# Rural land-use and landscape dynaamics - analysis of 'driving forces' in space and time

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# CHAPTER 5

# *RURAL LAND-USE AND LANDSCAPE DYNAMICS – ANALYSIS OF 'DRIVING FORCES' IN SPACE AND TIME*

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## INTRODUCTION

Land-use changes and landscape patterns are influenced by a wide range of parameters in such a complex way that forecasting becomes a difficult task. Within Danish land-use planning, this issue has been realised again and again over the last three decades. In the 1960s, for example, urban expansion into the countryside exploded due to the economic boom. Physical planning in Denmark at that time was not able to guide the rapid land-use change and, as a new main tool, a strict zoning system was set up to prevent urban sprawl into the countryside. However, the recession of the 1970s almost stopped urban growth pressure on the countryside and even zones reserved for urban growth were often reallocated to rural zones.

In the 1970s, a drastic reduction of the amount of small, uncultivated elements in the agricultural landscape was documented and related to ongoing technological and structural changes within agriculture. A public debate followed and field registrations, monitoring systems and planning measures were developed to counteract the threat. But in fact, already before these measures were put through, the tendencies had changed. In recent years, a general stabilisation of the spontaneous development, unpredictable at the end of the 1970s, has been observed. In the 1980s, much effort was put into forecasting the amount and localisation of the expected marginalization of agricultural land in Denmark. But up to now all prognoses (except those based on interviews with farmers!) have fundamentally failed. Until today, only a few hectares of farmland have been subject to spontaneous marginalization.

Generally speaking, we have to recognise that although it might be possible to predict changes at certain larger spatial and temporal scales, such forecasts cannot be extrapolated to finer levels in time and space. In consequence, any attempt to forecast future land use, at least at a local scale, will be doomed to failure. In spite of such inherent difficulties, important insights into the 'driving forces' of land-use dynamics might be gained during the process of defining an analytical framework (Stomph *et al.*, 1994). In this paper a simple framework for the description of land-use changes will be outlined. Three selected aspects of land-use changes will be presented and used to validate the framework as regards its ability to catch the important driving forces behind some major trends in land-use development of rural Denmark.

## AN ANALYTICAL FRAMEWORK

Land use and landscape patterns are often described by parameters such as fragmentation, crop pattern, land-cover composition, and biotope structure (Forman and Godron, 1986; Zonneveld and Forman, 1990; Hobbs and Saunders, 1993; Zonneveld, 1995). Changes in cultivation strategies and reclamation or the marginalization of farmland constitute important dynamic aspects. Rural land-use patterns and dynamics are closely related to the agricultural system. Farm type and farm size are important structural characteristics of this system, constituting the spatial aspects of the human use of the landscape. Thus landscape pattern dynamics are influenced by a variety of factors such as technology, natural conditions, socioeconomics, public policies and cultural factors, as shown in Figure 5.1.

The development of still more powerful *technologies* has enabled farmers to change the environment radically. Such changes have been reflected in clearly recognisable rural land-use changes. The purposeful application of new technologies, followed by an increasing number of regulations and planning measures, often produces many side-effects of which some may be considered as negative environmental impacts. These side-effects can influence land-use pattern dynamics in an order of magnitude which surpasses all planning intentions.

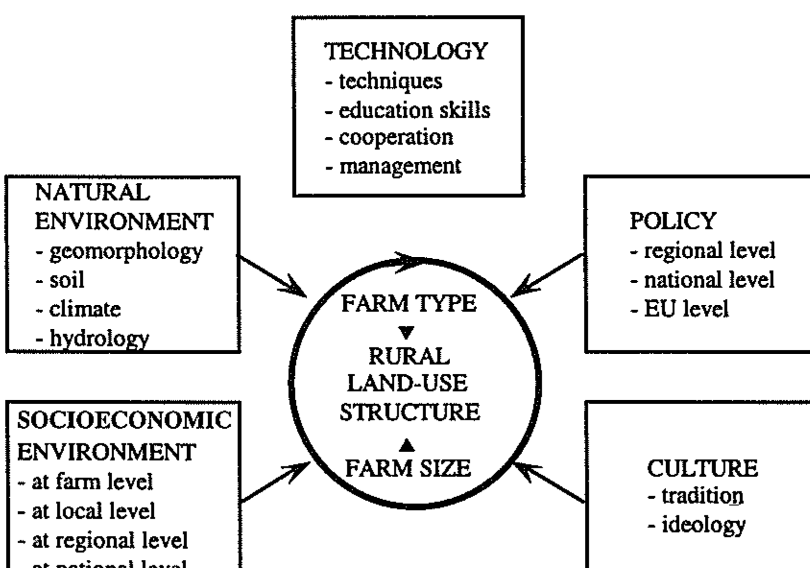


**Figure 5.1** Analytical framework. Driving forces influencing landscape pattern dynamics

*Variations in natural conditions* give rise to considerable regional and local variations in land-use dynamics, and so does a limited understanding of the landscape–ecological conditions and consequences of land-use changes in different landscapes.

*Socioeconomic conditions* strongly influence land-use pattern dynamics. Prices of input factors and agricultural products, alternative income possibilities and changing economies of scale are all important determinants for land-use strategies at the farm level as well as at the regional, national and global level. Global market developments have led to an increasing division of labour between land-use related industries, such as modern agriculture and forestry, and strengthened the specialisation of land use.

The basic functioning of the capitalist economy should also be considered a core issue for understanding land-use and landscape development (Bowler and Ilbery, 1992). It will nevertheless remain difficult to explain concrete land-use changes on the basis of economic forces only, because of the many state regulations and the mixture of short-term and long-term farmer decisions related to land-use changes in agricultural areas. Rapid changes in *public policies*, especially as regards supra-national levels, have a growing direct and indirect influence on land use (see Bowler and Ilbery, Chapter 7). However, considerable discrepancies in the intentions and the power to implement these decisions at the local and regional levels may occur. These should not be underestimated when the effects of policy on local land-use changes are addressed.

Finally, *cultural* differences and new priorities and ideologies have, under certain circumstances, much more impact on the land-use pattern than normally realised. For example, land-use decisions can often only be satisfyingly explained by incorporating farmers' values.

The *analytical framework* in Figure 5.1 is meant to provide a descriptive analytical framework only; yet, supplemented by relevant statistics and geo-related information, it might be useful as a guide to a profound understanding of land-use pattern dynamics in time and space. The close link between the factors has not been indicated on Figure 5.1, but should be taken into account when using the framework.

