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POLICIES FOR SUSTAINABLE LAND USE IN COSTA RICA

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Explorative Land Use Studies for the Regional Level.
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EXPLORATIVE LAND USE STUDIES FOR THE REGIONAL LEVEL

*M.K. van Ittersum and R. Rabbinge**

Introduction

Land use studies for the farm, regional or supra-regional level may have various aims: (i) analysis of current situation(s); (ii) exploration of future possibilities; (iii) planning of development. Different factors and disciplines are involved in different studies and the studies have different applications.

Both socio-economical factors and bio-physical factors play an important role when analysing the current situation. The analysis can be used to describe or explain the current situation and to make comparisons with other systems. With this knowledge predictions could be made, only for the near future, by extrapolating the trends.In explorative studies bio-physical factors and disciplines are most important. By confronting bio-physical factors with socio-economic constraints and objectives, technical possibilities for the future can be explored under different policy views.

In these studies with a time horizon of more than 15 years, it is assumed that socio-economic circumstances that are currently limiting could disappear or be abolished in the future by economical development and the right policy instruments. Explorative studies show the consequences of policy aims for land use and reveal trade-offs between different objectives from a bio-physical point of view. They aim at helping policy makers in chosing aims and to search for instruments in conformity with these aims. In planning studies main focus is on searching the appropriate policy instruments to realize desired land use options.

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This paper deals with explorative studies for the regional and supra-regional level. A methodology for the exploration of land use under different policy views, which uses insight in bio-physical processes, will be presented. Motives to carry out explorative studies can be various: agricultural overproduction, food shortage, setting research priorities, employment in agriculture, environmental issues, etc.. The final aim of explorative studies is to show the importance of explicitizing aims for land use policy. The following items are treated:

1. Basic principles and concepts of production-ecology.
2. Methodology for explorative land use studies.
3. Illustrations of methodology with EC-study 'Ground for choices'.
4. Conclusions and follow-up of explorative land use studies.

Basic Principles and Concepts of Production-Ecology

The basis of primary and secondary production is photosynthesis of plants. Leaves of plants intercept the radiation of the sun and use its energy for the production of sugars by means of a reaction between carbon dioxide and water. Knowledge on the physical, chemical and physiological processes involved can be quantified and forms the basis of production ecology. This can be used to calculate the crop performance under various circumstances. Dynamic crop growth simulation models can be used for that purpose.

At the crop level various groups of growth factors can be distinguished, i.e. the growth defining, limiting and reducing factors. In accordance, three production levels can be distinguished: the potential, attainable (water and/or nutrient limited) and actual yield level. The potential yield is determined by growth-defining factors, which include incoming radiation, temperature and characteristics of the crop; yields of agricultural crops can not continu to increase indefinitely, but have a well defined maximum. The attainable and actual production are determined by production limiting and production reducing factors. The growth limiting factors are water and nutrients and the growth reducing factors include weeds, pests, diseases and pollutants.

Attainable yields can be increased by applying water and nutrients. Actual yields can also be increased by using yield protecting measures. By applying knowledge about the effects of various growth factors and agricultural techniques, input-output relations for agricultural activities can be calculated which are not based on current situations and expectations by means of trend extrapolations, but on possibilities from a bio-physical point of view. These relations form the basis for explorative studies.

Methodology for Explorative Land Use Studies

Before starting an explorative study the motives and aims of the study should be clear. This will have consequences for the way the system under study is defined in time, space and influence of man. The longer the time horizon the more the influence of man in socio-economic and institutional factors can be seen as variable. Therefore, the time horizon of explorative studies is usually at least 15 years, such that 'trend breaks' are possible.

Fig. 1 gives a schematized representation of the methodology for explorative land use studies. The central technique which is used in the methodology is the Interactive Multiple Goal Linear Programming technique (De Wit et al., 1988; Veeneklaas, 1990). IMGLP is a linear programming technique with more than one objective function. In each interactive run of an IMGLP model, the model is optimized for one of the objective functions with upper or lower bounds on the other objective functions. In this way the consequences are revealed of putting upper or lower bounds on some objectives on the optimal value for another objective and the other way around; the trade-offs between objective become visible. With this technique scenarios can be generated for different policy views.

