

**30 YEARS OF SPATIAL PLANNING AND INFRASTRUCTURE POLICIES IN THE
NETHERLANDS: A SUCCESS?**

Karst Geurs

Milieu- en Natuurplanbureau, RIVM

Anco Hoen

Milieu- en Natuurplanbureau, RIVM

Guy Engelen

Research Institute for Knowledge Systems, RIKS

Bert van Wee

Technische Universiteit Delft, Faculteit Techniek, Bestuur en Management

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Samenvatting

30 jaar ruimtelijke planning en infrastructuurbeleid in Nederland: een succes?

In Nederland wordt vanaf eind jaren zestig ruimtelijk beleid gevoerd met betrekking tot compacte verstedelijking in verschillende vormen, maar met verschillende doelstellingen en effecten die tot nu toe niet goed zijn onderzocht. In deze paper is een eerste aanzet gegeven tot een beoordelingsmethodiek voor de effectiviteit van het gevoerde ruimtelijke en infrastructuurbeleid. In de studie zijn alternatieve scenarios ontwikkeld die beschrijven hoe Nederland er in 2000 uit had gezien als vanaf 1970 geen ruimtelijk beleid was gevoerd, en als de enorme uitbreiding van het rijkswegennet, zoals voorzien in de Tweede Nota Ruimtelijke Ordening, zou zijn gerealiseerd. De effecten op verschillende ruimtelijke en verkeersgerelateerde indicatoren zijn onderzocht met behulp van de LeefOmgevingsverkenner, een dynamische ruimtelijk-transport interactiemodel. Uit de eerste analyses blijkt dat het ruimtelijk beleid uit de periode 1970-2000, ten opzichte van een situatie met een liberaal ruimtelijk beleid en forse uitbreidingen van het wegennetwerk, succesvol is geweest in het beperken van het uitwaaiëren van verstedelijking (urban sprawl), het tegengaan van verstedelijking in open gebieden, versnippering van natuurgebieden en het beperken van autogebruik en gerelateerde milieuhinder. Het gevoerde beleid heeft dus bijgedragen aan de realisatie van de intenties van nationale ruimtelijke en verkeers- en vervoersbeleid.

Summary

30 years of spatial planning and infrastructure policies in the Netherlands: a success?

Since the late 1960s Dutch national authorities have pursued a policy of compact urbanisation in various forms, though with different policy goals and benefits that have not been well understood. This paper described a first attempt in establishing a methodology and evaluation framework for analysing the effectiveness of the national spatial planning policies. Firstly, alternative visions of the Netherlands are developed describing what the Netherlands would have looked like in the year 2000 if since 1970 the massive interventions in urban development had not been implemented, and if the extensive motorway network anticipated in the late 1960s had been realised. The impacts of the scenarios were computed and evaluated with a GIS based land-use/transport interaction model using a range of land-use, transport, accessibility, social and ecological indicators. The preliminary analysis shows that Dutch land-use and infrastructure policies have been successful in containing urban sprawl and preserving nature areas. The land-use policies as implemented in the period 1970-2000 certainly have contributed to the land-use and transport related intentions of the Dutch national government: they have contributed to open space conservation, and have resulted in less car use and related environmental impacts compared to a more liberal land-use policy and compared to the situation with the very dense motorway network as proposed in the late 1960s.

1. Introduction

Dutch spatial planning policies, especially the promotion of compact urban development, have a very good reputation in Europe. Since the late 1960s Dutch national authorities have pursued a policy of compact urbanisation in various forms, though with different policy goals and benefits that have not been well understood (Dieleman et al., 1999). The main aim in the 1970s was to contain urban sprawl and preserve open agricultural areas and natural environments, while in the 1980s and 1990s spatial and transport planning were focused on restricting private car use, and reducing energy use and emissions. Although the benefits of a compact urban form have long been under discussion in the literature, they have only been the subject of heavy debate in the Netherlands in the last few years. Nevertheless, the effects of Dutch compact urban development policies are still not very well understood. Essentially, what is lacking here is firstly a reference situation describing what the Netherlands would have looked like if the massive interventions in urban development had not been implemented. Secondly, a broader appraisal framework is needed, including land-use, transport, and economic, social and ecological impacts.

This study describes a first attempt to fill these two gaps. The study carried out here consisted of three phases. In the first phase, a dynamic GIS-based, land-use-transport interaction model, Environment Explorer (Engelen et al., 2003), was developed and applied in a study simulating the real world land-use and transport developments in the Netherlands on a yearly basis from 1970 to 2000 (the calibration phase). The second phase focuses on the development of alternative land-use and transport infrastructure scenarios for Netherlands for the 1970-2000 period. In the third, and final step, the impacts of the three scenarios were computed and evaluated with the Environment Explorer (Engelen et al., 2003), using a range of land-use, transport, accessibility, social and ecological indicators.