## LAND-USE DEVELOPMENT IN RURAL DENMARK – AN OVERVIEW

Danish agricultural landscapes have changed significantly within the last two centuries. The landscape patterns and the direction of the changes have been influenced in many cases by structures or characteristics of much older origin. Administrative boundaries (parishes, associations of landowners) have had a long-lasting effect on the basic structure of the landscape, surviving subsequent changes. A profound reallotment reform around 1800, which caused a comprehensive and rational restructuring of the farmland, gave rise to a farm structure with emphasis on middle-sized farms (15–25 ha) of considerable resilience.

As regards general land use – distinguishing land-use classes such as forest, heathland, permanent grassland and arable land – changes can be roughly summarised in an eastern and a western pattern, mainly related to differences in the soil types. The fertile morainic soils in the east have been continuously cultivated and the relative change of importance of the land-use classes is primarily related to draining of wetlands. However, reallotment has influenced the landscape patterns in this part of the country too. As a result of changing property rights for forests and commons, the landscape changed from a relatively atomised field pattern with extended commons, few and open forests and unclear boundaries, into a mosaic landscape with sharp boundaries between intensively used fields, pastures and closed, dense forests, protected for the main purpose of timber production. On the sandy outwash plains in the western part of the country, more radical changes can be observed. Heathland was transformed into cultivated land at the beginning of the century, and a substantial afforestation has taken place on former heathland as well as on abandoned fields.

In a European context, Denmark is generally considered an homogeneous and fertile agricultural region, a characteristic which can be illustrated by the very high proportion of arable land in rotation, even compared with north European standards (Jensen and Reenberg, 1986; Hoggart *et al.*, 1995). Within the last century, a comprehensive inclusion of new land has been made possible by various innovations in agriculture, namely investment in drainage around 1870, planting of hedgerows especially on the sandy soils, and intensive use of marl which has left numerous marl pits as important landscape elements.

The cornerstone of Danish agriculture, from late 1800 to mid-1900, was the mixed family farm; the emphasis of production was on cereals, beet and grass to feed to livestock that provided processed animal products for export (e.g. dairy products). Since 1960, the dominant trend has been towards mechanisation and industrialisation – leading to larger and more specialised farm units. Agricultural policies, planning, and public regulations of various kinds have played an increasing role in rural land-use changes. Today, all types of land-use changes involving agricultural land use would *either* require one or more permissions by the authorities *or* would have to be promoted by one or more subsidy measures.

European Union (EU) policies may currently be the most important single factor in rural processes of transformation. Thus, the 1992 reforms of the Common Agricultural Policy (CAP) had immediate impacts on rural land use. For example, about 8 percent of arable land (210,000 ha) was set aside in the growing season 1992/93 (Andersen *et al.*, 1995: 56). EU agro-environmental policies also have effects on landscape changes through landscape conservation, for example measures related to Environmentally Sensitive Areas (Primdahl and Hansen, 1993).

## THE FRAMEWORK IN USE – THREE EXAMPLES

In general, factors which determine landscape changes will be expected to be influential at different spatial scales and with variable strengths. The relative importance of these factors varies considerably with time. In the following examples, three issues mentioned in the introduction – urban fringe landscape development, biotope structure and marginalization – will be used to illustrate analytical opportunities and limitations. Specific attention will be given to the dynamic analysis of spatial patterns in rural landscapes.

### Example 1: Rural land use in the urban fringe

Land use in the urban–rural fringe is generally more dynamic than in other rural areas. This is due to a greater number of land-use types occurring in the fringe and to the higher demand for land and consequently a more intensive land market (Bryant *et al.*, 1982). Urban growth and sub-urbanisation are typical land-use changes taking place in fringe areas. In addition, the fringe areas often have several functions occurring on the same piece of land, for example, agricultural production and informal recreational functions. The urban fringe areas, therefore, are often more regulated by physical planning and other types of public control than is the rest of the countryside.

Although land development rights are strongly regulated by the planning system, there is a clear relationship between proximity to cities and land prices in Denmark. For small farms, which, contrary to larger ones, may be sold to anybody interested (farms > 30 ha may only be purchased by buyers with a farming education), land prices vary considerably according to soil quality and proximity to large urban areas. Thus, average prices of agricultural land (including building values) are two to three times higher in areas (municipalities) near Århus and Copenhagen as compared with the rest of the country. This is an expression of higher demand for land, particularly for smaller farms, rather than speculation on future urban growth. Thus, 64 percent of all farms in the region north of Copenhagen were part-time farms in 1992 (defined as farms operated with a maximum of 0.75 of a man-year), whereas the comparable figure for the whole country was 54 percent (Frederiksborg amt, 1993).

Land use and agriculture in urban fringe areas have been studied only to a limited extent in Denmark. In the following, examples are taken from one of the few studies which have been made in the Greater Copenhagen region.

#### *Land-use structure and dynamics in the Copenhagen region*

The location of agricultural land use in eight areas bordering different towns in Greater Copenhagen is shown in Table 5.1 and Figure 5.2. The eight areas are divided between northern locations, where hummocky moraines and terminal moraines with sandy soils dominate, and southern locations

**Table 5.1** Agricultural land use and husbandry in eight urban areas in Greater Copenhagen. 1 = Vejby, 2 = Asminderød, 3 = Ganløse, 4 = Smørum Ovre, 5 = Kirke Hyllinge, 6 = Sengeløse, 7 = Tune and 8 = Solrød (from Ogstrup and Primdahl, 1996)

| | *Northern areas* | | | | *Southern areas* | | | |
|---|---|---|---|---|---|---|---|---|
| | *1* | *2* | *3* | *4* | *5* | *6* | *7* | *8* |
| Grain | 71 | 47 | 55 | 56 | 60 | 50 | 60 | 65 |
| Fodder roots | 3 | 0 | 0 | 0 | 5 | 0 | 0 | 0 |
| Grass and green fodder in rotation | 5 | 0 | 5 | 0 | 8 | 0 | 0 | 0 |
| Seeds | 6 | 9 | 14 | 22 | 11 | 21 | 31 | 25 |
| Horticulture | 2 | 0 | 0 | 3 | 5 | 19 | 1 | 2 |
| Permanent grassland | 8 | 19 | 19 | 6 | 7 | 5 | 3 | 4 |
| Set-aside | 4 | 14 | 6 | 12 | 5 | 4 | 5 | 5 |
| Christmas trees and greenery | 1 | 11 | 0 | 1 | 0 | 2 | 0 | 0 |
| 100% = (in ha) | 241 | 261 | 633 | 383 | 406 | 413 | 383 | 369 |
| *Number of animals per 10 ha agricultural land* | | | | | | | | |
| Dairy cows | 0.4 | 0 | 0.2 | 0 | 3.5 | 0 | 0 | 0 |
| Cattle | 2.4 | 0.8 | 2.2 | 0.2 | 8.7 | 0.1 | 0.3 | 0.8 |
| Pigs | 10.2 | 0 | 1.1 | 0 | 45.6 | 10.6 | 53.2 | 7.6 |
| Poultry | 7.4 | 16.4 | 3.7 | 0.4 | 1.2 | 2.7 | 2.2 | 4.3 |
| Sheep | 0.1 | 1.5 | 1.9 | 0.5 | 4.0 | 0.5 | 0.2 | 0.2 |
| Horses | 1.0 | 2.5 | 0.2 | 0.4 | 0.1 | 0.7 | 0.3 | 0.6 |

