Influence of Land-use on Traffic and Environmental Impact of Traffic

B. van Wee [a] and B. van Bleek [b]

[a] Dutch National Institute of Public Health and the Environment
PO Box 1, 3720 BA Bilthoven, The Netherlands

[b] Dutch Ministry of Housing, Spatial Planning and the Environment
National Spatial Planning Agency
P.O.Box 30940, 2500 GX The Hague, The Netherlands

ABSTRACT

From the literature we know that the influence of land-use planning alternatives on passenger traffic and transport is potentially large. However, strong governmental policy will, especially at the 'higher than urban level', be required to arrive at a land-use situation where car use will be relatively low. One of the key issues in Dutch land-use policy at the urban level is the question about compact or diffuse urbanization patterns. A more compact pattern results in a lower level of car use and in some forms of environmental pressure on car use than a more diffuse pattern does. However, to have a significant impact, compact building has to be the guideline for urbanization over a long period of time. Apart from the direct effects, compact building will also offer better opportunities for future measures, such as car-free zones in (central) urban areas, improved public transport, stimulation to cycle and reduction of parking problems. In doing so local environment and liveability in cities are expected to improve.

1. INTRODUCTION

This paper will overview the possible impact land-use can have on traffic as well as the environmental impact of traffic itself. Specifically, Section 2 will survey the categories of land-use measures to reduce environmental pressure while Section 3 will review the literature on the possible influence of land-use on traffic. Section 4 will present scenario studies carried out by the Dutch Spatial Planning Agency of the Ministry of Housing, Spatial Planning and the Environment, with Section 5 giving possible effects of two scenarios ('compact' and 'diffuse') on traffic volumes and the environment. Finally, Section 6 will present the main conclusions.

2. LAND-USE MEASURES TO REDUCE ENVIRONMENTAL PRESSURE

Land-use measures can reduce environmental pressure in several ways, as outlined in Table 1.

Table 1
Categories of measures to reduce environmental pressure

Categories of measures	Example
1. Measures that reduce the volume of human activities producing environmental pressure, and so emission levels, or the structure of these activities.	Volume: the number of car kilometers can be reduced by a comprehensive planning of residential areas, working areas and infrastructure. Structure: land-use measures can influence the modal split (e.g. share of car and of public transport).
2. Land-use measures that influence the locations of human activities in such a way as to cause less environmental pressure.	If industrial activities are located far away from residential areas they will contribute less to local air pollution than if they are located within residential areas.
3. Land-use measures to influence the locations of the receptor.	If houses are built far away from existing motorways, concentrations of pollutants will be lower than if houses are built close to motorways.
4. Land-use measures related to the area between the source and the receptor.	If offices are built between a main road and a residential area, noise levels in this residential area will be lower than without these offices. Noise barriers; city parks and reducing concentrations of pollutants are also measures.
5. Another distribution of households within the same housing stock.	Students in city centers; families in suburban areas.
6. Spatial/technological measures to decrease pressure of human activities.	Building below the land surface, e.g. roads; vertical mixing of land-use; bedrooms in houses away from the roadside.
7. Compensating measures.	A city park close to areas with high environmental pressure.

The fifth point in the table deserves some explanation. It is related to the fact that not all people are affected by environmental pressure the same way. For example, students might experience less noise nuisance from cafes and bars in the city center than families with children, which means that changing the distribution of households within the housing stock could result in less nuisance.

To date we have not seen a comprehensive inventory of possible land-use measures for lowering environmental pressure, considering all the categories listed in Table 1. Although it is not the aim of this paper to fully describe the possibilities of these categories, we can conclude that because of the broad scope of the measures cited, both researchers and policy-makers can make more use of them in future (studies on) land-use policies.

Land-use can be studied on different spatial levels. Based on Van Wee (1993) we distinguish between the macro/meso level and the micro level. The macro/meso level is related to items like the position of the Randstad[3] within The Netherlands (macro) and the location of new urban areas (meso). The micro level is related to the location of individual households, companies and other institutions (forewith to be known as 'actors'). Besides this, we distinguish between a change in the function of land (e.g. the change from agricultural use of land to urban use) and a change of actors within a given land-use pattern (e.g. another distribution of households within the given housing stock or another distribution of companies within the given number of office buildings). See Table 2.

Table 2
Combining scale (macro or meso) with changes in land-use

	Change in function of land	Changes within a given land-use pattern
Macro/meso level	1	2
Micro level	3	4

[3] The highly urbanized western part of The Netherlands, including the provinces of Noord-Holland, Zuid-Holland and Utrecht.

