by man. Farmers are continuously engaged in changing the limiting and reducing factors into favourable conditions. This ranges from selecting the most favourable plots and burning the standing vegetation in slash-and-burn types of agriculture to soil improvement and manipulation of water availability by irrigation and drainage in modern farming systems. Agricultural research and extension systems help farmers in achieving their goals by investigating the nitrogen household of plants, the development of integral pest management systems, improving irrigation efficiency, developing modern forms of mechanical weeding and so on.

If an explorative model of the agricultural system that is based on properties of the system itself must be developed, the yield-defining factors are a good point to start from. The yield-defining factors of agricultural production all relate to the basic activity in agriculture: managing the *photosynthetic capacity* of green plants in such a way that maximum utility for humankind is attained. Photosynthesis is the process in green plants that transforms carbon dioxide and water into sugars, using sunlight as the primary source of energy. The yield-defining factors thus constitute the ultimate limitation to future agricultural production.

Although the variety in products, production situations, managing skills, farming systems and a number of other things in agriculture is very large, all activities boil down to the well-known physiological process of photosynthesis.
The basics of primary production in green plants have been researched intensively and there is an extensive body of scientific literature on the exact processes involved. Experimentation, simulation and verification in the field of theoretical production ecology have provided the quantification of the process at the level of the individual plant and the single crop. The amount of light a plant can intercept is fairly well known. From that it can be calculated how much carbon dioxide can be transformed and how much nutrients are necessary in the process. These figures constitute an upper limit to agricultural production.
No matter how much effort is put into management, research, farming systems and selection of varieties, agricultural production is limited by the extend to which green plants are able to produce usable sugars (De Wit et al. 1970).

The understanding of this process has led to the formulation of a large number of crop growth simulation models. These models can differ in their degree of detail, but they all share the following characteristics (Ritchie 1991; De Wit 1968):
- sunlight can be used to produce sugars;
- the properties of the plant determine the amount of intercepted sunlight; and
- the different stages in the development of the plant are crucial to the maximum quantity of sugars that are produced.

Thus, it can be concluded that highly invariable exogenous factors (CO_2, radiation, temperature) together with highly invariable properties of the agricultural system (photosynthesis, crop characteristics) define the potential yields in agriculture. Of course, the provision made here is that there will be no major changes in these highly invariable factors. If they do, for example as a result of greenhouse gas emissions (CO_2) or gene modification (crop characteristics) then the rules change. Given the current situation the combination of the exogenous factors and properties of the system puts a limit to the potential increase in productivity that was observed in Chapter 1.

The biological roots of agriculture form the starting point of a model that can describe the technical properties of the agricultural system. Sometimes even land-based agriculture is looked upon as an industrial activity, and consequently all types of substitutions among inputs are presumed. However, agriculture must obey the laws that govern biological processes. Yield-defining factors have to be observed, and this results in a set of technical constraints that limit the possibilities of agricultural production. In a true sense, these constraints form the biological limitations of agriculture and constitute the 'technical certainties' for the future.

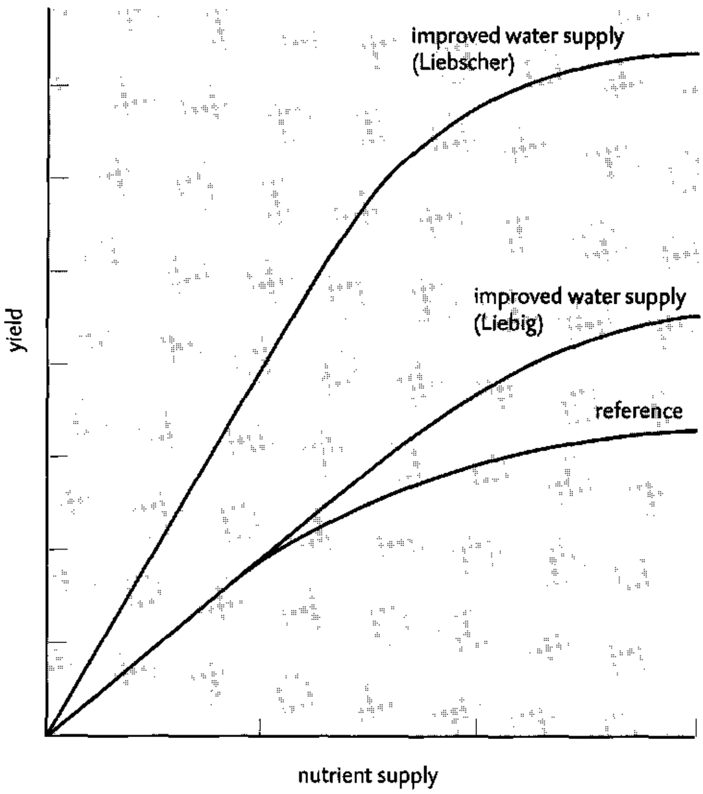
3.1.2 THE OPTIMAL MIX OF PHYSICAL INPUTS

The process of photosynthesis also gives information on the physical inputs that are required. At the level of biochemical reactions the ratio between non-substitutable, primary inputs (light, water, carbon dioxide and nutrients) is fixed. Also at the level of individual crops it can be argued that a fixed amount of inputs is needed to produce a certain level of output. For a given level of production, the minimal level of each resource can be assessed. The theoretical background of this phenomenon has been described extensively by De Wit (1992).

Starting point of De Wit's argument is Liebig's *Law of the minimum*, which says that the yield of a crop is proportional to the supply of the essential input that is available in the smallest amount. This law follows directly from the observation that biochemical processes are discrete and therefore need fixed amounts of inputs. The biochemical processes are indeed essential for the full development of the crop. The classical metaphor for this law of the minimum is the barrel with staves of different heights. The shortest stave determines the maximum height of the water in the barrel and thus the maximum quantity the barrel can contain. Hence, it is of no use to expand one of the other staves. This law does not give any information on the optimum mix that should be applied to a crop. It simply states that a continued increase of one of the essential inputs will not lead to the maximal attainable yield, since this will be prohibited by one of the other essentials.

Liebscher's *Law of the optimum* is necessary to solve this problem. This law says that the input that is in minimum supply contributes more to a yield increase if all other inputs are available in an amount that is closer to their optimum.
The differences between the two laws are schematically presented in Figure 3.2, which represents a field situation in which the water supply is improved while all other factors are kept at a constant level. According to Liebig the improved water supply will manifest itself only at the higher levels of nutrient supply. Liebscher, however, states that an improved water supply will be evident throughout the whole range of nutrient supply. De Wit showed that in field experiments both laws are observed, with Liebscher's law of the optimum being the more dominant one.

Figure 3.2 The effect of improved water supply on nutrient efficiency according to Liebig's law of the minimum and Liebscher's law of the optimum

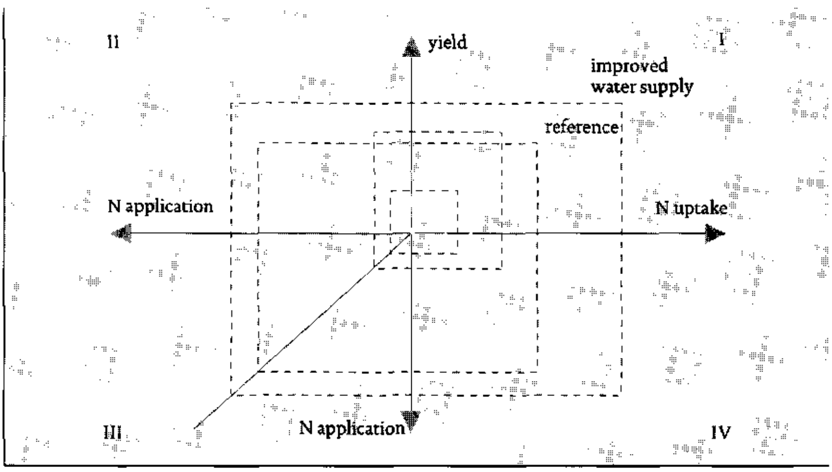


Source: De Wit (1992)

Liebscher's law of the optimum points to an increase of efficiency in relatively high yielding situations. Hence, the law states that there is a bonus to be gained if all other inputs are near their optimum. Again, this phenomenon can be demonstrated using the example of an improved water supply. For this purpose the original graph that links yield per hectare to nutrient supply must be expanded. The graph must be changed into a four-quadrant plot to depict the relation between yield and nutrient uptake. This will enable a transition of the original observation into a more descriptive representation of the processes that are involved (Van Keulen 1982).

In Figure 3.3 this graphical analysis is presented. The graph shows a plot of attained yields against nutrient applications. In quadrant II the breakdown of a normal field observation is illustrated. The plot reveals that a low yield is obtained if no fertiliser is applied. All the fertiliser that the crop needs is then extracted from the soil, eventually leading to a degradation of the soil. So, a base level of fertiliser application is needed to maintain soil fertility. If more fertiliser is added, the crop will produce a higher yield. A simple plot of yield versus nutrient application is not sufficient to facilitate a first assessment of the efficiency of nutrient application. The intermediate role of the soil complicates the simple dose-response relation. The soil factor can be eliminated if information is available about the nutrient content of the harvested crop and if this can be linked with the nutrient application. In quadrant I the results of a nutrient content analysis have been plotted. By combining the two observations (application response and average nutrient content at different yield levels), the nutrient uptake can be assessed as a function of the nutrient application (quadrant IV). From this quadrant it can be concluded that nutrient uptake improves considerably if the water supply is improved. The line does not only shift to the right, indicating an overall higher level of efficiency, but with an improved water supply the slope also increases. Therefore, improving the water supply does not only effect the yield directly, i.e. through water availability, but there is an extra benefit through the improved efficiency of nutrient uptake. A large number of field observations support this theory (De Wit 1992). The overall conclusion must be that the efficiency of individual inputs increases when yields tend to their maximum.

Figure 3.3 Three-quadrant analysis of nutrient - yield relationship under improved water supply



Source: after De Wit (1992)

Of course, there is no such thing as a free lunch. Investments in know-how, skills, machinery and other capital goods will be needed to attain this improved water supply. However, should these investments be made, the benefits are obvious. This mechanism is one of the main reasons for the dramatic rise in agricultural productivity in the last 50 years or so. The combination of improved water availability, soil quality, crop characteristics and nutrient availability stimulated the agricultural output while using less input per unit of output. It also led to a seemingly autonomous rise in productivity within agriculture. The disproportional relative advantage that becomes apparent if only one farmer improves on his conditions will be an impetus for all other farmers to follow these developments.

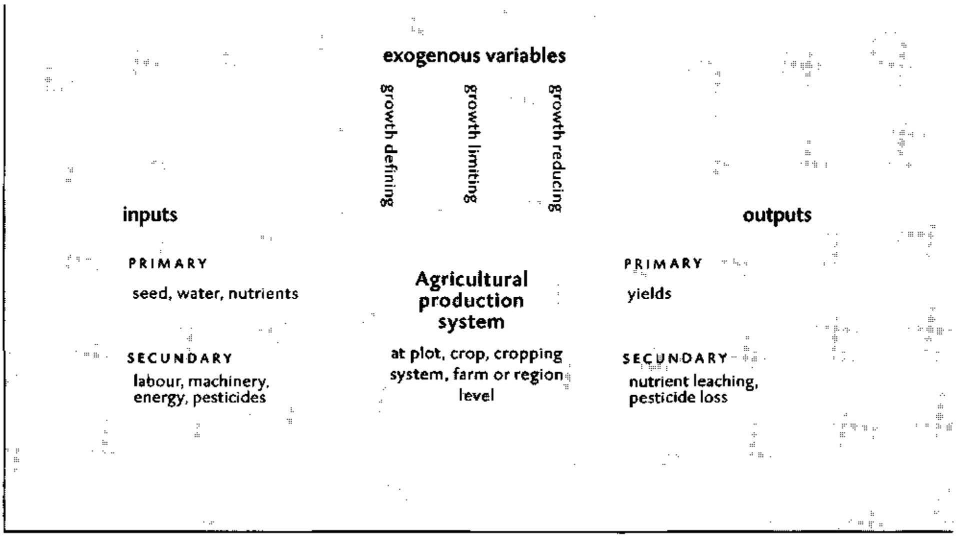
The basic process of photosynthesis together with Liebscher's law of the optimum enables us to explore the boundaries of the agricultural production system. The amount of sunlight available at different geographical locations is known. Crop characteristics that determine the photosynthetic activity are also known. Combined, these two facts can give information on the *potential yield* of a certain crop that can be obtained at a given location. From this potential yield, the necessary primary inputs can be deduced using Liebscher's law of the optimum. To that end, every single resource should be available at such a level that all other resources can be used to their maximum. This technical optimum for a particular potential yield can be used as a reference.

3.1.3 SCALING UP TO LEVELS OF SCALE RELEVANT TO POLICY

The reference of single crop potentials and primary inputs must be translated into figures that reflect a more realistic mode of agricultural production at higher levels of scale. First, it should be noted that agricultural activities are not aimed at single crops, but are grouped together in farming systems. Land-based arable farming systems are characterised by different rotation schemes or cropping systems primarily. So, the exploration of future possibilities necessitates the rotation schemes and their influence on the technical optimum of resource use to be identified. Second, next to primary inputs crops need other inputs that are susceptible to substitution.

Van Ittersum and Rabbinge (1997) described a conceptual framework that can clarify this situation. If the agricultural production system is considered at an abstract level, then the general structure is based on the continuous transformation of inputs into agricultural outputs. At the input-side it was noted earlier that non-substitutable, primary inputs are necessary. These consist of seeds, water and nutrients. Without any of these inputs agricultural production is impossible. Next to that, any agricultural production system needs other inputs, such as labour, machinery, energy and pesticides. These inputs, however, can be substituted by one another to a certain extent. For example: weeding of the crop can be done by hand (=labour) or by mechanised weeding (=machinery). The primary and secondary inputs together facilitate the intended output or yield, but next to that unintended outputs will also come about in the guise of, amongst others, nutrient leaching and pesticide losses. The production level of the system, defined as level of primary output per unit area, is controlled by exogenous variables that describe the growth defining, growth-limiting and growth-reducing factors mentioned earlier. The process of agricultural production can be described at various levels of scale, ranging from an individual plot to a geographical region. These concepts are summarised in the framework given in Figure 3.4.

Figure 3.4 Concepts for the analysis and quantification of agricultural input-output combinations



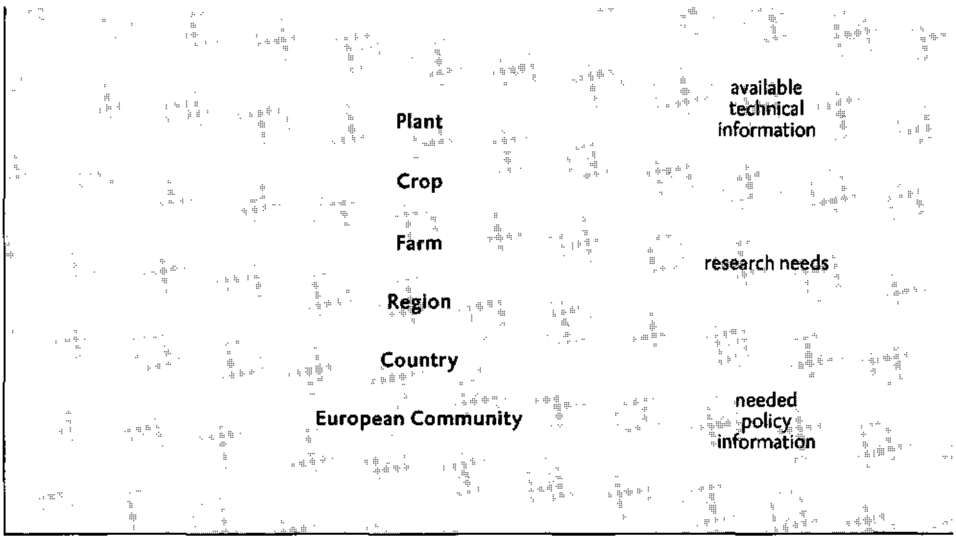
Source: after Van Ittersum and Rabbinge (1997)

The conceptual framework can be used to identify agricultural production systems at various levels of scale, i.e. from plot level up to regional level. For the explorative analysis in this study, the starting point of identification is the production level, or rather, the potential production level that was derived in 3.1.2. Starting from the potential production defined by the growth defining factors, the most efficient combination of primary inputs using agronomic knowledge can be calculated. The assessment of the secondary inputs must be based on current available knowledge of production techniques. Due to the substitutability of the secondary inputs the selection of techniques is not straightforward. It turns out that other, additional aims of agricultural production besides the primary production goal is very relevant for the final selection. However, in all cases the result of this procedure is referred to as *best technical means*, indicating that the primary inputs are based on the agronomically defined technical optimum and the secondary inputs on the best techniques available. It should be clear that these production systems are not a blueprint for tilling and production techniques at farm level; they merely describe the possible input-output relation of a farming system if the techniques used will lead to attaining the calculated potential yields.

There is ample information to be able to perform the necessary analyses, both at the level of the individual crop and at the level of cropping systems. In the last decades much of the agricultural research has been focused on improving the productivity in agriculture through changes in management, cultivars, machinery, inputs, pest control et cetera. This gave rise to an extensive body of scientific literature on basic processes in individual plants and crops, including the limitations of these individual plants and crops.

If all this information is available, the properties of the agricultural production system can be identified and the influences of these properties on policy goals related to agriculture can be examined. However, policy decisions are taken at much higher levels of aggregation, i.e. the EU-level or the national level. Policy problems, however, are perceived at the regional level. The scientific basis of these policy issues at higher levels of scale is generally constrained to economic analysis. This presents us with the problem that is illustrated in Figure 3.5. The level at which information is available does not correspond to the level where information is required. The gap between these levels of scale must be bridged if both the agronomists' knowledge of the lower levels and the economists' knowledge of the higher levels are to be used in the analysis. A systems approach turns out to be the answer to that question (Van Latesteijn 1993).

Figure 3.5 Levels of scale and research needs. Technical information is available at plant and crop levels, whilst policy information is needed at regional, national and supra-national level.



Source: Van Latesteijn (1993)

Using engineers' knowledge it is possible to construct a technical model representation of agriculture. Using economists' knowledge it is possible to translate policy goals into quantified objective functions and integrate these within the model. With such a model it is possible to assess the influence of policy objectives on agriculture and vice versa. Thus, it is explicitly not the intention to come up with more or less reliable predictions for the future of agriculture within the EU, but to explore the possibilities of the agricultural system in terms of feasible production systems and the consequences of these systems for different policy goals. For tactical policy decisions concerning the set-up and use policy measures this exploration will not be adequate, but for strategic policy planning purposes concerning the identification of relevant policy goals this type of analysis can be very useful.

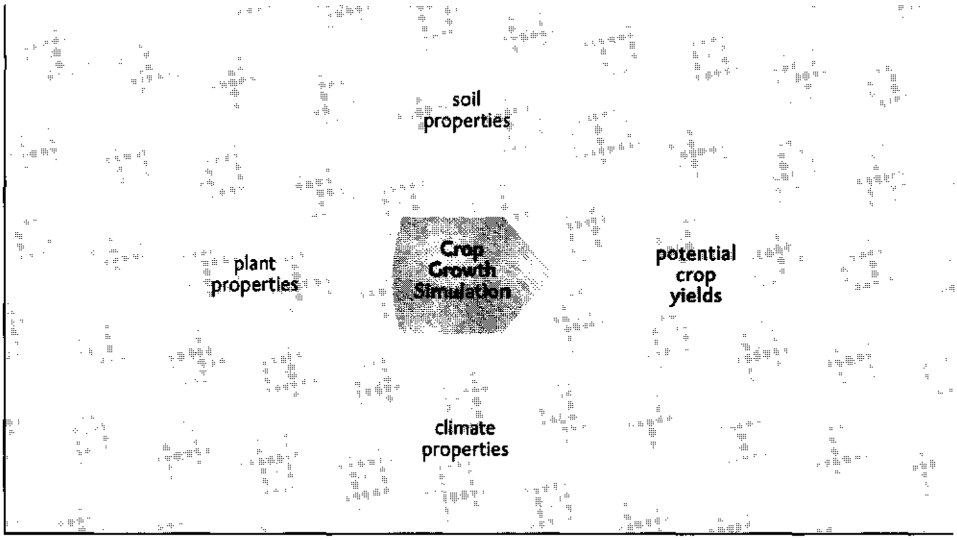
So, information on physiological processes at the level of individual plants and crops is used to assess the properties of the system. Next, this information must be scaled up to the level of cropping systems to allow for relevant additional information at the operational level. Finally, a second shift must be made to the regional land-use level, at which the political objectives come to life. Thus, three distinct levels of analysis are necessary to be able to bridge the gap between available information at crop level and required information at the level of the EU. The results of the analysis at one level have to be translated into inputs at the next higher level. Aggregating information to a higher level will inevitably lead to a certain loss of information. By restricting the aggregation to the next higher level and selecting information that is relevant input for this next higher level, this loss can be minimised (Fresco and Kroonenberg 1992). In the next section, the three levels of analysis are discussed.

3.1.4 LEVELS OF ANALYSIS

The first level of analysis is the level of the individual crop. Agronomy has produced a wealth of information on growth properties for crops. If this information can be combined with information on growth determining factors, the potential yield of a crop can be assessed.

In Figure 3.6 the inputs and outputs for the analysis at the individual crop level are visualised. Plant properties, soil properties and climate properties determine the potential crop yield of some indicator crop at a given location. To calculate this potential crop yield two steps are necessary. First it has to be assessed whether the soil is suitable for a certain crop so as to exclude all units where that crop cannot be grown (e.g. wheat on steep slopes and maize on clay soils).
This can be denoted as a qualitative land evaluation. Second, by means of a crop growth simulation model, potential yields have to be calculated for the suitable areas; i.e. a quantitative land evaluation (Van Lanen 1991).

Figure 3.6 **Analysis at crop level: potential yields of indicator crops are calculated using a crop growth simulation model. Inputs are soil and climate properties and relevant properties of the plant such as phenological development, light interception, assimilation, respiration, partitioning of dry-matter over plant organs and transpiration.**

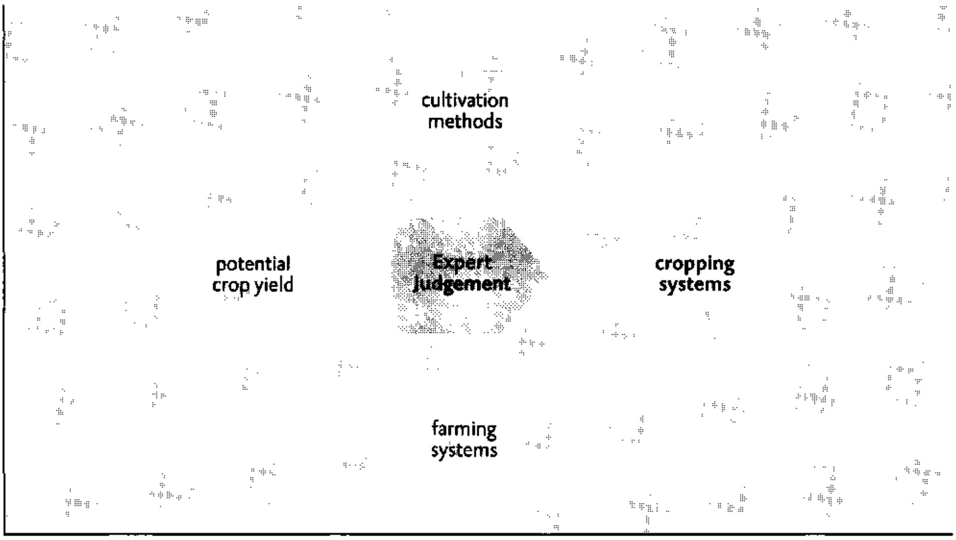


Source: Van Latesteijn (1993)

All crops are grown in a cropping system that defines all inputs and outputs. Moreover, in most cases monocropping does not provide sustainable agriculture and only a limited number of crop combinations can be used in practical cropping systems. Therefore, 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.

In Figure 3.7 the inputs and outputs at this level of analysis are given. At this level the assessment of secondary inputs and outputs is chiefly based on expert judgement. From his experience, both in practise and in experiments, the expert can deduce input and output coefficients of cropping systems. These systems are not commonly used yet, but they might be put into practise within the coming decades. As outlined above, cropping systems are defined according to the principles of best technical means, defined as the situation where all necessary inputs are minimised to such an extent that all inputs attain their maximum efficiency.