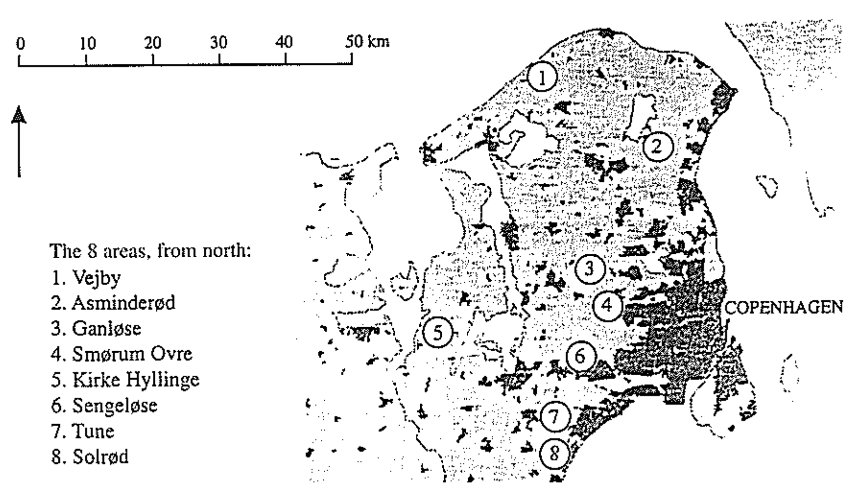


**Figure 5.2** The eight urban fringe areas studied

dominated by relatively flat and fertile ground moraines. It appears that cereals (mainly wheat and barley) and seeds (rape and seeds for sowing) are the two dominant crops. Forage crops are to some degree grown in three of the areas, and vegetables and horticultural crops are important in three areas including the two nearest to Copenhagen (4 and 6). In three of the four northern areas, permanent grassland is a major land-use category.

Livestock composition varies considerably within the eight areas. In some of the areas intensive pig production occurs, whereas it is absent in two of the northern areas. Except for area 5, located at the furthest distance from Copenhagen, dairy cattle are almost absent. Other grazing livestock (beef cattle, sheep and horses) are relatively abundant in the studied areas. Seen in total, the production and land-use pattern are clearly affected by many part-time and hobby farmers. On the other hand, the Table shows that intensively-farmed holdings exist within the areas, being most significant in the south.

Changes in the ownership structure from 1984 to 1994 are shown in Table 5.2. In five of the six areas for which 1984 data are available, full-time farmers were reduced in number, whereas the number of part-time and hobby farmers grew in most of the areas. Full-time farmers are clearly a minority in all areas. The rate of change within this ten-year period has been quite dramatic. In two of the areas, more than half of the total farmland was farmed by another person in 1994. One of the reasons for this is the great proportion of hobby farmers who lease their land on a one year or short-term basis to the first and/or highest bidder (Ogstrup and Primdahl, 1996).

In some of the areas, the landscape structure has changed dramatically as well. Based on interviews, landscape changes within the last 10 years are shown in Table 5.3. The main tendency is the same as described later: more landscape elements have been established than removed. The rate of change in some areas with respect to new hedgerows and new or restored ponds is remarkable. Again, another striking pattern is the variation between the areas.

**Table 5.2** Types of farmers in 1984–1994 in percent. In areas 4 and 6, data from 1984 are not available (from Ogstrup and Primdahl, 1996)

| | *Northern areas* | | | | *Southern areas* | | | |
|---|---|---|---|---|---|---|---|---|
| | *1* | *2* | *3* | *4* | *5* | *6* | *7* | *8* |
| Full-time[1] | 16–5 | 17–9 | 9–3 | -18 | 52–32 | -14 | 42–17 | 20–27 |
| Part-time[2] | 16–22 | 0–10 | 13–10 | -4 | 9–5 | -0 | 4–0 | 12–18 |
| Hobby[3] | 58–28 | 52–65 | 38–45 | -43 | 30–32 | -55 | 25–38 | 24–23 |
| Pensioners and others | 10–45 | 30–29 | 40–42 | -35 | 8–31 | -31 | 38–45 | 44–32 |
| 100% = number of owners | 19–18 | 23–21 | 32–31 | -23 | 23–22 | -22 | 24–24 | 25–22 |

[1]Farmers with farm unit as only income source
[2]Farmers with additional income and with more than half of income from the farm
[3]Farmers with less than half of income from the farm

**Table 5.3** Relative landscape changes from 1984 to 1994 in eight urban fringe areas in Greater Copenhagen. Hedgerows are shown in m/100 ha, forest and greenery in ha/100 ha, and ponds in numbers/100 ha (from Ogstrup and Primdahl, 1996)

| | *Northern areas* | | | | *Southern areas* | | | |
|---|---|---|---|---|---|---|---|---|
| | *1* | *2* | *3* | *4* | *5* | *6* | *7* | *8* |
| New hedgerows | 47 | 2,400 | 117 | 370 | 233 | 293 | 819 | 98 |
| Hedgerows removed | 28 | 71 | 6 | 0 | 145 | 0 | 0 | 24 |
| New forest | 2 | 0.8 | 0.2 | 0.2 | 0.1 | 0.1 | 0.2 | 0.2 |
| Forest removed | 0 | 0.1 | 0.2 | 0.1 | 0 | 0 | 0 | 0 |
| New greenery | 1 | 8.5 | 0.2 | 0.4 | 0 | 1.5 | 0 | 0 |
| New ponds | 0 | 2 | 0.6 | 0.8 | 0.9 | 0.7 | 0.7 | 0.4 |
| Ponds removed | 0 | 0 | 0.1 | 0.2 | 0 | 0.7 | 0 | 0 |
| Total agricultural area, ha | 275 | 315 | 807 | 500 | 534 | 461 | 404 | 543 |

Variations in natural environment and farm types cannot explain these differences. There is more variation within the northern areas than between the northern and the southern ones. In an open field landscape like the Tune area 20 km southwest of Copenhagen (Area 7), the new hedgerows will change the present open field landscape dramatically within a few years.