Traditionally, Dutch land-use policy focuses mainly on cell 1 in Table 2. The so-called Location Policy that tries to get 'the right business at the right location' is an example of cell 3 (see Van Wee and van der Hoorn, 1996). Most literature on the influence of land-use on traffic and transport focuses on the macro or meso level, with hardly any on the micro level.

3. INFLUENCE OF LAND-USE ON TRAFFIC: AN OVERVIEW OF THE LITERATURE

3.1. Introduction

We used to distinguish between the macro/meso and the micro level. However, because so little literature related to land-use measures on the micro level is found[4], it is better to distinguish between land-use alternatives at the urban level and higher (macro/meso level) and land-use alternatives within the urban environment (meso level). This categorization has some overlap. Studies that consider urban forms and types of urbanization as part of land-use on a higher level are described in the first category, whereas studies only considering urban forms within a given urban environment is part of the second category. We have based Section 3 on mainly two references reviewing the literature[5].

3.2. An overview of scenario studies on the macro/meso level

Van Wee and Van der Hoorn (1997) review four land-use - transport scenario studies cited below that were carried out for (parts of) The Netherlands between 1986 and 1995:

> Strategic Study Randstad (De Jong *et al.*, 1986)

> Working group EROMOBIL (EROMOBIL, 1990)

> Land-use scenarios for The Netherlands (Clerx and Verroen, 1992)

---

[4] The work of Van Wee and Van der Hoorn (1996) as previously mentioned holds one of the expectations.

[5] Other recent references showing the influence of land-use on transport are Bolt (1982), Cervero (1996a, b), Cervero and Radisch (1996), Curtis (1996) and Newman (1996).

> Model calculations of Randstad Scenarios (Verroen *et al.*, 1995)

The studies were carried out using more or less 'traditional' transport models. In these models the study area contains many zones, each of which has (at least) inhabitants / household data and labor data. These models also include road and public transport infrastructure by nodes and links between these nodes by which networks are formed. The behavior of people/households is modelled by means of a mathematical formula. The relationships between residential and employment locations depends mainly on distances and/or travel times per mode, car ownership levels and travel costs. The models calculate the so-called long-term equilibrium.

Van Wee and Van der Hoorn (1997) state that it is difficult to compare the results of the scenario studies because of the differences in base year and future (scenario) years, differences in the assumed 'default' scenario and differences in the character of the land-use scenarios. Nevertheless, they were able to draw some general conclusions:

> Potential influence of land-use planning alternatives on traffic and on passenger transport is large. The differences in car use between the scenarios can be more than 20 per cent when related to homes and employment locations with different locations in the scenarios.

> Differences in mobility between these alternatives are caused mainly by the extent to which there is a balance between working and living in regions.

> The alternatives that result at the lowest level of car use differ greatly from the situation brought about by the Dutch policy of the past 20 years. A strong governmental policy is therefore required to arrive at a land-use situation where there is a relatively low level of car use. Such a policy will result in strong opposition from some of the relevant 'actors'.

> Further urbanization of the so-called 'Green Heart' of The Netherlands can be beneficial from a transport point of view.

> Urbanization on the Ring of the Randstad and along the axes results in a relatively low level of car use, especially in the case of mixed land-use.

> Most scenario studies use only 'traditional' indicators to compare scenarios, such as car kilometers and public transport passenger kilometers. The studies do not use indicators for the total 'costs' (including external costs) and the 'benefits' of the

transport system.

To demonstrate the possible impact of land-use on transport, we will use the study of Verroen and Hilbers (1995). Although only six per cent of houses have different locations in the scenarios of 2015, the difference in car use is two per cent. This difference is not the largest possible: scenarios that are seen as 'undesirable' (e.g. scenarios with a very diffuse pattern for new urbanization or scenarios with the urbanization of areas that lack proper public transport) were not considered. So, relatively speaking, the possible impact of land-use on car use is very large.

3.3. An overview of the literature on the meso level: urban form, traffic and the environment

We will use a recent article of Anderson *et al.* (1996) for this section, with all the references taken from this work. Anderson *et al.* have reviewed a great deal of literature on urban form, energy and the environment. Some of the conclusions of the studies cited are listed below:

> Compact urban land-use patterns result in less car use than more disperse patterns.

> The least-desirable form of urban development from an environmental perspective is low-density sub-urbanization (see Roseland, 1992).

> Mixed land-use patterns result in less car use than non-mixed land-use patterns.

> Land-use patterns significantly influence possibilities for public transport and public transport use.