In the IMGLP model technical information about land use, constraints concerning land use and other resources, and information on food consumption and trade are confronted with different policy views. The technical information on land use is derived by using the principles and concepts of production-ecology. The policy views are made operational by distilling a set of explicit objective functions from these policy views. By optimizing the model for the most relevant objectives for each of the policy views land use scenarios are generated for each of the policy views. The results for the scenarios include the values for the objective functions and the optimal regional land allocation. The scenarios show the consequences of different aims and the conflicts between the policy views. Policy makers

can now see how their priorities affect land use and how the effects are distributed over the region.

Illustrations of Methodology with EC-Study 'Ground for Choices'

The methodology and the results of the study Ground for choices; Four perspectives for the rural areas in the European Community have been published in a report (WRR, 1992) and in several papers (e.g. Rabbinge & Van Latesteijn, 1992; Latesteijn, 1992). In this presentation only some illustrations from this study are presented.

The Common Agricultural Policy in the EC is faced with several problems: overproduction, continuing productivity, budget problems and growing importance of other objectives than agricultural production. The direct reason to carry out the EC study was the fact that the discussion on the reform of the Common Agricultural Policy in the EC shifted from aims to instruments before being clear about (consequences of) aims.

The study, resulting in four options for agriculture and forestry, shows the importance of objectives of European agricultural policy. The methodology described above in general terms was used to generate these options. The time horizon for the study was 25 years. The technical information about land use was derived with a land evaluation. In the evaluation the characteristics of soil and climate were confronted with the requirements for the mechanized growing of various crops (Fig. 2 and 3). For the suitable areas the potential and water-limited yields were calculated with crop growth simulation models. This resulted in maps showing the yield potentials of different areas in the EC.

Subsequently, production orientations and cropping systems were defined with expert knowledge (Fig. 2). The following production orientations were distinguished: yield oriented agriculture, environmental oriented agriculture and land use oriented agriculture. In the yield oriented agriculture, high yields with efficient use of inputs was the primary aim. In the environment oriented agriculture more account is taken of environmental hazards related to agriculture, by using less environmentally hazardous inputs (pesticides and nutrients), accepting a slight decrease in yield. In the land use oriented agriculture no pesticides are used and a low soil productivity is accepted to use more land for agricultural purposes. This could be positive for the countryside.

Input-output tables were generated with expert knowledge for these production orientations, with and without irrigation. The principle of best technical means was applied to calculate these input-output tables, which means that both the available knowledge and the available techniques are applied optimally in all areas of the EC. It was assumed that in 25 years the knowledge and techniques will increase and that the relative advantage of North Western Europe will disappear; production possibilities are only determined by bio-physical conditions.

The demand for agricultural products was estimated for two diets (current diet and a diet with more animal products) and two trade situations (free trade and autarky). To quantify the demand for food in a free trade situation the results of many econometric general equilibrium models for world trade in agricultural products were evaluated.

Four policy views were distilled from policy documents and discussions: (A) Free market and free trade; (B) Regional development; (C) Nature and landscape and (D) Environmental protection. The aims which play an important role in these policy views have been translated into eight objective functions:

1. maximization of soil productivity;
2. maximization of total agricultural employment;
3. maximization of regional agricultural employment;
4. minimization of total pesticide use;
5. minimization of pesticide use per hectare;
6. minimization of total N loss;
7. minimization of N loss per hectare;
8. minimization of total costs.

Distinct policy views can be fed into the IMGLP model by assigning different preferences to these aims and by varying the demand for products. In different interactive runs with the IMGLP-model four land use scenarios were generated for the four policy views, each characterized by the values for the eight objective functions and the optimal regional land allocation. Aims relating to nature and landscape cannot be expressed in figures in such a way that the model can interpret them. For this reason a spatial evaluation was built into the procedure.