### *Driving forces in urban fringe land-use changes*

Urban fringe farmers have the same *technologies* available as other farmers. However, skills, education and access to technical information are part of the 'technology' concept. There is some evidence that part-time farmers (a significant group in the urban fringe) have lower levels of formal education compared with full-time farmers, while, in the Copenhagen region, relatively few farmers are members of farmers unions: this means that they have less access to advisory services. Consequently, urban fringe farmers tend to operate their farms in a less modern, industrialised way compared with non-urban fringe farmers, although the small size structure of part-time farms also inhibits the adoption of new farm technologies.

The *natural environment* can influence urban form; for example, wetlands and steep slopes are often avoided for urban development and consequently these features tend to form the urban border. This can be seen at different spatial scales in many places in the Greater Copenhagen region. Here, farming is also affected by the lowering of the groundwater table due to groundwater use. The average decrease of the groundwater table in the region north of Copenhagen in this century has been about 5 m, which has made more wetlands available for reclamation; on the other hand, this trend has made it very difficult for farmers to obtain permission to irrigate. Indeed, no permissions to irrigate ordinary crops are granted over most of Zealand because of the competitive use of water for drinking. Finally, urban centres may affect the natural environment by pollution, although this has only been a problem in few places in Denmark.

*Socioeconomic conditions* include the increasing price level for agricultural land due to demand; this feature has already been mentioned as one of the most significant conditions for urban fringe farming. On the one hand, the higher price level makes it difficult for full-time farmers to maintain an acceptable income from farming; on the other hand, the great number of hobby and part-time farmers provides a relatively large supply of land to lease (rent). Thus, the average farm size (including leased land) for *full-time* farmers is higher in densely-populated regions as compared with the whole country, which is the case in the urban fringe areas studied.

The proximity to urban markets has traditionally been an important locational factor for market gardens, plant nurseries, orchards, etc. Better storage and transportation technologies have reduced the importance of proximity to the market, but it is still a factor affecting land use (Table 5.1).

*Planning* and other *public regulations* play an important role in rural land use in general and in urban fringe areas in particular. Agricultural and planning policies strongly affect the stability and structure of the fringe areas. The essential aspects of regulations affecting land-use changes are linked to the Danish land zoning system introduced in 1969, which is unique in an international context. It divides the whole country into three zones: (1) rural zone, (2) urban zone, and (3) summerhouse zone. Non-agricultural land use in the rural zone is only allowed on the basis of a so-called 'zoning permit' which is granted or (more often) refused by the regional authorities (Primdahl, 1991). The zoning system is the key to understanding the clear borderline between the urban and rural environment in Denmark. Without such a system, which ensures that all major urban changes occur within the physical planning system and that all projects not related to agriculture are subject to so-called 'rural zone permissions', the Copenhagen area would most likely be affected by urban sprawl. This, however, does not mean that all changes are controlled by regulations.

Suburbanisation in the areas studied is only regulated to a certain extent. For farms smaller than 30 ha, the land market is open; in consequence, many people with urban jobs buy a farm mainly as a rural living place. However, it is not permitted to buy a farm as a second home; the owner must live on the farm. Alternative uses of empty buildings for storage, repair shops, small factories, etc. can take place without a zoning permit. In most areas there has been a varying rate of increase in the number of farms with alternative uses of their buildings – a development which is almost uncontrolled. Furthermore, new farm buildings may be constructed (within some size and height limits) without any permission. The planting of hedgerows and greenery is usually not regulated, apart from some subsidies.

In Denmark there is no specific policy instrument for urban fringe areas, as in the 'green belts' of the U.K. Nevertheless, the zoning system works well in preserving the agricultural component of the landscape. There are no clear signs of underfarmed areas in urban fringe environments in Denmark, which is not the case in many other countries.

On *culture*, urban fringe areas are more dynamic and socially more mixed than other rural areas. This means that local cultural traditions concerning buildings and farming practice may not be easily conserved. Consequently, urban fringe landscapes may often appear more 'untidy' than the rest of the countryside. 'Horsiculture', small industries located in farm buildings, recreational areas like golf courses and similar non-agricultural types of land use are often widespread in the urban fringe. Such conditions may prevent the conservation of local building and landscape management traditions.

## Example 2: Small biotopes and landscape dynamics

In the intensively-used Danish agricultural landscape, about one third of the total natural and semi-natural habitat areas for wild plants and animals is made up by so-called 'small biotopes'. This term covers all linear and area elements of less than 2 ha with permanent vegetation or water cover (Agger and Brandt, 1988). Although mainly created by human activity, and commonly viewed as isolated features with little interest from a nature conservation point of view, small biotopes are of importance for landscape ecology because of their stabilising effect, their scenic and recreational functions, and their biological functions as small habitats and dispersal/movement corridors for wild plants and animals.

Small biotopes are an integral part of the agricultural land-use system: most of the 'residual', non-field areas of intensively-used agricultural landscapes are in fact small biotopes. Thus, in many ways changes in small biotopes reflect changes in agricultural land use, although they are subordinate to the factors influencing the agricultural system. As a consequence, small biotopes may be used as indicators for the changes in agricultural as well as other types of rural land use.

### *Long-term changes of small biotopes*

A rough outline of the long-term trend in the development of small biotopes in Denmark is shown in Figure 5.3. Most of these landscape elements are a product of agricultural development. For example, most hedgerows (planted as windbreaks and as enclosures for cattle) and a considerable proportion of the small ponds (mainly resulting from marl pits) were created in the last century in relation to the change towards modern Danish dairy farming. During this process, extensive bogs and wet meadows were drained, giving rise to an increase in open ditches which later disappeared when they were piped.