> It is desirable to preserve open spaces with relatively dense vegetation within urban areas. In addition to their recreational and aesthetic value, these spaces play a significant role in improving local air and water quality (see Spirn, 1984).

> There are large differences between the possibilities expected to reduce transport by land-use policies; some authors are very optimistic, others very pessimistic. The differences are mainly related to what the observers consider to be realistic changes and policies.

> Many of the studies are or can be criticized on grounds of methodology.

We conclude that the studies reviewed by Anderson *et al.* show that urban land-use patterns can significantly influence mobility in general, and car use too, especially if not only 'traditional' urban land-use patterns are concerned.

4. RECENT DUTCH SCENARIO STUDIES

In this section we will discuss two recent studies, RUIMPAD and The Netherlands 2030, in which the National Spatial Planning Agency of the Ministry of Housing, Spatial Planning and the Environment is involved.

RUIMPAD

RUIMPAD (VROM/V&W, 1997) is a long-term survey for the period up to 2050. It is aimed at support of future national land-use and transport policy of the Dutch government. Measures under category 1 in Table 1 and cell 1 in Table 2 dominate the survey. The most important measures having positive environmental and/or spatial effects are:

> urbanization in compact medium-sized towns near public transport centers.

Compact building and mixed land-use result in short travel distances for daily to weekly services. Cycling and walking can be stimulated in combination with a high level of infrastructure for slow transport modes. This strategy can also be adopted in existing urban areas and cities.

> spatial integration and connection of different modalities.

Spatial and organizational integration of infrastructures for different modes allow people to make easy use of different transport modes, e.g. building transferee, combining infrastructure for cars, public transport (national rail system; local/regional public transport) and slow modes (cycling, walking) at the edges of cities. All this can significantly reduce local car use and so improve local environmental quality.

> land-use measures to improve transport to and from the main public transport mode.

Public transport will have a higher market share if transport to and from the railway stations (and other high-level public transport nodes) does not take much time (short egress and access times). Compact building can reduce egress and access times. Improving infrastructure for slow-traffic modes and local public transport (resulting in reduced travel times and better quality) can improve the competitiveness of public transport. Besides, mixing land-use near public transport nodes gives better opportunities to combine longer distance trips by train with other destinations, such as shops.

The Netherlands 2030

At the time of writing this paper 'The Netherlands 2030', a survey to show the possible impact of long-term spatial planning dilemmas, was still in progress. Dilemmas on air pollution are:

1. Compact of scattered settlement patterns?
2. How to deal with demand for mobility without a loss in environmental quality?
3. How can we find the right balance between international economic developments and the environment?

To answer these (and other) questions, four scenarios have been created, with some of their characteristics shown in Table 3. An evaluation of the scenarios is to take place.

Table 3
Some characteristics of the scenarios for 'The Netherlands 2030' categorized according to urbanization, mobility, sustainable economy and setting

	Urbanization	Mobility	Sustainable economy	Setting
'Land of cities'	compact	public transport	knowledge and culture	large-scale
'Landscape park urbanization'	interwoven	individual transport	footloose activities	'cultural' natural
'Urbanization along streams'	water, road and rail axes as leading principles	public and multi-model	mainports and distribution	wetlands
'Scattered urbanization'	freedom of settlement	individual transport	freedom of settlement	consumer natural

Results for 'transport and the environment' are not available yet.

5. COMPACT OR DIFFUSE LAND-USE PATTERNS: WHAT'S THE DIFFERENCE?

5.1. Introduction

Section 4 concludes that one of the main current policy issues is the one on compact or diffuse building. On the basis of the literature and policy discussions as mentioned above, we calculated possible effects of two land-use scenarios in comparison with a

reference scenario[6]. The scenarios are:

> a reference scenario, representing current land-use policies for the period up to 2020

> a compact scenario: 10% of new dwellings to be built between 2010 and 2020 are additionally located within existing urban areas. New residential areas outside existing urban areas have relatively high densities (in the Randstad provinces: 30 dwellings per acre; outside the Randstad provinces: 25 dwellings per acre)

> a diffuse scenario: 14% of new dwellings to be built between 2010 and 2020 and located in the Randstad in the reference scenario will be built in the provinces of Noord-Brabant and Gelderland (southwest and west of the Randstad provinces, respectively), with a density of 25 dwellings per acre.