Figure 3.7 **Analysis at cropping systems level: theoretical cropping systems are defined based on expert judgement. The input consists of the calculated potential yields of indicator crops and information on cultivation methods, farm management, rotation schemes, etc.**

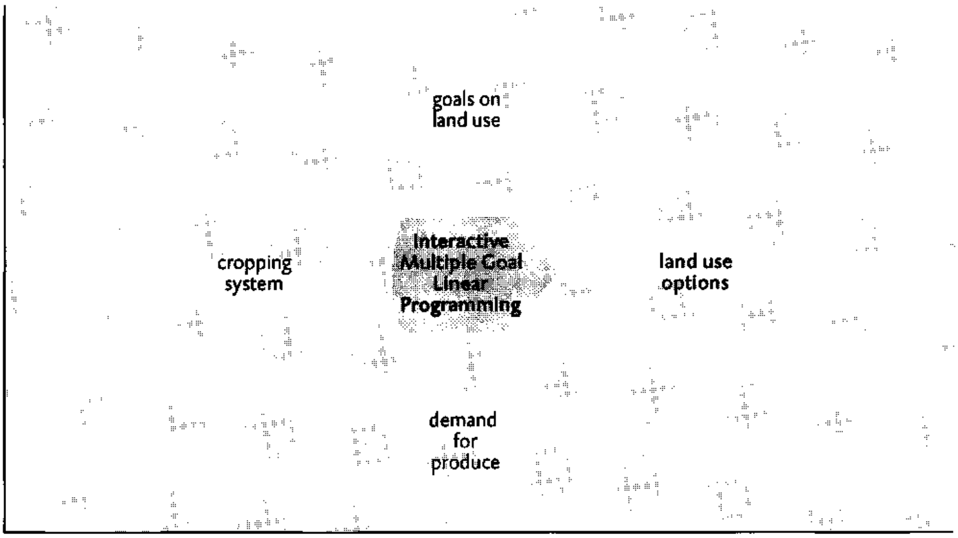


Source: Van Latesteijn (1993)

The information on possible cropping systems can be used at the level of *land-use* to assess future possibilities for land-based agriculture in the EU. To that end these possibilities are confronted with wishes regarding the performance of the agricultural system. These wishes are expressed in the form of policy goals.

In Figure 3.8 the procedure used at this level of analysis is illustrated. Requirements for various goals related to land-use together with alternative cropping systems and a demand for agricultural produce are used to construct a Linear Programming model. This LP-model is used in an Interactive Multiple Goal Programming Procedure to construct a number of differing land-use scenarios. In this stepwise procedure, the individual policy goals are optimised alternately to allow for a constant feedback of the results. The user can decide whether an improvement on one of the goals will be accepted. With every improvement of one goal, the possibilities to improve on another will diminish because the model will need a certain type and location of land-use to fulfil the demands. Eventually the results will reflect a certain preference in policy goals and the consequences of this preference for agricultural land-use in the EU. These results comprise the limits to the options that are available to the agricultural system.

Figure 3.8 **Analysis at land-use level: land-use alternatives are calculated using a linear programming model. The model finds an optimal solution to the problem of fulfilling the demand for agricultural produce while at the same time contributing to several different land-use related policy goals. This can be achieved by choosing different cropping systems and locate them in the most appropriate region.**



Source: Van Latesteijn (1993)

Identifying the relation of possibilities and wishes to different types of land-use reveals the confrontation of possibilities and wishes. These relations form the substance of the linear programming model that will be outlined below. Initially the possibilities are described in a purely technical fashion. Given the technical limitations of primary production and the qualities of the soil and the climate for all the regions of the EU the potentials are assessed. These possibilities are bounded since quantified policy goals have to be met. The resulting scenarios describe the utmost possibilities with respect to the wishes (goals) included in the model and the matching distribution of agricultural activities among the regions. The allocation of agricultural production thus obtained for each region needs further spatial evaluation. A separate analysis of the spatial claims for nature conservation is carried out to obtain information on the land-use claim for nature. Other spatial claims (for landscape protection and recreation) were also investigated but for different reasons proved impossible to complete.

Finally, the land-use scenarios can be used for strategic policy planning. The expected effects of current and proposed rural policies can be compared to the results of the scenarios. If apparent mismatches pop up, new directions for policy planning might be considered.

3.2 GENERAL OUTLINE OF THE GOAL MODEL

The construction of the linear programming model GOAL (General Optimal Allocation of Land-use) has enabled us to integrate the three levels of analysis. In this model future production possibilities of land-based agriculture and forestry are represented as a set of linear equations. The model can choose from a limited set of types of land-use to meet an exogenously defined demand for agricultural and forestry products. A set of policy goals is defined, each in its own dimension, that indicate the variety of notions that are considered to be essential for future land-use. Each of these goals is coupled to the various types of land-use in the form of objective functions.

However, a linear programming model is generally used to optimise a single objective function. With the aid of an Interactive Multiple Goal Linear Programming (IMGLP) the functionality of a single linear programming model can be expanded. The IMGLP procedure enables the consecutive optimisation of a set of objective functions in an iterative process. In this procedure the 'costs' of improving one of the objective functions are revealed by showing the related inevitable depreciation of the others. These 'costs' reveal the trade-offs between the different policy goals that are represented in the model by the objective functions. This type of information can always be translated into strategic questions: a better value for a particular goal will often imply a worse value for another one. On earlier occasions, this type of methodology turned out to work well in situations where an optimum between several conflicting goals had to be obtained (Scientific Council for Government Policy 1987).

3.2.1 THE LINEAR PROGRAMMING MODEL

Early attempts to confront agricultural engineers' knowledge with socio-economic knowledge in a linear programming model were made by De Wit and his co-workers (De Wit et al. 1988). The combination of a linear programming model and the IMGP procedure made it possible to 'dovetail' the two types of information. The domains become fully integrated if all relations could be specified with some degree of certainty. Dovetailing only presumes a defined framework to connect both domains without the need for an exact specification of all the relations. The technical information is introduced in the form of linear equations that connect a number of inputs of agricultural activities to a number of outputs. The socio-economic information is depicted by subjective constraints to several quantified policy goals (Veeneklaas 1990).

A linear programming model basically consists of an objective function that must be maximised and a set of restrictions in the form of linear relations.

The restrictions form the actual model. In general three different types of restrictions can be discerned:

1 *Logical restrictions*, for example agricultural production cannot exceed the capacity of photosynthesis, production of biomass is impossible without input of nutrients or irrigation cannot exceed the available quantity of water. This type of restriction will be included directly in the specification of the model.
2 *Probable restrictions*, for example prices and incomes in the EU will converge, the present level of investments in agriculture will be the driving force for future developments or the disparity in management skills between northern and southern member states will continue to exist. Because most of these relations are ill understood or can only be specified in terms of probabilities, this type of restriction should be left out. An exploration should be based on well-defined properties of the system, not on debatable assumptions.
   If a restriction of this type has to be incorporated, the assumptions that are made must be clearly documented.
3 *Subjective restrictions*, for example the need for regional employment or the level of acceptable pollution. It will be clear that this type of restriction cannot be incorporated in a direct fashion. Instead, subjective restrictions are formulated as constraints to the objective functions of the GOAL. Thus, they are treated as the steering variables of the system. Precisely these subjective restrictions are the political values and norms that will shape the future.
   The levels of the constraints are not purely input to the model, rather the possible combinations of levels form one set of outputs of the exercise.

In Table 3.1 the three categories of restrictions have been identified for agricultural developments.

Table 3.1 Different categories of restrictions that will confine future developments in land-use

type of restriction	
logical	photosynthesis (potential production) area of land availability of water
probable	managing skills relative price of labour infrastructural qualities
subjective	nitrogen pollution use of pesticides regional division of labour demand for nature conservation costs of agricultural production

The logical restrictions that form the core of the GOAL model describe technically feasible cropping systems in agriculture and forestry on a regional basis. A number of objective functions represent several policy goals related to rural land-use (Rabbinge and Van Latesteijn 1992). This is completed with other linear equations that define the availability of suited land, the availability of irrigation water, the conversion of primary products into secondary products and the demand for agricultural produce. So, primarily logical restrictions, and a few probable restrictions, constitute the bedrock of the model.

For the production of a certain final product the model can choose from a finite number of different ways of production, each of which has different consequences for the objective functions (policy goals). For example: wheat can be produced in a monocropping system without irrigation or in an irrigated rotational cropping system. The area of land, the nitrogen input and the pesticide use will differ considerably between these two systems. Whether the model chooses for the non-irrigated monocropping or irrigated rotational cropping system will depend on the constraints that are put to the model. If the use of pesticide is considered of paramount importance – reflected in the model exercise by severe constraints to the object function that reflects the application of pesticides – the odds that the model will opt for the irrigated rotational system will be very small. By varying the different constraints on the object functions a scenario can be constructed that shows a certain constellation of values that the objective functions can attain and a regional allocation of types of land-use that is consistent with these constraints.

The regional allocation can be obtained by specifying all restrictions at a regional level. However, in this type of model analysis the availability of data is of particular importance. Therefore the classification is adapted to the one used by Eurostat, the Statistical Office of the EU. Eurostat applies three levels: NUTS-I (64 regions), NUTS-II (167 regions) and NUTS-III (824 regions) (CEC 1989). The abbreviation NUTS here stands for *Nomenclature des Unités Territoriales Statistique* (Statistical Nomenclature of Territorial Units). Given the availability of data, classification at NUTS-I level is used for the analysis. Six of the sixty-four regions will not be used in this study, partly because they encompass urban areas (Hamburg, Bremen, Berlin and Brussels: population density > 1000 persons per km^2) and partly because they belong to completely different agro-ecological zones (the sub-tropical Canarian islands and the Portuguese islands). The names and locations of the NUTS-I regions that have been used in the analysis are listed in Appendix A.

3.2.2 THE IMGLP PROCEDURE

The Interactive Multiple Goal Linear Programming (IMGLP) procedure is a key element of the exploration. Therefore, in this section the basics of the procedure will be discussed at more length. With IMGLP several goal variables can consecutively be optimised in a structured procedure, i.e. by tightening the constraint on one of the goals and then optimising all goal variables one by one, thus obtaining the best value for each goal variable. So, in one step only one goal variable is actually optimised in an objective function; all others are restated in the form of 'normal' restrictions. After such a series of optimisations the constraint on one of these other goal variables can be improved in a subsequent series by optimising that goal, again restating all other goal variables to restrictions. This procedure is explained below by means of a simplified example.

Consider the case that we have a model with three goals, defined in three different objective functions. The goals are (i) total volume of labour, (ii) total costs of agricultural production, and (iii) total quantity of pesticide used. We want to maximise the first goal variable and to minimise the other two. The objective functions in this case are very simple. The total volume of labour is obtained by itemising all labour that is required in the farming systems and related conversion processes. The total costs of agriculture result from adding up all cost components and the quantity of pesticides used can be obtained straightforward from the ways of production used in the model.

The first step of the IMGLP procedure is to optimise the three goals while no constraints are put to each of the two other goals. Let us suppose that this renders the following results: maximum total labour = 6 million WPUs (working power units); minimal total costs = 120 million ECU and minimal use of pesticides = 20 million kg AI (Active Ingredient). In the next step we can tighten the constraint on total labour. Let us assume that we constrain maximum total labour to at least 4 million WPUs. If we try to minimise total costs with this constraint, we will find that the minimum of 120 million ECU can no longer be obtained; they will rise to 135 million ECU. This reflects a partial conflict between the two goals; the impossibility to attain both maximum employment and minimum costs at the same time comes into sight. There is also an effect on the minimal use of pesticides; here the minimum level will rise to 22 million kg AI.

The next step of the IMGP procedure might be to constrain total costs to 138 million ECU. This leads to a maximum total labour of 4.2 million WPUs (of course somewhat higher than the 4 million of the former step) and a minimum of 30 million kg AI pesticide use. Apparently low pesticide use can only be achieved if relatively high total costs for agriculture are accepted. In this way the procedure can go on and will ideally lead to a point solution if all goal variables attain their optimal values in relation to each other. However, in practice the procedure will be ceased if the model designates a reasonable scope for all goal variables.

A few important features of the IMGLP procedure should be clear from this example:

- The IMGLP procedure basically consists of restating objective functions in restrictions and vice versa.
- The constraints that are put on the goal variables are subjective. The user of the model applies the constraints and he is absolutely free in selecting the goal variable to be constrained, as well as the level of the constraint.
- The user of the model constructs the outcome in an active mode. The results are not generated or influenced by any other external source of information.

By stepwise tightening the constraints it can be shown how goal variables affect one another, especially each other's optimal values. After a constraint on a goal variable has been tightened, the maximum achievable values for the remaining goals will at best remain unchanged. Thus, the gap between the best and the worst values becomes smaller. In an ideal situation the user of the model would be the policymaker himself. In this study, however, values for the constraints on the goal variables are prompted by differences of opinion on the objectives to be achieved. In this way several *scenarios* are devised, built up from the values obtained for the various objectives and the associated allocation of types of land-use to the different regions. The results are denoted as 'scenarios' because they describe different, though equally feasible, futures.

According to Schwartz (1991) scenarios are stories about the future that are not used to find the most probable future, but to make sound strategic decisions for all plausible futures. Given the starting point of Schwartz to assess the impact of the two most relevant uncertainties about the system under investigation, this definition of scenarios is understandable. However, in this study the scenarios do not depict the maximum scope in uncertainty. Here the results of the model exercises taken together explore the borders of what is feasible with the agricultural production system in an EU policy context. Although this is a different specification of the concept of scenario than the description given by Schwartz, this terminology will be used to describe the results of the calculations with the GOAL model. Schwartz emphasised that scenarios are a tool for ordering our perceptions about alternative future environments. The results of the GOAL model stress a somewhat different aspect: they are descriptions of feasible alternative strategies and their consequences to better understand the effects of the choices that are made today. Thus, the scenarios that are constructed with the GOAL model do not pretend to give information on probabilities, they even do not pretend to shed some light on plausibilities, but they do pretend to explore the borders of feasibilities. With this specification the scenarios from the GOAL model can serve an identifiable purpose in the policy debate.

3.2.3 RESULTS TO BE PRODUCED

The results of the model exercise can be divided into two groups.

First, the input-output equations of the linear programming model have to be defined. Several steps must be taken to obtain the information that at the regional level is required on cropping systems that reflect best technical means. Other information must be collected separately, for example the need for land to conserve nature, the availability of irrigation water and the demand for agricultural produce. The results of this information gathering are presented in Chapter 4.

Second, the gathered information is used to generate a number of scenarios. These scenarios depict what results if the subjective combinations of goals related to land-use are taken to their logical conclusion. The resulting scenarios and some of the reactions to these scenarios are presented in Chapter 5.

4 THE 'TECHNOCRATIC' COMPONENT: ASSESSMENTS OF FACTS

4.1 INTRODUCTION

The modelling approach outlined in Chapter 3 will be made operational with a scientific analysis and a subjective exploration of policy goals. In this chapter the first activity will be discussed: the assessment of the possibilities of the agricultural system with the aid of a biophysical analysis. The results from this technical analysis will be used in the next chapter as input to an IMGLP procedure in which the preferences from the political arena will be explored systematically.

4.2 QUANTIFICATION OF POSSIBILITIES

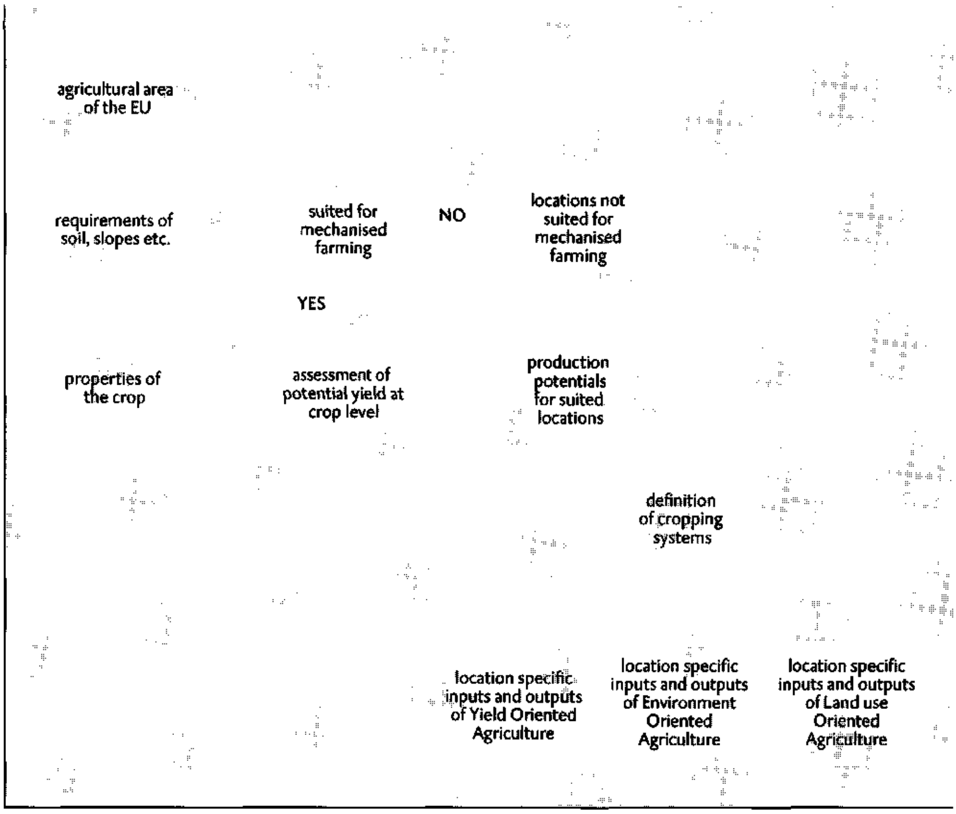
The possibilities for land-based agriculture in the EU can be quantified by combining elements of a Land Evaluation and some sort of Farming Systems Analysis. The possibilities of such a combination have been recognised earlier (Fresco et al. 1989). However, this combination can only be realised if amendments are made to the original aims and executions of both Land Evaluation and Farming Systems Analysis.

In a Land Evaluation according to the guidelines of the FAO, it is assessed whether land is suitable for alternative uses by identifying relevant land-use types, identifying the available types of land and matching both data sets. Land-use types (or LUTs) are characterised in terms of socio-economic and technical attributes and land qualities are characterised in terms of ecological, management and conservation requirements (i.e. biophysical conditions that affect yields, management of the land and availability of resources depending on land-use type). If arbitrary economic and political drivers are included in this type of land evaluation, a method results that claims predictive powers (Veldkamp and Fresco 1996). Considerations of plausibility and probability must be used to select the appropriate values for the subjective inputs. For the purpose of this study, the exploration of future possibilities, this characterisation is too arbitrary. Therefore, in this study, land evaluation will be restricted to the purely biophysical and input requirements (Van Diepen et al. 1990). The biophysical quality of a unit of land should not impose severe restrictions to the yield and prolonged agricultural use of the unit must be possible.

Farming Systems Analysis, again according to the FAO guidelines, is aimed at diagnosing and analysing farm level variables to account for the gap between experimental field yields and actual farmer yields. Hence, the ultimate aim of Farming Systems Analysis is to develop agricultural technology to overcome this gap. Although this type of analysis can be very useful for planning purposes, identification of the differences between actual yields and potential yields will not be sufficient for an explorative study. Rather, in this context some revised form of a Farming Systems Analysis should be used to identify feasible farming systems that may lead to (near) potential yield levels. This can be accomplished through the identification of those farm level variables that are crucial to attain the potential yields under known biophysical and climatic conditions at a given location. Thus, this revised form of Farming Systems Analysis gives an indication of the *Best Technical Means* that should be used to attain potential yield levels with a minimum amount of inputs.

The procedure that was used to integrate Land Evaluation and the revised form of Farming Systems Analysis is outlined in Figure 4.1. This procedure comprises three steps that will be discussed in the next sections.

Figure 4.1 Procedure to generate scenarios of future land-use with the GOAL model



4.2.1 STEP ONE: LAND EVALUATION

In the first step the suitability of the area of the EU for (mechanised) farming of various crops should be assessed. This *qualitative land evaluation* of the EU is accomplished through the use of a Geographical Information System (GIS) that holds all the relevant data on soil quality and climatic variation for the area under investigation. The GIS is also used as a core system to store all output information of the land evaluation (Bulens and Bregt 1992).

In a GIS it is possible to superimpose different maps that contain spatial information in the form of attributes attached to map units. Soil characteristics are most important in a land evaluation that aims at appraising the suitability of the land for agricultural purposes. However, the same GIS is also used for the next steps in the assessment of possibilities for agriculture, which require information on climate and administrative regions. For that purpose, Land Evaluation Units (LEUs) have been identified, that represent a combination of the NUTS-1 regional division of the EU and of soil and climate conditions considered homogeneous enough for the aim of this analysis.

Three maps in the GIS are superimposed to obtain the LEUs: the EU soil map, the Agro-climatic map and the map of NUTS-1 regions. The EU soil map comprises 312 soil associations, each characterised by a dominant soil and one or more associated soils. In the Agro-climatic map 109 different agro-climatic zones have been distinguished. The NUTS-1 map contains 58 regions. The overlay of these three maps leads to the identification of some 4,500 unique types of LEUs and some 22,000 physical units on the map.

The suitability for farming of each LEU can be assessed by looking at specific soil-related characteristics that are crucial to modern mechanised farming. Mechanised tilling requires that the slopes are not too steep, the soil not too stony and the land sufficiently drainaged. In addition, crops will impose different requirements on the soil with respect to texture and drainage conditions. Since the EU soil map does not contain information on these soil characteristics, these characteristics have to be derived from the information on the dominant type belonging to each soil association (Reinds et al. 1992).
This requires expert knowledge to distinguish the next seven characteristics for the dominant soil types:

1 texture: 5 classes (coarse, medium, medium fine, fine, very fine);
2 drainage condition: 6 classes (very poor, poor, temporary poor, moderately well, well, excessive);
3 slope: 4 classes (0-8%, 8-15%, 15-25%, >25%);
4 phase: 14 types (gravelly, stony, lithic, concretionary, petrocalcic, saline, alkaline, lithic/stony, petrocalcic/gravelly, concretionary, stony, lithic/gravelly, petrocalcic/stony, petrocalcic/concretionary, stony/gravelly);
5 maximum rooting depth: 5 classes (10 cm, 40 cm, 60 cm, 80 cm, 120 cm);
6 salinity: 2 classes (absent or saline);
7 alkalinity: 2 classes (absent or alkaline).

For three indicator crops (grass, cereals and root crops) land-use requirements have been defined – mainly based on expert knowledge – with respect to the soil characteristics mentioned above. These are given in Table 4.1.

Table 4.1 Land-use requirements of grass, cereals and root crops

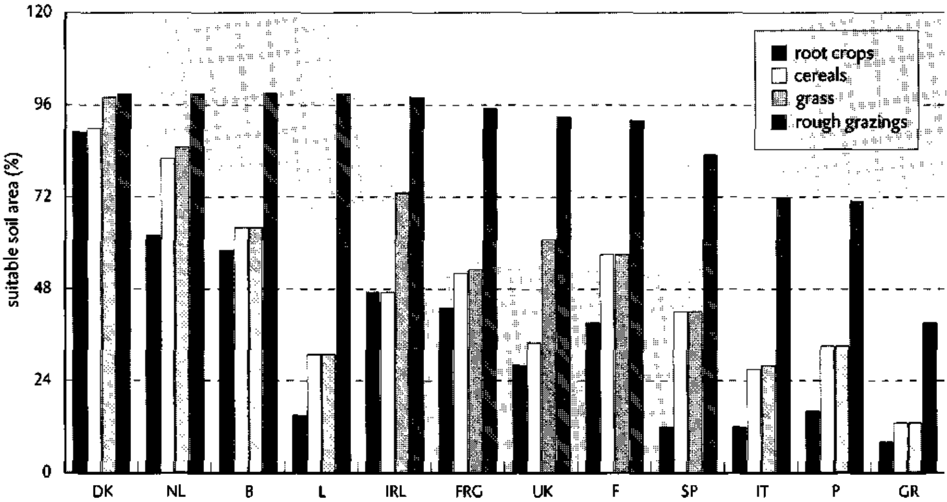
characteristics	rough grazings	grass	cereals	root crops
texture	none	< 70% clay	< 70% clay	< 50% clay
slope	< 25%	< 15%	< 15%	< 15%
drainage	none	> very poor	> temporary poor	> temporary poor
rooting depth	none	> 10cm	> 10cm	> 10cm
phase	none	gravelly and concretionary phase allowed	gravelly and concretionary phase allowed	no phase allowed
salinity	none	not allowed	not allowed	not allowed
alkalinity	none	not allowed	not allowed	not allowed

Source: Reinds and Van Lanen (1992)

The last three columns in Table 4.1 reflect the suitability of land for mechanised farming. However, on a large area in the EU extensive managed grasslands – or rough grazing – also contribute to the agricultural production. The only land-use requirement for these rough grazing is that the slopes may not be steeper than 25 percent (Table 4.1, second column). These rough grazings differ considerably from the category 'grass' that stands for tilled grasslands (meadows) where nutrients, irrigation of drainage are applied. Rough grazings are barely managed and therefore agricultural requirements are almost absent. If the land-use requirements for root crops, cereals, grass and rough grazings are applied to the LEUs and the results are aggregated to the level of EU member states, a clear indication of the suitability for agriculture of the different member states can be obtained. The result of this qualitative land evaluation is presented in Figure 4.2. The graph clearly reflects the differences in soil quality throughout the EU.
In each country the area suitable for rough grazings is the largest, the area suitable for grass production exceeds that for cereals, and that for root crops is smaller still. This is caused by the inclining demands that the soul quality has to meet for these crops, as presented in Table 4.1.