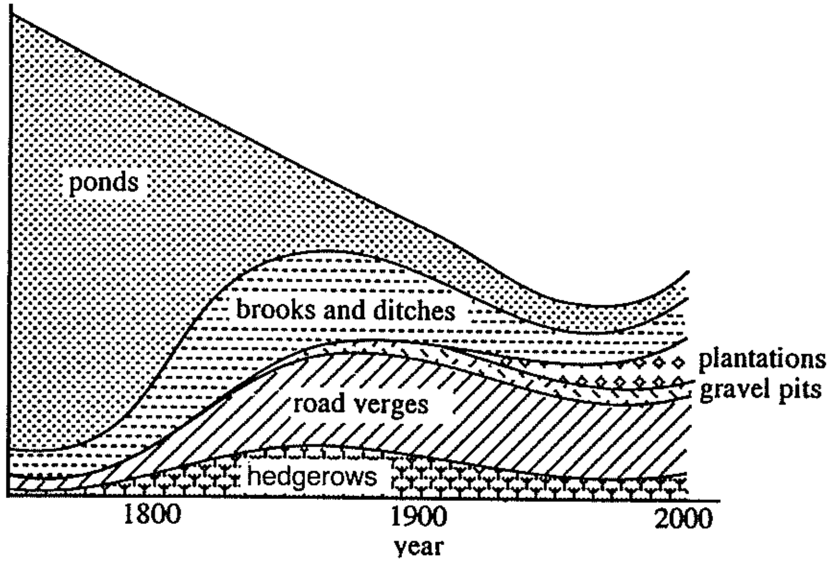


**Figure 5.3** A rough outline of the long-term development trend of Danish small biotopes

From the 1960s onwards, the industrialisation of agriculture had been accompanied by a tremendous decline in most types of small biotopes, resulting from the establishment of larger fields on holdings of rapidly growing size and supported by a widespread tendency towards mono-cropping, especially of barley. However, over the last 15 years this trend has been reversed. A stabilisation first observed at the beginning of the 1980s has been followed by a period of increase, which seems to be continuing during the 1990s (Table 5.4).

*Trends in the small biotope pattern*

It has to be emphasised that the broad trend towards stability in the structure of small biotopes masks diverging regional and local variations. Rapid agricultural specialisation since the 1960s, especially regional variations in specialisation, caused different regional changes in the structure of small biotopes. Also, variations in farm type, as well as in soil conditions, led to different regional tendencies in the dynamics of small biotopes, for instance as observed between eastern Jutland and the islands of eastern Denmark for the period of 1986–1991 (Brandt, 1994).

In more detail, holdings depending solely on crop production tend to destroy small biotopes so as to obtain bigger and more regular fields as a main way of intensification. In comparison, holdings specialised in livestock production tend to concentrate on technological improvements within farm

**Table 5.4** The development of small biotopes in Denmark in 1981–91 (Brandt, 1995)

| *Development of small biotopes in Denmark 1981–1991** | | *1981–86 (% per year)* | *1986–91 (% per year)* | *Wet line biotopes* | *Wet patch biotopes* |
|---|---|---|---|---|---|
| 13 Test sites | Wet line biotopes | -0.1 | -1.1 | Drainage ditch | Wet marl pit |
| in eastern | Wet patch biotopes | -1.8 | -0.8 | Canal | Other wet pit |
| Denmark | | | | Brook | Artificial pond |
| (52 km$^2$) | Dry line biotopes | -0.1 | +0.2 | River | Bog |
| | Dry patch biotopes | +0.9 | +2.0 | | Natural lake |
| | | | | | Village pond |
| 10 Test sites | Wet line biotopes | | +3.2 | | Alder swamp |
| in eastern | Wet patch biotopes | | +2.4 | | Rain water basin |
| Jutland | | | | | |
| (40 km$^2$) | Dry line biotopes | | 0.0 | *Dry* | *Dry* |
| | Dry patch biotopes | | +4.7 | *line biotopes* | *patch biotopes* |
| | | | | Road verge | Dry pit |
| 25 Test sites | Wet line biotopes | | +0.3 | Field divide | Barrow |
| in Denmark** | Wet patch biotopes | | +0.3 | Hedgerow | Plantation |
| (100 km$^2$) | | | | Slope | Natural thicket |
| | | | | Railway dyke | |
| | Dry line biotopes | | 0.0 | Tree row | Solitary tree |
| | Dry patch biotopes | | +2.6 | Stone wall | Ruderal area |
| | | | | Footpath | High power mast |

*Indicated as average annual change in percent for all test sites; the line biotopes in percent of length; the patch biotopes in percent of number
**Including two test sites on Bornholm on the Baltic Sea coast

buildings and thereby allow alternative functions for the existing biotope structure. Again, farms situated on good, well-drained soils on flat land tend to continue to eliminate small biotopes, while those on more sandy or mixed soils on hilly terrain tend to stabilise the small biotope pattern (Agger and Brandt, 1987).

The overall pattern of biotopes that in a landscape ecological context can be described as patches and corridors embedded in a matrix of agricultural fields seems to be repeated in a continuous manner throughout Danish landscapes. However, natural conditions are also of great importance for contemporary changes. Today, an increasing number of ponds and lakes are being dug (or re-dug) in former wet hollows which have been drained, while areas of semi-natural vegetation, as well as pastures, have emerged on sandy spots and slopes which are not well suited to modern agricultural machinery.

The removal of small biotopes during the period of agricultural industrialisation was mainly related to the enlargement and regularization of single fields to suit operations with bigger combines and other machinery. Consequently, small biotopes located *within* the land area of single farms were most threatened; whereas biotopes on the *borders* of the holding were more stable. As a result, by 1981 two thirds of the linear and one third of the areas of small biotopes were located at boundaries between two or more holdings (Biotopgruppen, 1986).

*Driving forces behind biotopes changes*

Both farm size and shape, including the fragmentation of holdings, as well as farm type, including on-going farm specialisation, form basic parameters for the structure and development of the small biotope pattern of agricultural landscapes. However, behind these basic farm characteristics, a range of interrelated driving forces also characterise and explain the dynamics of small biotopes.

Up to the present day, *technological change* has been one of the most important driving forces. Hedges were adopted as windbreaks and enclosures, especially in the nineteenth century, but the introduction of barbed wire constituted a much cheaper and more flexible way of enclosure that in practice rendered hedges superfluous for enclosure. Marl pits were established in the last part of the nineteenth century, but with the introduction of fertilisers they gradually lost their importance. Later they were used as land-fill sites for the increasing amount of waste created by industry. Today, the land-fill function has been legally prohibited and marl pits are often transformed into game habitats instead.

Ditches were dug as a part of agricultural water management. Later they disappeared because of the introduction of drain pipes, which, until recently, were subsidised by the state. The ditches are, however, now regaining importance because new farm equipment is available; drainage diggers have become a common type of machinery on many farms, and the re-establishment of open ditches, therefore, is again a cheap and efficient alternative to other types of draining.