The study produced much information and many results (WRR, 1992). Only some highlights can be presented here. All land use options of the study imply a strong diminished use of land for agricultural products (Fig. 4). By using the production possibilities formulated, agricultural employment radically decreases. At the same time, however, the use of pesticides and the loss of nutrients can be reduced dramatically.

These are the common results of the different scenarios. Of course, there are also distinct differences between the scenarios, both in terms of values for the objective functions as in terms of the regional land allocation. For instance, in the regional development scenario more land is used than in the free market scenario, and the land is spread wider across the regions in the EC to satisfy the objective of regional development. In the free market scenario only the most efficient regions are used for production.

Conclusions and Follow-Up of Explorative Land Use Studies

The results of explorative studies do not show a blueprint for future land use nor a blueprint for agricultural policy. In stead these studies show scenarios that explore possibilities of future land use. A policy which tries to achieve something else than the common results of the different scenarios has to 'go against the tide'. The differences between the scenarios show the 'scope for policy'. The response on the EC-study 'Ground for choices' indicates that there is a growing awareness of the relevance of having regional aims and insight in consequences of regional aims.

Explorative studies at the regional level clearly need a follow-up. Explorative studies for the farm level should be carried out and once the aims for future land use have been formulated, the appropriate policy instruments have to be found, to influence farmers in the preferred direction (Hengsdijk & Kruseman, 1993; Rabbinge & Van Ittersum, 1994). Farm household studies can help to understand response reactions of farmers to agricultural policy. By aggregating farm studies and disaggregating regional studies the conflicts between both aggregation levels can be revealed.

References

Hengsdijk, H. & G. Kruseman, 1993. Operationalizing the DLV Program: An Integrated Agro-Economic and Agro-Ecological Approach to a Methodology for Analysis of Sustainable Land Use and Regional Agricultural Policy, DLV Report No. 1, DLO/WAU, Wageningen, 107 pp.

Latesteijn, H.C. van & R. Rabbinge, 1994. Possible Change in Future Land Use in the European Community. In: L.O. Fresco et al. (Eds). The Future of the Land. John Wiley & Sons, New York. In press.

Rabbinge, R., 1993. The Ecological Background of Food Production. In: Crop Protection and Sustainable Agriculture. Wiley, Chichester (Ciba Foundation Symposium 177), pp. 2-29.

Rabbinge, R. & M.K. van Ittersum, 1994. Tension between Aggregation Levels. In: L.O. Fresco, L. Stroosnijder, J. Bouma & H. van Keulen (eds). The Future of the Land: Mobilizing and Integrating Knowledge for Land Use Options. John Wiley & Sons Ltd, Chichester, pp. 31-40.

Rabbinge, R., & H.C. van Latesteijn, 1992. Long Term Options for Land Use in the European Community. Agricultural Systems 40: 195-210.

Veeneklaas, F.R., 1990. Dovetailing Technical and Economic Information. Ph.D. thesis. Erasmus University, Rotterdam, 159 pp.

Wit, C.T. de, H. van Keulen, N.G. Seligman & I. Spharim, 1988. Application of Interactive Multiple Goal Programming Techniques for Analysis and Planning of Regional Agricultural Development. Agricultural Systems 26: 211-230.

WRR [Scientific Council for Government Policy], 1992. Grond voor keuzen; vier perspectieven voor de landelijke gebieden in de Europese Gemeenschap. [Ground for Choices; Four Scenarios for Rural Areas in the European Community] Rapporten aan de Regering nr 42. Sdu Uitgeverij, 's Gravenhage. 149 p.