A comparison of the two extremes (Denmark and Greece) illustrates the enormous diversity of land qualities in the EU. Practically all of Denmark is suited for rough grazings or mechanised grass production and cereals and root crops can be tilled on 90 percent of Denmark's area. The results for Greece show that only some 40 percent of the country is suited for rough grazings, some 10 percent can be used for mechanised grass production and to grow cereals and even less than 10 percent is suitable for the tilling of root crops

Figure 4.2 Percentage of total area per Member State of the EU that is suited for root crops, cereals, (meadow)grass and rough grazings



4.2.2 STEP TWO: PRODUCTION POTENTIALS

In the second step production potentials for suited areas are calculated with a crop growth simulation model. This is denoted as *quantitative* land evaluation (Van Lanen 1991). The quantitative land evaluation is accomplished with the WOFOST crop growth simulation model (Van Keulen and De Wolf 1986).
This model simulates development, growth and yield of a field crop and the water balance of the soil in time steps of one day. It needs technical information on soil (such as water holding capacity), climate properties and relevant properties of the crop (such as phenological development, light interception, assimilation, respiration, allocation of of dry-matter over various plant organs and transpiration) as its inputs.

The WOFOST model can calculate different production levels of a given crop.
In this study two levels are used:

a *potential yield*:
optical, physiological, phenological and geometric characteristics of the crop, incident radiation and temperature determine the yield per unit of land area;

b *water-limited yield*:
precipitation is the only source of water (no irrigation assumed), so growth and yield may be impeded by water shortage during part of or the entire growing season.

The potential yield denotes the production ceiling for a given crop under prevailing soil and climate conditions and the present crop characteristics. The model simulation gives an indication of the maximum attainable yield at a given location. The water-limited yield indicates the yield that can be attained in rain-fed production situations. For both production levels no yield-limiting or yield-reducing factors have been taken into account. These production levels can differ considerably from the actual yield. In addition to growth-limiting factors such as the shortage of water and nutrients, growth-reducing factors, such as diseases, pests and weeds play an important role in this respect.

From the climate information present in the LEUs and the crop parameters derived from the literature and field experiments, the water-limited and potential yields of wheat, grain maize, silage maize, sugar beet, potato, and grass can be assessed (De Koning and Van Diepen 1992). The WOFOST model calculates yearly yields, using weather data that have been available for a period of 26 years. The averages of these yearly yields were considered a reliable estimate of the water-limited and potential yields of the various crops. The results per crop and per region are given in Appendix B.

The validation of the simulation results from the WOFOST model is somewhat problematic. The simulations are not meant to model actual situations, but to give information on production potentials. One way of testing the model is to compare the simulation results with actual yields and yields in experimental field situations. It has been assumed here that in these experimental field situations the production potentials are (nearly) reached by applying state-of-the-art techniques. Although this is not a true validation, it is a pragmatic approach to test the simulation model for extreme outcomes. The results of this comparison do not give rise to amendments of the results obtained. De Koning and Van Diepen (1992) discuss a number of possible errors in the simulation that point to an under- rather than an overestimation of the results. Some examples:

- winter crops are assumed to start growing on the first of January;
- only a standard variety of a crop is considered and not the varieties of a crop that may be better adapted to local conditions;
- one crop per growing season is assumed whereas in some regions a second crop can be grown.

It may be concluded, therefore, that the simulation results make up a conservative estimate of the regional water-limited and potential yields.

Comparison of the water-limited and potential yield to the yield data from 1986 shows that the differences between the various regions of the EU are rather small. In Figure 4.3 the cumulative distribution of the three yield levels is presented for wheat. The actual yield shows a range from less than 2 t ha^{-1} to values over 8 t ha^{-1}. The range of water-limited yields is smaller. The lowest yield levels have been found at 3 t ha^{-1}, but the highest levels are lower than the actual yields. This can be accounted for by the fact that in the actual situation some regions have been irrigated or drainaged, whereas the water-limited yield assumes no irrigation or drainage to have taken place. The potential yields show a range from 6 to 10 t ha^{-1}. The graph clearly shows that especially at the lower yield levels improvements can still be made. The higher yield levels that are attained at present are fairly close to the ceiling of agricultural production as represented by the potential yield.

Figure 4.3 Cumulative distribution of actual (1986), water-limited and potential wheat yields across the NUTS-1 regions in the EU (in tonnes per ha). The lines indicate the fraction of the data that have a lower yield that the x-axis indicates. For example: 20 percent of the regions has an actual yield of less than ± 2.3 tonnes per hectare.

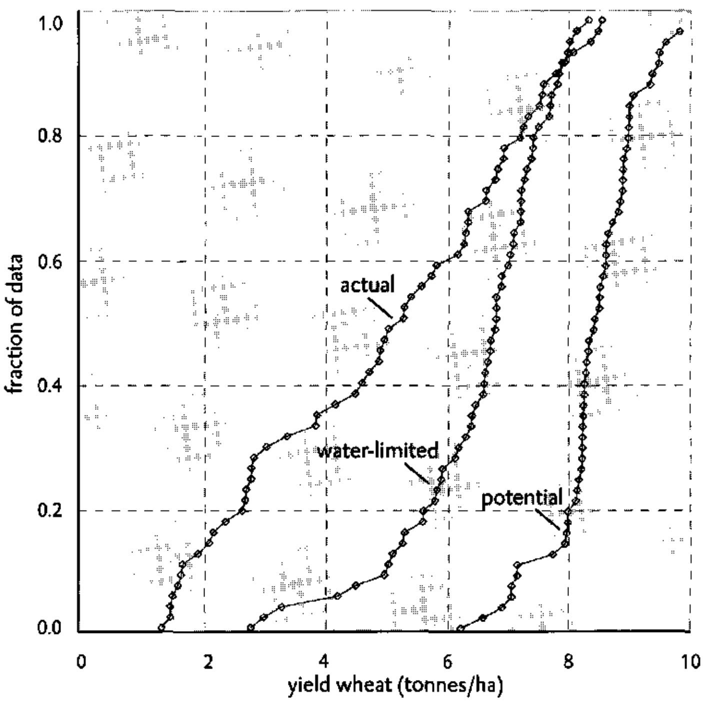
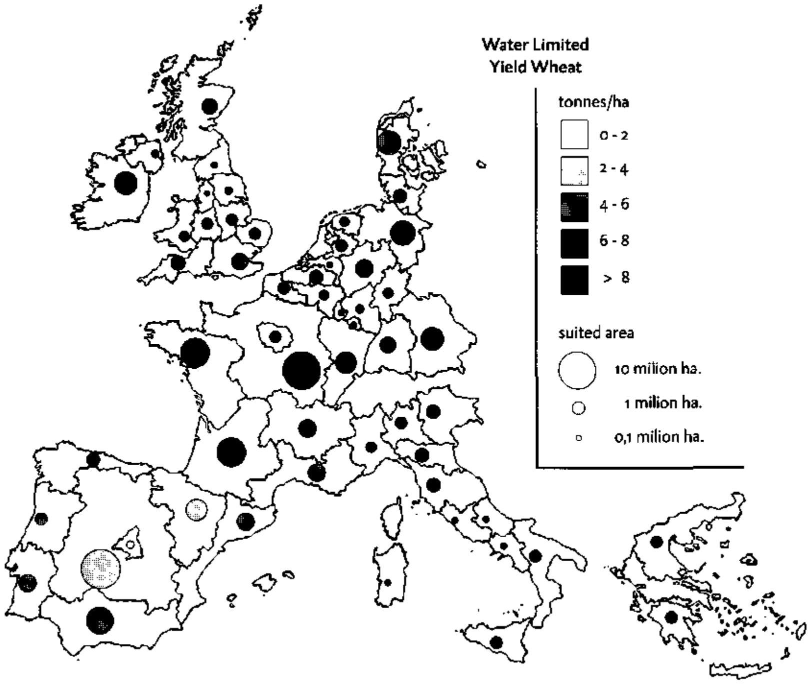


Figure 4.4 **Average water-limited and potential yield wheat for each NUTS-1 region. The absolute area suited for wheat production is also indicated for each NUTS-1 region.**



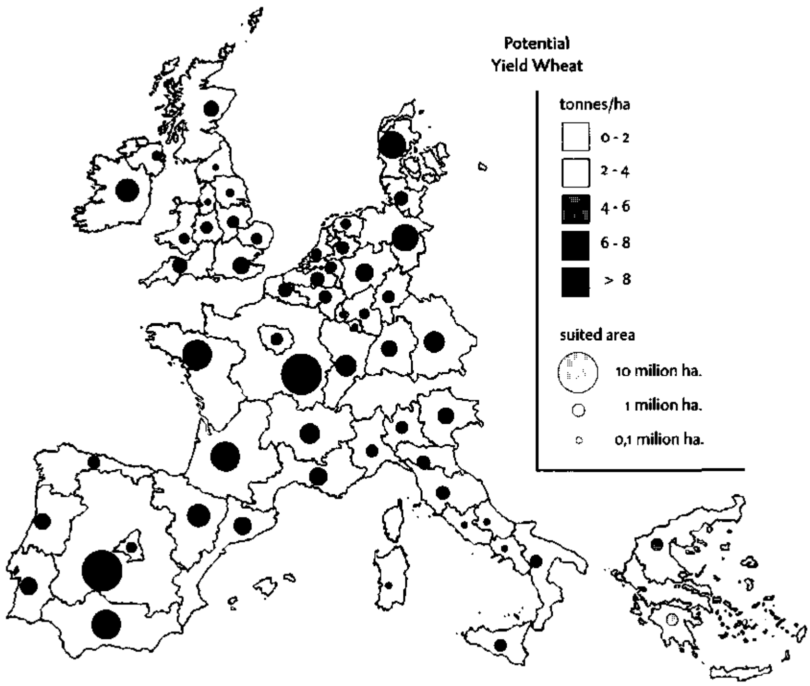


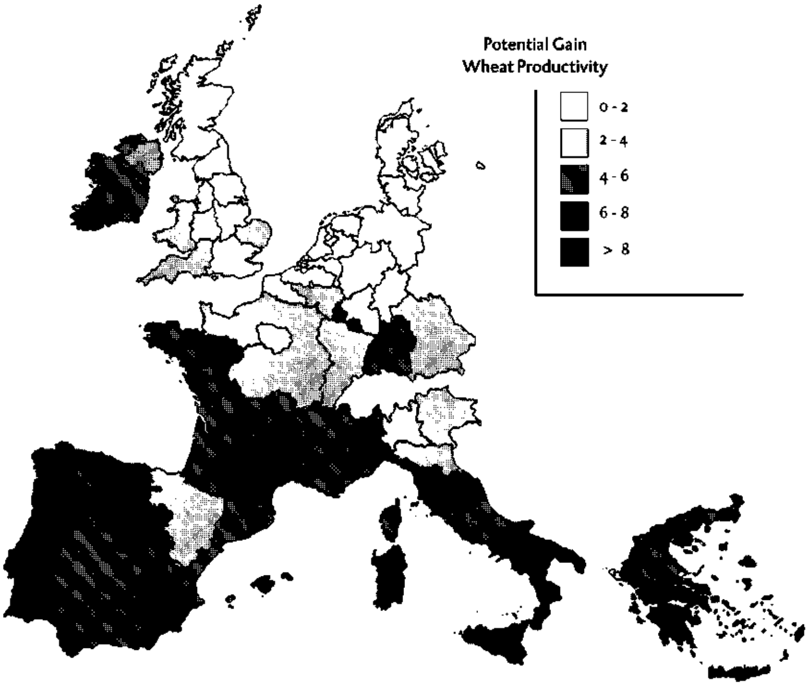
Figure 4.4 presents the same information in another format and, moreover, indicates the spatial distribution of the water-limited and potential wheat production. The crop growth simulations have been executed at the level of LEUs, but the results have been averaged at the level of NUTS-1 regions. It should be borne in mind, however, that not the whole area of the various regions will be suitable for production (cf. Figure 4.2). Therefore, the circles on the maps are proportional to the areas suited for wheat production. In combination with the shading, this gives an indication of the production potential of each region.

The regional distribution of water-limited yields in Figure 4.4 clearly reveals that the humid western parts of the temperate zone continent are most favourable for growing wheat. The water-limited yields of the southern regions lag behind, primarily as a result of water shortage. It is also apparent that the larger production areas for wheat are situated in France. In the Northern regions and the regions in the UK the water-limited potentials are substantial, but the areas are relatively small. If the water limitation is removed, the potentials of the southern regions appear to equal those of the humid regions. This is clearly visible in the potential yields shown in Figure 4.4: nearly all NUTS-1 regions fall into the category of more than 8 t ha^{-1}. Only in the elevated areas of Germany and the dry and hot areas in northern Italy and Greece the potential production is significantly lower.

The difference between the actual yield and the water-limited yield is a good indication of the productivity gain that is possible within agriculture. This is denoted in Figure 4.5. For a number of northern regions the possible rise in yield per unit area appears to be very small. For these regions the limits of soil productivity have almost been reached. So, given the present characteristics of crops and the environment, the theoretical production ceiling has become reality for at least part of the EU.

For any future study on agricultural developments this limitation should be considered carefully. The historical growth in productivity will have to come down in the next decades on account of the fact that the potentials have completely been used, especially in the northern regions of the EU. In most other regions the simulated water-limited yields are much higher (up to 6 t ha^{-1} dry matter) than the actual yields. In these regions soil productivity can still be increased, even if no irrigation is applied. For some regions in Spain, Portugal, Italy and Greece the potential gain in productivity, without the use of irrigation exceeds 200 percent. If for all regions irrigation is assumed, the potential production that results is 1 – 32 t ha^{-1} higher than the water-limited yields (see Figure 4.3). Even in the humid, well-developed northern regions, irrigation increases the yield potential by 1 – 2 t ha^{-1}.

Figure 4.5 **The potential gains in productivity for wheat of each NUTS-1 region derived from the difference between actual and water-limited yields**



It should be noted that the gains presented in Figure 4.5 are calculated by averaging the water-limited yields calculated for the various LEUs in one region and subtracting the averaged yield data for 1986 over the same LEUs. The results are therefore only a rough indication of the potentials of a particular region.

For permanent crops (fruit trees and forestry) a different approach is necessary. The WOFOST crop growth simulation model calculates in yearly cycles; every year the same cycle is gone through. For this reason the simulation model is apt for annual crops only. Virtually no crop growth simulation model is available for perennial crops. So, for permanent crops an adapted land evaluation procedure has been performed that provides information on the level of restrictions that soil and climate conditions put to the crop. To that end a decision support system ALES (Automated Land Evaluation System) was used that evaluates the suitability of LEUs for fruit trees and forestry by means of decision rules based on expert knowledge (Van Lanen et al. 1992). In this decision support system soil characteristics are used as input to decide on the degree of limitations that are put to the growth of perennials crops. Three classes of limitations are discerned: *no limitations, moderate limitations and severe limitations.* These limitations influence the maximum yield that can potentially be attained.

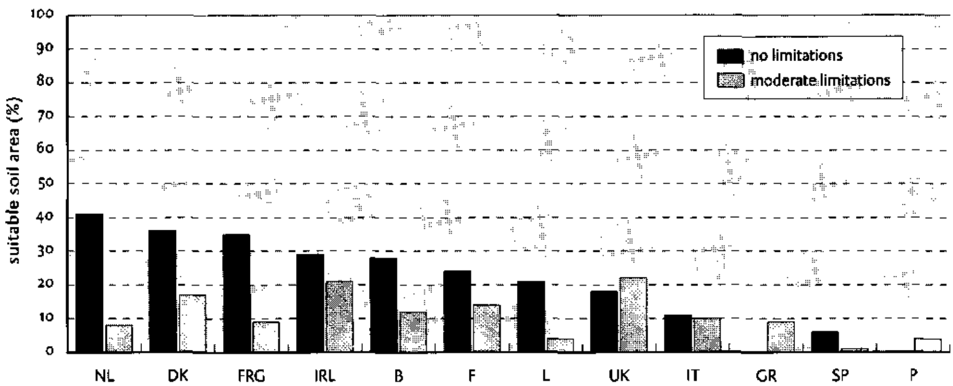
However, the potential yield for forestry is also related to the type of forest that is grown. So, in order to be able to assess whether LEUs are suitable for forestry, three types of forest have been identified. These cover the range of different tree species found in commercial forestry. Fast growing forests comprise tree species such as Poplar (*Populus spec.*), Willow (*Salix spec.*) and Eucalyptus tree (*Eucalyptus spec.*). On average this type of forest yields some 20 m^3 ha^{-1} $year^{-1}$. Moderate limitations resulting from soil water deficit, poor soil aeration, low natural soil fertility, chemical conditions, temperature regime and management conditions will lower the potential yield to 15 m^3 ha^{-1} $year^{-1}$. Severe limitations are prohibitive to commercial forestry.

Normal growing, more demanding tree species such as European silver fir (*Abies alba*), Western and Eastern Hemlock (*Tsuga heterophylla and Tsuga canadensis*) and Beech (*Fagus sylvatica*) make up a forest that can yield 15 m^3 ha^{-1} $year^{-1}$ under optimal conditions. However, these species are demanding with regards to the soil and other environmental conditions. Moderate limitations will decrease yields to a level of 10 m^3 ha^{-1} $year^{-1}$. Again, severe limitations imply that no forestry of this type is feasible.

Normal growing, less demanding tree species such as Scots pine (*Pinus sylvestris*) Maritime pine (*Pinus pinaster*) and Black pine (*Pinus nigra*) also show a normal yield, but are relatively tolerant as to soil conditions. Especially, this type of forest has a substantially lower water demand. Under optimal conditions potential yield will be 10 m^3 ha^{-1} $year^{-1}$. Moderate limitations will lower this to 8 m^3 ha^{-1} $year^{-1}$. Severe limitations will render forestry impossible.

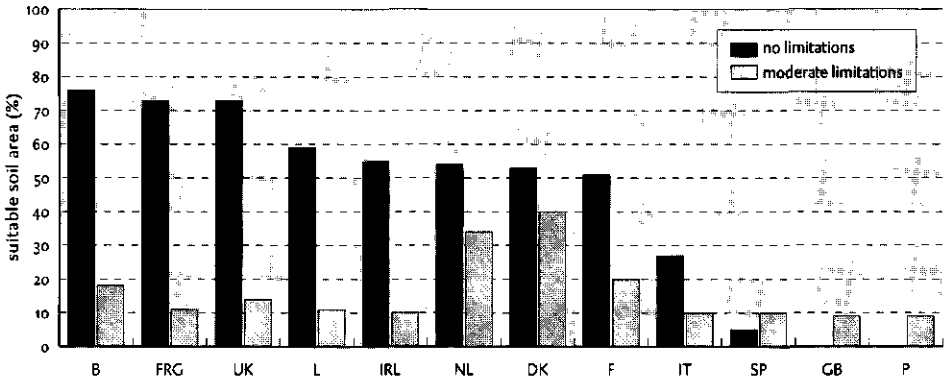
In Figure 4.6 the results of the ALES procedure for fast growing tree species are given. Large areas of the EU appear unsuitable for these high yielding tree species. This type of forest is mainly situated in the well-endowed agricultural regions in the northwest. The southern member states, and especially Greece, Spain and Portugal, show suitability percentages of less than 10 percent.

Figure 4.6 **Percentage of total area of the twelve EU member states with no or moderate limitations to the growth of fast growing tree species**



The southern member states are also unsuited for the least demanding type of forest, i.e. the normal growing, less demanding tree species. This can be seen from Figure 4.7. In the northern areas, the suitability for this type of less demanding forestry is in the range of 70-90 percent of total surface area. The southern regions stay at levels of less than 10 percent. The only exception is Italy, which has almost 30 percent suitable area for less demanding tree species with no limitations.

Figure 4.7 **Percentage of total area of the twelve EU member states with no or moderate limitations to the growth of normal growing, less demanding tree species**



4.2.3 STEP THREE: FROM CROP POTENTIALS TO CROPPING SYSTEMS

In the third step a revised Farming Systems Analysis has been used to translate the potential yields of indicator crops 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 expert knowledge a limited set of rotation schemes was set up and consequently the input and output coefficients have been deduced (De Koning et al. 1992; De Koning et al. 1995). There is no formal model or procedure for this type of analysis, so the following guidelines have been used to incorporate expert knowledge and experimental results in a set of feasible cropping systems.

The calculated water-limited and potential yields were the starting point. The water-limited yields are restricted by the availability of water at any point during the growing season. This gives an indication of attainable yields in non-irrigated field situations. The potential yields only depend on climate and soil conditions and on properties of the crop. Hence, the results reveal the maximum attainable yield in irrigated field situations.

By accepting the potential yield as the upper bound of future agricultural production in all regions of the EU, it is implicitly assumed that the best technical means may be applied throughout the EU. Only under this assumption regional soil and climate conditions can be held responsible for regional differences in production. The present situation is far from this assumption. Differences in management skills, training and infrastructure are almost exclusively responsible for the different yield levels in the various regions. However, a large part of the common agricultural policy is aimed at reducing these differences. Special subsidies have been made available to accelerate developments in regions that lag behind, and to diminish existing regional differences through the accelerated dissemination of knowledge, skills and know-how. In the past the agricultural sector went through dramatic shifts, mostly as a result of changing policies. This forced the sector to be very flexible and able to adapt to changing conditions. The conclusion may be that future convergence in agricultural performance is a reasonable assumption. Also from a logical point of view the assumption of EU-wide application of best technical means is defendable. The study is meant to explore future possibilities for agriculture and therefore investigates feasible arrangements of agricultural production. If there is no sound evidence that best technical means type of agriculture is not possible in any of the regions of the EU then the general application of this concept must be accepted as feasible.

Once the simulated water-limited and potential yields are known, this allows us to assess the minimum level of necessary (or primary) inputs. According to Liebscher's law of the optimum the optimum situation will be attained if each variable production resource is minimised to the level that all other production resources are used to their maximum.

The necessary level of water and nutrients can thus be assessed, which together define the technical optimum for that particular level of production.

To arrive at feasible cropping systems, however, expert knowledge must be used to define the secondary inputs that are acceptable from both an economic and an agronomic point of view. Therefore, information on nutrients and water is completed with information regarding other inputs such as labour and certain capital goods (costs of machinery, storage, buildings and irrigation). In the case of arable farming it is also very relevant to identify the possible rotation schemes, each of which will have an effect on the level of necessary inputs.

To steer the selection of the secondary inputs, additional information is necessary on the supplementary goals that are attached to agricultural production. These differences in supplementary goals can be denoted as *production orientation* (Van Ittersum and Rabbinge 1997). Even with the aid of these production orientations a number of assumptions had to be made in order to obtain quantification for all inputs. An elucidation of the assumptions and considerations is therefore essential to facilitate an open debate on this vital step. First, farming systems with excessive input of labour are excluded, implying that all systems have been mechanised (e.g. no manual weed control in field crops). Second, three distinct production orientations are described to meet the differing demands that legitimise the various and sometimes conflicting policy goals regarding agriculture in the EU. In the first orientation there is only a dominant production goal. The resulting set of cropping systems may be referred to as *Yield-Oriented Agriculture* (YOA).

The second production orientation takes more account of environmental hazards related to agriculture. This leads to the definition of a second set of cropping systems that use less environmentally hazardous inputs (such as pesticides and fertilisers), even if this means that yields will slightly decrease. Again, the criteria must be deduced primarily from expert opinions. Only little empirical data are available to underpin the choices that have been made. This set of systems is called *Environment-Oriented Agriculture* (EOA).

A third set of cropping systems is motivated by land-use concerns. This production orientation deals with the possibility that the agricultural area within the EU will diminish as a result of the ongoing rise in productivity combined with stagnating markets. This can be detrimental to an auxiliary goal of agricultural production, i.e. the maintenance of the countryside. Therefore a set of cropping systems has been defined that is characterised by relatively low soil productivity so as to keep as much land as possible under agricultural management. This set of

Table 4.2 **Examples of output-coefficients of the cropping systems per region, per orientation and irrigation situation (in tonnes per hectare per year). PWBW denotes a rotational cropping system of potato, wheat, sugar beet and wheat; S denotes a monocropping system of silage maize.**

rotation	region	orient.	irri.	wheat	grain maize	potato	sugar beet	oil-seed	field-bean	silage maize	silage grass	meadow grass
PWBW	Noord-NL	YOA	yes	4.93	-	-	-	15.9	19.1	-	-	-
PWBW	Noord-NL	YOA	no	3.99	-	-	-	14.0	16.7	-	-	-
PWBW	Noord-NL	EOA	yes	3.75	-	-	-	11.5	16.8	-	-	-
PWBW	Noord-NL	EOA	no	3.27	-	-	-	10.3	-	14.7	-	-
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
WFWOG	B. Parisien	YOA	yes	4.14	2.93	-	-	0.84	1.73	-	-	-
WFWOG	B. Parisien	YOA	no	3.08	1.81	-	-	0.75	0.97	-	-	-
WFWOG	B. Parisien	EOA	yes	3.08	2.76	-	-	0.62	1.19	-	-	-
WFWOG	B. Parisien	EOA	no	2.47	1.71	-	-	0.56	0.70	-	-	-
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
S	Nor.-Cont	YOA	yes	-	-	-	-	-	-	70.8	-	-
S	Nor.-Cont	YOA	no	-	-	-	-	-	-	17.2	-	-
S	Nor.-Cont	EOA	yes	-	-	-	-	-	-	69.7	-	-
S	Nor.-Cont	EOA	no	-	-	-	-	-	-	16.8	-	-
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
G	East Anglia	YOA	yes	-	-	-	-	-	-	-	31.6	-
G	East Anglia	YOA	no	-	-	-	-	-	-	-	26.6	-
G	East Anglia	EOA	yes	-	-	-	-	-	-	-	27.0	-
G	East Anglia	EOA	no	-	-	-	-	-	-	-	22.7	-
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
M	Lombardia	YOA	yes	-	-	-	-	-	-	-	-	103.4
M	Lombardia	YOA	no	-	-	-	-	-	-	-	-	72.4
M	Lombardia	EOA	yes	-	-	-	-	-	-	-	-	88.4
M	Lombardia	EOA	no	-	-	-	-	-	-	-	-	62.0
↓	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
6467	regional cropping systems											

systems which has been designated *Land-use-Oriented Agriculture* (LOA), has been assumed to be feasible only for extensive monocropping of wheat and extensive types of grassland management. For other types of arable farming there seem to be no middle position: either farming is carried out in an efficient way or farming is discontinued. On account of Liebscher's law of the optimum extensive use of farmland implies a relatively inefficient use of primary inputs. With monocropping of wheat and grassland management systems it is possible to counteract this detrimental effect by reducing management activities to a minimum.

