Urban Green and Integrative Urban Sustainability: Concepts and Relevance for Dutch Cities

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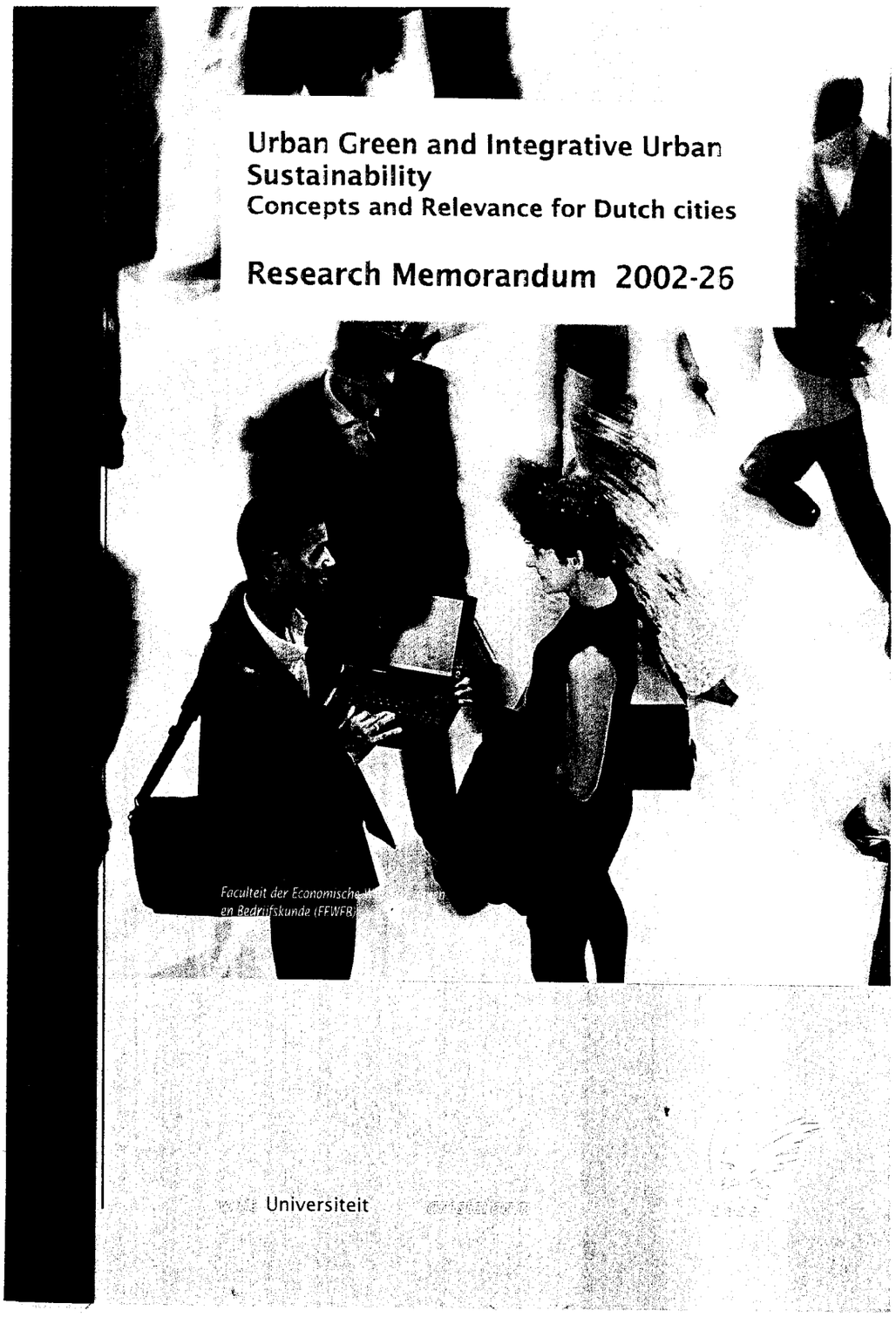

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Urban Green and Integrative Urban Sustainability
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Abstract

Urban sustainability comprises a variety of quality-of-life aspects, such as meeting human needs, protecting natural capital at local, regional and national levels, and ensuring that human activities or values are sustained. This paper aims to highlight the intricate relationship between urban sustainability and urban green; it offers a functional typology of urban green spaces that forms the basis for determining relevant assessment criteria and indicators that are crucial for the evaluation and management of existing urban green facilities, mainly from an economic point of view. These indicators are subdivided into four dimensions: the socio-economie dimension, the environmental dimension, ,the merit dimension and the financial dimension. This theoretical framework will be used for a socio-economie assessment of the quality and availability of green space in a sample of Dutch cities. To identify structural patterns in the empirical data base of these cities, factor-analytic methods will be deployed to represent common elements in the multidimensional information gathered by means of questionnaires and through statistical analysis. Policy-relevant conclusions will be drawn from this information as well.

