Future land-use change in the Netherlands: an analysis based on a chain of models

Zukünftige Landnutzungsveränderungen in den Niederlanden: eine Analyse durch eine Modellkette

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Abstract

Analyses of the impact of European policies on agricultural change are most often based on agricultural sector models. Such models have their limitations: they cannot specify the interaction between agriculture and the rest of the economy, and their spatial dimension is usually limited. Land use simulation models, on the other hand, usually depend on other models for assessing the demand for land. The consistency of those models with the assumptions and databases of the land use model is often not examined. This article reports on a research project where the links between a macroeconomic model, an agricultural sector model and a land use model were explicitly explored in order to arrive at a consistent model chain. This integrated framework was put to the test by applying it to two contrasting scenarios, which compare impact on agricultural incomes, land use and land management.

Key words

land use; CAP; agricultural policy analyses; Netherlands

Zusammenfassung

Studien zu Auswirkungen europäischer Politik auf Entwicklungen in der Landwirtschaft stützen sich überwiegend auf Agrarsektormodelle. Die Leistungsfähigkeit solcher Modelle ist jedoch begrenzt, da sie wenig über die Beziehungen zwischen der Landwirtschaft und anderen Wirtschaftssektoren aussagen und überdies räumlich meist unzureichend spezifiziert sind. Auf der anderen Seite sind Landnutzungsmodelle im Hinblick auf die Bestimmung der Nachfrage anderer Sektoren nach Flächennutzung in der Regel von weiteren Modellen abhängig. Diese Modelle sind aber in ihren Annahmen und Datengrundlagen nicht immer mit den Landnutzungsmodellen konsistent. Der vorliegende Beitrag referiert Ergebnisse eines Forschungsvorhabens, in dem die Verbindungen zwischen einem makroökonomischen Modell, einem Agrarsektormodell und einem Landnutzungsmodell mit dem Ziel der Sicherstellung einer konsistenten Modellkette untersucht wurden. Die Modellkette wurde an Hand von zwei unterschiedlichen Szenarien getestet. Insbesondere wurden die Konsequenzen für die landwirtschaftlichen Einkommen, die Landnutzungsmuster und die Art der Landbewirtschaftung miteinander verglichen.

Schlüsselwörter

Landnutzung; Gemeinsame Agrarpolitik; Politikanalyse; Modelle; Niederlande

1. Introduction

Most quantitative economic studies which analyze CAP reform and land-use patterns are based on agricultural sector models (EUROPEAN COMMISSION, 2003a; EUROPEAN COMMISSION, 2003b; DE BONT et al., 2003; HELMING, 2005; TABEAU and VAN LEEUWEN, 2005; OFFERMANN et al., 2005). However, the complexity of economic issues such as the CAP reform and land-use patterns is such that a model which is fully consistent at all levels of aggregation is not available and probably not feasible. Agricultural sector models, for instance, provide details about agriculture, but they contain no interaction between the agricultural sector and the rest of the economy. More macro-oriented models, on the other hand, yield few details for the agricultural sector. As a result, different types of models can produce different results for the same variables. Moreover, besides land use for agricultural purposes, other land-use functions are important as well. In this analysis several economic models have been linked with a land-use simulation model: the Land Use Scanner.

This chain of models is used to gain insights into the consequences of different long-term scenarios for land-use patterns in the Netherlands; different types of CAP reform are part of these scenarios. Behind this is the idea that it is difficult to predict the direction of further CAP reform because of the interactions with the wider process of economic change in Europe, driven by technological progress, economic growth and environmental concerns.

After a brief description of the scenario storylines, we ask the question of how farmers' behaviour is likely to change as a consequence of the new regulations. In answering this question, the wider process referred to above is taken into consideration. The second part of the article is concerned with the application of the models used in this exercise. The problems of linking the various models are discussed. The implementation of the models is briefly described, focusing on the aspects most directly relevant to land use. This is followed by a presentation and critical discussion of the results of the simulation exercise.

2. Scenarios including further CAP reform

The Common Agricultural Policy (CAP) was launched in 1962 in order to ensure an adequate supply of food at affordable prices as well as a reasonable income for farmers (EUROPEAN COMMISSION, 2004). In this it was entirely successful. However, by rewarding farmers for producing as much as they could under the guaranteed prices, it also led to large agricultural surpluses (partly dumped on the world market) and soaring expenditure. Only part of the extra money spent on agriculture by taxpayers and consumers actually ends up as farm income: most is leaked into production costs (OECD, 2001): fertilizers, pesticides, machines, energy etc. - leading to higher pressure on the environment. The income transfer efficiency of the CAP has therefore been less than optimal. It has also led to perverse incentives (VAN BEERS et al., 2004), in that state intervention causes farmers to do things that are not in the public interest. The effect is aggravated by subsidies on agricultural inputs such as fertilizers and fuel.

After many CAP reforms in the past, in 2003 the Fischler reform (also known as the Mid-Term Review or the Luxembourg Agreement) was introduced. Its principal feature is the decoupling of payments to farmers from production. Instead, direct income support will be given on the basis of past entitlements. These single-farm payments[1] will be conditional upon the farmer meeting certain land husbandry, animal welfare and environmental standards. Decoupling means that a larger proportion of CAP expenditure goes directly to the farmer, rather than to agricultural inputs, and the transfer efficiency of these payments is certainly higher compared to the classical market intervention schemes.

Further reforms are likely, in view of the demands made by other countries in world trade negotiations. It is possible that the market for agricultural products will be further liberalized, in order to meet these demands and reach a new trade agreement. However, the EU may also give priority to protecting its farmers, especially because of the multifunctionality of farming – functions such as maintaining the landscape (POTTER and BURNEY, 2002; BOHMAN et al., 1999). These different options are likely to take shape in different potential policy environments – hence the scenarios mentioned.