Table 4.2 provides a number of examples of output coefficients. These coefficients indicate the maximum attainable yield of different crops within a certain cropping system.

In Table 4.3 the input coefficients of the same cropping systems are presented. The table shows that for each combination of rotation, region (NUTS-1), type of system (YOA, EOA or LOA) and irrigation activity (yes or no) individual coefficients have been calculated. In total 6467 different combinations were identified and fed into the GOAL model.

Table 4.3 Examples of input-coefficients of the cropping systems per region, per orientation and irrigation situation

rotation	region	orient.	irri.	suited area	labour	water	nitrogen applic.	nitrogen uptake	nitrogen loss	pesticide applic.
PWBW	Noord-NL	YOA	yes	50.6	36.0	446.2	300.8	264.4	73.9	6.2
PWBW	Noord-NL	YOA	no	50.6	29.0	0.0	281.8	230.3	89.0	5.6
PWBW	Noord-NL	EOA	yes	50.6	32.6	266.8	226.0	206.8	56.7	1.6
PWBW	Noord-NL	EOA	no	50.6	28.9	0.0	220.4	187.0	70.9	1.6
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
WFWOG	B. Parisien	YOA	yes	61.1	40.2	823.4	290.8	219.7	42.3	3.9
WFWOG	B. Parisien	YOA	no	61.1	25.0	0.0	231.5	184.0	46.4	3.5
WFWOG	B. Parisien	EOA	yes	61.1	38.2	597.2	223.0	171.5	35.4	1.1
WFWOG	B.Parisien	EOA	no	61.1	27.5	0.0	185.0	148.4	39.5	1.1
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
S	Nor.-Cont	YOA	yes	24.6	129.4	5688.7	368.8	283.5	115.2	1.6
S	Nor.-Cont	YOA	no	24.6	24.7	0.0	67.8	57.1	40.6	1.6
S	Nor.-Cont	EOA	yes	24.6	130.6	5610.4	362.3	278.9	113.4	0.6
S	Nor.-Cont	EOA	no	24.6	27.4	0.0	65.8	55.6	39.9	0.6
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
G	East Anglia	YOA	yes	93.7	65.5	474.5	576.6	557.1	49.5	0.7
G	East Anglia	YOA	no	93.7	56.5	0.0	505.5	469.2	66.3	0.7
G	East Anglia	EOA	yes	93.7	59.1	405.7	488.6	476.3	42.3	0.0
G	East Anglia	EOA	no	93.7	51.5	0.0	427.8	401.1	56.7	0.0
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
M	Lombardia	YOA	yes	57.6	17.0	1031.2	516.9	496.4	50.5	0.7
M	Lombardia	YOA	no	57.6	13.6	0.0	378.0	347.5	60.5	0.7
M	Lombardia	EOA	yes	57.6	17.3	881.7	437.6	424.4	43.2	0.0
M	Lombardia	EOA	no	57.6	14.5	0.0	318.8	297.1	51.7	0.0
↓	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
6467 regional cropping systems										

With these input and output coefficients the future possibilities of land-based agriculture have been determined. The cropping systems defined for YOA, EOA and LOA are all available to the GOAL model. However, the GOAL model uses the demand for agricultural produce as its driving force. The production techniques and orientations determine the supply side of the system. The demand side is dictated by the needs of ultimate users of agricultural produce. This demand is not available in terms of the primary products given in Table 4.3, but rather in terms of final products. Therefore, the conversion of these primary agricultural products into final products has to be incorporated in the model also. This constitutes the next step in the procedure.

4.2.4 STEP FOUR: CONVERSION FROM PRIMARY PRODUCTION INTO FINAL PRODUCTS

A number of conversion processes have to be defined to link primary agricultural production to final products. For some of these processes the conversion is straightforward. For example, in sheep farming a conversion of rough grazings into mutton is needed only. Since sheep farming is assumed to be viable on rough grazings, one coefficient only has to be assessed that relates the production of mutton to the area of rough grazings. Other conversion processes are much more complex.

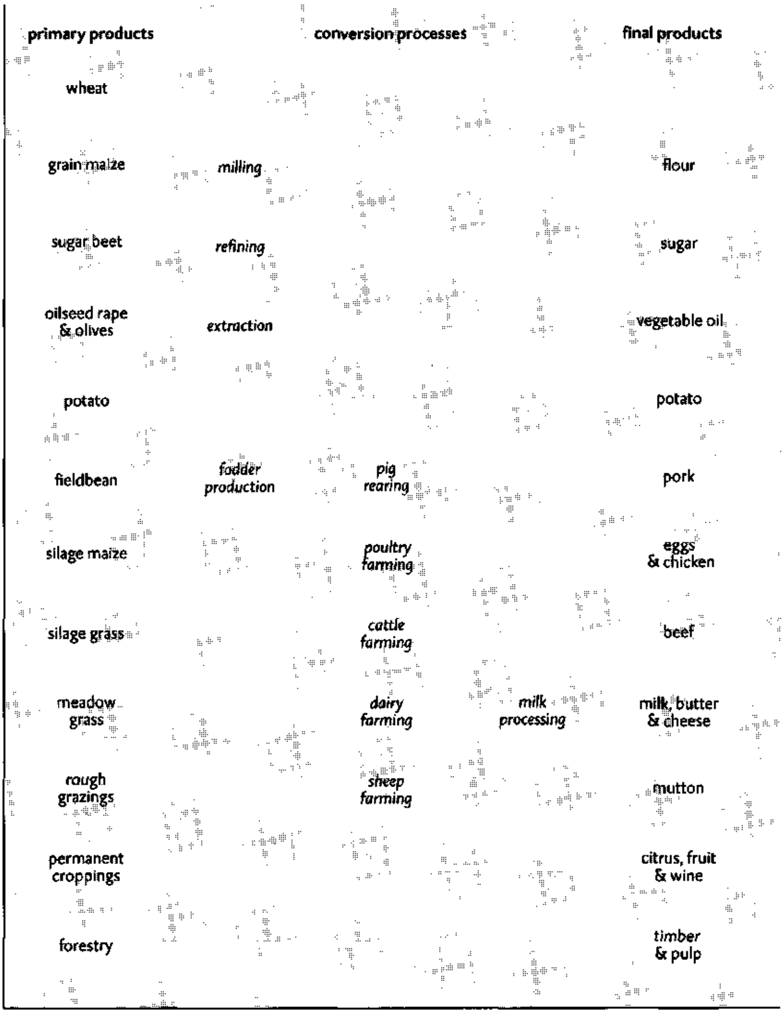
Especially the production of fodder is complicated, since this puts different demands to the fodder and the range of possible inputs. Side products are used from the milling process of grains, the refining of sugar beets and the oil extraction from oilseed rape and olives. Silage maize and grass as well as field beans are used directly to produce fodder. The rude protein content and energy content of these inputs have to be mixed in such a way that the resulting fodder is of the right quality. Also a minimum of fibrous material should be incorporated in the diet of the animals to prevent digestion problems. In Figure 4.8 the general outline of the conversion processes is given.

Scheele (1992) provides a more elaborate quantitative description of these processes. All processes are formulated in a set of equations that had been added to the original set that describes the production possibilities. In the next section, further additions to this basic set that stem from logical and probable considerations are described.

4.3 QUANTIFICATION OF ASSUMPTIONS

Next to information on the possibilities of agricultural production the GOAL model must also contain information on the environment within which the production takes place. A number of assumptions have to be made regarding competitive types of land-use, the availability of water, and the demand for final products.

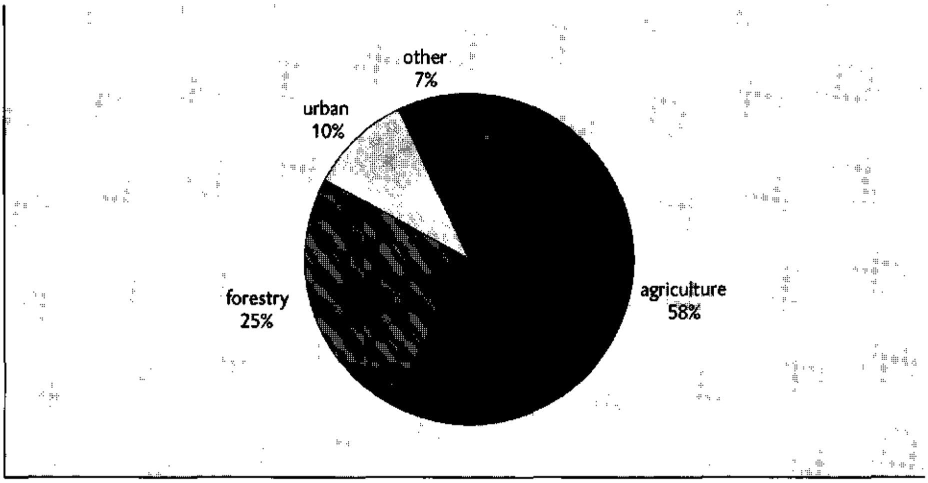
Figure 4.8 Conversion processes from primary products into final products, as they are modelled in the GOAL model



4.3.1 COMPETITIVE TYPES OF LAND-USE

According to Eurostat statistics, agriculture accounts for 58 percent of the area of the EU, forestry consumes 25 percent and urban land-use is around 10 percent of the total area. So, only 7 percent of the area of the EU can be denoted as 'unused'. This division might change in the future. Possible claims on future non-agricultural land-use that can limit the developments should be identified.

Figure 4.9 The division of land-use categories in the EU-11

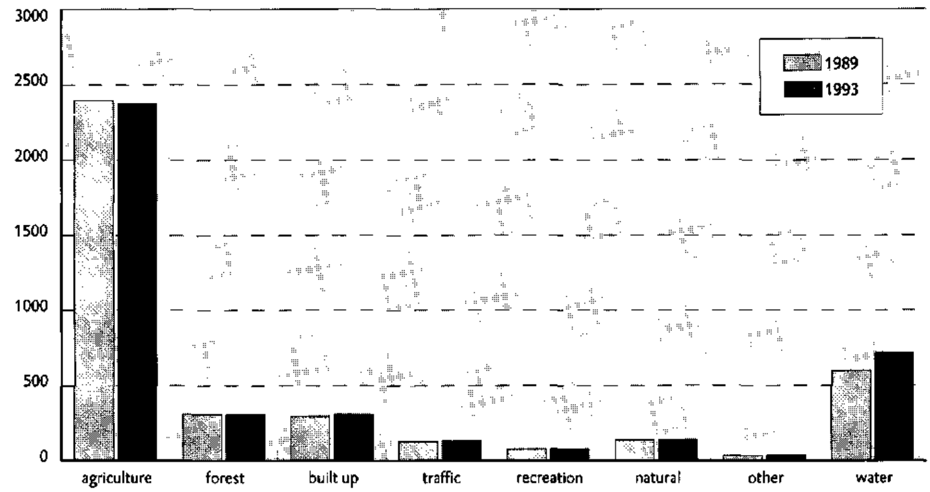


Source: Eurostat

With respect to urban land-use the estimate of 10 percent is rather high. Very few empirical data are available here, probably because it is problematic to define urban and non-urban areas. A survey showed that in 1981 7.8 percent of the area of the EU-10 fell into the urban category (Clout 1984). Since that time the growth in urban land-use has been very little. The scarcely available estimates indicate an almost zero growth.

Of course there are regional differences. Especially in the densely populated areas in the northwest, urban expansion may pose a limitation to agricultural developments in the region. The northwestern part of the EU is characterised by vast residential areas and suburban activities, next to expanding cities. At the regional level, it might be expected that these two categories would get into conflict with agricultural uses of the land. In Figure 4.10 the development of land-use in The Netherlands is presented. Although an increase is visible in built up area, even in the most densely populated country of the EU, the growth of the urban area is minimal. The average yearly decline in agricultural area between 1989 and 1993 was 6000 ha (RPD 1996). Given the roughly 2 million ha of agricultural area in the Netherlands this indicates a yearly decrease of 0.3 percent and only a part of that decrease is transformed into urban area. It can be concluded from these figures that on average urban land-use will not be competitive to agricultural land-use at the level of the EU in the next decades.

Figure 4.10 The development of land-use in the Netherlands for the categories agriculture, forest, built up, traffic, recreation, nature, other and water between 1989 and 1993



Source: Statistics Netherlands

About 3 percent of the category 'unused' is destined for nature conservation and development. It is expected that this function of land will become much more important in the near future. In the Habitat directive, the Commission has stated that in ten years time roughly 10 percent of the total area should be designated as protected wildlife areas (CEC 1992). New ideas evolve concerning the minimum areas that should be reserved for conservation purposes in order to sustain wildlife at an acceptable level. In line with these ideas the potential claims and demands for nature conservation and development have been assembled (Bennet 1991; Bischoff and Jongman 1993). Several types of conservation areas have been identified (nature protection, landscape protection, international protection, nature expansion and nature development) that on average add up to 36 percent of the total area of the EU.

The resulting Tentative Ecological Main Structure that is presented in Figure 4.11 is used to confront the outcome of the agricultural analysis with demands from another category of land use. The needed agricultural area can be compared to the wanted nature conservation area and conflicts can be identified.

Figure 4.11 A Tentative Ecological Main Structure for the European Union. The shaded area should be assigned the primary function of nature area based on a set of ecological criteria. The resulting area constitutes some 36 percent of the total area of the EU.

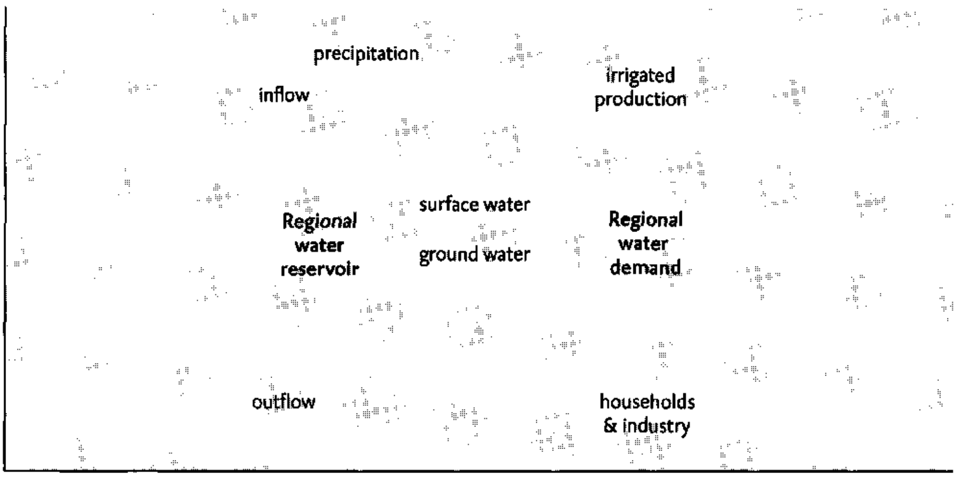
Source: Bischoff and Jongman (1993)

4.3.2 AVAILABILITY OF WATER FOR IRRIGATION

The calculations with the WOFOST crop growth simulation model have shown that the availability of water throughout the growing season is the major growth-limiting factor to be considered. In several regions the differences between the rain fed water-limited production and the potential production are substantial. However, the shift from water-limited to potential production presuppose that sufficient water is available for irrigation purposes at the regional level. Therefore, additional information on the availability of water is needed to be able to assess the limitations for future agricultural production.

Because water is demanded by several competing categories – i.e. drinking water, industry and agriculture –, at least a rudimentary analysis of water supply and demand on a regional basis is needed. In its most simple form, the relation between supply and demand of water can be outlined as in Figure 4.12.

Figure 4.12 **Regional supply and demand of water. Estimates on precipitation, the inflow and outflow of rivers and the demand for water from households and industry are necessary to assess the availability of irrigation water.**



Of all surface water, 50 percent is assumed to be available for use by households, industry and agriculture. The other 50 percent are necessary for other functions of surface water, especially transportation. All surface water originates from precipitation surpluses, which can be indicated with a run-off coefficient (Van Leeden 1975). Estimates of these coefficients can be used to assess the available quantity of surface water in each region. For some regions, inflow and outflow of surface water through rivers should also be taken into account. The net effect of these two flows must be added or subtracted from the available surface water.

The use of groundwater should be restricted so as to avoid depletion. The sustainable use of groundwater can be calculated from the maximum quantity of water available to replenish the groundwater storage. This has been assessed for nine member states of the EU (CEC 1982). For the other three countries (Greece, Spain and Portugal) the maximum use has been set at 7 percent of the yearly precipitation, an estimate that is in line with the observation that the extractable quantities of groundwater in the other member states vary between 5 and 10 percent of the yearly precipitation.

The demand of households and industry in a region can be deduced from figures on the level of member states (International Institute for Environment and Development and World Resources Institute 1987). The number of inhabitants in a region is used as a proxy to arrive at a regional breakdown of water use in households; the regional breakdown of water use in industry is based on the regional share of the GNP. A substantial part of this water can be reused, because it is not transformed but only serves a throughput.

For example: a large share of the industrial water demand is used as cooling water, which after having served its purpose is re-introduced into the regional water basin. This 'recycling' of cooling water implies that 100 percent can be reused for irrigation purposes.

In Table 4.4 the regional gross need for irrigation water is compared with the water availability. The need for irrigation water has been deduced from the difference between the water demand in the potential and in the water-limited situation. Grass has been taken as the standard crop here because it has the highest water requirements stemming from the long growing season and constant soil coverage. Thus the figures represent an estimate of the maximum need for irrigation water. The water availability results from the regional precipitation surpluses from which the demand by households and industries has been deducted. Hence, agriculture has been given a lower priority for water use than households and industry.

A number of additional assumptions have to be made to complete the set of equations. First, not all water meant for irrigation will indeed be utilised. This can be referred to as the 'irrigation efficiency' of a system; there will always be losses due to transportation, evaporation and other leakages. In this study, the irrigation efficiency is set at 75 percent, implying that 25 percent of water available for irrigation purposes will be lost. This is an arbitrary assumption that may be adapted when more knowledge and expertise enables an increased efficiency. Second, not all water shortages will be covered with additional irrigation water. Rainfall is highly unpredictable and shortages will occur at all places, be it that the incidence will vary enormously. It would be impossible to provide irrigation facilities for every event. Therefore, a maximum allowable shortage has to be defined. In this study, the maximum allowable shortage has been calculated as the amount of irrigation water needed per month if only once in a five-year period a deficit occurs. The resulting water balance indicates whether the demand for irrigation can under these assumptions be covered by the useable stocks and flows of surface and groundwater. The additional information on precipitation and surface flow that is needed to calculate the water balance can be found in Appendix C. It can be seen from Table 4.4, that in 20 regions there is not enough water to fully cover the maximum need for irrigation water. In the model calculations these shortages have been taken into account by incorporating a number of equations that represent the regional water balance (Scheele 1992).

Table 4.4 **Regional water balance. The available water for irrigation purposes is not enough to cover the need for irrigation water in all regions. This need is indicated by a maximum allowable shortage that indicates a water shortage during the growing season once every five years.**

	needed irrigation water		water balance		maximum shortage
Schleswig-Holstein	729	45	297	19	-93
Niedersachsen	1768	37	1057	22	-84
Nordrhein-Westfalen	649	19	-2729	-80	-80
Hessen	447	21	-1042	-49	-83
Rheinland-Pfalz	321	16	1083	55	-78
Baden-Wurttemberg	313	9	-453	-13	-39
Bayern	1248	18	6034	85	-76
Saarland	51	22	-144	-63	-84
Ile-de-France	767	64	-7277	-606	-102
Bassin-Parisien	11391	78	7652	52	-102
Nord-Pas-de-Calais	767	64	-682	-56	-88
Est	2193	45	3825	79	-91
Ouest	6501	75	3994	46	-97
Sud-Ouest	8389	79	5346	50	-92
Centre-Est	3102	43	7441	103	-95
Mediterranee	7129	101	8	0	-133
Nord-Ovest	947	28	7204	212	-87
Lombardia	1738	71	3730	151	-72
Nord-Est	2255	56	11414	286	-51
Emilia-Romagna	1651	73	1996	89	-126
Centro	2949	70	6291	150	-139
Lazio	886	50	1342	76	-148
Campania	547	39	2998	210	-141
Abruzzi-Molise	779	49	2500	157	-140
Sud	5051	108	1746	37	152
Sicilia	3900	142	-1640	-60	-160
Sardegna	1041	42	2569	104	-155
Noord-Nederland	149	17	-1	0	-72
Oost-Nederland	296	29	-17	-2	-79
Zuid-Nederland	200	28	-884	-126	-83
West-Nederland	138	15	-3186	-354	-82
Vlaams-gewest	536	39	-4556	-334	-80
Region-Wallone	438	26	1147	68	-86
Luxembourg (G.D.)	61	23	351	133	-75
North	40	2	4420	273	-48
Yorkshire & Humberside	312	20	785	51	-74
East-Midlands	583	37	884	56	-83
East-Anglia	520	42	1177	94	-80
South-East	1566	56	-6021	-215	-86
South-West	1123	47	2079	87	-96
West-Midlands	510	39	2095	161	-87
North-West	195	27	-1200	-165	-93
Wales	545	27	2516	122	-87
Scotland	448	6	33029	418	-58
Northern-Ireland	224	16	4489	320	-69
Ireland	1501	22	24836	357	-72
Danmark	3423	79	4904	113	-88
Ellas (North)	3518	59	3380	57	-166
Ellas (Central)	3500	56	2045	33	-183
Ellas (East)	838	52	439	27	-185
Noroeste	1959	42	5735	122	-105
Noreste	12529	170	-8003	-109	-134
Madrid	2398	287	-2390	-286	-191
Centro	48978	219	-30630	-137	-188
Este	10106	159	-8842	-139	-151
Sur	29634	291	-23491	-231	-202
Norte-do-Continent	5074	109	2846	61	-179
Sud-do-Continent	11182	240	-8382	-180	-197

4.3.3 DEMAND FOR FINAL PRODUCTS

The primary function of the agricultural system is to meet the demand for food. In this model exercise too, the demand for agricultural produce has been taken as the main driving force. In this exploratory approach, it is not very relevant to predict the future demand for food. Instead two elements that would seem most uncertain with regard to future demand, i.e. foreign trade and diet change, have been selected to provide four estimates for future food demand.

The selection of these two uncertain elements implies that other factors are considered to be more constant. The standard feature of almost all future studies concerns population growth. Since population statistics of the EU indicate that population growth will come to a standstill, this factor is not likely to change the total volume of agricultural consumption. Population growth has therefore been left out of the analysis.

It is conceivable that an increasing average income will lead to a change in diet. This factor is, however, subject of uncertainty. Current figures suggest that people tend to eat more meat, eggs, and snacks if their average net income rises (Goodland 1997). This implies that food demands shift from primary production (vegetables, grains) towards secondary production (livestock and dairy).
To incorporate this behavioural response a potential change in diet is determined that reflects a shift from grains towards meat and dairy products (Scientific Council for Government Policy 1992: 80). This change will have a dramatic effect on agricultural production, since large areas of land will be needed for the conversion of primary plant products (feedstuffs) into animal products (meat and eggs).

The second uncertainty relates to the way in which trade may develop. If the EU will pursuit a policy aimed at self-sufficiency (or at price protection with self-sufficiency as a result), agricultural products will not be imported or exported. If, on the other hand, free trade becomes the prevailing trend, imports and exports of different agricultural products will result (Scientific Council for Government Policy 1992: 82).

The combined effect of a change in diet and a shift in trade relations is presented in Table 4.5. A changed diet will lead to a rising demand for potatoes, sugar, fruit, beef, mutton, chicken, eggs and dairy products. The demand for flour will decrease. In a self-sufficiency situation no imports or exports will occur. In a free-trade situation imports of wheat and in particular grain substitutes like oilseed and oilseedcake will rise. The figures in Table 4.5 represent the yearly needed agricultural production within the EU for four different situations.
The GOAL model has been applied to all these four different demands, be it that some perturbations have been left out on considerations of logic.