1. Sustainable Cities

In the last century there has been much interest in public health in dense urban agglomerations. As social and medical knowledge about how diseases spread has developed, urban authorities have sought to improve local environments by implementing measures controlling sewage and ensuring a clean water supply in order to reduce the diffusion of germs and infection. With time, this trend has led to the creation of policies consisting of various initiatives in clean air legislation designed to reduce local atmospheric pollution. In addition to being concerned with economic growth, societies have become concerned with the built environment and with shaping nature in urban areas in ways they found aesthetically pleasing. Over the century this has led to specific landscape patterns in the countryside and to the creation of parks and gardens in urban areas. In other words, a general concern for quality of life and sustainability, with a particular focus on the city, has emerged. (Goede et al., 2001)

According to the World Commission on Environment and Development's 1967 definition, 'sustainable development' means meeting the needs of the present without compromising the ability of future generations to meet their own needs. It involves the interrelationship between poverty, economic development and the state of the natural environment (Perman et al., 1999).
The concept of sustainable development has been interpreted in many different ways. In recent debates and studies three major aspects of sustainable development have been identified: meeting human needs, sustaining or keeping intact natural capital at local, regional and national levels, and ensuring that human activities or values can be 'sustained'. When we concentrate on only one of these aspects, it may have a different meaning. The relationship between sustainable development and economic growth, for example, can be explained in different ways. If 'sustainable development' designates, for example, the capacity to manage the maintenance and repair of water supplies, drainage systems and power stations, then there are potential complementarities, since wealthier enterprises and households can afford to pay more for welt functioning and well maintained infrastructure. But the relationship between economic growth and sustainable development may be different if 'sustainable development' refers only to a concern for ecoiogical sustainability. In this case, economic growth might cause a decrease in ecological value (Satterthwaite, 1999). 'Sustainable development' may also refer to an interest in reducing ecological disruption or damage and in protecting natural capital. The concept of sustainability is therefore highly relevant for cities, given that a high proportion of the world's production, consumption and waste generation is concentrated in cities. The cities in OECD countries consume approximately 60 to 80 percent of the total energy demand (see OECD, 1995).
Cities, however, are also sources of new ideas, techniques and inventions. Jane Jacobs has recognised the importance of cultural activities for the economic strength of cities: the wealth of both cultural and commercial ideas present has an important positive impact on the diverse economic, spatial and cultural structure of a city (Lambooy et al., 1997). Both cultural and commercial ideas can lead to new inventions regarding environmental issues and resource use. Another important advantage of the city lies in its scale advantages and in the possibility to create conditions for more efficient energy use within the city.
'The sustainable city' is a concept that can refer to the potential for the urban agglomeration to ensure environmentally benign city development through focused environmental and energy initiatives that stimulate a balance between economic progress, social equity and environmental quality (Capello et al., 1999). But urban sustainable development is not merely a matter of environmental quality control. Three main intersecting forces are essential in a city; these are social, environmental and economic forces. Urban sustainability is related to the interaction between these three forces.

The Local Agenda 21, which emerged from the UN conference on Environment and Development in Rio de Janeiro, has set the agenda for a wide spectrum of policy and management issues in the twenty-first century. It has also broadly assessed the acceptance of sustainability based on the inseparability of social, environmental (ecological) and economic issues. The conference has called attention to such environmental concerns as climate change, biological diversity and forest management (Capello et al., 1999).