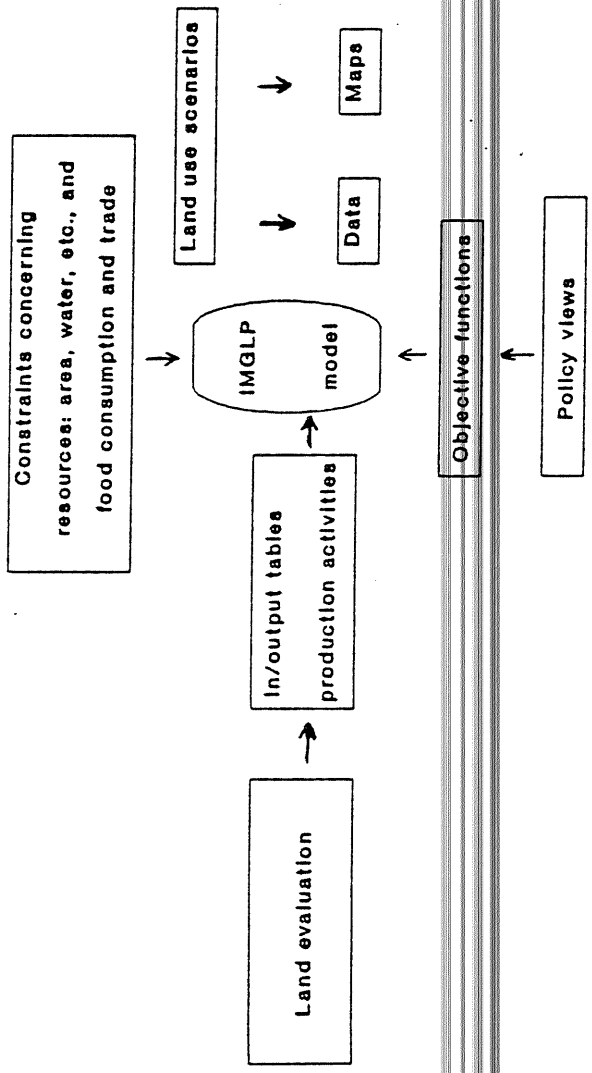


Figure 1: Methodology for Explorative Land Use Studies.

Figure 2: Land Evaluation and Definition of Location Specific Inputs and Outputs for Agricultural Activities in the EC. Source: WRR (1992).