To put the model chain to work the first steps, then, were to construct the relevant scenarios and to put together a common database. The scenarios address key uncertainties concerning the degree of economic globalization and the extent of government intervention. Two scenarios were used, based on a set of four developed by the Netherlands Bureau for Economic Policy Analysis (DE MOOIJ and TANG, 2003) for long-term forecasts: one in which the trend towards free trade and less government intervention is strengthened; and one with a more regional outlook, in which social and environmental goals are fostered through protective policies and where economic growth has a lower priority. The former is termed Global Economy (GE), the latter Regional Communities (RC). The first scenario predicts further CAP reforms. The RC scenario can be seen as one where agricultural policies return to a pre-Fischler pattern of market intervention in order to maintain a large farming sector and food self-sufficiency. Table 1 lists some of the principal assumptions.

Table 1. Scenarios

Global Economy	Regional Communities
Strong commitment to free-market principles	Strong commitment to protection of environment and landscape
Lean government	Reliance on government intervention for guaranteeing societal values
Further enlargement of EU, liberal migration policy	No further enlargement, no extension of supranational powers, closure of external borders
Agricultural subsidies gradually phased out, quota abolished	Agricultural subsidies and quota maintained, with environmental conditions
Land use restrictions relaxed	Trend towards decentralization, local communities seen as cornerstones of society

Source: adapted from DE MOOIJ and TANG (2003)

3. Putative effects on farmers' behaviour: theory of agricultural change

Before we can model the scenarios, we must consider theoretically how they will affect the farm economy. One way to do this is to look at the general process of agricultural change. A sketch of this process, formulated by FRIEDRICH KUHLMANN (2000), can be helpful. KUHLMANN postulates seven stages of agricultural development and describes their effect on land use; these stages can also be characterized as different trends, most of which can happen simultaneously. In his third stage ('special intensification') a decrease in agricultural prices occurs, which in modern farming systems with high fixed costs will affect intensive farm types more than extensive ones. Such a price fall - as the CAP reform will also trigger - would thus lead to extensification of land use.

KUHLMANN's fourth stage is the reduction of fixed costs through labour-saving devices (labour being considered here as quasi-fixed, because it is only partially related to production size), and here this reduction works to the advantage of intensive systems. The two effects of direct income support and lower product prices would thus work in opposite directions.

The fifth and sixth stages are concerned with sustainable production and multifunctionality. Both of these play a role in the CAP reform: the former reflects the condition of reducing negative environmental externalities as a condition of support. Attention for the multifunctionality of agriculture is seen as a consequence of ever-increasing yields, which lead to the possibility of producing Europe's food needs on a limited part of the land. This means that other functions of the land (recreation, water catchment, and the conservation of nature, landscape or other values) can re-

[1] Or alternatively, a flat rate per hectare which is set per region within each country.

ceive greater attention; these functions may be performed by the farmer, but at some cost to agricultural production – precisely one of the objectives of the reformed CAP.

KUHLMANN's final stage has to do with globalization: driven by a reduction in transport costs, food and other agricultural products will be produced increasingly in areas with the right comparative advantages, rather than within the consuming country. In this respect, the basic goal of the CAP in ensuring food supplies through domestic production is at variance with the times and, in KUHLMANN's view, ultimately destined to fail.

Thus, in some sense the present reform will bring European agriculture more in line with global economic trends: by removing price support it will force farmers to become more competitive. However, by providing direct income support it reduces the farmer's downside risk of being in business. This will result in a larger number of farms than would otherwise exist; which is indeed one of the goals of the CAP. The cross-compliance aspect of the reform is fully in line with the trend towards increased multifunctionality in agricultural development – at least in rich countries.

Some further aspects must be mentioned which are likely to limit the impact of the reform in Europe in general and in the Netherlands in particular. Firstly, a sizeable part of the Dutch farming sector is engaged in products which have never attracted direct subsidies: flowers, vegetables, fruit, potatoes (other than for starch), onions, pigs and poultry. About 30 000 farms out of a total number of 84 000 do not receive support under CAP at present. They represent two thirds of total Dutch farm production. On average, only 2% of farm revenue (13% of net income) is made up of CAP subsidies (OSKAM et al., 2005: 122/3). For this reason, the effect of the CAP reform will be more limited than in other countries. The future of Dutch agriculture will be determined more by other driving forces such as technological progress, economic growth and environmental concerns.

Yet, more than 50 000 farms will be affected by the CAP reform, and it is expected that the single farm payments will become a sizeable part of the income of these farmers – perhaps some € 16 000 per year, which may account for half of an average farmer's income; this is particularly the case for producers of field crops and for extensive livestock farmers (*ibid.*).

Secondly, the amendments made by the European Council to the original Fischler proposal include restrictions on the use of land to which the single-farm payment will apply: land which was formerly used for products that attracted price support cannot be used for any of the 'free' products mentioned above. Land owners have the choice between continuing production under the new regime as before, shifting to another formerly protected product, leaving the land fallow while maintaining it in good condition, or selling the land.

4. The model chain

In the research on which this article reports, several models were used to forecast the consequences of the wider process of change of which the CAP reform is part. These models had to be linked: the output of one becomes input for the other. In analyses with a single model, the output of other models is implicitly also used. For instance, when an economist forecasts GDP growth, he will use population growth as an exogenous variable. That figure will have been computed by a demographer; one component of population growth is migration, for which economic growth is commonly used as a determinant. But is the demographer's assumption on economic growth compatible with the figure which the economist arrives at? Such problems can be solved by (a) the different models using a common database; (b) working with the same scenarios; (c) checking the assumptions in the different models for compatibility; and most importantly (d) where the same variable occurs in different models (whether exogenously or endogenously), iterating model results until they converge towards one another.