Public and private decision makers want and need better information about the value of urban nature in order for them to weigh the advantages and disadvantages of human actions that may affect the natural urban environment (Bingham et al., 1995; Haughton and Hunter, 1994). When applying economic theoty to the environment, one must face the task of evaluating non-market benefits in order to include them in the general theory according to the notions of welfare, external effects and public goods. This leads to the question why people are interested in urban green spaces from an economic point of view. An important element in this problem is the scarcity of green spaces. Goods are scarce when they are available in limited finite quantities and when there are alternative competing uses for them (Perman et al., 1999; Edwards-Jones et al., 2000). The last century has witnessed a rise in material welfare, so that scarcity in an absolute sense has vanished in many parts of the world. In the last part of the twentieth century, however, a new type of scarcity has emerged, the scarcity of healthy environments to work and live in. This new scarcity is reflected in a decline in air, water and soil quality as well as in a general decline in biodiversity. There is also a new scercity of available space for (urban) green (Goede et al., 2001).
This paper presents economic criteria and indicators that are important for the evaluation of existing urban green structures and green spaces. It is hoped that these criteria and indicators will yield precise information that will help determine the amount of supply and demand for the functions of urban green spaces. These indicators are part of the EU project 'Development of Urban Green Spaces to Improve the Quality of Life in Cities and Urban Regions' (URGE)[1]. This project will be described briefly in Section 2, which deals with the definition of urban green. After the presentation of the criteria and indicators, in Section 3, we will focus on one criterion: the availability of urban green in and directly around cities. With help of factor analytic methods, relations between cities and the availability of different categories of urban green will be described in Section 4. The last section will show the study's relevance for policy making and will offer conclusions.

2. Definition of Urban Green Space

A clear definition of urban green space is essential for the creation of economic indicators for it. Because this paper is related to the URGE project, the process of formulating a clear definition within that project has had a large impact on the definition used in this paper. The aim of the URGE project is to improve the future management of green spaces in cities and urban regions by providing methods and procedural guidelines for the inclusion of ecological, social and economic factors in the process of urban planning and maintenance.
In the URGE project, urban green spaces are considered an important contributing factor in the sustainable development of cities. The research group has recognised the potential for green spaces to improve the quality of urban life. They are, however, aware that this potential is not being realised, since current management practices are sub-optimal. The project therefore includes the elaboration and testing of an interdisciplinary catalogue of methods and measures for urban management, based on experiences from various European cities (URGE, 2001). Ecoiogists, economists, social sclentists and planners formulated the definition used in the URGE project. They agreed on the following definition:

> *By urban green spaces we understand public and* **private** *open spaces in urban areas, primarily covered by vegetation, which are directly (e.g. active or passive recreation) or indirectly (e.g. positive influence on the urban environment) available for the users.*

Green areas can be privately owned or an entrance fee can be charged for access to them (such as is the case for botanica1 gardens etc.), as long as they are available for public use. Since URGE plans mainly for the residents of a city, tourist use is not relevant for URGE. The colour (i.e. urban blue, urban brown, etc.) is also essentially irrelevant. Their importance lies in public access to

[1] The project is funded under Key Action 4: 'The City of Tomorrow and Cultural Heritage' of the Programme 'Energy, Environment and Sustainable Development' of the 5" Framework Programme of the European Union.

them. Cemeteries and allotments are excluded. These could, however, be considered if they are mainly used as parks or recreation areas. Trees in streets and other small green features are generally excluded (they are not green "space"), but may be regarded on a city scale as part of the green structure (URGE, 2001).

The definition of urban green spaces used in this paper is largely the same as the URGE definition as mentioned before. The relation between urban sustainability and urban green spaces on which we are focussing in this paper makes it necessary to expand the definition somewhat. In addition to what is included in the URGE definition, this paper also refers to natural areas and forests within the boundaries of the municipality when using the term 'urban green spaces'. When we focus on the availability of urban green, we also include recreation areas, both for daily recreational activities and for longer stays. We think that these functions and activities all contribute to urban sustainability and to the quality of life in the city.

3. Economic Indicators

A general framework

Economic indicators and criteria can be very useful for evaluating urban green spaces. An evaluation starts with the formulation of criteria that determine functions of urban green spaces. Criteria can be measured with the help of indicators. Indicators are pieces of information designed to communicate complex messages in a simplified, (quasi-) quantitative manner so that progress in the field of decision-making can be measured (Rotmans, 1997). indicators can be measured with the help of necessary input. This necessary input consists of data that must be collected by, for example, statistical analysis or quantitative and qualitative surveys.