Table 4.5 **Four different variants of the demand for agricultural produce in the EU. In the self-sufficiency situation no imports and exports take place. In the free-trade situation a part of the final demand is covered by imports and some of the final products are exported (columns 2 and 4). All figures are in million tonnes.**

	CURRENT DIET		CHANGED DIET	
FINAL PRODUCTS	Internal production	Im/export under free trade	Internal production	Im/export under free trade
flour	46.9		37.5	
potatoes	31.3		37.9	
sugar	10.3	1	14	1.4
vegetable oil	5.6		5.3	
fruit	20.2		26.1	
beef	7.6	0.8	11.4	1.1
pork	12.5		12.5	
mutton	1.2	0.3	2.1	0.5
chicken	5.4		7.9	
eggs	4.6		7.3	
milk	31.2		44.9	
butter	1.7	-0.2	2.3	-0.2
cheese	4.4	-0.1	6.6	-0.1
full milkpowder	0.2	-0.2	0.3	-0.2
skimmed milkpowder	0.3	-0.1	0.4	-0.1
timber & pulp	78.5		78.5	
INTERMEDIARY PRODUCTS				
wheat		2.3		1.9
oilseeds		15		15
oilseedcake		10		10

5 THE 'DECISIONISTIC' COMPONENT: ASSESSMENTS OF GOALS

5.1 INTRODUCTION

The analysis of the maximum productivity gains described in Chapter 4 forms the technocratic part of the pragmatic approach in this study. The scientific analysis of the agricultural production system constitutes a firm basis for the following decisionistic part. Here, a strict scientific analysis will not be possible. Rather, an analysis is made of policy goals related to land-based agriculture that are to be achieved within the EU. The confrontation of these political goals with the technical possibilities of the system can give valuable information on feasibilities, conflicts and impossibilities. To arrive at that type of information an optimisation approach is necessary in which the various policy goals are given explicit priorities. The information that this exercise produces may be used to focus the political debate in the EU on issues that are relevant to attain the various policy goals. In this chapter the deduction of the policy goals and the process of optimisation using the GOAL model is explained. The results will consist of a set of scenarios that describe different optimisations of sets of policy goals given the technical structure of the agricultural production sector described in Chapter 4.

The specification and optimisation of policy goals will undoubtedly introduce a subjective element in the methodology. It should be clear that this does not in any way undermine the robustness of the methodology or the relevance of the results. One of the key factors of a pragmatic approach is the possibility to modify the chosen specification and optimisation if the results of the exercise are not satisfactory and an evaluation leads to the formulation of alternatives. A possible rephrasing of the decisionistic component can be regarded as an intended outcome: with the evaluation of the first results and the reformulation of the specification and/or optimisation the facilitation of the policy process has begun.

5.2 HOW TO OPTIMISE WISHES?

5.2.1 THE SELECTION OF GOAL VARIABLES

The GOAL model is ultimately used to confront wishes regarding a number of land-use related goals with possibilities that have been defined by the technical features of the agricultural sector. The wishes, or goals, that have been incorporated in the model were extracted from national and supra-national policy documents. Thus the model reflects the actual political debate as closely as possible. Since the goals are to be incorporated in an optimisation model, all goals have been defined in terms of maximising or minimising a certain variable.
Eight goals have been selected:
1 maximisation of yield per hectare;
2 maximisation of total labour;
3 minimisation of deviation from current regional distribution of labour;

4 minimisation of total pesticide use;
5 minimisation of pesticide use per hectare;
6 minimisation of total N-fertiliser use;
7 minimisation of N-fertiliser use per hectare;
8 minimisation of total costs.

In various documents, these goals play an important part in the considerations to initiate or continue a given policy. However, publications do not deal with all goals, rather in each publication a different goal prevails. Maximisation of yields per hectare has been the dominant aim of the CAP since its first formulation in the Treaty of Rome in 1957. According to article 39.1 the promotion of technical progress should lead to a rise in agricultural productivity. Productivity rise can be measured in a number of different ways. Since the present study is primarily concerned with land-use, soil productivity has been selected as a method to determine productivity rise.

Maximisation of total labour may need some clarification. Initially the CAP sought to augment the competitiveness of the agricultural sector while at the same time supporting family farms in their existence. This had already been stated in the conclusions of the Stresa Conference in 1958 that paved the way for specific policy measures. The pursuit of these two improvements made it clear that from the outset of the CAP at least partly conflicting policy goals were involved. Especially in a situation of market saturation, any increase in efficiency inevitably leads to a decrease in the volume of labour needed. On the other hand, Member States have also formulated objectives as to maintain the rural structures of production, which ultimately boils down to maintaining the labour force in agriculture (Winters 1990). To address these policy goals labour has been incorporated in this study in two ways: total labour in agriculture can be maximised and the current regional distribution of labour can be maintained as much as possible. The first goal variable can be used to illustrate the tension between pursuing efficiency and maintaining labour at the level of the EU. The second goal variable may illustrate the potential conflict at the regional level between upholding regional agricultural labour and increasing productivity at the same time.

The next four goal variables reflect the recent political awareness that agriculture does also produce a number of less desired outputs. Negative effects on the environment do occur, differing from amenity aspects to human health hazards. The sprawl of agricultural activities may lead to diminution of biotopes, eutrophication of nature areas and contamination problems (OECD 1989). The wide diversity of effects opens up a wealth of possibilities to measure the potential influence of agriculture on the environment. In this study pesticides and nitrogen fertiliser have been chosen to address two different types of problems. Pesticide use leads to direct ecotoxicological concerns, because it relates to health hazards. The use of nitrogen fertiliser represents a pollution problem (eutrophication) with major impacts on nature values.

For both substances, a distinction has been made between emissions per unit of land area and emissions per unit of product so as to emphasise the difference between nature conservation concerns and environmental concerns.
Nature conservation deals with the quality of a given area of land, which can be threatened by local emissions. Therefore controlling the levels of emissions per hectare is relevant to this green environmental concern. On the other hand, environmental protection deals with the overall effects of human activities on environmental quality. In this case, control over the total level of emissions from agriculture is more adequate. The two goals illustrate that there is no simple, unidimensional environmental goal that can be related to agricultural production. To assess political relevant impacts on the environment it is necessary to define more explicitly what aspect of the environment is of political concern.

The last goal variable can be regarded as the overall stimulus on the whole production system. All efforts must eventually lead to reducing the total costs of production so as to enhance the profitability of agricultural activities. Again, in various policy documents variations on this goal variable can be found: farmers should earn a reasonable income and consumers should have products at reasonable prices. Both these goals are served by lowering the costs of production.

5.2.2 POLITICAL PHILOSOPHIES AS GUIDELINES

The GOAL model as described in Chapter 4 has been used to investigate the effects of the eight policy objectives that were defined. However, a fragmented analysis of these policy objectives would not really contribute to the overall policy debate that was introduced in Chapter 1. A better way to link the analysis to the actual policy debate is the construction of scenarios that constitute a recognisable stance. In a technical sense this was achieved with the aid of the IMGLP procedure, in which the values of individual goal variables have been optimised interactively to arrive at scenarios that reflect combined sets of policy constraints. With eight goal variables and no other additional information, this may lead to a profusion of possible scenarios. This implies that for each scenario one needs some clues as to the extent to which the goal variables should be constrained and in what combination this should be done. To that end four political philosophies have been discerned indicate which goal variables should be preferred and which critical values should be observed.

In real life ideas about the regional dominance of economic efficiency and environmental concerns are related. Thus, in the model exercise the possibilities of the eight policy goals are visualised by setting up combinations of policy objectives in a limited number of scenarios. The appraisal of these scenarios will be subjective by definition. The assessment of the net impact of a policy requires subjective judgement of the value of the different objectives in terms of other objectives. With the IMGLP procedure, it is possible to exhibit the trade-offs between various objectives in quantitative terms.

By combining the objectives in policy scenarios, it is possible to exhibit the consequences of an actual position in the political debate.

Four contrasting political philosophies related to land-use have been fed into the model by assigning different preferences to the eight policy goals. The philosophies have been chosen to represent maximally differing opinions in the debate. They must be regarded as extreme positions; their differences can give an indication of maximum policy influence. The four philosophies are:

1 Free trade and Free market (FF);
2 Regional Development (RD);
3 Nature and Landscape conservation (NL);
4 Environmental Protection (EP).

The philosophy of *Free market and Free trade* (FF) considers the agricultural production sector to be no different than any other economic sector. Hence, in a liberal market system the sector will prosper. To achieve this situation, a free and open international market for agricultural products has been assumed. To avoid market disturbances the restrictions on the sector stemming from other than economic objectives should be as little as possible. Hence, a minimum of restrictions in the interests of social provisions and environment result. This philosophy is frequently encountered in international bodies, especially within the WTO.

The philosophy of *Regional Development* (RD) accords priority to the development of regional employment within the EU. It is regional employment that creates regional income in the agricultural sector. This implies that policy measures that threaten the current division of labour over the regions of the EU will be contested. Through time the measures within the CAP can be understood if measured against this philosophy: improvement of the agricultural productivity should be accompanied by measures to uphold the workforce in agricultural regions. Therefore this philosophy can be regarded as a continuation and extension of current EU policy.

The conservation of natural habitats forms the basis for the philosophy of *Nature and Landscape* (NL). The greatest possible effort should be made to identify and secure scenic area and nature reserves for example by creating zones to separate these areas from agricultural areas. Only by securing large relatively undisturbed areas it will be possible to conserve valuable wildlife and plant species. This implies that agriculture should take place on as little surface area as possible, with a minimal impact on the surrounding environment. Besides protected nature reserves, areas would also be set aside for human activities. Nature conservation groups are exponents of this philosophy.

The last philosophy of *Environmental Protection* (EP) is primarily aimed at preventing alien substances from entering the environment. In contrast to scenario NL, the main aim is not to preserve or stimulate certain plant and animal species, but to protect soil, water and air. Therefore, nature conservation areas and agricultural areas do not have to be physically separated. Farming may take place everywhere, but subject to strict environmental restrictions. This philosophy is in line with the concept of integrated agriculture that was developed partly at the instigation of the Scientific Council for Government Policy (Van der Weijden et al. 1984).

5.2.3 CONSTRUCTING SCENARIOS FROM PHILOSOPHIES

The four political philosophies direct to divergent restrictions to the eight policy goals selected. In the IMGLP procedure these divergent sets of restrictions produce four different outcomes of the optimisation procedure with the goal model. In principle, four different scenarios would result from this exercise, but since demand is an exogenous variable that can take on different values, the number of scenarios might increase. However, not all combinations of internal constraints stemming from the political philosophies and external demand stemming from information on developments in diet and international trade are relevant. A few examples can illustrate this.

In scenario FF, the total cost of agricultural production is minimised and no other restrictions are put to the objectives. Moreover, free trade implies that import and export are allowed, so the demand for agriculture produce from within the EU 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 to meet the demand defined by free trade circumstances. Still two different calculations can be made according to a final demand for agricultural produce in line with either current or changed diet requirements. In contrast to that, in scenario EP again the costs of agricultural production are minimised, but here strict limitations are put to the use of fertilisers and pesticides. Next to that, the demand for agricultural produce is fitted to self-sufficiency, since a combination of strict legislation for environmental purposes is not very well imaginable in a free market trade orientation.

With these different sets of restrictions the model will select regional types of land-use that agree with the imposed restrictions. This is done interactively in the IMGP procedure by alternately minimising or maximising an objective function while restricting the other objective functions to a certain domain.
For example: total cost is minimised while labour is not allowed to drop below 6 million manpower units (MPUs). In this way, scenarios can be constructed that show the effects of prioritising the various policy objectives. Still, there are numerous ways in which the model can comply with the imposed constraints. For example: to maintain the labour force above 6 million MPUs, the model can select various types of land-use with a relatively high input of labour,

while at the same time minimising the costs. Therefore the different political philosophies should give a sense of direction to further constrain the additional goals so as to attain a result that is identifiable.

In a number of consecutive steps the user of the model can create different scenarios for land-use. In this study, the four policy views replace the actual policymaker as the user of the model. The constraints that are put to the objective functions are chosen in line with the various philosophies. The resulting scenarios may show policymakers how their priorities can affect land-use and how the effects are distributed over the EU.

5.3 POLICY OBJECTIVES IN FOUR SCENARIOS

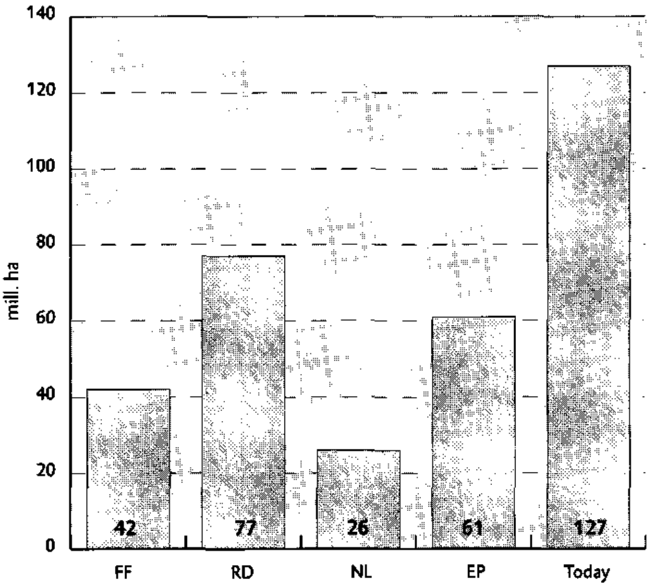
5.3.1 RESULTS AT THE LEVEL OF INDIVIDUAL GOALS

The model calculations point to dramatic differences between the four scenarios. The values of the individual goals differ from scenario to scenario and from one area of policy to another. When it comes to land-use the highest value is some three times higher than the lowest. The difference is twofold as far as land-based agriculture, employment and use of nitrogen (total and per hectare) are concerned. Highest values for use of crop protection agents per hectare are 4 times the lowest, while the totals differ by a factor of 7.

Land-use

Although the highest and lowest values for land-use vary widely, all four scenarios lead to a considerable reduction in agricultural land. This is illustrated in Figure 5.1, where the area of land required under the four scenarios is compared with the current amount of land under cultivation. The highest land productivity is achieved in scenario NL, where the area of agricultural land is smallest. Of the 127 million hectares of agricultural land now in use, some 26 million hectares remain in scenario NL. The other scenarios also lead to a sharp fall in the area of land required: 42 million hectares in FF, 76 million hectares in RD, and 60 million hectares in EP. These results indicate that policies that aim to maintain the area of agricultural land at the current level will have to fight an increasingly fierce battle to withstand the overall trend. This is relevant for the current set-aside schemes that aim to prevent the production of surpluses, but at the same time prohibit the definitive abolition of agricultural land.

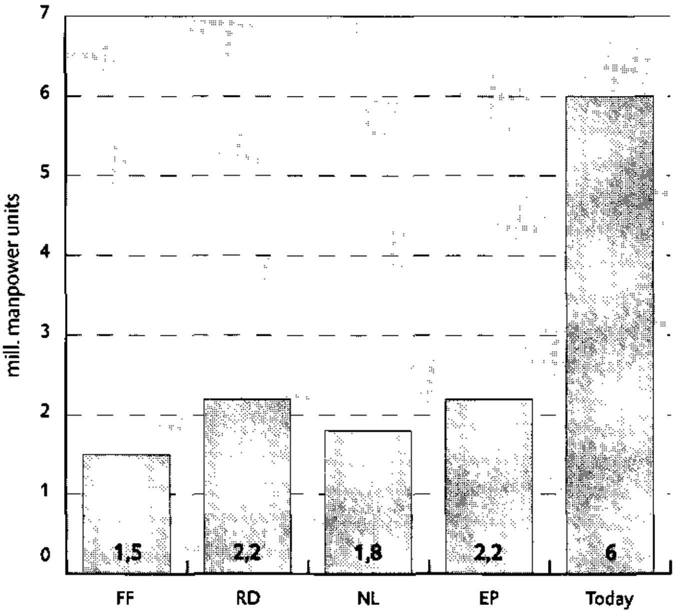
Figure 5.1 **Land-use in the four different scenarios compared with current land-use (in mill. hectares)**



Employment

All scenarios show a further reduction in agricultural employment (see Figure 5.2). The current level of employment in agriculture cannot be continued. Even in scenario RD, in which an attempt is made to keep as many people as possible employed in land-based agriculture in the EC without subsidies, employment declines. Of the 6 million MPUs today (figure from 1988/89), no more than 2.8 million remain. Preserving the current level of employment, then, amounts to maintaining hidden unemployment (in some regions up to 50 percent), and this costs a great deal of money. Moreover, the loss of jobs in the agricultural sector already amounts to 2 to 3 percent a year. If this trend continues, in 15 years' time employment will be about 40 percent lower than today, despite all the measures taken.

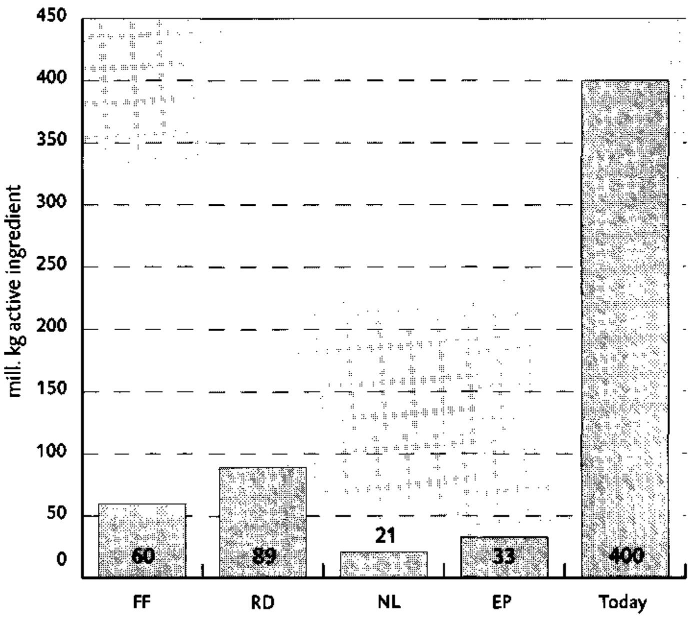
Figure 5.2 **Employment in the four different scenarios compared with current employment (in mill. manpower units)**



Environment

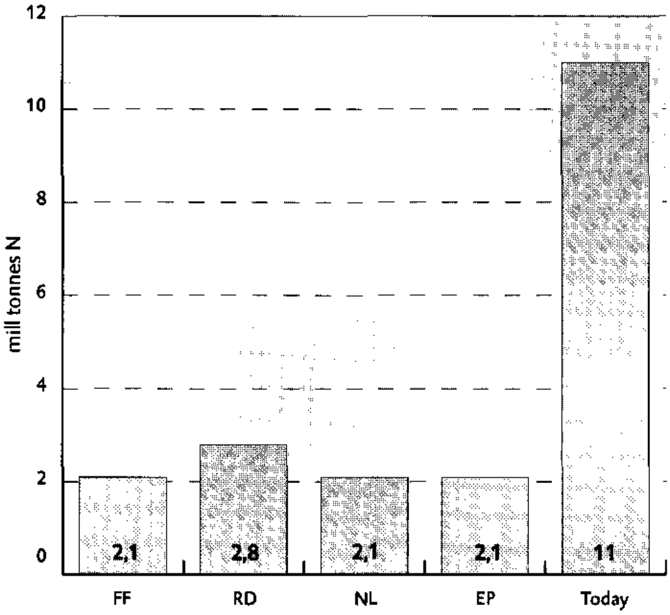
The quality of the environment is affected mainly by the use of crop protection agents and artificial fertiliser. It is technically possible to significantly reduce the use of both nitrogen fertiliser and crop protection agents without adversely affecting production. This is shown in Figure 5.3 and Figure 5.4. In particular crop protection offers scope for a dramatic improvement due to the superiority of the cropping techniques that have been defined. In particular, more sensible rotation schemes can avoid the necessity to decontaminate the soil in-between successive crops.

Figure 5.3 **Use of crop protection agents in the four different scenarios compared with current use (in mill. kg)**



In current European policy a reduction in the use of fertilisers and pesticides is seen as a service which farmers render to society. It is assumed that consequently they will suffer a loss of income and must therefore receive compensation. However, the scenarios show that the surplus of nitrogen and the use of crop protection agents can be sharply reduced without loss of production.
So, there is no need for compensating measures if policies are set up that aim at this target. However, there are considerable regional differences as far as the environment is concerned. In the northwestern corner of Europe in particular, where the use of pesticides and nutrients is highest, a reduction in use can take place without necessarily leading to a lower level of production. From a rational and efficient management point of view, the current situation can be characterised as overuse. These results show that it is precarious to take general policy measures with regard to a highly differentiated, regional activity such as agriculture. The differences between current practice and the scenario results indicate the technical feasibility of successfully promoting more environmentally friendly production methods, policy amendments that limit the use of nitrogen fertiliser and, above all, reduce the overuse of crop protection agents.

Figure 5.4 Loss of nitrogen fertiliser in the four different scenarios compared with current loss (in mill. tonnes)

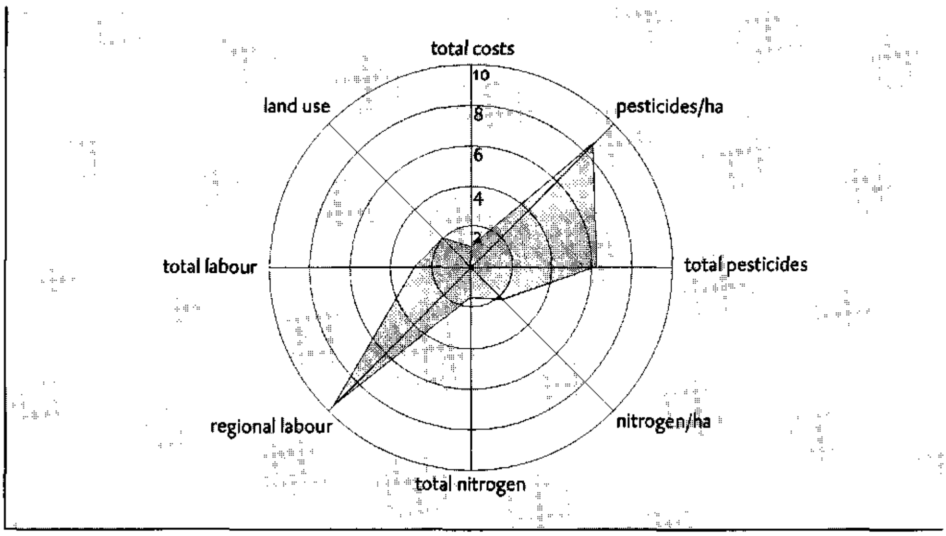


With respect to the costs of agriculture, a difference of 20 billion ECU exists between scenarios FF and NL. This difference can be seen as the price to be paid for converting large areas into protected nature areas. The difference in costs between RD and EP is difficult to attribute to a single factor. However, the uniform distribution of employment required in RD offsets the lower use of nitrogen in EP. Maintaining the current distribution of employment or attaining a relatively low level of environmental pollution can be accomplished at comparable costs.

5.3.2 COMPARISON BETWEEN THE FOUR SCENARIOS

Although it is possible to compare the individual scores for the four scenarios, it would be more informative if a comparison could be made between the four scenarios as a whole. This can be accomplished by standardising the outputs of the model calculations (Van Latesteijn and Rabbinge 1994). In the IMGP procedure, first all goals are optimised without any constraint put to each of the other goals. These optimisations render the best values that can be obtained for each of the goals, given the technical possibilities and other constraints that have been built into the model. The final results in the scenarios can be standardised by taking these best attainable values for each of the goal variables as the unit. This is illustrated in Figures 5.5, 5.6, 5.7 and 5.8. These radar plots show for all goal variables how much worse the score is in the scenarios compared with the best attainable score for that goal. So, Figure 5.5 shows that in the scenario FF the minimisation of pesticides per hectare is 8 times worse than the best attainable value, whereas the minimisation of total costs is almost perfect (=1).

Figure 5.5 Standardised scores for all goals in scenario Free Trade & Free Market (FF)



In Figure 5.6 the standardised results are given for the scenario RD. It is clear from a comparison with Figure 5.5 that the resulting radar plot has a much more regular shape. This indicates that better results may be achieved with respect to pesticide use and the division of regional labour in particular, but at the same time that these improvements lead to an increase in total costs of agriculture.

The same type of conclusions can be drawn when comparing Figures 5.6 and 5.7. In the NL scenario the regional employment goal scores rather bad as a result of concentration of agriculture in regions where production causes the least negative effects on the environment. A comparison of Figure 5.7 with Figure 5.8 reveals that the NL scenario does not score much worse on the environmental goals expressed in a per hectare basis. Again this can be understood given the fact that the EP scenario seeks to minimise the local emissions of agriculture to the environment. This is achieved by using production techniques that are environmental friendly, but also by spreading agricultural production over larger areas. However, where the NL scenario strives for an efficient agriculture in environmental terms, it does so using the smallest area possible. Still, the EP scenario does not show a favourable value for the regional labour goal variable, which indicates that the areas under agricultural production in this scenario differ from the areas where agriculture is presently concentrated. Or, in other words, an efficient distribution with respect to environmental efficiency does not comply with the current distribution of agricultural production.