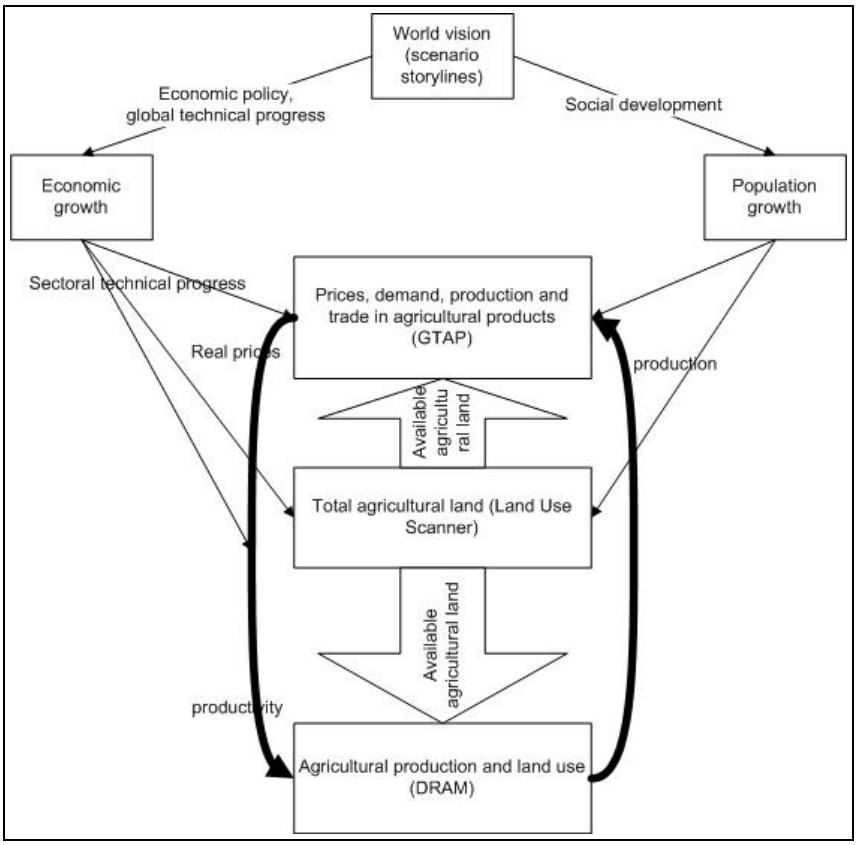
A central place in the model chain is occupied by a land-use simulation model developed for the Netherlands: the Land Use Scanner. This model was designed in the late 1990s by a consortium of several research institutes, in order to predict the likely consequences of expected economic developments and of government policies on the use of space (HILFERINK and RIETVELD, 1999). The Land Use Scanner combines land claims with spatial data on existing land use, land suitability and policies into a forecast for future land use. This forecast is in cells of 500 x 500 metres. Land claims per land-use class are exogenous to the model. They were calculated on the basis of regression equations for the relationship between area per class and population plus real gross domestic product (RGDP).

The land-use projections from the Land Use Scanner are fed into a global general equilibrium model and its associated database to assess the consequences of the scenarios for the Netherlands as a part of the world economy. The model takes the GTAP (Global Trade Analysis Project, DIMARANAN and MCDOUGALL, 2002) as a starting point and adds a number of new features relevant to the agricultural sector. Next to the inclusion of production quota for milk and sugar beets in the EU, the modified model pays much attention to land allocation. It uses a nested structure to model the supply of land for alternative uses as a function of relative returns (see HUANG et al., 2004 for a description). A national land supply curve has been added to the model in order to predict the availability of land endowments for agriculture at national level; it is for this land supply curve that the Land Use Scanner provides input. Projections were made up to 2030, using a methodology that takes key macro-economic variables as exogenous throughout the projection period. Exogenous variables form an essential part of the scenario assumptions thay include national GDP growth rates and changes of endowments in the primary production factors capital and labour.

The next step in the chain is the Dutch Regionalized Agricultural Model (DRAM), a non-linear programming model of the Dutch agricultural sector which generates production volume for a number of crops and animal products as well as (among other outputs) manure at the regional level (HELMING, 2005). DRAM distinguishes 14 regions on the basis of agricultural potential. The area available for agriculture per region is exogenous to DRAM and supplied by the Land Use Scanner.

Of special importance in the model chain is the iterative linkage between DRAM and GTAP. The parameters of the non-linear cost functions corresponding to a certain scenario are calibrated on the basis of price and quantity pairs derived from GTAP simulations. This is achieved by mapping price and quantity changes of outputs per sector from GTAP to price and quantity changes of corresponding outputs and sectors in DRAM, and subsequently recalibrating the parameters of the relevant functions that determine supply and demand, such that marginal revenue equals marginal costs. Moreover, results from GTAP for a given scenario are also used to calculate scenario-specific price elasticities of demand per sector. With these elasticities, the parameters of the inverse linear demand functions for domestic final demand and for export demand functions for roughage and young animals can then be calibrated.