The rest of the paper is structured as follows. Section 2 gives a short overview of Dutch national spatial planning policies from the late 1960s. Section 3 describes the modelling and appraisal methodology. Section 4 describes the results of the study, and Section 5 presents the conclusions.

2. Spatial planning in the Netherlands

2.1 30 years of Dutch compact urbanisation policies

Dutch spatial planning, especially at the national level, has been characterised by a great number of spatial policy concepts, however the basic principles continued to be the same (Hajer & Zonneveld, 2000). For 30 years national spatial planning policies in the Netherlands were aimed at implementing compact urbanisation in various forms. The *Second Report on Physical Planning* (VRO, 1966) took the first powerful stand against suburban sprawl. The main rationales were an efficient use of land (land is seen as an irreplaceable asset), funding of services and infrastructure and to preserve the Green Hart. The proposed alternative was to channel suburbanisation into ‘concentrated deconcentration’, i.e. accommodating new urban growth outside existing urban areas in a number of designated overspill centres. This policy was seen as a feasible compromise between concentration and low-density dispersal of urban activities. Compact urban development remained the cornerstone of Dutch physical planning ever since. One of the most important issues in the plan was how to facilitate the booming growth in car traffic. The report was based on forecasts showing a huge population and car ownership increase; population was forecasted to increase from 21 million people in 2000, the number of cars from 1,25 to 6-7 million. To facilitate the expected growth in car traffic, a huge expansion of the road network was planned for the period up to 2000 (see Figure 1). The road network expansion planned was only partly realised, although the forecasted car growth for 2000 was realised (5.5 million cars in 2000) with a much lower population size (about 16 million inhabitants in 2000).

The policy of concentrated deconcentration was continued in the *Third National Report on Physical Planning* (VROM, 1977), and more strictly regulated and controlled. The locations of new towns were now pinpointed by the national government, as in the preceding period the spatial planning process of provincial and local authorities was insufficiently controlled (Van Straten et al., 1996). The Third Report added the reduction of (the need for) car travel while promoting non-motorised and public transport as a new rationale for compact urban development, aiming to reduce energy use and environmental pollution and the demand for road infrastructure.

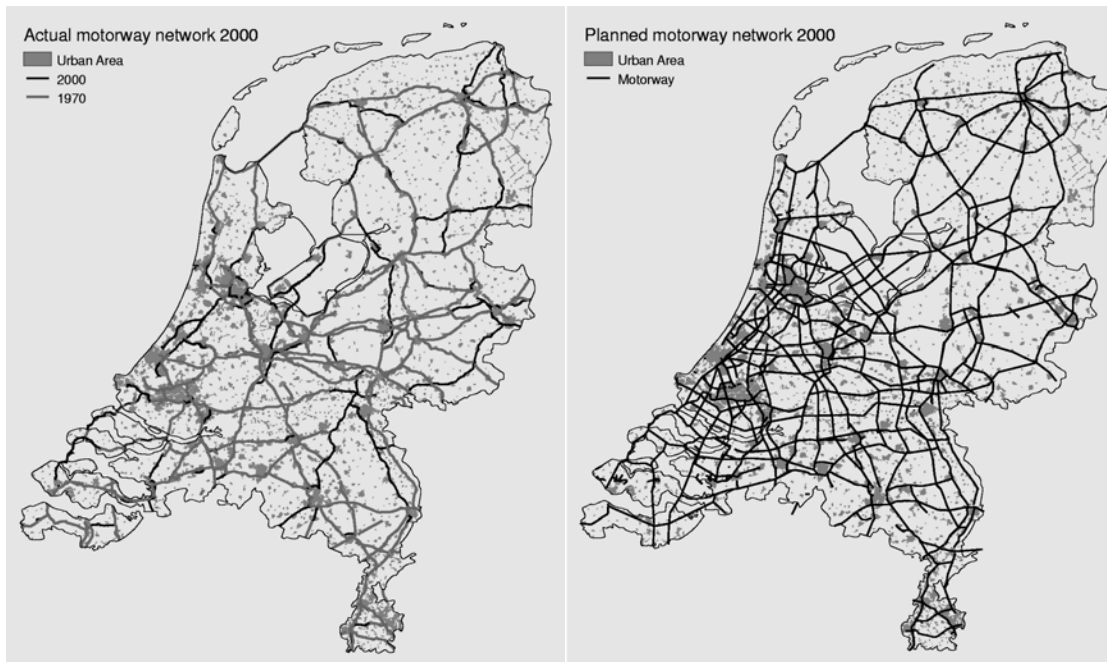


Figure 1: Actual motorway network and planned motorway network in the Second Report on Physical Planning for 2000