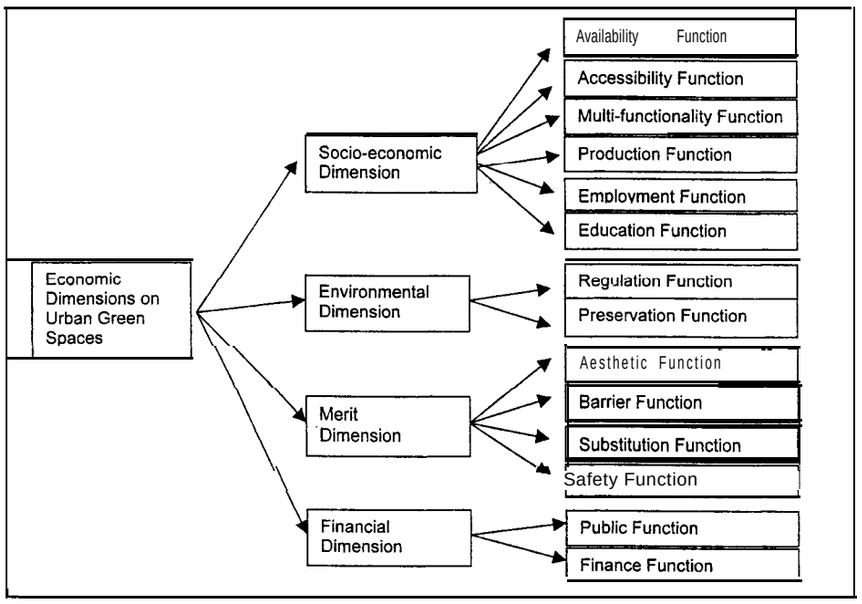

Figure 1: Four economic dimensions on urban green spaces with their criteria
source: Rodenburg et al., 2002

To evaluate the urban green spaces from an economic point of view, we have classified the functions into four economic dimensions. These are, successively, the socio-economie dimension, the environmental dimension, the merit dimension and the financial dimension (see Figure 1).

The socio-economie dimension contains the functions that have an impact on welfare and quality of urban life, such as the employment function or the education function. The environmental dimension refers to scarcity elements that are linked to the physical surroundings and the environment, such as the regulation function. The merit dimension shows the virtue of urban green to the residents. It concerns external effects that are useful to visitors, such as the barrier function, which occurs when vegetation works as a windbreak or noise barrier. The financial dimension is related to the way urban green is financed and the importance of urban green to the local authorities (Rodenburg et al., 2002). In the next part of this section, the four dimensions will be described in further detail and their criteria and indicators will be shown.

Socio-economie dimension

The socio-economie dimension consists of utilisation, production, employment and education functions. These functions all have an impact on the socio-economie quality of urban life and are measured by means of six criteria (see Table 1). There are many ways to indicate these criteria. In this paper we have selected some of these indicators. More detailed information and additional indicators can be found in the URGE project's main report on economic indicators (Goede et al.. 2001).

Table 1: Criteria and Indicators of the Socio-Economic dimension

Criteria	Indicators
Availability	• Area of urban green space per resident • Number of visitors of urban green as a percentage of the total urban population
Accessibility	• Number of residences within a maximum walking distance of 15 minutes or 1000 meters from the urban green space • Number of entrances to urban green spaces, related to the outline of the park
Multi-functionality	. Number of permanent functions, related to the total area of the park • Intensity of exercised permanent functions, related to the total area of the park
Production	• Number of products delivered by urban green space per km^2 urban green space
Employment	• Number of "green" jobs per km^2 urban green space • Contribution of the salary costs of "green" jobs to urban income
Education	• Area of children's farms in the city as a percentage of the total area of the city

The first set of socio-economie criteria for urban green spaces is related to the ways urban green spaces are utilised, one of the most important reasons for their development. Urban green spaces are extremely suitable for a large number of types of recreation. This **multi-functionality** is of great importance; the number of users for each of the different types of recreation could indicate the green area's success rate. The natural and cultural environment must be of high quality in order to be visited continually and successfuliy. Issues of **accessibility** and **availability** are therefore of vital importance. These issues include the distance to and accessibility of the area through, for example, infrastructure or public transport (Stanners et *al.,* 1995). Another criterion for the socio-economie function of urban green spaces is **production:** a green space might deliver products such as wood or fruits. One can also think of compost and energy as results of urban

green production. **Employment** is important for the development, maintenance and governance of the area. Furthermore, employment is required by the facilities that are attracted by urban green space, such as catering. The final socio-economie criterion of urban green space is **education.** Urban green spaces • especially places such as schoot gardens and children's farms • play an important role in the basic education of schoolchildren with regard to the environment and nature. Urban green spaces such as botanica1 gardens play an especially important role in education.

Environmental dimension

The environmental dimension consists of functions that are linked to the surroundings and the environment: the regulation and preservation functions. The criteria in the environmental dimension can be measured by means of the indicators presented in Table 2 (Goede et al., 2001).