*Variations in natural conditions* have given rise to certain regional differences in the pattern and density of small biotopes. A somewhat dense network of hedgerows has been planted on the sandy soils of central and western Jutland. Marl pits were established at the end of the last century on almost every field in the eastern Danish Weichsel morainic landscape, but only occasionally on the sandy outwash plains of western Denmark. Obviously, wet biotopes such as small lakes, ponds, bogs, ditches, etc. are most frequent in areas with loamy soils and a high groundwater table. However, due to the adoption of management practices and other measures that provide favourable conditions for specific types of agriculture, no clear correlation can be observed between variations in natural conditions and spatial variations in the structure and density of small biotopes (Brandt, 1986).

Since the reorientation towards export of dairy products at the end of the nineteenth century, the *socioeconomic conditions* for Danish agriculture have been highly influenced by the cooperative movement. A strong position on the world market for processed livestock products, combined with legislation that favoured middle-sized farms, enabled cooperatives to maintain this size structure of farms until the 1960s, when a concentration and specialisation of holdings started. Although a reduction in the amount of small biotopes has been observed within the last 100 years, the agricultural strategy of the cooperatives has had a stabilising effect by ensuring the profitability of middle-sized holdings. However, the ongoing processes of specialisation and concentration have resulted in more varied socioeconomic conditions for individual holdings and this has weakened the cooperative movement in general and led to a less uniform farm type and size structure. It has been observed, for example, that the density of small biotopes generally drops with increasing farm size. Thus, a diversity in the small biotope pattern is created at a landscape level as a result of the growing differentiation in farm type and size.

With a few exceptions, *public policies* did not directly affect small biotopes before the 1970s. Until then, agriculture was not seen as any threat to nature conservation values. The so-called 'conservation orders' were the only significant conservation instrument for the countryside which, with compensation being paid, could (and still can) protect specific areas (Primdahl, 1991). One exception were the subsidies for planting shelter belts on sandy soils; in the last hundred years, these changed a great part of Jutland from completely open landscapes into a closed-field landscape dominated by a dense pattern of shelter belts.

In recent years, public policies have come to exert an important influence on small biotope dynamics by subsidising drainage, heathland reclamation and other types of intensification. Since 1937 the Nature Conservation Act has contained a 'general protection rule' that defines those landscape elements which must not be removed or actively changed without permission. Refusals are given without compensation and the regulation has been extended several times since it was introduced. Today, moors, heathlands, natural meadows, pastures, and salt marshes larger than 2,500 $m^2$ are protected by this regulation, as well as all lakes larger than 100 $m^2$, all barrows, and most of the earth and stone walls in the country (Brandt *et al.*, 1994). This makes public policy a powerful factor in small biotope change. New landscape restoration programmes, as well as new EU agri-environmental policies, are also expected to become important, positive factors in the development of small biotopes (Brandt, 1995).

Finally, *culture* influences the small biotope pattern much more than is normally believed. Several regional peculiarities, such as the impressive lilac hedgerows on southern Funen or the well-preserved stone walls in manorial landscapes, are to be explained culturally. Agro-economic considerations in land-use planning and management can also be subject to culture factors. The growing awareness of the importance of small biotopes obviously contributes to stabilisation of the small biotope pattern. This environmental awareness is linked to contemporary cultural and ideological value changes. Landscape management, including non-productive objectives, is again being seen as part of good agricultural stewardship (Brandt, 1992).

## Example 3: Marginalization and landscape structure

In this context, the term *marginalization* will be used for changes in agricultural land towards less economically-intensive uses. Even so, the reclamation of farmland has had, and still has, a significant influence on the landscape pattern of Denmark, as well as in other countries where cultivated land constitutes a major part of the rural landscape.

### *Statistical trends of marginalization*

If we look at the development of cultivated land in Denmark over a period of hundred years, two main regional trends can be distinguished. From 1860 to 1940 there was a gradual increase in the total acreage of cultivated land in the western part of Denmark (Jutland) by an order of magnitude of one third; since then, there has been a modest decline (10 percent). In the eastern parts of the country (dominated by morainic soils), the cultivated area has changed less; the main trend can be summarised as a 10 percent increase until 1880, followed by an equivalent decrease mainly related to urban growth of the cities to the present day.

Recent statistics reveal that these trends continue, but not at the accelerated speed anticipated in the public debate of the mid-1980s; at its peak there was strong public concern about an expected large-scale marginalization of farmland. Nearly one fifth of the farmland was expected to be marginalized before the year 2000. The prognosis caused intensive research related to the marginalization process and to the future use of the abandoned land (Miljøministeriet/Skov-og Naturstyrelsen, 1987), and influenced the legislation concerning the environment, nature conservation and agriculture (Miljøministeriet/Skov-og Naturstyrelsen, 1992).

### *Spatial pattern of marginalization*

The rough description given above, however, does not suffice to reveal the important spatial patterns in the marginalization process at landscape level. This is illustrated by a closer look at a regional example.

The extent of the afforestation of farmland has been used as an indicator for marginalization on dry soils and to identify the regions dominated by abandoned farmland (Jensen, 1976; Breuning Madsen *et al.*, 1990). The marginalization of farmland has been most intensive on the sandy soils of the central part of Jylland (Figure 5.4). Comparisons with geomorphological maps reveal that the abandoned farmland is located on sandy terraces along the rivers and on coarse sandy soils close to the main limit of the last glaciation. The afforested land, however, is not evenly distributed, as might be interpreted from the map.

The landscape dynamics related to marginalization are rather complex and often include shifts in the various land-use categories (especially cultivated land) which are not visible in traditional statistics (Reenberg and Baudry,

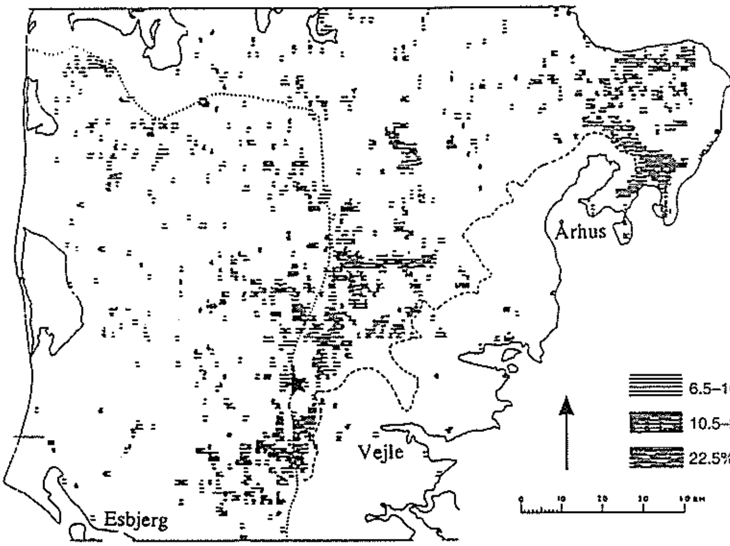


**Figure 5.4** The map shows the localisation and intensity of abandoned arable land in a cross section of Jutland. Registrations are made on the basis of a 1-ha grid, in which the percentage of abandoned land is calculated. The intensity is largest on coarse sandy soils in the central part of the area (e.g. on land close to the fertile soils in the eastern part). In the west, where less-fertile soils also dominate, marginalization of farmland has been less well developed because many soils have never been included in rotation in these more remote areas. Asterisk denotes the region represented in Figure 5.5. Based on findings from Jensen (1976)