Figure 5.6 Standardised scores for all goals in scenario Regional Development (RD)

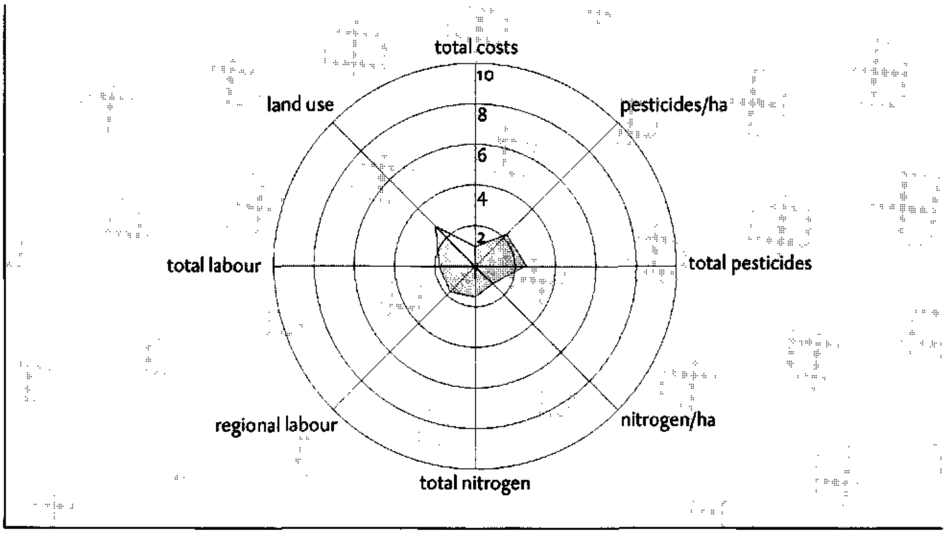
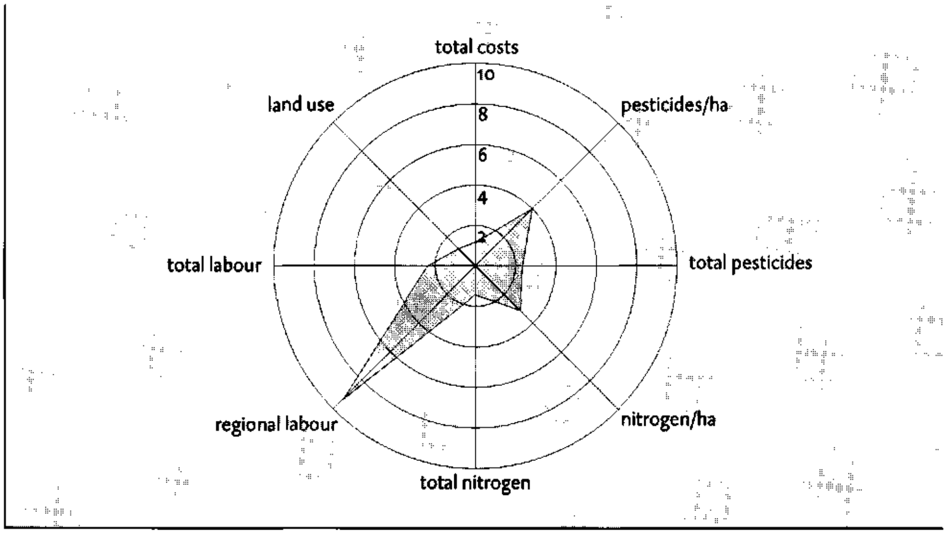
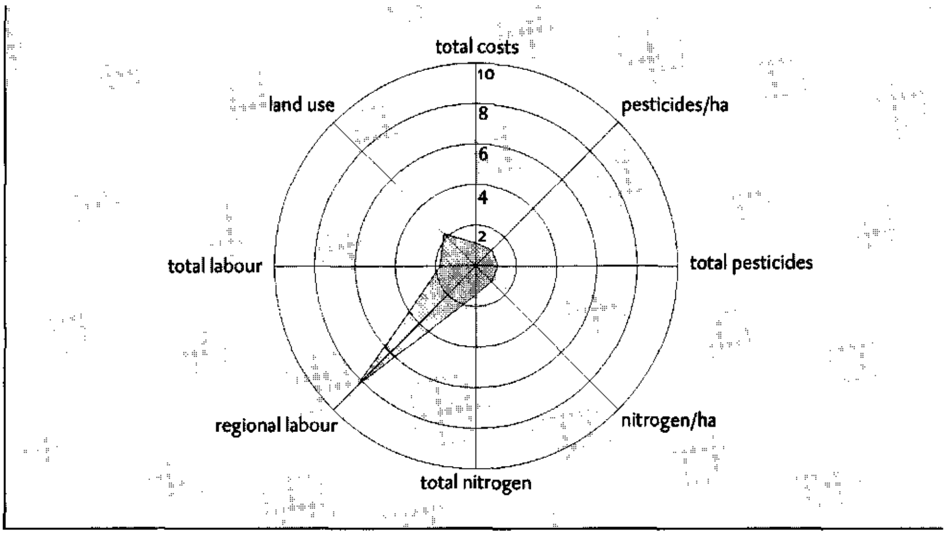


Figure 5.7 Standardised scores for all goals in scenario Nature and Landscape (NL)



This way of presentation has the additional advantage that the area of the plot indicates the average score of the scenario. If in a scenario all goals are much worse off than their optimal values, the resulting plot will cover a relatively large area. If, on the other hand all goals are near their maximum, the resulting plot will be close to a circle with radius 1. One must bear in mind that possible weighing factors have not been taken into account: a doubling of total costs may be valued quite differently than a doubling of land-use. Therefore, the areas of the radar plots are no more than a first proxy of the relative valuation of the scenarios.

Figure 5.8 Standardised scores for all goals in scenario Environmental Protection (EP)



5.4 LAND-USE IN FOUR SCENARIOS: PROPORTION, LOCATION AND TYPE

In Figures 5.9 to 5.12 the regional distribution of land-use in the four scenarios is represented. The maps show the percentage of Utilised Agricultural Area (UAA) per region that is used for agriculture (arable farming, grassland and rough grazings, but without forestry). Five categories are discerned. These categories indicate the fraction of the currently used agricultural area that is utilised in the different scenarios. For example: a classification 0 to 20 percent for the UK in the scenario FF indicates that under this scenario at the most 1/5 of the current area under cultivation will still be used for agriculture. More than 80 percent of the present agricultural area may be used for other purposes.

Figure 5.9 **The percentage of the current utilised agricultural area (UAA) that is used in the scenario Free trade & Free market (FF)**

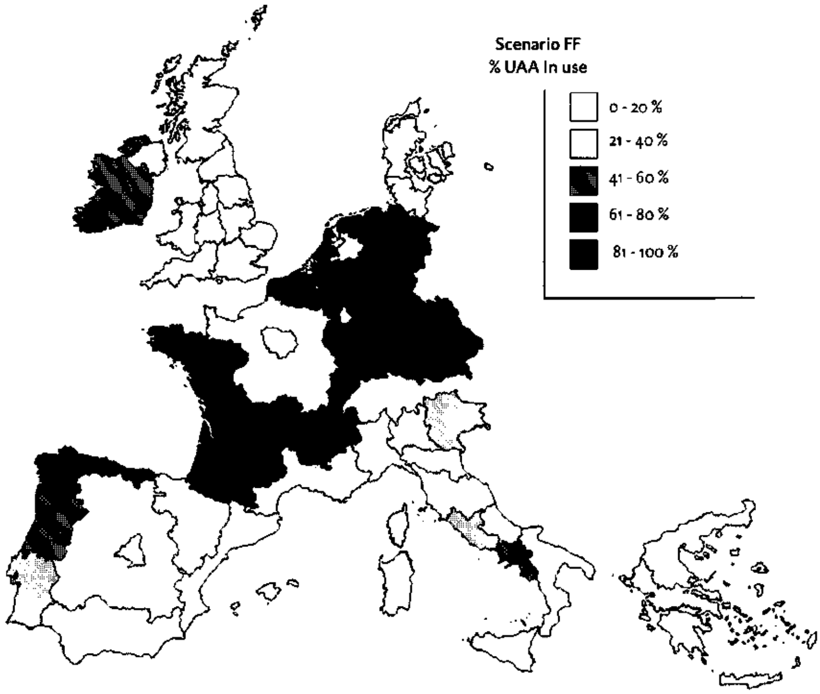


Figure 5.9 shows that under the free trade and free market scenario agriculture is confined mainly to Germany, France, the Netherlands and Belgium.
These regions fall into the range of 81 – 100 percent. Ireland and Portugal are also involved in agriculture, be it that in these regions only about half of the present area is used. The rest of the EU comes into the category of 0 – 20 percent, which in most cases implies 0 percent. So, from an economic point of view, large parts of Italy and almost all of Spain, Greece and the UK are not preferred; other areas are capable of producing the needed volumes of agricultural products against lower costs.

In the regional development scenario agricultural activities are distributed fairly evenly throughout the EU (Figure 5.10). This, of course, is a direct consequence of the goal that in this scenario the regional distribution of labour must resemble the current pattern. Since the available techniques all encompass a significant improve in productivity, all areas show some decline in use. With the exception of Scotland, almost half of the current agricultural area can still be used for agricultural production.

Figure 5.10 The percentage of the current utilised agricultural area (UAA) that is used in the scenario Regional Development (RD)

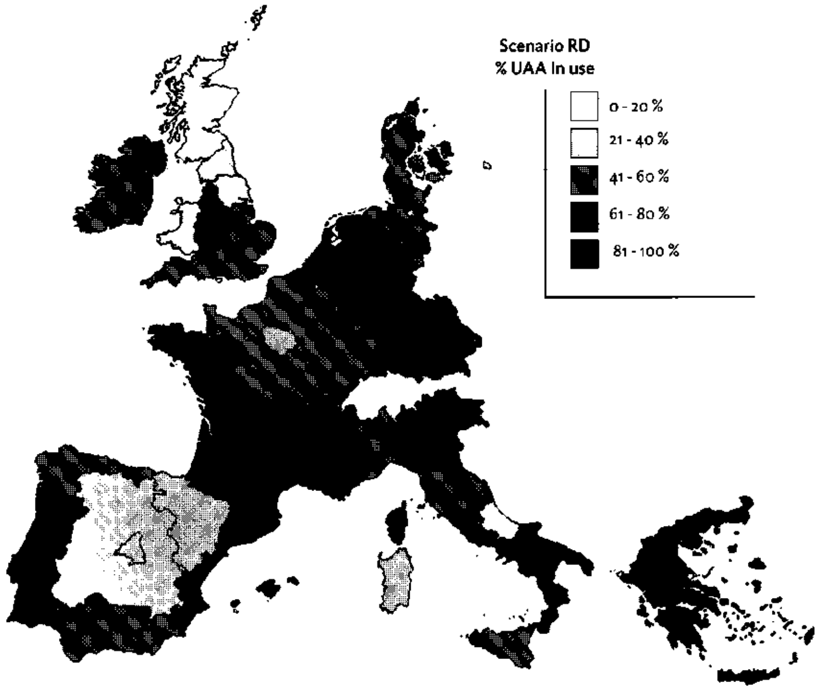
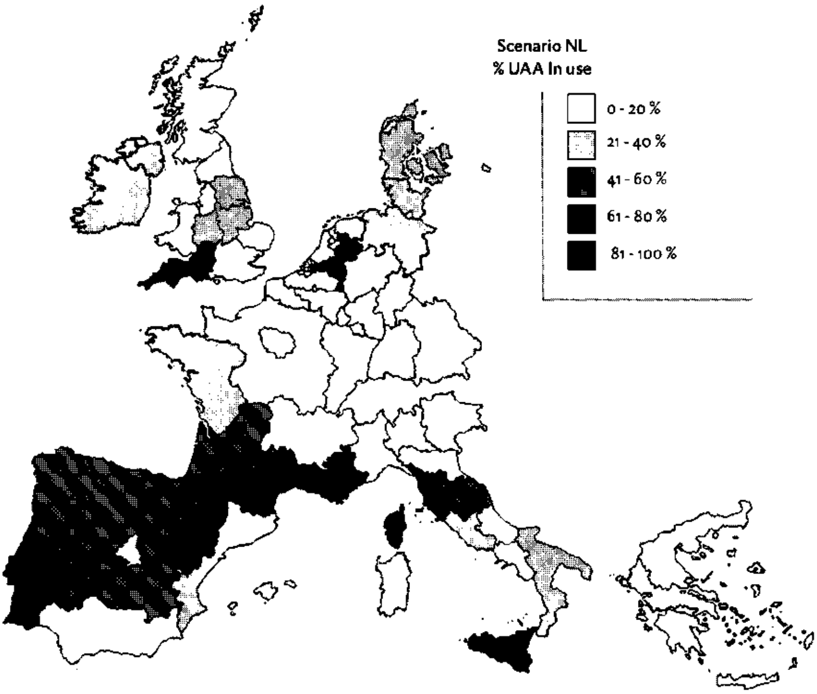


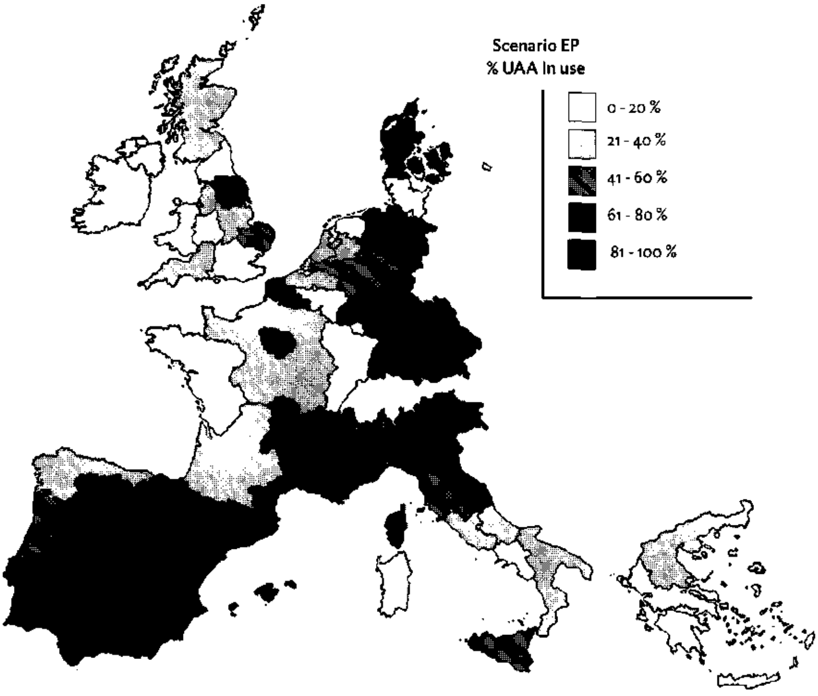
Figure 5.11 shows the distribution of agricultural activities according to the nature and landscape scenario, a pattern almost opposite to the one that is shown in Figure 5.5 (scenario FF). Apparently it is very beneficial to the environment to concentrate agricultural production in a few southern areas of the EU. Given the policy goals involved this result is understandable. For the conservation of nature it is necessary to concentrate agriculture on the smallest surface area possible. This can be done by using environment friendly production techniques (EOA type techniques) and especially the variants that involve irrigation. This selection leads to an agricultural production system that attains relatively high yields on a small area with – again relatively – low levels of losses to the environment.

Figure 5.11 **The percentage of the current utilised agricultural area (AUU) that is used in the scenario Nature & Landscape (NL)**



Finally, in the environmental protection scenario agricultural activities are again fairly evenly spread over the EU (Figure 5.12). Under this scenario the dominant objective is to lower the losses to the environment on a per hectare basis. Since there is no additional constraint to confine agriculture to a small area, one way of achieving this goal is to spread agricultural activities over a large area. Again environment friendly techniques are used, but mainly without using irrigation so as to lower the inputs (and with that the unwanted outputs) on a per hectare basis. Comparison of this distribution with the one given in Figure 5.10 (scenario RD) reveals that the regions that are favourable from an environmental point of view do not coincide with the regions that currently provide an important part of the labour force within the sector. A striking difference between the two scenarios is the relative absence of agriculture in the northwest (United Kingdom, Ireland, the Netherlands and large parts of France) in scenario EP. Apparently the present regional distribution of agricultural production is not in line with an optimal allocation of production aimed at improving the environmental performance of the sector.

Figure 5.12 The percentage of the current utilised agricultural area (AUU) that is used in the scenario Environmental Protection (EP)



The significant differences between the four scenarios show that regions have different potentials for productivity increases if policy constraints are put into effect. 'Weak' regions that are almost out of production in scenario FF show a strong increase in scenario NL. In the latter scenario, which seeks to minimise the area of agricultural land in favour of large nature areas, land-based agricultural activities virtually disappear in a number of regions that hold 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 land-use and agricultural employment problems in the northern member states.

Scenarios RD and EP present a relatively uniform distribution of land-use over the EU. In the RD scenario this results from the condition that maximum employment must be retained in all regions, i.e. 29 percent of the current level of 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. In scenario EP the percentages differ throughout the regions: 50 percent of the present level of employment is retained in Spain, 14 percent in southern Italy, 11 percent in Greece, and 10 percent in Portugal. In general in these two scenarios a shift of agricultural activities to southern Europe results.

For the regions that are currently considered 'strong', mostly situated in the northwestern part of the EU, the Netherlands is representative. In scenario FF, only 5 percent of employment in land-based agriculture is retained in the east of the Netherlands (the minimum allowed in any scenario), 18 percent in arable and livestock farming in the south, 26 percent in the west, and 36 percent in the north. In scenario RD, 29 percent of employment is retained in all regions; a condition imposed in this scenario. In scenario NL, land-based agriculture disappears from the Netherlands almost completely; the remaining 5 percent employment is provided by forestry and some livestock farming in the south. In scenario EP, the same picture emerges: 5 percent employment remains in arable farming in the north, east and south and in forestry in the west. Similar effects occur in Denmark, Germany, Belgium and Luxembourg. These results show that 'strong' is a relative term and conditional to the policy objective that is prioritised.

6 DISCUSSION

The results provided by this study can be evaluated at three different levels. First, a comparison can be made between the stated demands for a method to explore future possibilities in agriculture and the method that has evolved in this study. Does the method comply with these demands? Were these demands sufficient so as to develop a useful method? Are there additional remarks to be made after having developed the methodology? Second, the results of the exercise can be evaluated. The scenarios that were constructed were meant to clarify the policy debate on the continuation of the CAP. Do the scenarios add to the information that was already available? Can this additional information be used to improve the debate on policy reforms? And is this improvement noticeable in the ongoing discussions? Thirdly, the methodology can be looked upon from a more general level. The objective of this study was to develop an explorative method to assess future possibilities for land-based agriculture in the EU. This methodology was defined as a confrontation of technical features of the system and political goals that are to be achieved with this system. Can this type of reasoning also be transferred to other questions and other domains? What are the pertinent elements that should be watched carefully? Is there a possibility, in short, that this type of analysis can be more commonly used? These three fields of discussion will be addressed below.

6.1 THE FEATURES OF THE GOAL MODEL

The GOAL model can be characterised as a combination of already existing scientific approaches. The scientific basis of the model is formed by crop growth analyses, which are abundant in agronomy. This is combined with classification results from soil sciences, characterisation of policy goals from political science and then put into a linear programming framework that stems from operations research. What is new is the combination of these elements into one methodology.

This combination made it possible to come up with an end result that is neither technocratic, nor decisionistic by nature. Overstating either the importance of scientific facts or political wishes does not disturb the delicate balance between science and policy. Instead, the GOAL model contains both technocratic and decisionistic aspects. The technocratic aspect is formed by the basic assumption that the laws of nature necessarily bound productivity rises within the agricultural sector. No matter what level of production one tries to achieve, the limit of what is possible is governed by some biophysical order: agricultural production consists of utilising the productive capacity of plants and precisely this capacity is governed by a set of relatively well known scientific principles. If this would have been the sole factor involved in assessing future possibilities, the result might easily have been dismissed as technocratic or far-fetched and therefore irrelevant to the present policy debate.

If, on the other hand, the model had been based primarily on a set of subjective political preferences, the critique could have been that the exercise consisted of nothing more than an inventory of wishes. However, the GOAL model transcends these two narrow extremes by combining the estimation of the maximum technical potential of the agricultural production system with a number of political goals that play an important role in the current debate on the reconstruction of the CAP. With this combination the GOAL model tries to reconcile the different priorities in the two extreme positions. A pragmatic approach to the problem at hand results: neither the scientific facts, nor the political beliefs are taken as a point of departure. Within the model the role of the two domains is restricted to their strongest points: a scientific analysis can indicate to the limits of development and the appraisal of political goals can indicate inconsistencies in our striving.

In Chapter 2 it was stressed that scientific information has to be convincing to affect the prevailing opinions in the policy debate. It was also illustrated that projective future analyses can hardly ever deliver this type of 'hard evidence'. For that reason in the methodology described in this study another direction was chosen. The GOAL model is not aimed at producing a forecast. The scenarios explore technical possibilities to attain a set of well-founded policy objectives. These possibilities are explored by investigating the technical limitations that restrict the potentials of the agricultural sector. These limitations form the 'hard facts' that are needed to convince policymakers. Policy instruments such as price changes and assumptions on the behaviour of actors as well as institutional obstacles are deliberately excluded. Hence, although its results indicate the technical limitations to such changes, this is not a study of the effects of possible amendments to the CAP. In many other policy areas such a definition of technical limitations would be impossible (for example, when should a country be considered 'full', or what level of prosperity is 'enough'?). It is possible for land-based agriculture in the EU, though, because here well-known quantitative data (demand for agricultural products, technologies, possible use of land, etc.) form a sound basis.

After publication of the report 'Ground for choices' the first critiques showed that the deliberate restriction to a description of future possibilities was not well understood. To some reviewers this methodology was of not much use in view of the agricultural problems in the real world, which asked for an immediate solution. Generally the discussions revealed that much of this opposition could be traced back to a certain degree of misunderstanding or misinterpretation. There is a rather strong tradition of performing future studies for the agricultural sector that are based on econometric modelling. Most reviewers compared the results of this type of forecasts (viz. predictions) to the outcome of the four scenarios presented in 'Ground for choices' and upon observing differences rejected the study, including the methodology. Only after some time the reciprocity of the two approaches came to the fore. Recently first attempts have been made to combine the two approaches.

However, care should be taken when integrating two approaches that aim at very different targets, as will be more extensively argued in paragraph 6.3.

Among agronomists discussion started on the scope of the farming systems defined in the GOAL-model. Especially advocates of ecological and/or organic farming stated that these types of farming were not sufficiently represented by the three orientations (YOA, EOA and LOA) in the model. By itself, of course, the production orientations may be contested. The specification of techniques in the framework of the GOAL model does not imply an outline for tilling and a specification of farm-level activities. It merely states a possible input-output relation within the agricultural production system that may be realised with different farming practices. The real challenge in the context of the GOAL model lies in the formulation of 'other' farming systems in usable model specifications. If the critics of the study would take up the challenge, the discussion on the alleged advantages of a specific type of agriculture might be rationalised considerably with the aid of a series of model calculations. Consensus building on these issues would benefit greatly from such an endeavour.

A separate discussion that runs through all other debates concerns the usefulness of the concept of best technical means. The question that is raised time and again is whether it is *realistic* to assume that at any given location within the EU high skilled farmers will be able to put optimal management techniques into practice and realise optimal efficiencies. For a number of critics these production levels are too far fetched. However, the problem can also be reversed. An exploration of future possibilities should not be based on assumptions regarding plausibilities (= realistic) but it should be based on scrutinising feasibilities (=possible). So the question should be whether there are any sound arguments to assume that certain farmers or regions will not be able to perform in a best technical way. Or in other words: will the northwestern European farmer be superior to his Mediterranean colleague at all times? If there is no convincing answer to this question, then the possibility of optimal performance in all regions of the EU should be faced. An explorative study that would postulate a structural constraint would be very difficult to defend indeed.

The same holds true for the more general concept of 'inevitable efficiency losses' that was put forward. The idea here is that potential production levels will never be realised, because there will always be losses that cannot be avoided. However, if this line of thought is adopted, how much less than optimal is 'realistically' feasible? For example, in a projection of future land-use in the Rhine basin area an 'attainability factor' of 90 percent is introduced to account for the losses due to imperfect control over weeds, diseases, pests and nutrient provision (Veeneklaas et al. 1994). With this factor the authors try to increase the reliability of their estimations that were obtained using a similar approach to assess future agricultural production. However, the 10 percent loss is as arbitrary as 15 percent or 5 percent. Moreover, if such a factor had been used in this study, given the substantial differences between actual and potential water-limited yields the effect on the results would have been marginal. If there is no independent information on the proportion of the potential yields that will not be feasible in future, any factor could be introduced. For a study that investigates the limits to productivity growth an estimation of future production based on potential and water-limited yields and best technical means seems to be the only sensible approach.

Finally, the level of the potential and water-limited yields for the different regions and the various crops can also be debated. The estimations for the GOAL model are based on information that was available in the early 1990's about crop characteristics and climate conditions. Although the differences between these calculated levels and the observed yields at that time are apparent from model scenario results, in retrospect these calculated potentials seem rather conservative. For example: during the last few years Dutch wheat growers realised yields of over 10 tonnes per hectare, which is even higher than the potential yield for wheat that was used in the GOAL model. Next to this it may be that plant breeders create new variants that increase the potential yield even further. The overall effect of all this would be that the potential yields are even higher than anticipated in the present GOAL model. This would imply a slight sharpening of the general results of the model exercise.

6.2 SCENARIOS AND POLICY

A popular way of expressing the relationship between (scientific) research and policy is the metaphor of the gap. This gap prevents the immediate use of research findings in the policy arena. The obvious solution for this unwanted situation is the construction of a 'bridge' that crosses the gap. Almost always the construction of this bridge encompasses a set of rules that is meant to structure the process of research and tries to get researchers and policymakers in a collaborative mode. Again, almost without exception these efforts are in vain.
After some time it is recognised that the gap is still present and new propositions are put forward to construct another type of bridge.