Table 2: Criteria and Indicators of the Environmental dimension

Criteria	Indicators
Regulation	• Amount of pollution in the air/around the park compared to an area with no urban green spaces in the neighbourhood, with regard to the size of the area. • Amount of massive vegetation in the urban green area concerned
Preservation	• Annual discounted future savings of costs for protection of urban wildlife and urban resources per km^2 urban green space • Presence of botanica1 gardens\children's farms related to the total area of the city.

Urban green space moderates the impact of human activities by, for example, absorbing pollutants and releasing oxygen (Hough, 1984). Due to this purification ability some environmental problems can be reduced and others prevented. In general this is called the **regulation** function of urban green spaces.

The second function of the environmental perspective is the **preservation** function. Urban green spaces preserve the local natural and cultural heritage, because they provide, on a local scale, habitats for a diversity of urban wildlife (such as birds and insects) and conserve a diversity of urban resources (such as trees and plants). The presence of green is a pre-condition for sustainable development (Priemus, 1999) that meets the needs of today's generation without compromising the ability of future generations to meet their own needs (Boyd, 1997).

Merit dimension

The merit dimension is a collection of aesthetic, substitution, barrier and safety functions. The functions are usually related to external effects and they benefit the quality of urban life for the different user groups of urban green spaces. A selection of the indicators is shown in Table 3 (Goede et al., 2001)

Table 3: Criteria and Indicators of the Merit dimension

Criteria	Indicators
Aesthetic	• Price and rent differences between houses\companies with and without an urban green space in the neighbourhood • Average household income around urban green space as a percentage of the average urban income
Substitution	• Price and rent differences between houses/companies with and without gardens/balconies • Number of captive visitors as a percentage of the total number of visitors of the urban green space

Barrier	• Number of trees and their size in the urban green space related to the total area of the urban green space • Noise level in the urban green space compared to the noise level outside the park
Safety	• Annual number of incidents in the park compared to the annual number of urban incidents • Annual costs of crime prevention and control for the urban green compared to the total costs of crime prevention in the city

In our discussion of the merit functions we have assumed that urban green spaces are beautiful and therefore have **aesthetic** appeal. The presence of urban green spaces in a city increases the quality of life. This occurs not only because of their beauty, but also because the aesthetic quality of urban green spaces enables people to orient themselves in space and time. Urban green spaces give neighbourhoods their own identities, making them more attractive to live in. Urban green spaces can additionally be seen as a compensation for low-quality areas.

In general, city parks are places of peace and quiet. This is because urban green spaces have a barrier function; they provide a barrier to noise and can function as a visual screen (Dole, 1989). This is especially the case when urban green areas function as buffer zones between parts of the city. Trees' ability to serve as windbreaks and to provide camouflage also increases the quality of neighbourhoods.

The third important element in the merit dimension of urban green spaces is their substitution function. Urban green spaces can be seen as an alternative that compensates for shortcomings in other fields. If people don't have the opportunity to carry out the activities they perform in urban green spaces elsewhere, they are called 'captive users'. An example of a captive user is someone who cannot afford to join a sporting club and therefore goes jogging in the park.

The final element of the merit dimension has to do with **safety.** This can be seen from a positive and a negative perspective. The positive effect of urban green spaces is that they provide safe play space for children (Jacobs, 1961), which can reduce accidents by causing fewer children to play on roads or in other unsafe areas. However, urban green spaces can also be a source of crime and can therefore be unsafe, especially at night.

Financial dimension

The fourth and final economic dimension of urban green spaces is their financial dimension. The financial dimension consists of public authorities and the finance function. These functions are important to government authorities and investment partners. A selection of the indicators related to these criteria are shown in Table 4 (Goede et al., 2001).

Table 4: Criteria and Indicators of the Financial dimension

Criteria	Indicators
Public authorities	• Number of hours planned/spent on urban green policy as a percentage of the total number of hours planned/spent on urban policy • Budget for urban green spaces as a percentage of the total urban budget
Finance	• Alternative ways of financing • Amount of budget/number of expenditures for development, maintenance and revitalisation per km² urban green space (public or private) • Annual income derived from an entrance fee for the green area

By **public authorities, we** mean the green area's position on the priority list or agenda of policy makers or public urban authorities. Although this might initially be a negative indication (most often

cases are only discussed after problems have been detected), we assume that this ultimately has a positive influence on urban green spaces. The more attention is paid to urban green spaces in urban policies, the more funding will be budgeted for urban green spaces, and the higher the quality of urban life will be. The finance function of urban green spaces is essential, since money is needed to develop and maintain them. There are different ways to finance an urban green area. One method is private financing, such as sponsoring, but there are also public-private partnerships.