Chapter 2). Geo-related mapping of land use reveals that landscape patterns have changed significantly and a statistical 'stability' of the cultivated area occurs only because the area of new cultivation (on former meadows) almost matches the area of afforested farmland. The landscape is a highly fragmented and dynamic patchwork of various land-use classes, as shown in the one-year example in Figure 5.5; thus a statistical description fails to provide a satisfactory basis for analysis of the landscape changes.

### *Driving forces behind changes*

Once again, the lessons learned from landscape changes related to the marginalization of farmland can be summarized in relation to the various factors listed in Figure 5.1.

The *natural environment* determines both the enabling and constraining preconditions for cultivation. However, environmental factors, such as soil, geomorphology, climate and hydrology vary substantially in their functions as limiting factors for agriculture because of farmers' *technological* (and thus also economic) ability to cope with natural constraints. The long-term trends

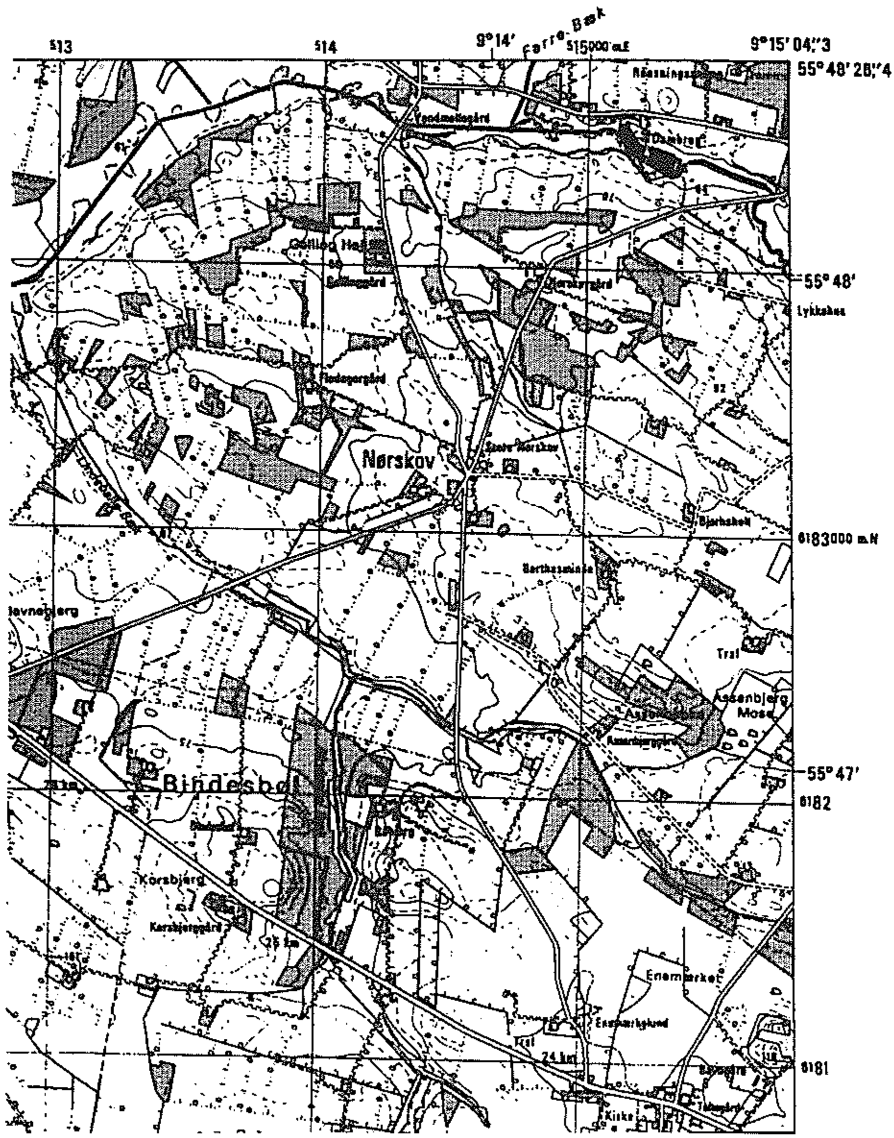


**Figure 5.5** Part of a topographical map (1213 IV NV BILLUND, 1:25,000, 1983) of central Jutland. The location is indicated by an asterisk on Figure 5.4. It shows the fragmented landscape pattern dominated by a large amount of more or less randomly distributed plantations on former cultivated land, which is typical for regions dominated by soils marginal to cultivation

reflect, for instance, how the farmers' ability has changed in manipulating water availability by irrigation and drainage. Thus we find that the expansion of cultivated land has largely been located on sandy soils where access to irrigation has been improved, and on organic soils where the majority of wet meadows have been transformed into arable land within the last hundred years. The introduction of fertilisers has reduced the constraints set by low soil fertility and also contributed to this expansion.

The prevailing agricultural 'tradition' (production priorities, crop and livestock composition, etc.) has also played an important role in the value of natural resources. Sandy soils were not marginal in an agricultural system with crop rotations that included grass cover in winter and spring and employed light agricultural equipment. But in the 1960s the shift to spring-grown cereals and larger farm equipment caused marginalization and abandonment. The sandy soils proved too susceptible to wind erosion during heavy storms in the spring when the soil is uncovered by crops. Much of the marginalization can be related to these changes in production traditions at the farm level. Natural factors continuously influence the comparative advantages for farming and are a main condition for the land-use pattern at the regional level.

The *socioeconomic environment* is important at different spatial levels. For example, calculations have shown (Rude and Dubgaard, 1987) that cereal prices, even when reaching rather high levels as in 1985, were approaching the economic limit for profitable cultivation in most parts of Denmark. Farming only slowly responds to economic conditions and, to date, only a small proportion of arable farming on coarse sandy soils has been converted into grassland, afforested or abandoned. Again, land-use strategies in regions dominated by livestock rearing have been influenced by the fact that fodder production practised on the farm, up to now, has proved to be more economic than other feeding strategies.