The study area contains the Randstad provinces, Noord-Brabant and Gelderland. According to current demographic projections we assume that between 500,000 and 550,000 dwellings have to be built in the period 2010 to 2020 (about 7.5% of all dwellings in The Netherlands in 2020). The scenarios differ with respect to both the location of dwellings and the so-called 'critical design dimensions', as presented by Verroen (1994) and Verroen and Hilbers (1996) and outlined below:

- Single-core as opposed to multi-core orientation: Further urbanization through the development of separate metropolitan areas or assuming the development of networks of cities with the idea of spreading the daily patterns of activities out over several metropolitan areas.
- Clustered as opposed to dispersed: Development of large-scale, urban extensions with emphasis on the main infrastructure vs. a development of small-scale urban extensions with emphasis on the secondary.
- Mixing as opposed to separating: Mixing or keeping all kinds of spatial functions separate, such as living, working and facilities in various sub-areas within the urban areas (thus as the 'small municipality' or as 'metropolitan district/central

[6] The authors would like to thank Mariëlle Damman, Hans Eerens, Karst Geurs, Marianne Kuijpers, Hans Nijland and Brigit Staatsen for their contribution.

municipality').

These design dimensions are combined with the compact and diffuse scenarios. The compact scenario has a single-core orientation, clustered urban development and mixed land-use. The diffuse scenario has a multi-core orientation, dispersed urbanization and activities which are not mixed.

Mobility effects of the scenarios are based on the TNO-INRO reports that describe the study 'Model calculations of Randstad Scenarios' (Verroen *et al.*, 1995), using interpolation and extrapolation techniques. Calculations of pollutant concentrations are based on the method as described in Van Wee *et al.* (1996). Calculations of noise nuisance levels are based on dose-response functions as given in the literature. Other variables in the table below are based on expert judgement.

Table 4 gives indicative results of the comparison between the compact and diffuse scenarios using the reference scenario.

Table 4
Indicative results of the scenarios
(index reference scenario = 100)

			Compact	Diffuse
Urban land-use	national		< 100	> 100
	Randstad		< 100	< 100
	Brabant/ Gelderland		< 100	>> 100
Car use	national		99	101
	Randstad	within built-up area	101	98
	Brabant/ Gelderland	within built-up area	99	106
Noise nuisance	national		100	100
	Randstad	within built-up area	100	100
	Brabant/ Gelderland	within built-up area	100	>100
Local air pollution (concentrations of pollutants)	national		101	99
Safety (number of accidents)	national		> 100	< 100
	Randstad	within built-up area	> 100	< 100
	Brabant/ Gelderland	within built-up area	< 100	> 100

Source: RIVM, partly based on Verroen *et al.* (1995)

The compact scenario results in a lower level of car use and related emissions on a national scale, and in a lower level of overall urban land-use. Urban land-use is higher in the diffuse scenario, but the claim for urbanization moves towards Noord-Brabant and Gelderland, where pressure on land-use is lower than in the Randstad. The scenarios

hardly differ with respect to noise nuisance. In the diffuse scenario noise nuisance is marginally higher in Noord-Brabant and Gelderland. Compact building leads to more road accidents than diffuse building if the traditional form of urbanization is assumed. However, additional measures can improve road safety in such areas (Hilbers, 1996).

The overall impression might be that from an environmental point of view it hardly makes any difference whether a more compact or a more diffuse form of urbanization is implemented. However, we think this conclusion is incorrect for two reasons: Firstly, the variation between the locations and densities of all dwellings in 2020 will be only a few percentage points, so that even with large relative implications, the overall differences cannot be high. Secondly, compact building offers better opportunities for future measures, such as car-free zones in (central) urban areas, improved public transport, stimulating cycling, reducing parking problems etc. If such measures are implemented, compact building will probably be rated better for all indicators in Table 2. In other words, compact building does not necessarily reduce environmental pressure, but gives better opportunities for future measures to improve the local environment and liveability in cities.

6. CONCLUSIONS

1. There are several categories of possible land-use measures: measures to reduce volume of activities, measures related to the polluter, the receptor or the intermediate zone and measures to redistribute population within the existing housing stock. We have not yet seen a comprehensive inventarization of possible land-use measures that can contribute to lower environmental pressure taking all categories into consideration.
2. To date, national Dutch land-use policy has mainly focused on changes in land-use at the meso or macro level (the urban level and higher). Hardly any attention has been paid to the micro level (individual actors, such as companies and households) and to possibilities for redistribution among individual actors within the existing urban structure.