4. A Multidimensional Assessment of Urban Green in Dutch cities

Data base

This paper focuses on one of the criteria of the socio-economie dimension, the availability criterion. This approach implies that the larger the area of usable urban green space available to households, the better it is for health, privacy, recreation and development. In addition, the lower the density of residential use, the better (OECD, 1978). The amount of green in the city can be related to the number of inhabitants of the city and to size of the built up area. This gives some information about the real availability of green space in the city. The number of visitors compared with the amount of green space could indicate the extent of the inhabitants' need for urban green spaces and couid perhaps tell something about the successfulness of urban management or the supply of urban green space. Unfortunately it was not possible to get sufficient information about the number of visitors to urban green spaces for the purposes of this study. This section will therefore only deal with the availability of urban green to the inhabitants of the city.

A large amount of data from Statistics Netherlands (Statistics Nehterlands, 2002) was used for the economic assessment of the Dutch cities. For 24 different municipalities[2] around 16 variables concerning land use were used, as welt as 16 demographic variables. The variables concerning land use were especially important for the analysis.

Most of the cities were selected according to the number of inhabitants, with a minimum of 100.000. A few municipalities have fewer people within their borders, but related to their province or region they are considered a 'big city' in terms of regional functions and facilities. Middelburg, for example, has only 44.920 inhabitants but is the biggest city from the South-western province of Zeeland. The twenty-four cities can be divided into four groups: Big cities (4), New cities (4), Peripheral cities (8) and Intermediate cities (8) (See Table 5).

Table 5: Four groups of cities

Big Cities	*New Cities*	*Intermediate Cities*	*Peripheral Cities*
Amsterdam	Almere	Breda	Deventer
Rotterdam	Alpen aan de Rijn	Ede	Den Helder
The Hague	Zaanstad	Eindhoven	Emmen
Utrecht	Zoetermeer	's-Hertogenbosch	Middelburg
		Leiden	Roermond
		Nijmegen	Enschede
		Tilburg	Groningen
		Zwolle	Maastricht

The big cities are relatively old; they are located in the Randstad, the most urbanised region of The Netherlands. They have the highest population and housing density. A high percentage of the residents of these cities are ethnic minorities, and the average amount of disposable income is rather low in these areas. This is often combined with a high unemployment rate.

[2] Statistics Netherlands provides data about municipalities. This implies that in some cases not only are cities taken into account, but also smaller villages that are administratively related.

The new cities are situated near the big cities and were developed or expanded because of, for example, pressure on the housing market in the big city. There are also people who prefer not to live in big cities but who want to live near them because of their work. There are some significant differences between the big and the new cities. The population of the new cities is relatively young, with many children under 15 and few people older than 60. The unemployment rate is very low in the new cities and the income levels are relatively high. The housing and population densities are much lower in the new cities than in the big cities.

The intermediate cities show intermediate scores for the different variables shown in Table 6, although the income per inhabitant and the income per household are quite high. The unemployment rate and the percentage of ethnic minorities are relatively low.

The peripheral cities are often smaller cities situated in peripheral areas with an important regional function. They are the biggest city or sometimes the only city within their region. Because they are situated in peripheral areas, their housing and population densities are low. These cities often have a smaller percentage of ethnic minorities and a larger number of elderly than other cities. Their unemployment rates are very high and the disposable incomes are low (see Table 6).

Table 6: Socio-economic variables per city group

Variables	Big cities	New cities	Intermediate cities	Peripheral cities
% population 60+	18.0	14.1	15.5	16.9
% population 15-	16.2	20.9	18.8	16.8
% foreigners	11.3	5.7	4.4	3.9
Average spendable income per household (Euro)	19675	24450	22100	20575
Average spendable income per inhabitant (Euro)	9675	9900	9588	9075
Unemployment rate	7.0	4.3	5.1	8.1
Population density	4392	1806	2036	1227
Housing density	2110	729	868	543

Source: Statistics Netherlands (CBS)

A large amount of data was available for each of these cities. These data have been used to perform a factor analysis.