In the course of the 1980s, the concept of concentrated deconcentration changed to the 'compact city' policy. The main cause was that the decline of inner cities was in part blamed by the policy of concentrated deconcentration (Dieleman et al., 1999). Under the *Fourth Report on Physical Planning Extra* (VROM, 1991) the government tried to guide new urban (re)development towards locations within existing urban areas ('brownfield' locations) and new 'greenfield' locations near existing cities in the Randstad pinpointed by the national government (called 'VINEX' locations). At the same time, restrictive planning measures protected the Green Hart from major urban development, and the National Ecological Network was developed, i.e. a network of nature conservation areas enjoying special protection against land-use developments. The main arguments for compact urban growth were the same as in the 1970s, but adding bringing a halt to inner-city decline. Furthermore, the Fourth report and Second Transport Structure Plan (V&W, 1990) set a target to reduce the projected growth of car traffic which was to be met with spatial planning and transport policy measures.

In recent years, there no longer seems to exist a broad consensus of compact urbanisation as the corner stone of spatial planning which is reflected in the current

draft *Fifth National Policy Report on Spatial Planning (VROM, 2001)*, which has a mixed perspective on compact urbanisation. Compact city development is replaced by a 'network city' as a planning concept, and supervision on local authorities is to be reduced (decentralisation) (see for a discussion Hajer & Zonneveld, 2000). Furthermore, policy targets for reducing car travel are abolished. However, at the same time, restrictive land-use zoning is used to preserve natural environments, open agricultural areas (the Green Hart) and other important landscapes, and the policy of compact greenfield housing locations is continued for the period 2005 to 2010 (to realise 226.000 dwellings), although with lower housing densities and more decentralised infrastructure funding (Spaans & Trip, 2003).

2.2 *Dutch compact urban development: a success?*

As described above, Dutch spatial planning has pursued a policy of compact urbanisation during the last 30 years in various forms and with different arguments. However, the effects of Dutch compact urban development policies are still not very well understood in literature and there is still no consensus on its benefits. Dieleman et al. (1999) conclude that the implementation of compact urbanisation policies was largely successful. The new towns from the Third Report were developed as intended, certainly as far as housing is concerned, and in the 1990s the dwelling stock and number of inhabitants in the large cities started to grow again after a decade of serious decline. More than half a million dwellings were built in the designated growth centres and urban sprawl was stemmed by restricting the growth of villages in the Green Hart, reducing the rate of population growth in rural municipalities (Van Straten et al., 1996). Furthermore, the Fourth Report's brownfield and greenfield (VINEX) locations were built or are being developed as planned, although the realisation of some greenfield locations is delayed (Spaans & Trip, 2003). As a result, major suburbanisation of the Green Hart and important nature areas were avoided.

The impact of urban form on passenger travel has long been under discussion in the literature. Some say that influencing travel behaviour through land-use planning is an illusion, while others say it is a very fundamental way to influence travel behaviour. See for recent literature overviews Snellen (2001), Stead & Marshall (2001), Van Wee (2002) and Schwanen (2003). In the Netherlands, relatively little empirical analysis is conducted on links between land-use patterns and travel behaviour. Hilbers

et al. (1999) analysed travel behaviour of residents of different type of VINEX locations in the Netherlands. The authors conclude that different types of residential areas show significant differences in travel behaviour, corrected for socio-economic variables. Car use of inhabitants of brownfield locations, built within an existing city or towns, is about one-third below the level of car use of inhabitants of VINEX greenfield locations, built at the edges of existing towns. However, differences in travel behaviour between several types of greenfield locations are rather small. Schwanen (2003) conducted empirical analysis using 1998 national travel surveys and concludes that the influence of urban form on travel behaviour is relatively small; only 3% of the variation in commuting time and distance can be explained by the spatial context, when controlling for individual and household characteristics. Next to empirical studies several model simulation studies in the Netherlands have been conducted to forecast travel behaviour impacts of concepts of future urbanisation, which without exception showed that land use can have a relatively strong impact on travel behaviour (Van Wee & Van der Hoorn, 2001).

From the literature it is clear that, even after many years of scientific and policy debate, the effects of Dutch compact urban development policies are still not very well understood, and that there is still no consensus on its benefits. Firstly, a thorough analysis of impacts according to a broad range of land-use, transport, accessibility, economic, social and ecological impacts is lacking. Secondly, it is not easy to develop land-use policies that result in large travel behaviour benefits related to current practice in the Netherlands. But this does not mean that the policies do not have important benefits. What is essentially lacking is a reference situation describing what the Netherlands would have looked like if the massive interventions in urban development had not been implemented, and a thorough analysis of its impacts.