3. Potential influence of land-use planning alternatives on traffic and transport of persons is large. However, strong governmental policy is required to arrive at a land-use situation that will result in a relatively low level of car use. Such a policy will result in strong opposition of some actors.
4. Further urbanization of the so-called 'Green Heart' of The Netherlands and urbanization of the Randstad Ring, and along the axes, results in a relatively low level of car use, especially for mixed land-use.
5. It is desirable to preserve open spaces in urban areas with relatively dense vegetation. In addition to their recreational and aesthetic value, these spaces play an important role in improving local air and water quality.
6. A more compact form of urbanization and mixed land-use will result in a lower level of car use and some kinds of environmental pressure from car use than with a more diffuse pattern of urbanization. However, to have a significant impact, compact building has to be the long-term guideline for urbanization.
7. Compact building offers better opportunities for future measures, such as car-free zones in (central) urban areas, improved public transport, stimulating cycling, reducing parking problems etc. and in so doing will improve local environment and liveability in cities.

REFERENCES

1. Anderson, W.P., P.S. Kanaroglou, E.J. Miller (1996), Urban Form, Energy and the Environment: A Review of Issues, Evidence and Policy, Urban Studies, Vol. 33, No. 1, 7-35
2. Bolt, D. (1982), Urban form and energy for transportation. Delft: Research center for physical planning, Organization for Applied Scientific Research (TNO).
3. Cervero, R. (1996a) Transit-Based Housing in the San Francisco Bay Area: Market Profiles and Rent Premiums, Transport. Quar., Vol. 50, No. 3, 33-49
4. Cervero, R. (1996b), Mixed land-uses and commuting: evidence from the American housing survey, Transportation Res.-A, Vol. 30, No. 5, pp. 361-377
5. Cervero, R., C. Radisch (1996), Travel choices in pedestrian versus automobile

oriented neighborhoods, Transport Policy, Vol. 3, No. 3, 127-141

6. Clerx, W.C.G., E.J. Verroen (1992), Land-use scenarios for The Netherlands: transport patterns and environmental impact. Delft: INRO-TNO (in Dutch)
7. Curtis, C. (1996), Can strategic planning contribute to a reduction in car-based travel? Transport Policy, Vol. 3, No. 1/2, 56-65.
8. De Jong, M.A., L.H. Immers, J.W. Houtman, C.W.W. van Lohuizen (1986), Strategic Study Randstad. Delft: INRO/TNO (in Dutch).
9. EROMOBIL (1989), Interaction between land-use and mobility in the Randstad (Report of the EROMOBIL working group - in Dutch).
10. Hilbers, H. (1996), Urbanization and road safety, Delft: TNO-INRO (in Dutch).
11. Newman, P. (1996), Reducing automobile dependence, Environ. Urban., Vol. 8, No. 1, 67-92.
12. Roseland, M. (1992), Toward Sustainable Communities: A Resource Book for Municipal and Local Governments. Ottawa: National Round Table on the Environment and the Economy.
13. Spirn, A.W. (1984), The granite Garden. Urban Nature and Human Design. New York: Basic Books.
14. Van Wee, G.P. (1993), Location Policy and Land-use: the Effects on Traffic and Transport. Literature Study. Bilthoven: National Institute of Public Health and the Environment. Report nr. 251701010 (in Dutch).
15. Van Wee, G.P., K. Van Velze, H.C. Eerens (1996), Traffic and local air pollution: a forecasting method applied to The Netherlands, Paper prepared for the symposium 'Verkeer en Milieu: een duurzame tegenstelling?', Amsterdam, 29-10-1996.
16. Van Wee, B., T. van der Hoorn (1996), Employment location as an instrument of transport policy in The Netherlands. Fundamentals, instruments and effectiveness. Transport Policy, Vol. 3, No. 3, 81-89.
17. Van Wee, G.P., T. van der Hoorn (1997), The Influence of Land-use on Traffic and Transport: A Comparison of Scenario Studies. Tijdschrift Vervoerswetenschap, 1/97, 43-61.
18. Verroen, E.J. (1994), Accessibly proximity. An investigation of mobility friendly forms of urbanization of the ring of towns in the Center of The Netherlands after 2005. Delft: INRO-TNO (in Dutch).
19. Verroen, E.J., H.D. Hilbers, C.A. Smits (1995), Model calculations of Randstad Scenarios. Delft: TNO-INRO (in Dutch).

20. Verroen, E.J., H.D. Hilbers (1996) Promising mobility friendly urbanization strategies: time for a paradigm shift? Paper presented at the PTRC summer annual meeting, London, 1996.
21. VROM/V&W (1997) (Ministry of Housing, Spatial Planning and the Environment (VROM), Ministry of Transport and Public Works and Water Management (V&W), Choosing for space to move. Exploring the future of mobility, urbanization and transport networks. The Hague: Ministry of Housing, Spatial Planning and the Environment, Spatial Planning Agency.