The use of factor analysis

Factor analysis is a statistical approach that can be used to analyse interrelationships between a large number of variables and to explain these variables in terms of their common underlying dimensions. The objective is to find a way of condensing the information contained in a number of original variables into a smaller set of variates (factors) with a minimum loss of information. This smaller number of factors is often easier to interpret than the original set of variables.

With help of factor analysis, separate dimensions of the structure can be identifled and the extent to which each variable is explained by each dimension can be determined. Then the data can be reduced and summarised. Factor analysis derives underlying dimensions that, when interpreted, describe the data in a smaller number of concepts, thereby summarising the data. Data reduction can be achieved by calculating scores for each underlying dimension and substituting them for the original variables (Hair, 1998).

The factors themselves must be mutually independent. Because orthogonal vectors are independent and uncorrelated, the factors are often determined so that they can be represented as orthogonal vectors. Factor analysis is an interdependence technique in which all variables are considered as each relates to all others, and the concept of the variate, the linear composite of variables, is employed (Hair, 1998).

In this paper we use ***principal component analysis,*** which transforms the set of originally mutually correlated variables into a new set of independent variables. It is a non-stochastic approach and it only deals with the common variance of the original variables. It first derives the first factor or the first principal component, which is supposed to account for the greatest part of the common variance. The second factor is supposed to account for the next greatest part of the common variance, and so on. A minimum part of the common variance is set, and factors below this critical level are eliminated.

For this factor analysis three groups of data were used. One group contains demographic data such as the number of inhabitants, amount of disposable income per inhabitant, population density, etc., while the second group contains data concerning land use in and directly around the city such as recreational use, infrastructure, or forest. The third group contains data about the 'green areas' in and directly around the city, such as sporting areas or urban green spaces (See appendix I and II for the data used). For the last two groups a factor analysis has been performed, which will be discussed in the next part of this paper.

Statistics Netherlands gathered the land use data with the help of aerial photos and city maps. The different categories of land use are defined in the same way for each city.

- Agricultural use: this category includes greenhouse farming, grassland, horticulture, farmland and orchards.
- Forest: areas with trees and bushes with a production, screening or recreational function or a combination of the three of these. An aerial view must show that trees and bushes cover at least 20% of the surface area. Areas smaller than 6m² or containing (holiday) cottages are not included.
- Residence area: areas with a mainly residential function including such facilities as shops, schools, streets, parking places, gardens and playgrounds.
- Infrastructure: areas related to and containing railways (for train, tram and metro), unpaved-, partially-paved and paved roads and airports.
- Recreation area: areas containing parks and public gardens, sports fields, daily recreation facilities, holiday facilities and allotments
  - Parks and public gardens: these areas are freely accessible to the public and include facilities such as benches and litter baskets. Animal farms and small playgrounds can also be included.
  - Sporting areas: areas for field sports, but also swimming pools, rowing courses and sport centres. Parking places and small forest areas (smaller than 6m wide) are also included.
  - Day recreation areas: places which often provide many facilities and services, such as zoos, safari parks, amusement parks, open air museums and yacht basins. Also animal farms and playgrounds not related to parks and public gardens are included.
  - Holiday and longer-stay recreational areas: areas that function as campgrounds, or contain second homes, holiday parks and youth hostels. Places that are used by day for daily recreation and by night for longer-stay recreation are included among the daily recreation areas.
- Nature areas: nature reservation areas, military areas and water-collection areas. A distinction is made between dry- and wet nature areas.
- Other places: can include dumping grounds, cemeteries or building areas.
- Water: water reservoirs, water with a recreational function and areas of water wider than 6 meters.

Land use in and directly around the city

To perform the factor analysis nine types of land use were distinguished for 24 Dutch cities (see Appendix I). After the analysis two factors were identified, producing a 79% variance.
The factors divide the variables into two different groups: the first of these is the 'manmade' group, which includes Built-up areas, Residence areas, Infrastructure areas, Recreation areas, Other areas and Water. The second group contains mainly 'Natural areas' such as Nature areas, Agricultural areas and Forests (see Table 7).

Table 7: Land use in and directly around the city

	Land use	Factor 1 'Man made'	Factor 2 'Natural areas'
1	Built-up area	x	
2	Residence area	x	
3	Infrastructure area	x	
4	Recreation area	x	
5	Other	x	
6	Water	x	
7	Nature area		x
8	Agricultural area		x
9	Forests		x

Green areas in and directly around the city

The second factor analysis performed contained seven groups of variables. These variables concerned Green areas in and directly around the city such as Parks and public gardens, Sporting areas, Daily recreation areas, Longer-stay recreation areas, Forests, 'Dry' Nature areas and 'Wet Nature areas (see Appendix II). The analysis identified three factors, which produced a 91% variance (See Table 8). The first factor describes the real urban green areas, the Parks and public gardens and Sporting areas. The second factor relates the Longer-stay recreation areas and Dry nature areas with the Forests. The third factor describes the Day recreation areas and the Wet nature areas.