The gap metaphor assumes that without the gap there is a continuous plane that consists of researchers and policymaker. But, as explained in Chapter 2, it is very questionable whether such a continuous plane exists in real life. It is more likely that researchers and policymakers live in their own realms, their own cultures, and that only occasionally there are functional relations between these two realms. Therefore, another metaphor should replace the gap and, consequently, the bridge. Maybe a better way of describing the situation is the metaphor of two tribes that try to establish a peaceful coexistence. This implies that they sometimes need a bridge, while on other occasions there is much more need for a strict separation to maintain the integrity of the tribe. Fully bridging the 'gap' between two tribes would lead to the extinction of the original tribes and the creation of a new one. From the viewpoints of both the original tribes this result is not very attractive.

This metaphor is consistent with the observation that science has its own system of quality control and that policy has its own rationality. In applied science an occasional bridge between the two realms is constructed if the scientific analysis is able to serve the policy process at the right level. In this study the optimisation of stylised policy goals is used to arrive at such a level.

On an earlier occasion Sicco Mansholt, the late agricultural commissioner of the EU, revealed that he would have wanted the results of a GOAL model when he was involved in developing the CAP in the late 50's and early 60's (Rabbinge et al. 1994a). The reason for his sigh was that a GOAL model would have enabled him to focus the debate on the consequences of all the incremental wishes that were brought into the policy debate. Model calculations like these can act as a more or less unimpeachable authority that may discipline the discussion. In the absence of such an authority every argument brought into the discussion will inevitably lead to counter arguments and a seemingly endless game of give and take. However, the optimisations of relevant policy goals obtained with the GOAL model do not try to bridge a gap between science and policy, between knowing and wanting, rather the outcomes may fulfil a functional role in the way in which the political issues are brought under discussion. Formulated this way, it will be very difficult to trace the precise impact of any scientific finding in the policy debate, although it can be illustrated that there are numerous issues that may benefit from this type of information. Whether or not the information that was brought in from science has played, or will play, a crucial role in the political decision process is highly speculative.

This study did not aim to build a bridge by stressing the plausibility of the scientific analysis. It was demonstrated in Chapter 2 that scenario studies that lean heavily on plausibility may give rise to an oversimplified maximisation of policy goals. This type of policy-oriented future study may backfire if the scenario results go beyond the limits of normative policymaking. For the policy process it is not very relevant to receive a message that contains a maximisation that will never be encountered in the political reality. In the pragmatic approach presented in this study the aim was to provide information on future possibilities. These possibilities are not based on an assumption of plausible developments, but on scientific information on production potentials and normative information of acceptable combinations of policy goals. This information on possibilities is still very relevant. The discussion on the reform of the CAP did not end with the policy reforms effectuated in 1992. New initiatives for a major transform of the CAP have been brought up. The ideas of the Commission have been stated in the Agenda 2000, but these policy proposals are now being overtaken by the actual developments. The most intriguing and challenging task will be to find an answer to the intended enlargement of the EU. If the EU is extended with several new member states that have a considerable potential for agricultural production, the findings of this study will be further sharpened.

But even without this complication the results as they stand can be used to question a number of assumptions and expectations that go without saying in the current policy debate. A few examples may illustrate this.

The current EU policy is aiming for *extensification* of the agricultural production. This political attention to the means of production stems from the underlying assumption that less inputs (nutrients and pesticides) will lead to a diminished impact on the environment. However, the research carried out to define the GOAL model has underlined that this relationship is somewhat more complex. The environment benefits from an agricultural production system that shows the lowest possible losses of nutrients and pesticides to the environment. However, there is no simple and direct relationship between inputs and losses. In the study it was shown that this minimisation of losses can be expressed both per unit of production and per unit of surface area. Which of these two is preferred is governed by the precise definition of what element of the environment is prioritised: conservation of nature areas or a general environmental quality. In both cases the environment benefits if agriculture is performed in a highly efficient manner. Hence, only in an agronomically efficient production system the inputs are efficiently used and thus the losses are minimised. The policy plans of the EU seem to neglect this relationship. The policies tend to follow the easy route by aiming at a reduction of inputs. According to the same logic, reducing inputs below the optimal level will bring the production system further away from its agronomic efficient optimum. If the production system drifts away from its optimum, not only the inputs of nutrients and other primary inputs will go down, but to a larger extent the yield will be lower too. Of course, in some regions current practices show a considerable overuse of inputs. But this problem should be addressed by sanitation measures. A generic policy that aims at extensification per se may therefore be counterproductive and, most importantly, have a detrimental effect on the environmental quality by stimulating sub-optimal ways of production.

A second example is the afforestation policy of the EU. The idea behind this policy is that former agricultural areas may be used for forestry and this may kill two birds with one stone: part of the problem with agricultural overproduction can be solved and at the same time the demand from society to reforest the countryside is addressed. This study shows that indeed there is ample space within the EU to set up commercial forestry on a large scale. However, it is also clear that the agricultural well-endowed regions are also the regions where forestry might prosper. Even worse: large areas in the southern regions of the EU – for which the afforestation policy was devised so as to alleviate the agricultural problem – are not suited for forestry from an agronomic point of view. Thus forestry might develop in the regions that politicians did not have in mind when they set up the policy. On top of this the estimates of high yielding forest reveal that in potential only about four million hectares of forest will be sufficient to meet the demand for forestry products within the EU. These figures indicate that afforestation policies will only scratch the surface of the real problems within the agricultural sector.

A third and final example concerns the notion that with sufficient accompanying measures the rise in productivity can be controlled. The idea here is that set-aside programs and agri-environmental programs will subdue the ongoing rise in productivity. The results of the GOAL model indicate that the potentials for a further growth in productivity differ considerably from region to region.
In Spain and Portugal there can be an almost 40 percent increase before the yields will come into the range of the technical maximum. In the Netherlands the technical maximum has virtually been reached; at present yields are recorded that even exceed the calculated potentials. This indicates that generic policy measures that aim at slowing down the productivity rise will be off target in two ways. For regions in Spain and Portugal the effort will have to be tremendous to control such an enormous potential. For regions in the Netherlands the measures will be superfluous, since the technical maximum has already been reached. The effect of this can only be that the costs involved with this policy will show a rampant increase where the results in terms of controlling productivity will be negligible.

The strength of the model scenarios obtained with the GOAL model lies in the possibility to take any policy goal that is related to land-based agriculture to its logical conclusion. This information can help to concentrate the debate on the relevance of these goals and put into perspective the actual attention that is given to them. At present great effort is given to maintain the situation that all agricultural area is used for agricultural production. The results in the different scenarios demonstrate that this policy will be difficult to uphold if no other constraints will impede the process of productivity growth and no new perspectives for agricultural markets will announce themselves. As a consequence, the costs of the CAP will not decrease, environmental objectives will not be achieved, surpluses will increase and socio-economic goals will be jeopardised. Therefore, a more targeted adaptation of the CAP is needed. The scenarios may help in defining that target and it might well be that, all things considered, other goals should be given preference. The answer to the question what we want must be formulated in a political decision process. The scenarios obtained with the GOAL model form only one source of the instruments to facilitate that process.

6.3 THE FUTURE OF EXPLORATIVE FUTURE STUDIES

The methodology described in this study was crafted with an explicit question in mind, i.e. whether it is possible to define structural limitations of the agricultural production system, and if so, whether this description of the system with its limitations can be used to asses the possibilities for achieving a set of policy goals. The questions guided the development of the methodology into the direction of an exploratory future research. The resulting model approach can be characterised as pragmatic, to discern the method from technocratic and decisionistic approaches. In this pragmatic approach it was possible to produce information that may improve political decision making. Whether or not this improvement will occur is only mildly related to the model exercise itself.

The policy arena has its own dynamics that determine the outcome of a complex process of information consumption, display of power, dealing, et cetera.

The interaction between science and policy has its own dynamics also.
In Chapter 2 it was illustrated that policy-oriented studies are under a constant strain to deliver results that comply with the expectations within the policy domain. An exploration of the future will not immediately convince policymakers that the information contained in this type of study is relevant to and useful for their core activity. The natural tendency of policymakers is to ask for information that can diminish the level of uncertainty and point into the direction of the 'right' decision. Against this background information on possible future developments will not be sufficient but information of the most likely chain of events is badly needed. Therefore, the dynamics of the interaction between policymakers and scientists will push into the direction of projective future studies.

The debates following the publication of the report 'Ground for choices' clearly illustrate this tendency. The call for a more 'realistic' description of possibilities and the incorporation of other than biophysical constraints in the model are good examples of the type of improvements that are suggested. De Koeijer et al. (1999) propose an agro-economic framework to address the perceived problem of over-estimation of potentials if only biophysical constraints are considered. The framework is intended to help identify new farming systems. For this purpose it connects an explorative future study to normative farm economics and behavioural economics. Normative farm economics introduces the farm, as an economic agent surrounded by constraints and objectives, in the exploration. Given behavioural economics the variation in rational behaviour of the economic agents is also taken into account. It should be clear, however, that by combining different approaches the essence of the exploratory approach is lost.
The mixture of approaches is apparent from the different types of efficiency that play a part in the framework (agronomic, ecological and economic) but also from the different claims as to the type of results that should be obtained. Instead of identifying feasibilities, the framework aims at identifying plausible farming systems by incorporating normative economics and even probable developments by incorporating behavioural economics.

The purpose of the GOAL model, however, is to inform the political decision making process. The basic assumption in the general approach is that the political process is sovereign with respect to political choices and the scientific community is sovereign with respect to analyses of order and regularity in nature (and society). This implies that within the scientific community the singular agronomic, ecological and economic efficiencies can be assessed, whereas the weighing of these efficiencies against each other is a political prerogative.
This approach is truly pragmatic in the sense that it is fully understood that the analysis must provide policymakers with the best available information to facilitate an informed decision, but it is never forgotten that 'political efficiency' will ultimately be the decisive force.

Policy-oriented future studies should therefore be explicit in their aims. Exploratory future studies may be used to provide information on feasibilities with the ultimate aim to enable an informed discussion on policy goals. Information obtained from an economic analysis incorporates the plausibilities of human reactions to changing market conditions and sometimes even the probabilities of a given chain of events; therefore the aim of this type of analysis is different. Economic analysis tries to systemise the reactions of economic agents and from that infer the probability of future developments. Precisely this type of information is needed to enable an informed discussion on the effectiveness of proposed policy measures. These two aims and intentions should not be mixed in a research design. The persuasive power of an exploratory future study is weakened if the 'hard scientific facts' that underlay the analysis are mixed with estimations of elasticities that can hardly be transposed to the frontiers under exploration. Vice versa the predictive capacity of an economic projection is weakened if the balanced system of behavioural equations is merely used to mitigate calculations based on extreme possibilities. In both cases the combination of the two approaches impairs the message that each of the two methods can bring.

A more fruitful strategy might be an iteration of both approaches, each dealing with one aspect of information supply towards the policy domain.
Exploratory future studies may help the strategic policy debate. Furthermore, an exploration of feasibilities can provide scientific information that may improve the economic model that is used for projective purposes. For example: the boundaries presented in this study on productivity rise per region and per type of production technique can help targeting policies but they can also be used as additional technical constraints in an economic analysis. Exploratory studies describe future possibilities, without taking into account the current situation and the dynamics that may influence changes in the near future.
Economic analyses address precisely those elements: from information on observed elasticities the behaviour of economic agents is derived and this information can be used to project future developments. The quality of this projection can improve if the information gained from an exploration of feasibilities is taken into account. Results from exploratory scenario studies can be used to formulate the boundary conditions for further research with 'econometric' models. The rephrased question then becomes how a technically feasible and politically desired situation might be attained, given the present situation and information on behavioural constraints of all parties involved. The transfer of information obtained from economic analysis to exploratory scenario studies is also relevant. In that case the specification of the model used in the exploration benefits from insights gained in economic optimisation studies. In the GOAL model, for example, it was necessary to define so-called non-essential inputs such as labour and machinery. The levels of these inputs stem from farm models that mimic the rational behaviour of farmers in optimising these economic inputs.

Whenever economic analysis leads to new information about these levels the specification of the exploratory model can be adapted. In this way the understanding obtained in both approaches is used most efficiently.

In all configurations of policy-oriented scientific research and analysis there will always remain a grey area between information that can be legitimised from science (cf. the normal science in Figure 2.2) and value judgements that are contested in the political arena. The methodology developed in this study clearly deals with both these elements. This methodology differs from other possible approaches in that scientific facts and political goals retain their identity throughout the process of analysis. The assessment of the physical boundaries to production is a scientific activity that can be judged by the peer community for its scientific quality. The construction of scenarios based on political philosophies is an attempt to inform policymakers. The assessment thus shows all the symptoms of post-normal science as described by Funtowicz and Ravetz (1991). In the application of this methodology on the future possibilities for land-based agriculture in the EU it proved possible to make a clear distinction between scientific assessment and subjective optimisation. This implies that the debate on the quality of the scenarios can only partly take place within the scientific community. Still, the persuasive power of the scenarios can benefit from the quality of the 'hard scientific facts'. However, a debate on the quality of the results (the scenarios) extends the scientific peer review community and should encompass the subjective notions of stakeholders and the uncertainties that are illustrated by the different scenarios. If this debate focuses the attention on the relevance of prioritising policy goals related to land-based agriculture, then the methodology was successful in attaining the objective of the study.

It is almost self-evident that limits to agricultural production derived from physical and biological laws can act as boundary conditions for the optimisation of agricultural policy goals. In other areas of research and policy this distinction between scientific analysis and political optimisation cannot easily be made. But simply denying the differences in quality and information content of the numerous facts, assumptions and beliefs that constitute our understanding of complex systems will not overcome this difficulty. Nor is it very helpful to wait until a 'Newton' appears in sociology, political science or economy who will formulate the 'laws' that seem to be necessary. Developing those laws by trial-and-error and opening up the new possibilities that will flow from those efforts may well be seen as a daunting task for policy-oriented science. A first assignment is then to systematically separate facts from more subjective assumptions and goals in all policy-oriented future studies and treat these two categories differently in the analysis.

This study has revealed that a pragmatic approach to future agricultural land use in the context of EU policies leads to reproducible results that can also be translated into political priorities. The combination of scientific analysis and subjective optimisations made it possible to produce the needed 'hard facts' from science without overestimating their relevance. However elegant the combination of these facts with the more decisionistic analysis of policy goals may be, ultimately the reform of EU agricultural policy is a political decision and the legitimisation of this decision is therefore political and not scientific by nature.

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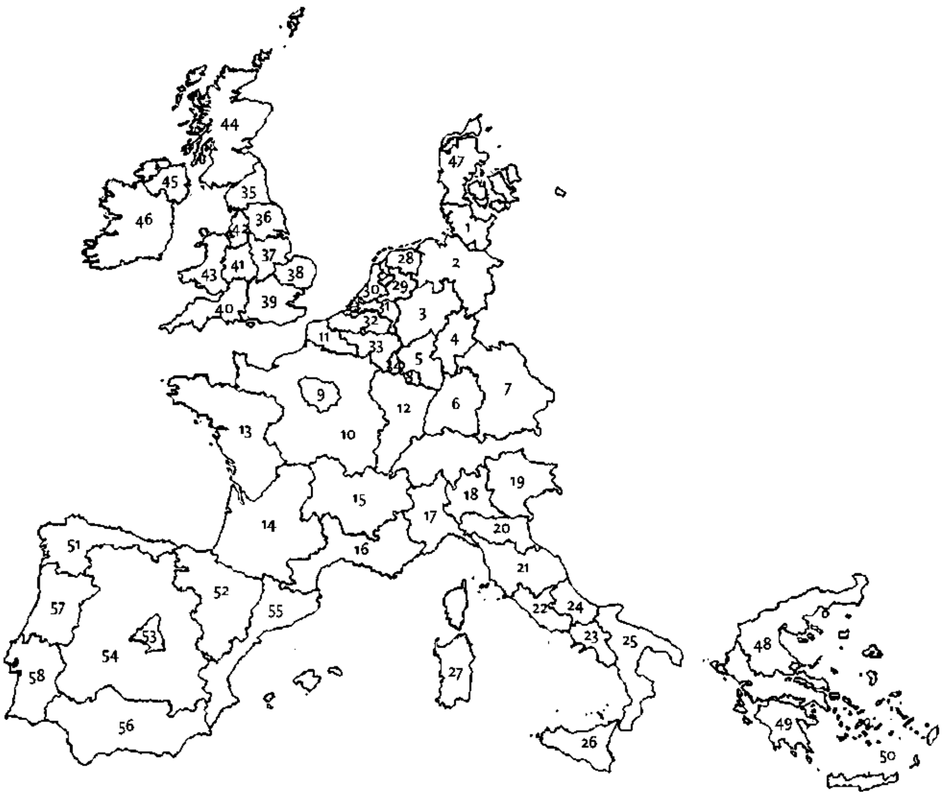
8 APPENDICES

A THE NUTS-1 REGIONS OF THE EU-12 USED IN THE GOAL-MODEL



Nr Official NUTS-1 name			
1 Schleswig-Holstein	16 Mediterranée	31 West-Nederland	46 Ireland
2 Niedersachsen	17 Nord-Ouest	32 Vlaams-gewest	47 Danmark
3 Nordrhein-Westfalen	18 Lombardia	33 Région-Wallone	48 Ellas (North)
4 Hessen	19 Nord-Est	34 Luxembourg (G.D.)	49 Ellas (Central)
5 Rheinland-Pfalz	20 Emilia-Romagna	35 North	50 Ellas (East)
6 Baden-Wurttemberg	21 Centro	36 Yorkshire & Humberside	51 Noroeste
7 Bayern	22 Lazio	37 East-Midlands	52 Noreste
8 Saarland	23 Campania	38 East-Anglia	53 Madrid
9 Ile-de-France	24 Abruzzi-Molise	39 South-East	54 Centro
10 Bassin-Parisien	25 Sud	40 South-West	55 Este
11 Nord-Pas-de-Calais	26 Sicilia	41 West-Midlands	56 Sur
12 Est	27 Sardegna	42 North-West	57 Norte-do-Continent
13 Ouest	28 Noord-Nederland	43 Wales	58 Sud-do-Continent
14 Sud-Ouest	29 Oost-Nederland	44 Scotland	
15 Centre-Est	30 Zuid-Nederland	45 Northern-Ireland	

B. ACTUAL, POTENTIAL AND WATER-LIMITED PRODUCTION IN 58 NUTS-1 REGIONS OF THE EU-12

In the following tables the potential and water-limited yield of the indicator crops wheat, grain maize, silage maize, sugar beet, potato and grass are presented for the 58 NUTS-1 regions. The figures indicate the average yield per region in kg fresh weight per hectare. These averages were calculated with the WOFOST crop growth simulation model over a period of thirty years using historical climate data. For each region the percentage of the agriculural area suited for the crop is also included in the tables. Actual yield figures for grass are not available.

Source: De Koning and Van Diepen (1992)

WHEAT	%suited	actual	potential	water-limited
Schleswig-Holstein	86	5985	8404	6797
Niedersachsen	74	4830	8203	6627
Nordrhein-Westfalen	60	5166	7941	7293
Hessen	34	4851	7969	6884
Rheinland-Pfalz	28	4473	7987	7027
Baden-Wurttemberg	38	4431	8591	8325
Bayern	43	4725	8114	7485
Saarland	42	3969	7987	7205
Ile-de-France	56	5670	8864	6471
Bassin-Parisien	72	5292	8791	6798
Nord-Pas-de-Calais	83	5712	8538	7200
Est	62	4473	8272	7194
Ouest	62	4158	9308	8513
Sud-Ouest	60	3717	9032	7698
Centre-Est	32	3906	8587	6595
Mediterranee	29	2646	8583	5623
Nord-Ovest	20	3192	7080	6400
Lombardia	47	4074	7082	6197
Nord-Est	40	4242	7160	5911
Emilia-Romagna	43	4292	7163	6144
Centro	23	2646	8219	6608
Lazio	13	2184	8474	6709
Campania	11	1974	8312	6668
Abruzzi-Molise	15	2058	7740	5287
Sud	24	1302	8245	5935
Sicilia	30	1512	8486	6414
Sardegna	10	966	8971	6881
Noord-Nederland	70	5439	8281	7087
Oost-Nederland	93	6258	8217	6790
Zuid-Nederland	97	6006	8134	6796
West-Nederland	68	6447	8230	7403
Vlaams-gewest	99	5061	8163	6992
Region-Wallonne	36	5229	8397	7259
Luxembourg (G.D.)	31	3318	8217	6314
North	9	5565	8214	7657
Yorkshire & Humbers.	23	5838	8858	6719
East-Midlands	48	5649	8857	7394
East-Anglia	63	5754	8924	7370
South-East	55	5586	9345	7193
South-West	54	5250	10295	8050
West-Midlands	52	5166	8324	7076
North-West	15	4809	8949	5842
Wales	32	5061	9554	7798
Scotland	19	6006	8969	7829
Northern-Ireland	29	4788	8874	7859
Ireland	47	5817	9440	8453
Danmark	90	5523	8232	5808
Ellas (North)	14	2050	6931	5125
Ellas (Central)	11	2050	6618	5616
Ellas (East&S.Isl)	10	2050	6251	5315
Noroeste	18	1680	9777	7674
Noreste	42	2604	8692	3316
Madrid	59	1764	8491	2810
Centro	44	1848	8823	3021
Este	40	2856	8625	4987
Sur	49	2604	8243	4533
Norte-do-Continent	25	1117	9445	4235
Sud-do-Continent	42	1117	8958	5054

GRAIN MAIZE	% suited	actual	potential	water-limited
Schleswig-Holstein	0	4945	0	0
Niedersachsen	0	4945	0	0
Nordrhein-Westfalen	1	5354	12358	10530
Hessen	30	5569	12413	10934
Rheinland-Pfalz	28	5246	12673	11217
Baden-Wurttemberg	15	5096	12463	11514
Bayern	3	5440	12173	11153
Saarland	42	3806	12653	11081
Ile-de-France	56	6450	12352	8218
Bassin-Parisien	62	5440	12583	8180
Nord-Pas-de-Calais	37	5568	12514	8479
Est	60	6042	12217	10020
Ouest	52	5332	13448	9264
Sud-Ouest	60	5440	13340	8345
Centre-Est	27	4644	13983	9555
Mediterranee	28	4945	12737	3654
Nord-Ovest	20	5375	12187	7603
Lombardia	47	6536	11913	7228
Nord-Est	40	6364	11886	7429
Emilia-Romagna	43	6622	11902	6810
Centro	23	5805	12227	3059
Lazio	13	5246	12054	983
Campania	11	2838	12704	2214
Abruzzi-Molise	15	3956	11838	2933
Sud	24	2193	11564	735
Sicilia	30	5031	11624	572
Sardegna	10	5418	12368	671
Noord-Nederland	0	0	0	0
Oost-Nederland	0	0	0	0
Zuid-Nederland	0	0	0	0
West-Nederland	0	0	0	0
Vlaams-gewest	0	0	0	0
Region-Wallonne	18	6257	12423	8563
Luxembourg (G.D.)	31	0	11654	8900
North	0	0	0	0
Yorkshire & Humbers.	0	0	0	0
East-Midlands	0	0	0	0
East-Anglia	0	0	0	0
South-East	0	0	0	0
South-West	0	0	0	0
West-Midlands	0	0	0	0
North-West	0	0	0	0
Wales	0	0	0	0
Scotland	0	0	0	0
Northern-Ireland	0	0	0	0
Ireland	0	0	0	0
Danmark	0	0	0	0
Ellas (North)	14	7482	11114	3547
Ellas (Central)	11	7482	9977	2370
Ellas (East&S.isl)	10	7482	10801	1112
Noroeste	18	2580	13736	4959
Noreste	42	6622	12754	2298
Madrid	59	7138	12415	685
Centro	44	6708	13263	850
Este	40	5074	11713	2330
Sur	49	7482	11254	272
Norte-do-Continent	23	1643	14473	759
Sud-do-Continent	42	1643	13340	262

GRASS	%suited	potential	water-limited
Schleswig-Holstein	99	17621	14848
Hamburg	87	17982	15364
Niedersachsen	99	18134	15614
Bremen	91	18024	15572
Nordrhein-Westfalen	93	18673	16543
Hessen	98	19251	14795
Rheinland-Pfalz	95	19545	15379
Baden-Wurttemberg	96	18211	16564
Bayern	90	18035	15388
Saarland	95	19688	16237
Ile de France	85	21184	15129
Bassin-Parisien	99	20990	15134
Nord-Pas-de-Calais	96	20471	16084
Est	88	19761	15116
Ouest	98	23164	15923
Sud-Ouest	91	23625	16785
Centre-Est	76	21615	14283
Mediterranee	81	24470	11459
Nord-Ovest	67	22366	15168
Lombardia	79	21840	15744
Nord-Est	71	21737	15798
Emilia-Romagna	81	22715	13444
Centro	73	24550	10649
Lazio	71	26077	9528
Campania	61	25692	10230
Abruzzi-Molise	69	23812	9282
Sud	70	25880	8948
Sicilia	78	26986	8693
Sardegna	67	26577	9239
Noord-Nederland	99	18466	17318
Oost-Nederland	99	18498	16637
Zuid-Nederland	100	18633	16876
West-Nederland	96	18445	17230
Vlaams-gewest	99	19041	16611
Region-Wallonne	99	20131	15612
Brussel	48	19582	17000
Luxembourg (G.D.)	99	19001	15450
North	91	16362	15743
Yorkshire & Humberside	97	18966	17000
East-Midlands	98	19478	16483
East-Anglia	99	19546	16598
South-East	91	20461	16123
South-West	98	22265	17893
West Midlands	93	19374	16356
North-West	86	19543	17517
Wales	84	20503	17038
Scotland	94	18255	17394
Northern-Ireland	95	18624	16930
Ireland	98	19834	17987
Danmark	99	17278	12289
Ellas (North)	42	23523	8370
Ellas (Central)	39	23479	7360
Ellas (East&South Islands)	29	24761	6744
Noroeste	61	25244	14757
Noreste	60	25175	9926
Madrid	85	25366	7838
Centro	83	24227	7702
Este	90	25841	10211
Sur	87	25491	8207
Norte-do-Continente	68	25202	8285
Sud-do-Continente	74	27710	7945