3. Modelling and appraisal methodology

3.1 Introduction

The ultimate goal of an analysis of the benefits of compact urbanisation policies implemented in the Netherlands would be an in-depth appraisal of their sustainability impacts, incorporating land-use, transport and accessibility effects and the integrative impacts on the economy, society and the environment. This makes the case for using a

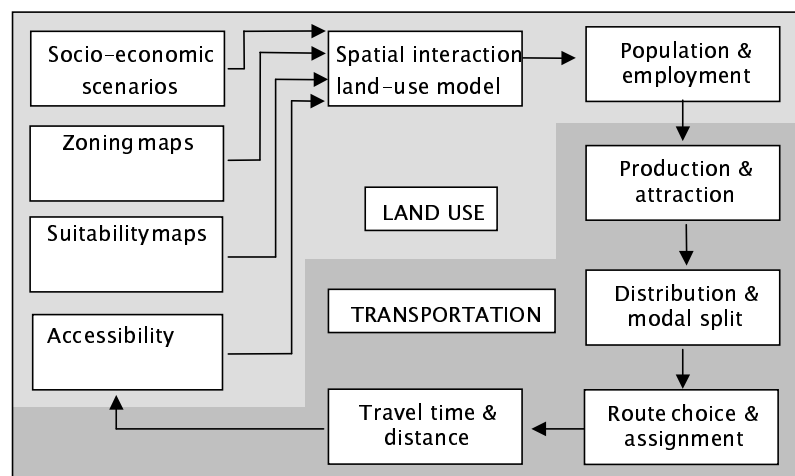
land-use/transport interaction model, with which we can firstly take full account of the complex interactions and synergies, which may occur between land-use and transport changes. Secondly, land-use/transport interaction models are at present the only available method considering an important range of the economic, social and ecological impacts which may arise from planning decisions in land-use and transport.

In this paper, we conduct a simplified sustainability impact analysis, focusing on a range of land-use, transport, accessibility, ecological and economic effects. For this purpose, we use a luti model as an appraisal tool, the Dutch Environment Explorer, which considers a range of relevant potential impacts at a relatively high spatial resolution. Section 3.2 describes the Environment Explorer, Section 3.3 the indicators used and Section 3.4 the scenarios constructed for this study.

3.2 *The Environment Explorer 1970-2000*

The Environment Explorer is a dynamic land-use/transport interaction model for the Netherlands, developed to design, explore and evaluate long-term spatial policies relative to the development of the physical environment in an economic, social and ecological context (Engelen et al, 2003). So far, the Environment Explorer has been applied to forecast land-use developments in scenario studies for the period of 1995 to 2030, see for example (De Nijs et al., 2002; De Nijs et al., 2001). For this study, a new version was developed to simulate the period of 1970 to 2000.

The Environment Explorer consists of a land-use module and a transport module that are dynamically linked, thus allowing *feedback* processes. Figure 2 gives a schematic illustration of



the models' architecture.

The transport module is a traditional 'four-stage' transport demand model that takes the spatial distribution of

Figure 2: A schematic illustration of land-use and transport linkages in the Environment Explorer

population and employment resulting from the land-use module as its input. Likewise, the land-use module takes the accessibility measures available from the transport module as one of the factors determining the allocation of land. A short description follows.

The **land-use model** operates at three distinct levels of spatial aggregation: the national level, the regional level (40 regions, called COROPS) and the detailed local level (25 ha cells). Additionally the land-use model produces results at a sub-regional level (345 zones) as input for the transport module. At the national level, the model integrates national figures taken from economic and demographic growth scenarios considering developments in the Netherlands. Growth figures for the national population and the activity per economic sector are derived from these figures and entered into the model as trend lines. They form the input for the models at the regional level. At the regional level, consisting of 40 large administrative regions, a classic dynamic spatial interaction-based model provides for the allocation of national growth as well as for the interregional migration of economic activities and population on the basis of the relative attractiveness of the regions. In this paper, the development of population and economic activities by COROP region is given for the period 1970-2000, taken from data from Statistics Netherlands.

At the local level (351,000 grid cells of 25 ha each), the allocation of economic activities and people is modelled by means of the Cellular Automata model that runs on top of detailed GIS information. Cellular Automata account for the influence of the neighbouring activities within the surrounding grid cells. Location rules describe the relationships between the different forms of land-use, classified in 10 (urban and non-urban) land-use categories, 6 of which are modelled dynamically. Land-use allocation depends on four elements: (1) the physical *suitability* of cells to support a land-use function, (2) the land-use *zoning* or institutional suitability, as described in national or regional land-use policy plans (e.g. ecologically valuable areas), (3) cellular *accessibility*, based on zonal accessibility levels by car and public transport for different activities, and local distances to road and rail infrastructure, railway stations, motorway approaches and exits, and (4) the *neighbourhood effect*, which is the combined effect of attraction and repulsion by the functions present in the neighbourhood. The strength of the interactions is articulated in rules and is a function

of the distance separating the different functions within the neighbourhood. The neighbourhood consists of all cells found within a radius of 4 km. On the basis of these four elements, the model calculates the *transition potential* for each cell and function for each simulation step. In the course of time and until regional demands are satisfied, cells will convert to the land-use function for which they have the highest potential. A simulation step is made on a yearly base.