Figure 1. The model chain



Both DRAM and GTAP calculate production changes – the one per region, the other at the national level – and they may differ. This can be explained by a variety of factors, including different behavioural assumptions and differences in the cost structures of DRAM and GTAP. For example, the former takes into account such elements as manure policy and product- and region-specific production technologies which are not present in GTAP. Consistency between prices and quantities in GTAP and DRAM can only be reached by applying an iterative procedure. After a first round of which output from GTAP are used into DRAM, sectoral production in GTAP is fixed at the level obtained by DRAM. This in turn will produce a new set of product prices and productivity changes, which are used for DRAM simulations to calculate the new output changes. The iteration process stops when the agricultural production changes in DRAM cease to vary significantly between two consecutive iterations. Figure 1 presents a graphic view of the model chain.[2]

5. Implementation of the land use component

The Land Use Scanner requires claims for all land use functions, so as to allocate the available land between users. Various classifications of land use have been used for different research projects; for our purpose we use the following classification:

- Residential: including cemeteries and streets other than main thoroughfares, but excluding parks, sports fields, shopping areas, and public facilities.
- Business: industrial areas, retail zones, central business districts, social and public services, waste disposal sites, mining areas, and building sites.
- Recreation: parks, sports fields, garden allotments, theme parks, campings, bungalow parks, landscaped recreation sites, and the like.
- Agriculture: cultivated areas, fallow land, farm buildings and farmyards.
- Nature: forests, moors, dunes, wetlands and other areas set aside for nature protection.

There are three more classes in the Land Use Scanner, but these are treated as fixed and cannot be manipulated by the model in its present form. They are:

- Infrastructure: paved roads, railways, and airports (but not port areas, which are classified as industrial). The Land Use Scanner is not well equipped to forecast these, as they tend to be linear (at least the roads and railways) and the Land Use Scanner works with areas rather than lines. However, planned extensions to infrastructure can be fitted into the model as part of the forecast.
- Water: surface water bodies. The Land Use Scanner does not consider the possibility of reclaiming or flooding land.
- Abroad: land areas outside the Netherlands. This is a formal category, which exists only because the total area of the Land Use Scanner is a rectangle of grid cells; some of these necessarily fall outside the national territory.

[2] The model chain used in the research described here included two further models: FIONA, a farm-level optimization model for assessing the profitability of agriculture and on-farm nature conservation (based on BERENTSEN, 1999); and SOMMA, a spatially explicit model which simulates the impact of farm-level decisions on species of wild animals living in the area (GROENEVELD et al., 2005). In this way, the research ultimately aims at forecasting the impact of global economic events on animal populations. However, that part of the research is beyond the purview of the present article.

To generate the claims, for each of the first five categories, we have assumed a double-log relationship between these categories. Moreover, we introduced dummy variables to the equations to explain structural changes in the pattern of the estimated relationships. Such a dummy explains decrease of the agricultural land due to the MacSharry reform or government policy towards nature. For residential land, it covers the relatively slow growth compared with population change after 1994.

The equations were estimated using 1973–2000 data for the Netherlands using the Ordinary Least Squares (OLS) method[3]. Overall, the estimation results are satisfactory. The goodness of fit varies between 89% and almost 100% and nearly all parameters are significant on a higher than 1% significance level. The estimated coefficients are presented in table 2 in terms of short- and long-term elasticities of land areas with respect to population and RGDP.

Table 2. Estimated short- and long-run elasticities* of land areas in the Netherlands

		agri-culture	nature	recrea-tion	residen-tial	busi-ness
Population	short-term	1.58	-0.81	0.53	-9.48	
	long-term		-0.81	1.83	1.70	
RGDP	short-term	-0.08	0.19			0.09
	long-term	-0.08	0.19			0.39

* Short-run elasticity reflects the immediate response of land to the RGDP or population change, whereas long-run elasticity reflects the response to the RGDP or population change that occurs in the long term after all adjustments took place.

Source: calculated from data of the Netherlands Central Bureau of Statistics

As expected, population growth has had a positive and economic growth a negative impact on the agricultural land area. However, the long-term population impact is zero, which is caused by increasing yields and imports of agricultural products substituting for domestic production. The population growth generates demand for residential area and therefore has a negative impact on the nature area. On the other hand, economic growth creates resources for the expansion of nature.

The estimation results confirm the positive impact of population on recreation, infrastructure and residential areas. They also confirm that economic growth is not reflected in the development of these areas. Since the expansion of residential areas is a rather long process, the short–term population changes are not reflected in residential areas, which explains the negative short-term population elasticity. Finally, as expected, the extent of business areas is strongly correlated with economic growth. Since the increase of nature area is rather weakly explained by economic and population changes since 1995, we decided that policy is a better predictor for this category. Hence, for the RC scenario we use the official government target for creating new natural reserves as the claim, whereas for the GE scenario we let the claim be determined by population and RGDP. Tables 3 and 4 show the final claims which were entered into the Land Use Scanner.

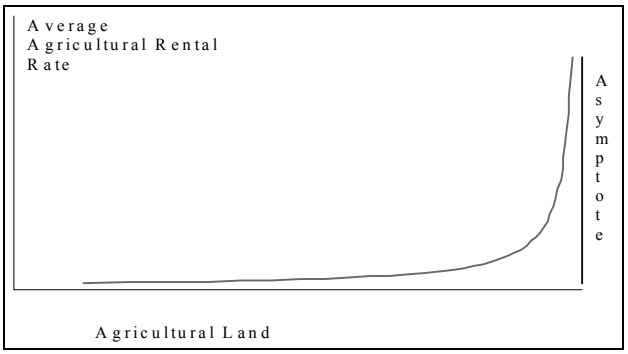
In the standard GTAP model total land supply is exogenous. In the extended version of the model, the total agricultural land supply is modelled using a land supply curve, which specifies the relation between land supply and a rental rate (figure 2). Land supply to agriculture as whole can be adjusted as a result of fallow, conversion of non-agricultural land to agriculture, conversion of agricultural land to urban uses and land abandonment. The general idea is that when there is enough land available, an increase in demand for agricultural purposes will lead to