POTATO	%suited	actual	potential	water-limited
Schleswig-Holstein	73	6908	15982	12000
Niedersachsen	66	7321	15634	11891
Nordrhein-Westfalen	56	7519	15128	12784
Hessen	27	5869	15112	11126
Rheinland-Pfalz	16	5874	15246	11192
Baden-Wurttemberg	26	6292	15633	13504
Bayern	37	6595	15514	12334
Saarland	1	4829	15373	13463
Ile-de-France	43	6864	15841	9894
Bassin-Parisien	43	7574	15622	10295
Nord-Pas-de-Calais	70	8949	15317	10983
Est	13	5846	15448	11897
Ouest	55	5528	15606	9277
Sud-Ouest	49	4956	15464	9779
Centre-Est	24	4428	15759	9225
Mediterranee	24	4246	15190	7307
Nord-Ovest	2	4609	14104	9194
Lombardia	9	5379	13906	9311
Nord-Est	16	5918	13894	9442
Emilia-Romagna	26	5918	13906	8947
Centro	16	2816	14757	6740
Lazio	7	3927	14626	5106
Campania	8	3861	14750	6164
Abruzzi-Molise	9	3223	14364	5940
Sud	8	2585	14584	5674
Sicilia	18	3817	15048	5701
Sardegna	6	3718	15021	5303
Noord-Nederland	51	7579	15522	13675
Oost-Nederland	76	9438	15326	13079
Zuid-Nederland	86	9801	15211	12870
West-Nederland	39	9009	15182	13399
Vlaams-gewest	88	7585	15110	12310
Region-Wallone	35	7684	15331	11048
Luxembourg (G.D.)	15	6528	15617	9497
North	9	7964	14521	13091
Yorkshire & Humbers.	22	8360	15484	10983
East-Midlands	28	8492	15492	11074
East-Anglia	41	8360	15632	10172
South-East	42	6600	15899	9580
South-West	46	7590	16144	10390
West-Midlands	47	8712	15079	10892
North-West	14	8316	15507	10897
Wales	31	6490	15687	10802
Scotland	19	7876	14642	12806
Northern-Ireland	29	5764	14879	11900
Ireland	46	4851	15145	11850
Danmark	89	7419	16206	9590
Ellas (North)	10	4213	12902	8120
Ellas (Central)	7	4213	12240	7182
Ellas (East)	6	4213	12959	5084
Noroeste	2	3608	16567	11844
Noreste	12	4246	15088	7852
Madrid	32	4862	14382	6104
Centro	12	4268	15028	5990
Este	12	3938	14723	9180
Sur	13	4202	14063	6238
Norte-do-Continent	6	1848	15982	4996
Sud-do-Continent	25	1848	15426	3745

SILAGE MAIZE	%suited	actual	potential	water-limited
Schleswig-Holstein	86	9990	18383	16027
Niedersachsen	74	10861	19597	17003
Nordrhein-Westfalen	60	11773	20199	18655
Hessen	34	13473	22875	21385
Rheinland-Pfalz	28	12636	23406	21810
Baden-Wurttemberg	38	12645	19720	19053
Bayern	43	12910	22576	21208
Saarland	42	16092	23388	21751
Ile-de-France	56	15617	23258	18202
Bassin-Parisien	72	12435	22851	18092
Nord-Pas-de-Calais	83	14731	21920	19262
Est	62	12447	22707	20333
Ouest	62	11744	23455	19606
Sud-Ouest	60	9180	24160	18138
Centre-Est	32	11394	25213	19584
Mediterranee	29	9395	23862	13422
Nord-Ovest	19	12230	22079	17142
Lombardia	47	14338	21767	16718
Nord-Est	40	12663	21708	16704
Emilia-Romagna	43	12352	21613	16059
Centro	23	11044	22927	12392
Lazio	13	10108	23110	9814
Campania	11	9423	23742	11366
Abruzzi-Molise	15	9369	22098	11807
Sud	24	10250	22539	9658
Sicilia	30	9179	22575	9199
Sardegna	10	17631	23789	9431
Noord-Nederland	70	11889	18707	17409
Oost-Nederland	93	11844	18667	16798
Zuid-Nederland	97	11799	18937	17104
West-Nederland	68	12003	18437	17249
Vlaams-gewest	99	13068	19695	17573
Region-Wallonne	36	12123	21732	19241
Luxembourg (G.D.)	31	11709	22222	18301
North	9	0	6135	6013
Yorkshire & Humbers.	23	12433	14890	13836
East-Midlands	48	10658	15557	14431
East-Anglia	63	9774	15762	14203
South-East	55	9801	17288	15376
South-West	54	10951	17582	15718
West-Midlands	52	10863	14363	13511
North-West	15	11998	15427	13411
Wales	32	11862	15009	14346
Scotland	19	0	6858	6701
Northern-Ireland	29	0	11362	11151
Ireland	47	0	12680	12402
Danmark	90	10667	18956	15316
Ellas (North)	14	3383	21244	13223
Ellas (Central)	11	3383	18285	10062
Ellas (East&S. Isl)	10	3383	19767	8977
Noroeste	17	4731	25162	13683
Noreste	142	12142	24127	11187
Madrid	59	13102	23435	9076
Centro	44	12504	24413	8293
Este	40	9304	22787	11727
Sur	49	13719	22042	7336
Norte-do-Continent	25	0	26268	7132
Sud-do-Continent	42	0	25629	6573

SUGAR BEET	Xsuited	actual	potential	water-limited
Schleswig-Holstein	73	8415	16665	13689
Niedersachsen	66	8740	17464	14121
Nordrhein-Westfalen	56	9645	17690	15570
Hessen	27	9320	19228	16291
Rheinland-Pfalz	16	10100	20038	16797
Baden-Wurttemberg	26	10110	19032	17504
Bayern	37	10880	19760	17507
Saarland	1	6955	20502	18777
Ile-de-France	43	11360	20717	14218
Bassin-Parisien	43	11460	20291	14538
Nord-Pas-de-Calais	70	10425	19290	15181
Est	13	9880	20890	17028
Ouest	55	10165	21006	14058
Sud-Ouest	49	0	21881	13408
Centre-Est	24	10850	22138	13431
Mediterranee	24	0	21325	8856
Nord-Ovest	2	9320	19638	11909
Lombardia	9	9840	18917	11827
Nord-Est	16	9690	18899	11972
Emilia-Romagna	26	8847	18861	11266
Centro	16	6180	20416	7461
Lazio	7	9887	20362	5990
Campania	8	3913	20730	6865
Abruzzi-Molise	9	8340	19465	7087
Sud	8	6200	19092	6356
Sicilia	18	0	19979	6678
Sardegna	6	6747	20949	5949
Noord-Nederland	51	9640	16975	14824
Oost-Nederland	76	12147	16866	14532
Zuid-Nederland	86	10540	17002	14524
West-Nederland	39	11293	16631	14688
Vlaams-gewest	88	10635	17461	14808
Region-Wallonne	35	10250	19079	14841
Luxembourg (G.D.)	15	8880	20025	12760
North	9	0	11070	10528
Yorkshire & Humbers.	22	8560	16048	13165
East-Midlands	28	8695	16326	13282
East-Anglia	41	8560	16458	12801
South-East	42	6758	17692	12924
South-West	46	7772	18290	13774
West-Midlands	47	8920	15876	13567
North-West	14	8515	16257	12648
Wales	31	6645	16432	13929
Scotland	19	0	11783	11086
Northern-Ireland	29	0	14172	13072
Ireland	46	9050	15283	13942
Danmark	89	9010	16582	12308
Ellas (North)	10	12026	17399	8948
Ellas (Central)	7	12026	14069	7579
Ellas (East&S.Isl)	6	12026	12578	5966
Noroeste	2	0	23633	13871
Noreste	12	7720	21237	9318
Madrid	32	8400	20155	6244
Centro	12	7620	21544	6156
Este	12	0	19819	10534
Sur	13	7280	18512	6567
Norte-do-Continente	6	7658	24394	4938
Sud-do-Continente	25	7658	22872	4290

C PRECIPITATION, RUNOFF AND USABLE QUANTITIES OF SURFACE WATER AND GROUND WATER FOR THE 58 NUTS-1 REGIONS IN THE EU-12

	precipitation		runoff coeff.	useable surface water		useable ground water	
Schleswig-Holstein	14859	925	0.39	2897	180	536	33
Niedersachsen	31583	653	0.39	6159	127	2460	51
Nordrhein-Westfalen	27504	810	0.39	5363	158	3847	113
Hessen	14797	693	0.39	2885	135	788	37
Rheinland-Pfalz	15197	766	0.39	2963	149	694	35
Baden-Wurttemberg	25629	709	0.39	4998	138	1577	44
Bayern	63400	898	0.39	12363	175	2491	35
Saarland	1751	766	0.39	341	149	252	110
Ile-de-France	7728	644	0.4	1546	129	347	29
Bassin-Parisien	101391	694	0.4	20278	139	4320	30
Nord-Pas-de-Calais	8495	703	0.4	1699	141	347	29
Est	36580	756	0.4	7316	151	1419	29
Ouest	58196	672	0.4	11639	134	2554	29
Sud-Ouest	68429	646	0.4	13686	129	3122	29
Centre-Est	60292	837	0.4	12058	167	2144	30
Mediterranee	41767	591	0.4	8353	118	2081	29
Nord-Ovest	27100	796	0.62	8401	247	2681	79
Lombardia	25165	1022	0.62	7801	317	1924	78
Nord-Est	33972	850	0.78	13249	332	3122	78
Emilia-Romagna	12068	537	0.62	3741	166	1766	79
Centro	35773	852	0.47	8407	200	3280	78
Lazio	13232	751	0.45	2977	169	1388	79
Campania	15209	1070	0.56	4259	300	1104	78
Abruzzi-Molise	9711	610	0.53	2573	162	1261	79
Sud	30927	660	0.34	5258	112	3690	79
Sicilia	15147	552	0.23	1742	63	2144	78
Sardegna	11300	456	0.39	2203	89	1955	79
Noord-Nederland	6626	772	0.33	1093	127	536	62
Oost-Nederland	7768	772	0.33	1282	127	631	63
Zuid-Nederland	4824	686	0.33	796	113	442	63
West-Nederland	6942	772	0.33	1145	127	568	63
Vlaams-gewest	10952	802	0.37	2026	148	410	30
Region-Wallone	18935	1120	0.37	3503	207	536	32
Luxembourg (G.D.)	2175	821	0.41	446	168	63	24
North	16901	1043	0.62	5239	323	599	37
Yorkshire & Humberside	9074	592	0.62	2813	184	568	37
East-Midlands	8905	567	0.62	2761	176	568	36
East-Anglia	8226	657	0.54	2221	177	473	38
South-East	26733	955	0.34	4545	162	1041	37
South-West	16674	695	0.54	4502	188	883	37
West-Midlands	16165	1245	0.56	4526	349	473	36
North-West	6300	867	0.54	1701	234	284	39
Wales	12533	610	0.56	3509	171	757	37
Scotland	91595	1160	0.72	32974	418	2933	37
Northern-Ireland	14581	1040	0.66	4812	343	536	38
Ireland	78429	1126	0.6	23529	338	3185	46
Danmark	32795	757	0.39	6395	148	2870	66
Ellas (North)	31304	524	0.31	4852	81	2334	39
Ellas (Central)	25992	414	0.31	4029	64	2050	33
Ellas (East)	7710	479	0.31	1195	74	158	10
Noroeste	29086	618	0.51	7417	158	725	15
Noreste	24208	329	0.33	3994	54	946	13
Madrid	4377	524	0.21	460	55	32	4
Centro	84936	379	0.21	8918	40	9965	44
Este	23353	367	0.13	1518	24	788	12
Sur	46651	458	0.19	4432	44	2491	24
Norte-do-Continent	41989	899	0.31	6508	139	4068	87
Sud-do-Continent	22319	479	0.31	3459	74	2144	46

D DUTCH SUMMARY

SAMENVATTING

De hervorming van het Gemeenschappelijke Landbouw Beleid (GLB) staat de laatste jaren hoog op de politieke agenda. De oorspronkelijke doelstellingen van het GLB – die al in 1957 werden geformuleerd – waren er vooral op gericht de landbouwproductie te verhogen en de consumentenprijzen voor landbouwproducten te verlagen. Dat dit beleid succesvol was, blijkt uit de enorme en snelle toename van de landbouwproductiviteit in de Europese Unie. Door deze ontwikkelingen werd echter ook een aantal negatieve externe effecten van landbouwbedrijvigheid zichtbaar en de oorspronkelijke doelstellingen van het GLB bleken niet langer voldoende om de problemen van de hedendaagse landbouw het hoofd te bieden. Nieuwe beleidsdoelen werden opgesteld om de negatieve effecten van landbouwproductie op de maatschappelijke structuur, natuur en landschap en op het milieu tegen te gaan. Toen het GLB bovendien een almaar stijgend beslag bleek te leggen op de beschikbare middelen, werd de roep om hervorming steeds luider. Deze roep alleen bleek echter niet voldoende om het hervormingsproces in gang te zetten.

Veel hervormingsvoorstellen beperken zich tot relatief kleine veranderingen in het gebruikte instrumentarium. Het blijkt moeilijk te zijn een beleid op te geven dat heeft geleid tot een gezonde landbouwsector met redelijke inkomens voor de boeren, redelijk stabiele interne markten, een gegarandeerde voedselvoorziening en redelijke consumentenprijzen. De vraag of het vigerende instrumentarium werd gebruikt om het geformuleerde beleid te realiseren en of bepaalde combinaties van beleidsdoeleinden wel konden worden bereikt, werd niet gesteld. De recente geschiedenis laat echter zien dat veel van de nieuwe voornemens van het GLB worden bemoeilijkt door de voortgaande productiviteitsgroei.

In deze studie wordt gesteld dat het hervormingsprobleem te maken heeft met de relatieve onwetendheid van het GLB ten aanzien van toekomstige mogelijkheden. In hoofdstuk 2 van de studie wordt onderzocht of een toekomstverkenning licht kan werpen op een denkbare en realiseerbare mix van beleidsdoelstellingen. Methoden uit het toekomstonderzoek worden kritisch onderzocht om tot een voor dit doel toereikende methodologie te komen. Geconcludeerd wordt dat een exploratieve benadering, gebaseerd op de beschrijving van de kenmerken van het landbouwproductiesysteem en additionele informatie over de externe condities van het systeem, iets kan zeggen over de technische realiseerbaarheid van het systeem. Een tweede vraag is vervolgens wat de consequenties zijn voor de verschillende aan grondgebonden landbouw gerelateerde beleidsdoelen als er bovengrenzen aan de productiviteitsstijging kunnen worden gesteld. Deze combinatie van een technische verkenning van de realiseerbaarheid en een politieke optimalisatie wordt aangeduid als een 'pragmatische' methodologie. Zo wordt onderstreept dat noch de technische mogelijkheden noch de politieke doelen vorm geven aan de toekomst, maar een combinatie van de twee.

Deze methodologie wordt vervolgens toegepast op de casus van grondgebruik in de EU. Na een algemene beschrijving van de methodologie in hoofdstuk 3 worden in hoofdstuk 4 de technische mogelijkheden voor grondgebonden landbouw in de EU gekwantificeerd. Ten eerste wordt een gewasgroeisimulatiemodel (WOFOST) ingezet om de potentiële opbrengsten van de indicatorgewassen tarwe, korrelmaïs, snijmaïs, aardappelen, suikerbieten en gras te bepalen. Het model gebruikt informatie over gewaskarakteristieken, de bodemkwaliteit en klimaateigenschappen als input. Naast de potentiële opbrengst wordt ook een watergelimiteerde opbrengst berekend voor toekomstige situaties waarin geen irrigatie wordt toegepast en dus uitsluitend gebruik gemaakt kan worden van het van nature aanwezige water. Vervolgens worden de potentiële opbrengsten van de indicatorgewassen vertaald naar landbouwproductiesystemen met een zekere gewasrotatie, managementbeslissingen en gebruik van bepaalde inputs.
Voor deze vertaalslag is additionele informatie nodig over mogelijke landbouwsystemen en teeltmethoden. De vertaling zelf vindt plaats op basis van een deskundigenoordeel. Ten slotte worden de aldus gedefinieerde technische mogelijkheden geconfronteerd met de wensen uit de arena van het gemeenschappelijke landbouwbeleid. De vereisten voor de verschillende doeleinden met betrekking tot grondgebruik, tezamen met alternatieve beschrijvingen van productie-systemen en de vraag naar landbouwproducten worden gebruikt om het lineaire programmeringsmodel GOAL te ontwikkelen.

Acht beleidsdoelen zijn geselecteerd voor opname in het model, te weten maximalisatie van de opbrengst per hectare, maximalisatie van de totale hoeveelheid benodigde arbeid, minimalisatie van de afwijking van huidige regionale arbeidsspreiding, minimalisatie van de inzet van gewasbeschermingsmiddelen, minimalisatie van de inzet van gewasbeschermingsmiddelen per hectare, minimalisatie van de inzet van stikstofbemesting, minimalisatie van de stikstofbemesting per hectare en minimalisatie van de totale kosten. In hoofdstuk 5 wordt beschreven hoe de verschillende beleidsdoelen in een iteratief proces worden geoptimaliseerd om zodoende verschillende toekomstscenario's op te stellen. In dit proces zullen noodzakelijkerwijs keuzen gemaakt moeten worden, waarmee de scenario's per definitie een normatieve lading krijgen. De gecombineerde scenario's weerspiegelen bepaalde preferenties ten aanzien van beleidsdoelstellingen en de consequenties van die preferenties voor het landbouwkundig grondgebruik in de EU. Deze resultaten bepalen de grenzen aan de voor het landbouwsysteem beschikbare mogelijkheden. Vier politieke visies worden gebruikt om verschillende scenario's voor toekomstig grondgebruik vorm te geven: vrije markt en vrijhandel, regionale ontwikkeling, natuur en landschap en milieuhygiëne.

De uitkomsten van de modelberekeningen, weergegeven in hoofdstuk 6, laten aanzienlijke verschillen tussen de scenario's zien. Zo blijkt het agrarisch grondgebruik een factor drie te verschillen tussen de hoogste en de laagste berekende waarden. Deze verschillen belopen een factor twee als naar werkgelegenheid en het gebruik van stikstof wordt gekeken.

De hoogst gevonden waarden voor het gebruik van gewasbeschermingsmiddelen per hectare ligt een factor vier hoger dan de laagst gevonden waarde, terwijl het totale gebruik van gewasbeschermingsmiddelen een factor 7 verschil laat zien. Alle vier scenario's laten een aanzienlijke afname van het landbouwareaal zien. Van de huidige 127 miljoen hectare resteert in het scenario natuur en landschap nog slechts ongeveer 26 miljoen hectare. In de andere scenario's is eveneens een scherpe afname ten opzichte van de huidige situatie te zien; deze varieert van 42 miljoen hectare in het scenario vrije markt en vrijhandel tot 76 miljoen hectare in het scenario regionale ontwikkeling. Deze resultaten maken duidelijk dat beleid gericht op het instandhouden van het huidige landbouwareaal een toenemende strijd zal moeten leveren met een algemene trend van afname van het areaal. Voor de andere beleidsdoelen kunnen soortgelijke conclusies worden getrokken.

De resultaten van de studie kunnen op drie verschillende niveaus worden geëvalueerd. Dit gebeurt in hoofdstuk 6. Ten eerste kan worden bezien of de abstract geformuleerde eisen aan een exploratieve methode om toekomstige mogelijkheden voor de landbouw te verkennen overeenkomen met de methode die in de studie uiteindelijk is ontwikkeld. De scenario's die met behulp van het GOAL model zijn opgesteld, verkennen de technische mogelijkheden om een verzameling goed beargumenteerde beleidsdoelen te realiseren. De mogelijkheden worden verkend door de technische beperkingen van de grondgebonden landbouw te onderzoeken. Deze beperkingen vormen de 'harde' feiten die benodigd zijn om beleidsmakers te kunnen overtuigen. Hoewel sommige van de aannamen die zijn gedaan om het GOAL model te kunnen opstellen ter discussie kunnen worden gesteld, leiden vrijwel alle denkbare aanpassing van die aannamen tot een verscherping van de uitkomsten. De combinatie van een technische analyse met een meer subjectieve optimalisatie van doelstellingen heeft inderdaad geleid tot een wetenschappelijk beargumenteerde beschrijving van de grenzen van grondgebonden landbouwproductie en tot een beleidsmatig navolgbare optimalisatie van doelstellingen.

Ten tweede laten de uitkomsten van de modelexercities zien dat dit type resultaten kan functioneren als min of meer onverdachte informatiebron waarmee de beleidsdiscussie aan helderheid kan winnen. De optimalisaties van beleidsdoelstellingen met behulp van het GOAL model zijn niet bedoeld om de gepercipieerde kloof tussen wetenschap en beleid te overbruggen, maar de uitkomsten kunnen wel heel functioneel zijn voor de agendering van politieke kwesties. Als de ambitie van wetenschappelijk onderzoek ten dienste van het beleid hiertoe beperkt blijft, dan zal het bijzonder moeilijk blijken te zijn om de precieze invloed van de wetenschappelijke informatie op het beleidsdebat te traceren. Uit een aantal voorbeelden van beïnvloeding wordt echter duidelijk gemaakt dat er talloze onderwerpen zijn die baat kunnen hebben bij de inbreng van dit soort wetenschappelijke informatie.

Ten derde kan de vraag worden gesteld of de methodologie die in deze studie is ontwikkeld, overgezet kan worden naar andere onderwerpen of beleidsdomeinen. De basale aanname in de benadering bestaat uit de erkenning dat het politieke besluitvormingsproces soeverein is waar het gaat om politieke besluiten en van de soevereiniteit van de wetenschappelijke benadering waar het gaat om de analyse van orde en regelmaat in de natuur en wellicht ook in de maatschappij. Deze benadering is daarmee ten principale pragmatisch in de zin dat volledig wordt erkend dat de wetenschappelijke analyse moet leiden tot de best beschikbare informatie voor beleidsmakers, maar dat tegelijkertijd de dynamiek van het politieke proces eigen wetmatigheden kent die uiteindelijk van doorslaggevende betekenis kunnen zijn. Wat deze methodologie anders maakt dan andere mogelijke benaderingen is dat zowel wetenschappelijk feiten als politieke doelen in het gehele analysetraject herkenbaar en zichtbaar blijven. Bij het vraagstuk van mogelijkheden voor grondgebonden landbouw in de EU bleek het mogelijk om met behulp van deze methodologie een duidelijke scheiding aan te brengen tussen wetenschappelijke analyse en normatieve optimalisatie. Op andere terreinen van onderzoek en beleid kan dit onderscheid veel minder gemakkelijk worden gemaakt. Het door middel van trial-and-error proberen te ontwikkelen van dit functionele onderscheid kan daarom worden gezien als een uitdaging voor beleidsgericht onderzoek. Hiertoe moeten allereerst wetenschappelijk onderzoekbare feiten en meer subjectieve aannamen en doelstellingen in het beleidsgerichte toekomstonderzoek systematisch worden onderscheiden.

E CURRICULUM VITAE

Henk van Latesteijn (1953) studied Biology at Leiden University from 1976 –1981. He specialised in environmental biology and biomathematics. In his BSc thesis he applied both specialisations in a research on the influence of recreation on breeding bird populations in woods adjacent to urban areas. His interest in the combination of quantitative analysis and environmental concerns was further developed during his work as researcher at Leiden University from 1981 until 1988. During that period he was involved in several research projects on environmental impact assessment, environmental policy development and regional environmental policy planning and environmental monitoring systems. A common factor in these activities was the interdisciplinary approach to the subjects. In 1986 he joined the bureau of the Scientific Council for Government Policy in The Hague. As a member of the scientific staff he was involved in the preparation of several reports to the Dutch government on subjects such as the relation between economy and ecology, future systems of social benefit policies, instruments for environmental policy, the relevance of the notion of sustainable development to national policies, the orientation of physical planning policies and the future of agricultural land-use in the EU. This last report formed the basis for his further research into the methodologies of policy-oriented future studies and eventually led to this PhD thesis. In 1996 Van Latesteijn was appointed to the post of Deputy Secretary/Deputy Staff Director at the Scientific Council for Government Policy.