In this study, the calibration of the model is aimed at reproducing the 1996 land-use coverage (at the grid cell level) based on 1970 land coverage data (derived from 1:50,000 topographic maps and additional data), and yearly activity data at the regional level.

A traditional ‘four-stage’ **transport model** estimates car and public transport travel for 345 transport zones. The model computes passenger travel for an average working day (24-hour period) for one year, incorporating congestion effects. The transport model simulates a land-use transport system equilibrium state within one year, providing output to the regional and local land-use models for the subsequent time period. The land-use module uses zonal potential accessibility measures (to work, population, recreational facilities) as input for the computation of cellular accessibility values. In this study, the transport module is run less frequently than the land-use module (i.e. every five years instead of every year) to simulate time-lags in interaction between transport and land-use. For each of the five year periods, road infrastructure networks were constructed, using road maps and 1986 and 1995 infrastructure networks from the National Model System (NMS) (Gunn & Van der Hoorn, 1998). Public transport level of service matrices were constructed using 1973, 1983, 1993 and 1986 and 1995 travel time data from the SMART model (Smits et al., 1996) and the NMS, respectively. The calibration of the transport model is aimed at reproducing aggregate passenger mobility trends for the period 1970-2000 (i.e. national car and public transport trip length and volumes) and detailed 1995 travel behaviour (road traffic levels, congestion, etc.).

3.3 *Indicators*

To study the sustainability impacts of compact urbanisation policies, a broad range of indicators is used, including land-use, transport and accessibility effects and their

impacts on the economy, society and the environment. Here, we are only able to conduct a partial sustainability impact analysis. The main goal here is to present a range of relevant impacts. In this paper we focus on the most distinctive land-use, mobility, accessibility, social and ecological indicators. Clearly, a final aggregate score of impacts using cost-benefit-analysis or multi-criteria analysis is beyond the scope of this study. This would imply a full impact analysis of the social and economic costs and benefits of the land-use and infrastructure policies implemented in the last 30 years.

3.4 *Scenarios*

The main goal of the scenarios developed in this study is to analyse the bandwidth in potential impacts if the massive policy interventions in urban development in the Netherlands had not been implemented, and if a radically different infrastructure policy had been followed. Two alternative land-use and transport infrastructure scenarios were constructed in this study for the 1970-2000 period, which are rather extreme in terms of land-use and transport policies. The scenarios are characterised as follows:

- ❑ A **Liberal Urbanisation** scenario, assuming no spatial policies restricting urban sprawl and preserve open agricultural and natural environments in the 1970-2000 period. Furthermore, we assume that all locations are physically suitable for urbanisation, except water surface.
- ❑ A **Draughtboard Infrastructure** scenario, assuming the realisation of the extensive motorway network proposed in the 1966 Second Report on Physical Planning to facilitate the expected demand for car travel (see Section 2.1; Figure 1). The motorway expansion increases the current total length of Dutch motorways by about 50%. Furthermore, this scenario also assumes a liberal urbanisation development, with no land-use restrictions. Although the Second Report envisioned the road network to be realised by the year 2000, we assume the infrastructure expansion to be fully realised by 1980 to allow for long-run land-use adjustments. The public transport network and level-of-service is assumed to be the same as the reference case.

The scenarios are used as input for the Environment Explorer to analyse the land-use, transport, social and ecological impacts as described in Section 3.2. It is important to

note that the scenarios presented in this paper are the result of the initial scenario construction phase. In this phase, population and employment developments at the regional level (40 economic regions) are assumed to be the same as the reference scenario. It is thus implicitly assumed that the land-use and infrastructure changes do not influence population and firm migration at the interregional level. In reality, however, interregional migration can be expected, as the scenarios are relatively extreme in terms of land-use and infrastructure changes. The main problem is that migration trends from the past can not be used as input for ‘policy free’ land-use scenarios, as they have been strongly influenced by the compact urbanisation policies implemented. In the next phase of this study, additional scenarios will be developed to examine the impacts of alternative regional distributions of population and firms. These scenarios will be constructed in a workshop in which Dutch spatial planning and transport experts will participate. Unfortunately, the results of this phase can not yet be reported here.