Table 3. Projection of land claims, Global Economy (in km²)*

year	land area	agriculture	nature	recreation	residential	business	total
2000	33,784	23,261	4,835	889	2,251	1,418	33,784
2010	33,784	23,261	4,810	983	2,832	1,606	34,599
2020	33,784	23,261	4,820	1,099	3,182	1,789	35,258
2030	33,784	23,261	4,840	1,214	3,544	1,975	35,941
change 2000-2030:		0%	0.1%	36.5%	57.4%	39.2%	

* (a) The total claim includes the area for infrastructure in the base year, so it can be compared with the total land area. (b) In other work with the Land Use Scanner, regional land claims have been used. Claims at national level have the advantage of giving the model greater freedom in allocating the land in accordance with suitability.

Figure 2. The land supply curve



Source: adapted from VAN MEIJL et al. (2006): 25

[3] The set of equations we have estimated can be seen also as a seemingly unrelated regression model. In the general case Generalised Least Squares (GLS) is the efficient estimator of such a model. However, if the equations of such a model are unrelated, GLS and OLS estimators are identical (GREENE, 1993). One can argue that the estimated equations are connected by the identity saying that the sum of all land categories has to be equal to the total available land at any data point. Such restrictions, however, cannot be introduced into the estimation procedure since the number of such restrictions is higher than the number of the estimated parameters. Also in the case of related systems, use of the OLS method can be defended in several ways (KENNEDY, 1998).

Table 4. Projection of land claims, Regional Communities (in km²)

year	land area	agriculture	nature	recreation	residential	business	total
2000	33,784	23,261	4,835	889	2,251	1,418	33,784
2010	33,784	23,261	5,753	950	2,367	1,548	34,986
2020	33,784	23,261	6,385	968	2,272	1,623	35,616
2030	33,784	23,261	6,705	955	2,142	1,671	35,841
Change 2000-2030:		0%	38.7%	7.4%	-4.8%	17.8%	

additional land put into cultivation and a modest increase in rental rates (as in the left part of figure 2). However, if almost all potentially agricultural land is in use, then an increase in demand will lead to a steep rise in rental rates (land becomes scarce, as in the right part of figure 2). When land conversion and abandonment possibilities are limited then the elasticity of land supply in respect to land rental rates is low and the land supply curve steep. This corresponds, for instance, to the situation in densely populated western Europe. In the opposite case the curve is flat, which would correspond more to some parts of eastern Europe or countries such as Brazil, where agricultural land is in ample supply.

Table 5. Changes in area under two scenarios, 1996-2030

		Global Economy		Regional Communities	
Land use class	Area in 1996 (hectares)	Area in 2030	% change	Area in 2030	% change
Residential	242,126	354,463	46.4%	234,255	-3.3%
Business	121,996	197,461	61.9%	167,137	37.0%
Infrastructure	110,656	110,656	0.0%	110,656	0.0%
Recreation	83,035	121,377	46.2%	95,484	15.0%
Nature	464,611	557,402	20.0%	670,491	44.3%
Agriculture	2,360,940	2,048,110	-13.3%	2,111,440	-10.6%

Source: projections with Land Use Scanner

6. Outcomes of the scenarios

The Land Use Scanner forecasts a sharp decrease in agricultural land under the Global Economy scenario, as table 5 shows. We may compare this with the decline over the period 1967-2000, which was less than 8%. Even under the RC scenario it is forecast that the process of taking agricultural land out of production will accelerate, but to a lesser extent. Most of the 300 000 hectares of agricultural land becoming available under the GE scenario will be used for the expansion of built-up areas (the residential and business categories), with the remainder being converted into green areas (nature and recreation); the additional nature areas may be private estates as well as public reservations. The change in destination is very different in the RC scenario: here, nearly all of the 250 000 hectares freed will be converted into nature. Residential land use actually declines under this scenario, a consequence of the decrease in population.

As stated above (section 3), the Land Use Scanner works at the level of 500x500 metre grid cells, so it is possible to generate detailed maps of projected patterns of land use. This is best viewed in a specific area, for which we have chosen an area around the city of Utrecht, in the central part of the country. Map 1 shows how land use changes under the two scenarios until 2030, compared to the pattern in the base year 1996. The most striking change under the Global Economy scenario is the large increase in built-up area, spreading out eastwards from the city and eliminating most of the forested area to the north and east. In the process, several smaller towns and village merge to form a single urban area.