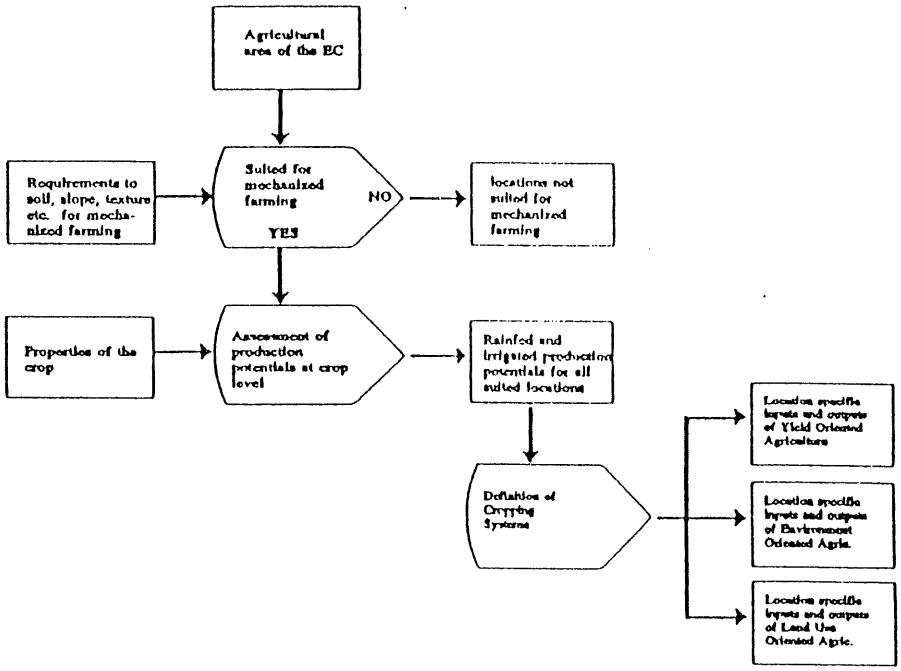
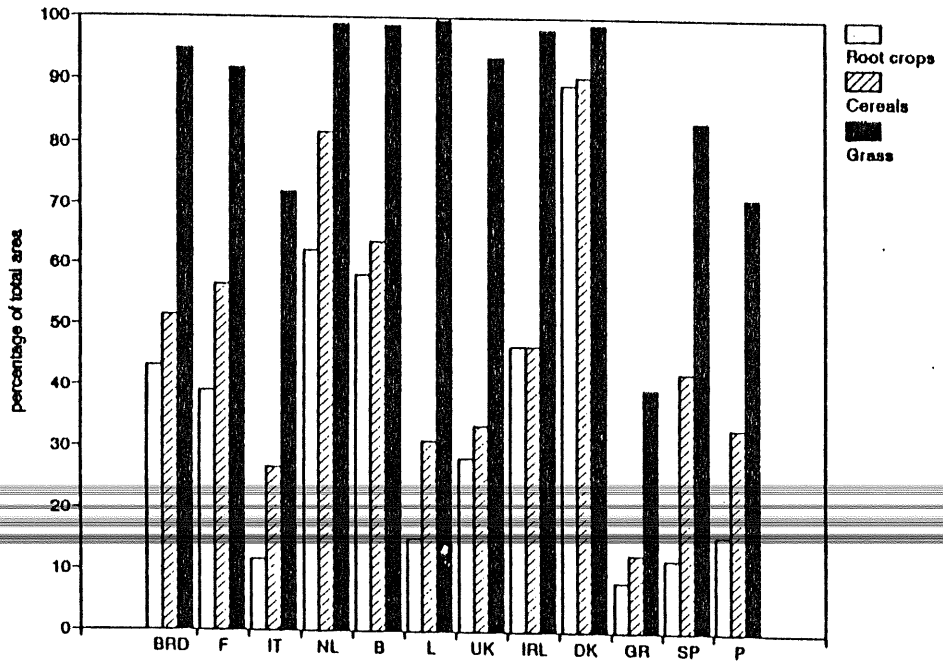
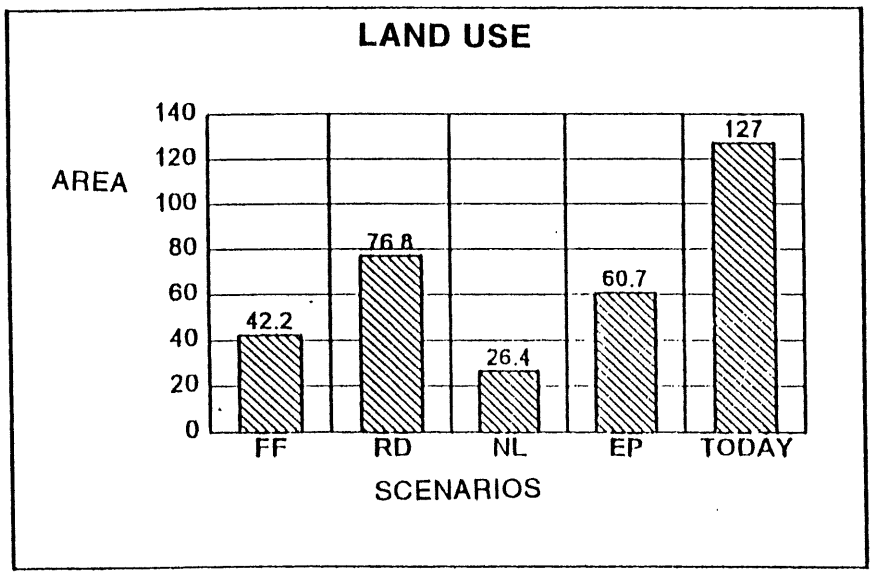


Figure 3: Percentage of Agricultural Are Suitable for Root Crops, Cereals and Grass. Source: WRR (1992).



Source: Staring Centre.

Figure 4: Land Use in the Different Scenarios Compared with Current Land Use in the EC (in mill. ha). Source: WRR (1992).



Scenario FF - Free market and free Trade
Scenario RD - Regional development
Scenario NL - Nature and landscape
Scenario EP - Environmental protection

Source: WRR