4. Results

4.1 Land use

In the last three decades the Netherlands have seen a process of regional suburbanisation and national deconcentration of urbanisation (WRR, 1998). This is illustrated in Table 1, showing population growth to be much stronger in suburban areas and peripheral areas than central urban areas for the period 1970-2000. The same effect is seen when looking at employment developments (not shown here). The land-use developments estimated by the Environment Explorer show that compact urbanisation policies have successfully moderated urban sprawl, i.e. in the *Liberal Urbanisation and Draughtboard Infrastructure* scenarios show a much stronger level of suburbanisation for the 1970-2000 period. The Environment Explorer shows significantly different land-use developments for both scenarios 2000, i.e. about 20 percent of the Dutch population is redistributed within (corop) regions. Both scenarios show a population shift from rural, peripheral, regions to suburban regions, illustrating preferences for housing locations at relatively close proximity to urban facilities and natural environments. In the reference case, further urbanisation of suburban areas, for example in the Green Heart, was restricted and controlled by land-use regulations, whereas expansions of existing villages and small towns in peripheral

areas were allowed. Furthermore, the Draughtboard Infrastructure scenario shows a somewhat stronger population shift from peripheral regions to central urban and suburban areas compared to the Liberal Urbanisation scenario, locations where most of the infrastructure expansions were anticipated and which become more attractive due to a higher accessibility levels.

Table 1: Population development by urbanisation type

	1970	2000			
		Reference		Liberal Urbanisation	Draughtboard Infrastructure
	total (*1000)	total (*1000)	index 1970=100	index reference case 2000 =100	
central urban areas	3389	3548	105	89	94
suburban areas	5135	6874	134	113	114
peripheral areas	4459	5447	122	90	86
total	12983	15870	122	100	100

4.2 Passenger mobility

As in most Western European countries, passenger mobility in the Netherlands has grown very strong in the last decades, mainly as the result of population changes (growth and composition), income growth, land-use changes and infrastructure investments. Car use increased by more than a factor two and public transport use by about 90% between 1970-2000. Surprisingly, the *Liberal Urbanisation* scenario shows, at the national level, roughly the same level of car and public transport use in 2000, although there are significant differences at the local level. This can be explained as follows. Firstly, the scenarios underestimate mobility impacts due to the assumption of fixed activities at the regional (COROP) level (see Section 3.4). The mobility impacts will be greater if interregional migration of the population and firms are included. Secondly, the mobility impacts estimated by the Environment Explorer are primarily the result of changes in trip length and modal shifts between public transport and the car mode. The scenarios do not show differences in the total number of trips, which is due to the rather simplified method of trip generation in the transport model, typical for most trip-generating models (McNally, 2000). In the Environment Explorer, trip generation is a function of the number and composition of activities and urbanisation degree in each zone, but does not reflect travel impedance or accessibility. As a result, a strong increase in travel costs, for example, does not result in fewer trips. Furthermore, potential mode shifts to non-motorised modes are not

included. Thirdly, we have not considered differences in car ownership. In reality, however, the land-use and infrastructure changes envisioned are likely to have an impact on car ownership.

The *Draughtboard Infrastructure* scenario shows 2-8% higher car use levels in the 1970-2000 period at the national level, whereas public transport use is reduced by about 2-5%. This impact is, given the accessibility effect, and the assumptions described above, significant, i.e. the average day car travelling speed increases by about 4-6% for the period up to 2000.

4.3 Accessibility

In this study we estimated infrastructure-based and location based accessibility measures. The infrastructure-based measures, congestion and average travelling speed, show the functioning of the road network. The location-based potential accessibility measure evaluates the combined effect of land-use and transport elements, incorporating assumptions on a person's perceptions of transport by using a (negative exponential) distance decay function (consistent with the transport model). See for a discussion on accessibility measures Geurs & Van Wee (2003).

Table 2: Overview of accessibility changes, 1970-2000

	Reference case	Liberal Urbanisation	Draughtboard Infrastructure
	index 1970-2000	index reference 2000=100	
congestion (peak hour)	633	118	65
average car travelling speed (24-hr period)	94	99	106
potential job accessibility			
- car	175	99	109
- public transport	143	103	103
- logsum car and public transport	171	100	108

Table 2 summarises the results of the accessibility indicators. The table shows that peak hour congestion, expressed as the number of road sections with a traffic intensity/capacity ratio of more than 0.85, strongly increased between 1970 and 2000. The Environment Explorer shows a reduction of average day car travelling speed by about 6%, which implies a reduction of about 20% during peak hours. Note that this forecasted trend is a rough estimation and does not fully reflect all transport system developments. That is, from the 1970s the policy response in the Netherlands to

increasing congestion was to expand road capacity on the motorway network, whereas in urban areas car traffic was discouraged by traffic free zones, introducing parking fees, bicycle and bus infrastructure, etc. (Transpute, 1993). The Environment Explorer is not able to incorporate the latter as the model does not include a full urban road network and does not model local traffic. Furthermore, the model uses a simplified traffic assignment and congestion computation method. The *Liberal Urbanisation* scenario shows an increase in peak hour congestion and a decrease in car travelling speed. As can be expected, the large infrastructure expansion in the *Draughtboard Infrastructure* scenario reduces congestion and increases car travel speed.