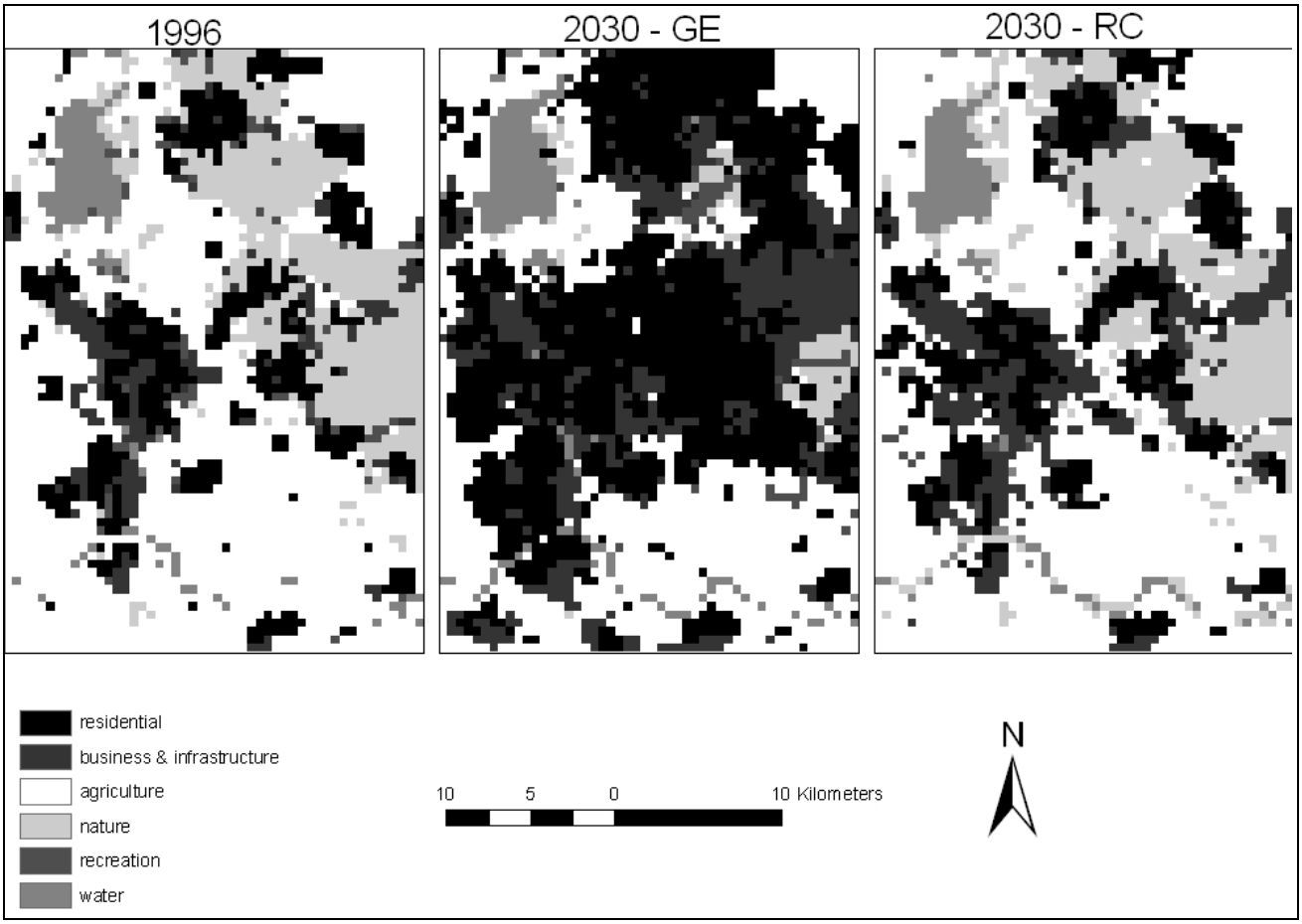
In the Regional Community scenario, such urban expansion is less extensive and much more dispersed; here there is relatively more growth of business areas compared to residential zones – a consequence of the projected population decline coupled with the high attractivity of this central location for enterprises.

Map 1 shows only the dominant form of land use for each cell. A different picture is obtained when we look at what happens for a particular land use class under each scenario. Map 2 does this for agriculture, showing the percentage of land lost to (or gained by) agriculture per cell, as a proportion of the total area per cell. We see that the agricultural sector has to give up land mostly near the larger cities and along axes of infrastructure; this is the case in both scenarios, but under Regional Communities the loss is lower and less concentrated. Notably, there is more loss around the main northern city of Groningen than under the Global Economy scenario. There is also some increase of agricultural land under both scenarios, mostly in or near nature zones – and rather unrealistically also in large cities. This is an aspect of the model that will still need working on, although the changes are small: typically, the model allocates a few percentage points of land per cell to agriculture in these zones. The increase of agricultural land is more dramatic under the Global Economy scenario, where because of its higher bid price it is able to outcompete nature in some areas, notably the Veluwe, which is the largest forest area in the country. There and in the coastal dunes, in some cells up to 40% of the land changes from nature to agriculture. These are, one must assume, farmers pushed out of other areas as a result of urbanization.

The Land Use Scanner is also capable of specifying areas for different crops and for pasture. In the present research, however, this has been left to DRAM which can model these variables in a more sophisticated way although not in the same spatial detail.[4]