At the farm level, economics largely determine a farmer's decisions concerning individual fields. For example, farmers can choose not to take into consideration the cost of their own labour at normal rates; an individual farmer might need fields for the distribution of manure in order to fulfil prevailing regulations; or a farmer's debts might be less than average. Consequently, soil maps can be used only partially to identify the fields most likely to be abandoned. For the individual farmer, the production strategy also often varies over the course of time. Thus, the strategies of young farmers are usually more expansionary than those of older ones (Potter *et al.*, 1991). This leads to the patchwork landscapes (Figure 5.5) found in less fertile regions, determined by the decision to abandon the land; such a decision is rooted in the highly diverse economic conditions at the farm level.

National *policies* influence land-use development in general. Examples of specific relevance with respect to marginalization can be found throughout the time period considered, but a general point is that the relative importance of environmental conditions has increased. At the beginning of this century the alternative use of marginal farmland was furthered by public support for afforestation and wetland reclamation. The objective was to develop employment programmes during times of severe unemployment. Later, environmental regulations limited the drainage of potentially acid sulfate soils, started the protection of groundwater resources, and required 2 m of uncultivated 'natural zone' along watercourses. This has led to some reduction of farmland. Other policies, however, have acted as impediments to the marginalization of less fertile soils, as in the case with laws demanding a certain area per animal unit at the farm level.

Recently, the national policy for the regional distribution of land set-aside under the 1992 CAP measures has maintained marginal land ready for use. An equal regional distribution of the amount of land set-aside has been adopted and this strategy has maintained relatively marginal land under cultivation in the less fertile parts of the country.

EU agri-environmental policies have also affected the marginalization process. For example, management agreements have secured the extensive grazing of marginal grasslands which would otherwise have been abandoned. Approximately 50,000 ha of farmland, most of which is permanent grassland, are subject to such agreements (1995) and the number is expected to grow significantly in the years to come. Again, EU beef and sheep premiums are playing a role in preventing, or at least delaying, the marginalization of poor farmland.

Lastly, *cultural* aspects of the marginalization process deserve attention. Marginalization has often been more intense in regions dominated by a relatively early expansion of cultivated land. The example shown in Figure 5.4 reveals that more farmland has been marginalized on poorer soils located close to the fertile morainic soils towards the east. This can be seen as a result of the local perception of appropriate agricultural stewardship. In line with the national spirit in late 1800, and with the examples shown in the fertile regions close by, farmers have tried to include as much land as possible in rotation. Later expansions of farmland onto the less fertile heathlands in the west at the beginning of this century were preceded by a much more critical evaluation of soil quality. In consequence, abandoned land occurs more frequently in the regions cultivated at an early stage of the expansion of farmland.

## CONCLUSION

Technology, natural environment, socioeconomics, public policies and cultural values have been suggested as key 'driving forces' in rural land processes. This analytical framework has been applied to three different rural issues: changes in the urban fringe, the dynamics of small biotopes and marginalization. The main conclusion is that the framework is to a high degree useful for the study of changes in rural land-use structures. All major changes are caused by one or more of the five 'driving forces' but the major ones vary in space and time with the specific type of change (see Table 5.5).

Public regulation, including planning policy, together with economics is a major force in explaining changes in the urban fringe. This is especially true for understanding the urban growth process. In the rural part of the fringe

**Table 5.5** Driving forces affecting the three types of rural land-use changes

| | |
|---|---|
| *Technology* | |
| A Marginalization | Determine comparative suitability for cultivation of different landscape patches |
| B Small biotope density | Replace functions needed for biotope creation and management<br>Make it easier to remove/establish new biotopes |
| C Land-use changes in the urban fringe | (NO FACTOR) |
| *Natural environment* | |
| A Marginalization | Determine basic precondition |
| B Small biotope density | Enable or constrain removal and construction of small biotopes<br>Influence type of agricultural system |
| C Urban fringe changes | Enable and constrain alternative uses, including urban |
| *Socioeconomic* | |
| A Marginalization | Determine limits to feasible agricultural cultivation patterns<br>Influence demand for land |
| B Small biotope density | Lead to specialisation and concentration in agriculture which results in differentiation of small biotope patterns |
| C Urban fringe changes | Proximity to urban areas leads to high prices and diverse land-use structures |
| *Policy* | |
| A Marginalization | Stimulate desirable changes from arable to grasslands/ forests<br>Reduce unwanted abandonment of grasslands |
| B Small biotope density | Stimulate new biotopes<br>Protect existing biotopes |
| C Urban fringe changes | Reduce land speculation and thus prevent 'under-farming'<br>Reduce urban sprawl |
| *Culture* | |
| A Marginalization | Determine farmers perception of marginality |
| B Small biotope density | Determine farmers appreciation of small biotopes |
| C Urban fringe changes | Determine differences in urban and rural values |

areas, natural conditions, economics, public policies and cultural values jointly affect market conditions, ownership structure and the resulting changes of the rural land-use structure. Thus, the analytical framework is a useful tool for analysing the differences between the changes of rural land use in the urban fringe and other rural areas, but it is not very helpful in preparing urban fringe studies in detail.

Small biotopes are also affected by all five 'dynamic forces'. A factor like technology is particularly important in explaining changes over the course of time because it replaces or introduces agricultural functions resulting in the removal or creation of small biotopes. New technologies often have different, sometimes adverse, effects on areas with different natural conditions. Farmers' values related to small biotopes, together with public policies, also play an important role for dynamics.

In describing the marginalization of agricultural areas, the framework is clearly operative. All five 'forces' are of relevance and affect marginalization. Socioeconomic conditions are of high importance for the marginalization process in general, whereas the relationship between technology and the natural environment may have major effects in a specific space–time situation.

In brief, the general conclusion from the material presented is that a multidisciplinary analytical framework is both necessary and useful for the investigation of land-use dynamics. At a general level, it is possible to list the relevant key parameters which should be included in the framework. The relative importance of these parameters does, however, vary considerably and in an unpredictable way in time and space. Consequently, there is no straightforward, if any, possibility of modelling or forecasting land-use dynamics.

However, a framework, such as the one proposed, might prove to be a most valuable checklist in the initial phase of research design. It will be a relevant tool to ensure that important parameters are not left out – an issue which still deserves attention even if it is presupposed that it might not be possible to create a total, quantitative model.

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