The potential accessibility measure shows a radically different development of accessibility. Average potential job accessibility by car increased strongly between 1970 and 2000, despite increased congestion levels. The increase in job accessibility is much lower for public transport users (43% increase) than for car users (75% increase), despite the increase in public transport service levels and decreased car travelling speeds. This clearly illustrates the effect of the regional suburbanisation and national deconcentration processes, which resulted in population and employment growth at locations well accessible by car (suburban and peripheral regions) but not at locations very well accessible by public transport (central urban areas). The aggregate job accessibility level, computed as the composite, or logsum costs (Williams, 1977) increases by about 71% and shows the dominance of the car mode in total accessibility growth. The *Liberal Urbanisation scenario* shows a small decrease in job accessibility by car and a small increase by public transport. The latter is the result of the population and employment shift from peripheral regions to suburban locations, which are better accessible by public transport. The *Draughtboard Infrastructure scenario* shows an average 9% increase of job accessibility. Furthermore, Table 2 shows for the Draughtboard Infrastructure scenario a relatively stronger increase in potential job accessibility than travelling speed, showing that jobs are somewhat more concentrated at locations near road infrastructure, well accessible by car.

4.4 Ecological impacts

Table 3 gives an overview of changes in the ecological indicators as estimated by the Environment Explorer.

Table 3: Overview of changes in ecological indicators, 1970-2000

	reference case	Liberal Urbanisation	Draughtboard Infrastructure
	index 1970-2000	index reference case 2000=100	
compactness of the built-up area	62	60	83
noise levels in residential areas	107	100	100
noise levels in natural environments	108	100	102
habitat fragmentation	93	102	104

The table shows the development of the compactness of the built-up area, computed as the total surface of unbroken urbanised area within a certain radius for each grid cell. This indicator is thus sensitive to compact and disperse urbanisation patterns. The reference case clearly shows a trend towards more disperse urbanisation. However, urban sprawl has successfully moderated by compact urbanisation policies, i.e. in the *Liberal Urbanisation* and *Draughtboard Infrastructure* scenario show a much stronger dispersed urbanisation pattern for the 1970-2000 period.

Noise levels from road traffic, expressed in the logarithmic dB(A) scale, increased by about 7-8% in the reference case between 1970 and 2000, which is more than a doubling of noise emissions. Noise levels increase significantly stronger in natural environments than in residential area. In reality, this effect is even stronger as the modelling of noise emissions does not incorporate the impact of noise mitigation measures (such as silent asphalt and noise barriers) taken in residential areas.

Furthermore, Table 3 shows the development of habitat fragmentation of the Dutch National Ecological Network, the network of nature conservation areas connected by ecological corridors. The degree of habitat fragmentation is sensitive to the total surface of natural environments and the degree of fragmentation due to built-up and intensively cultivated areas, the location of road infrastructure and traffic levels at the roads. Nature conservation areas are strongly fragmented, which is not surprising as the Netherlands is a densely populated country with an extensive infrastructure network. The overall size of nature reserves is relatively small, and the larger nature conservation areas (e.g. the Veluwe, Utrechtse Heuvelrug) are clearly fragmented by road infrastructure. The reference case, however, does show a 7% decrease of habitat quality at the national level between 1970-2000, despite increased urbanisation and infrastructure construction. This is due to land-use function changes in rural and peripheral regions of the country, mainly in the Northern provinces, where

agricultural area was changed to natural areas, resulting in an overall increase of the total surface of natural environments. This effect is, however, rather uncertain as part of the land function changes are due to changes in definitions in land-use coverage data over time. Both the *Liberal Urbanisation* scenario and the *Draughtboard Infrastructure* scenario show an increase of habitat fragmentation.

The road network expansion envisioned in

the *Draughtboard Infrastructure* scenario results in an additional increase of fragmentation, which is visualised in Figure 3.