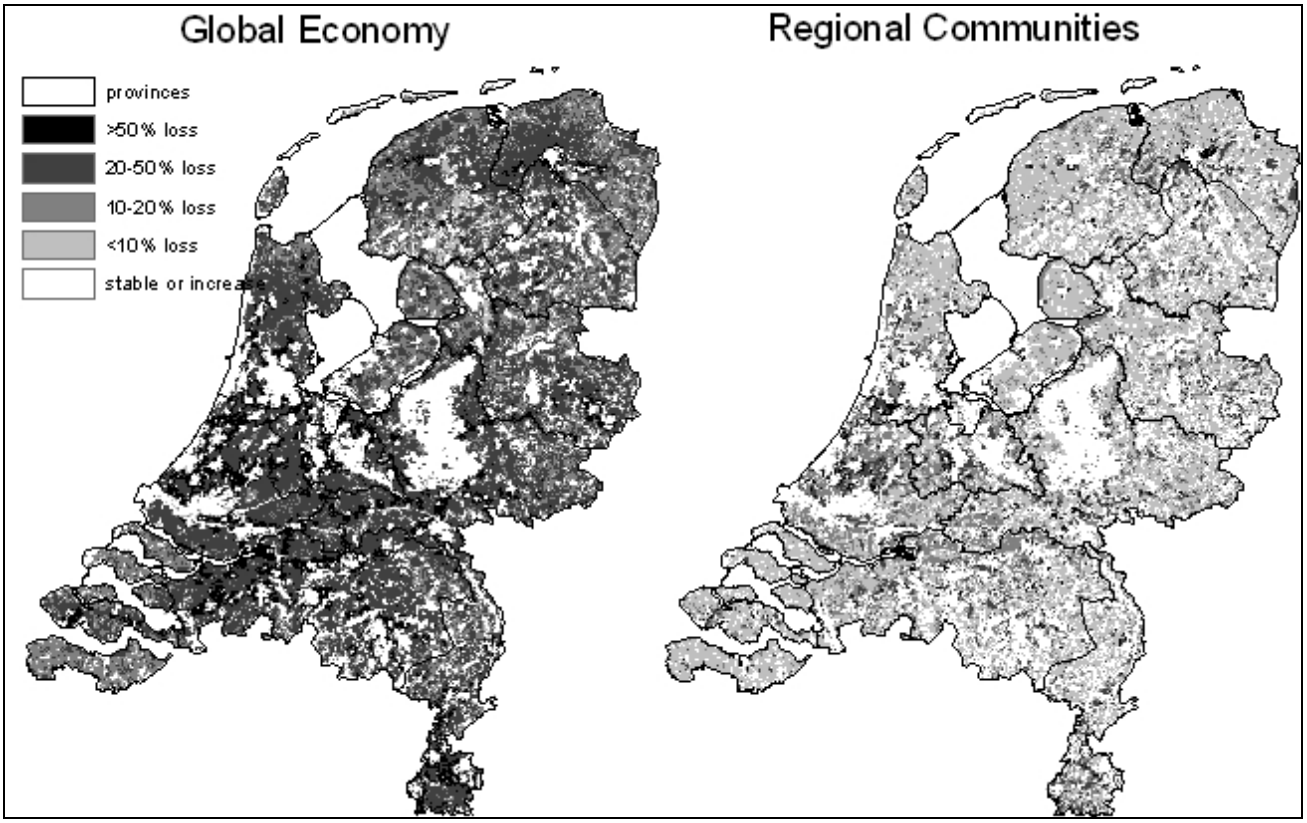
[4] It is possible to get both the spatial and the functional detail by using the output of DRAM as claims on land for another run of the Land Use Scanner.

Map 1. Land use changes



Source: projections with Land Use Scanner

Map 2. Changes in agricultural area



Source: projections with Land Use Scanner

Thus, DRAM shows that the area allocated to field crops decreases by no less than 30% under the GE scenario; for cereals the decrease is even 50%. By comparison, under the RC scenario the decline of arable land is slightly less than 20%.

A decrease in agricultural area does not, of course, necessarily mean a drop in production – although for cereals it does. GTAP forecasts crop production as a whole to rise by 5% under the RC scenario and 23% (with a smaller total area) under Global Economy. For livestock production the increase is 5% under RC and 31% under GE. These increases are generally less than the average for the EU-15, except for the livestock sector under the RC scenario.[5]

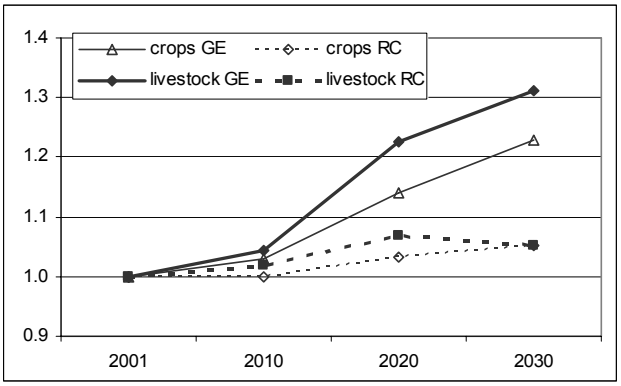
The main land user in livestock production is the dairy sector. There production will rise by 40% under the GE scenario, even with a decrease in area. There are some regional differences in this rise, with production rising least in the western part of the country. This is the region where most land is taken out of production, partly as a result of urban pressure but also because of the marginal quality of the soils. Under the RC scenario, milk production will remain bound by quota. It is assumed that milk quota in the Netherlands increase by 1.5% as agreed upon under the Luxembourg agreement in 2003.

The development of agricultural incomes is also relevant spatially, because lower sectoral incomes will coincide with a smaller number of farms which will work on a larger scale – usually with consequences for the type of agricultural landscape. Figure 3 (generated by GTAP) shows the results for the crops and livestock sectors, respectively. Now, since in both scenarios aggregate agricultural incomes remain behind overall GDP growth, the decline in the number of farmers is likely to continue – resulting in a strong tendency to larger-scale farms even under the Regional Communities scenario.

In contradiction to the general orientation in the RC scenario which favours maintaining traditional small-scale farming, the limited economic and population growth will lead to lower agricultural incomes as compared to the GE scenario. This may come as a surprise, since the agricultural policies under the RC scenario are supposed to support farm incomes. However, the explanation is simple: the effect of overall lower economic growth is larger than that of policies aimed at the protection of farmers.

Besides changes in land allocation, DRAM also delivers some information about the intensity of production under different scenarios. Figure 4 shows the development of the share of grassland with high nitrogen input per hectare in total grassland acreage under the two scenarios. Under GE the trend is increasing whereas under RC this trend is decreasing. This is explained by relatively high shadow prices of land under the GE scenario as compared to the RC scenario. Under the RC scenario land prices are relatively low and prices of milk quota relatively high.