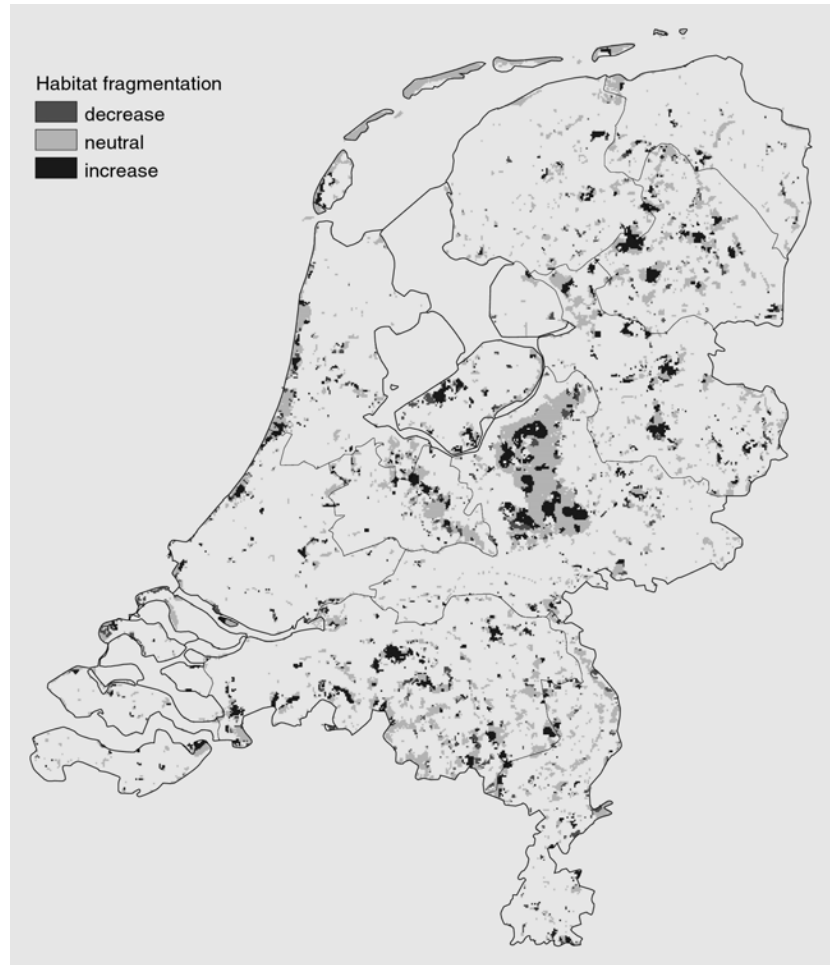


Figure 3: Difference in habitat fragmentation between the *Draughtboard Infrastructure* scenario and reference case, 2000

6. Conclusions

Since the late 1960s Dutch national authorities have pursued a policy of compact urbanisation in various forms, though with different policy goals and benefits that have not been well understood. The main rationales were an efficient use of land and infrastructure, to preserve open agricultural areas and natural environments, to stop inner-city decline, and to reduce car travel. This paper described a first attempt in establishing a methodology and evaluation framework for analysing the effectiveness of the national spatial planning policies. Firstly, alternative visions of the Netherlands are developed describing what the Netherlands would have looked like in the year 2000 if since 1970 the massive interventions in urban development had not been

implemented, and if the extensive motorway network anticipated in the late 1960s had been realised. The impacts of the scenarios were computed and evaluated with a GIS based land-use/transport interaction model using a range of land-use, transport, accessibility, social and ecological indicators.

The analysis shows that Dutch land-use and infrastructure policies have been successful in containing urban sprawl and preserving nature areas. To conclude, land-use policies as implemented in the period 1970-2000 certainly have contributed to the land-use and transport related intentions of the Dutch national government: they have contributed to open space conservation, and have resulted in less car use and related environmental impacts compared to a more liberal land-use policy and compared to the situation with the very dense motorway network as proposed in the late 1960s.

However, the analysis presented in this paper is preliminary, as the scenario construction phase was not yet finished at the time of writing this paper. The results presented here underestimate the impacts of compact urbanisation policies, as we have not considered population and firm migration at the interregional level. Furthermore, we have not considered potential impacts on in car ownership levels and trip generation. As a result, impacts on travel behaviour, an important rationale for compact urbanisation policies in the Netherlands and elsewhere, could not yet be thoroughly addressed. In the final phase of this study, additional scenarios will be developed to examine the impacts of alternative regional distributions of population and firms.

In this paper we focussed on the most distinctive land-use, mobility, accessibility, social and ecological indicators. Future research directions are pointed at a more in-depth appraisal of the sustainability impacts, incorporating land-use, transport and accessibility effects and their impacts on the economy, society and the environment. This would include a more elaborate analysis of the social and economic costs and benefits of land-use and infrastructure policies, and using cost-benefit analysis and multi-criteria analysis to aggregate the results, which was beyond the scope of this study.

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