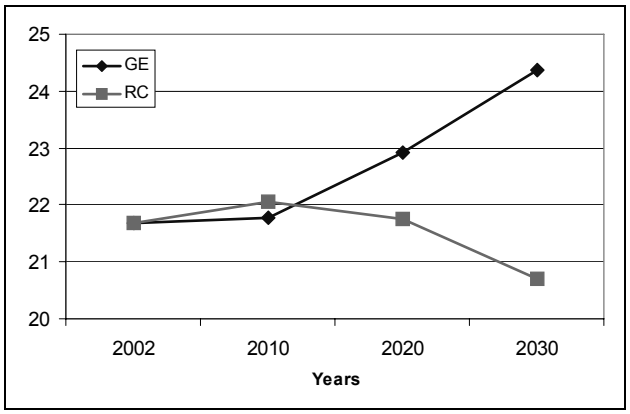
Figure 3. Development of real incomes in the crop and livestock production sectors



Note: Index number on vertical axis with 2001 = 1

Source: projections with DRAM

Figure 4. Development of grassland with high nitrogen input per hectare. Percentage in total acreage of grassland



Source: projections with DRAM

7. Conclusions

Naturally, the consistent simulation of the two contrasting scenarios yields a host of insights, which cannot all be discussed in this contribution. The two contrasting scenarios, i.e. a very liberal Global Economy scenario and a world of regulation and regional orientation in the Regional Communities scenario, result in two development paths which form a kind of confidence interval for future projections. The macro-economic assumptions underlying the scenarios turn out to be the main driving forces, even for detailed micro-level results. Hence, the plausibility of these macro assumptions is of great importance.

According to the projection results, the Netherlands will face a significant, but not massive decline of agricultural area: In the RC scenario the decline is estimated at 7% and in the GE scenario 10% by the year 2030, as compared to 2004. However, due to increases in yields the level of agricultural production is still projected to grow, despite the decline in area. Aggregate agricultural incomes are also expected to grow, although at rates well below the economy as a whole.

The spatial implications show marked differences between the two scenarios. The high-growth GE scenario results in a

[5] The pre-2004 members of the EU have been used in this analysis because they form a region in the GTAP model of which the Netherlands is part. Forecasts for the ten new members of 2004 follow quite different patterns and do not concern us here.

continuation of current trends in land use: more urbanization and concentration of activities in the densely populated western parts of the Netherlands. The low-growth RC scenario shows a more dispersed pattern with smaller-scale agriculture and more mixing of agricultural and non-agricultural activities in rural areas.

The scope of the scenarios used is wider than the CAP reform alone, which makes it difficult to interpret the results in terms of consequences of the reform. But we may note that the results are broadly in line with other national studies (DE BONT et al., 2003) and European-wide studies (EUROPEAN COMMISSION, 2003a; EUROPEAN COMMISSION, 2003b; OFFERMANN et al., 2005).

However, the main goal of the research reported here is methodological rather than substantive. The consistent simulation of scenarios served as a vehicle to study the possibilities and problems in linking models at different scales of analysis: global economic, national economy-wide, national agricultural, and national spatial levels are integrated into a consistent modelling framework.

The principal strategy to integrative modeling was top-down, hence trying to avoid all the problems related to representing an aggregate (macro-) system from micro-behaviour (see for example VAN TONGEREN, 1995). Only in two instances did we encounter the need to include (iterative) feedback mechanisms in our system.

The first instance is land use, where both our macro-model (GTAP) and our spatial land allocation model generate results that may not be compatible. Here, we decided that the detailed land allocation model has precedence over the blunt macro-results for aggregate land availability to agriculture and we engage in a one-step feedback loop to the macro-level.

Perhaps of greater importance is the interaction between the detailed agricultural sector model, (DRAM) and the general equilibrium model (GTAP). In a sense, we replaced the agricultural supply equations for the Netherlands in GTAP by the DRAM model, and used the general equilibrium framework to deliver a consistent set of prices for outputs and inputs. At the same time, we made the demand equations in DRAM consistent with the general equilibrium outcomes. All this was achieved through an iterative procedure that is guaranteed to converge.

It is interesting to note that the greatest amount of disagreement between DRAM and GTAP in the first iterations occurs in those cases where quantitative policy restrictions are in place. For example, cattle and intensive livestock production limitations related to environmental constraints (Nitrate Directive). Here, a model such as GTAP is not bound by such factors and would tend to overstate production, especially in the high growth GE scenario. On the other hand, the partial sectoral model clearly benefits from the capability of GTAP to deliver a consistent set of prices for outputs and inputs. Especially for long-run projections this is an important issue.

The most important difficulties occurred with respect to the databases used. Coming from two different 'worlds' the definition and specification of variables differs between the two models. The database which supports the general equilibrium model is based on the United Nations System of National Accounts, and has at its heart an extended input-output table which registers transactions in money terms. The agricultural sector model, on the other hand, is based on agricultural sector accounts with supply and utilization tables in physical units as its centrepiece. Unsurprisingly, the two datasets do no always agree, and occasionally significant discrepancies occur. In our view, the harmonization of databases is the key area for future research of this kind.

Notwithstanding the many challenges we conclude that there are many gains to be had from exploiting the comparative advantages of different models. For GTAP the explicit technology description in DRAM improves the modelling of agricultural supply, while DRAM gains from the linkage with GTAP as restrictions coming from general equilibrium requirements are taken into account.

Finally, the translation of sectoral results into land-use patterns not only visualizes model results, but also adds a spatial dimension which is crucial to understanding the environmental impact of economic changes.

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