After another factor analysis was performed with variables describing the amount of urban green area per inhabitant and the amount of urban green area in relation to the total built up area in the city, the same variables were grouped together. This does not mean that the scores per city are the same but that these variables are clearly related to each other, as the factor analysis aims to analyse interrelationships between a large number of variables and to condense the information contained in a number of original variables into a smaller set of factors.

Table 8: Urban green and recreation

	Land use	Factor 1 Urban recreation areas (U)	Factor 2 Structural, long-term recreation areas (S)	Factor 3 Daily leisure areas (L)
1	Parks and public gardens	x		
2	Sporting area	x		
3	Daily recreation area			x
4	Longer-stay recreation		x	
5	'Dry' Nature area		x	
6	'Wet' Nature area			x
7	Forests		x	

When the factors are compared with the scores per city some conclusions can be drawn about the cities and the availability of (urban) green areas.

Considering the types of land use in and directly around the cities in terms of the manmade and natural factors, it becomes clear that the big cities place an especially high value on the manmade factor. The more natural cities are not found in a single group. Emmen, Enschede (peripheral cities), and Ede (an intermediate city), show especially high values.

The second factor analysis concerns urban green and recreation areas and shows some interesting patterns. Three factors appeared several times: Urban recreation areas (factor 1), Structural, long-term recreation areas (factor 2) and the daily Leisure areas (factor 3) (see Table 9).

Table 9: Four groups of cities and their scores

Big Cities		*New Cities*		*Intermediate Cities*		*Peripheral Cities*	
Amsterdam	U	Almere	L	Breda	-	Deventer	-
Rotterdam	U	Alphen aan de Rijn	L	Ede	S	Den Helder	S
The Hague	U	Zaanstad	L	Eindhoven	U	Emmen	S
Utrecht	U	Zoetermeer	U	's-Hertogenbosch	L	Middelburg	-
				Leiden	-	Roermond	L
				Nijmegen	L	Enschede	S
				Tilburg	-	Groningen	-
				Zwolle	-	Maastricht	-

It appears that the big cities have an especially high score in terms of the Urban recreation factor. They are older cities with high population densities, which may explain their need for urban green areas. The new cities, which have been planned and built recently, have lower population and housing densities than the big cities. They have higher scores on the Daily leisure factor. The Peripheral cities do not all show clear results, but those that do show clear results are related to the Structural, long-term recreation areas. This factor is more natural, also including forest and longer-stay recreational areas.

The next step is to take a look at the amount of green per inhabitant and the area of green related to the built up area. The factor analysis aims to analyse interrelationships between a large number of variables and to condense the information contained in a number of original variables into a smaller set of factors. It also gives a score per city for a parlicular factor but this is not by definition directly related to the area of green in the city.

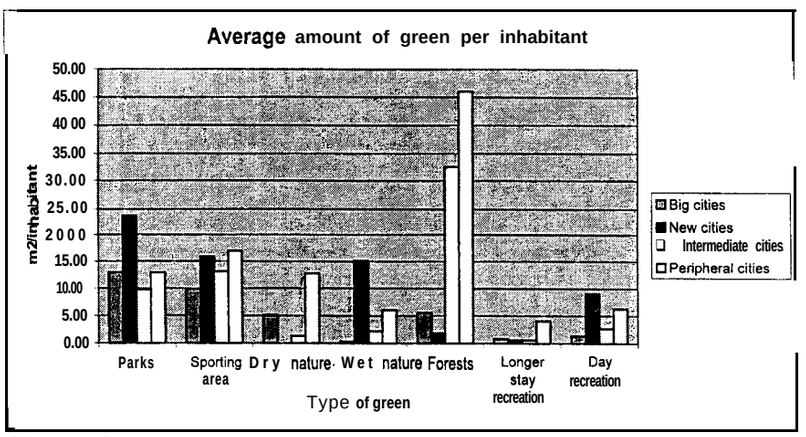

Figure 2: Average amount of green per inhabitant

Source: Statistics Netherlands (CBS)

The amount of green per inhabitant can be different from the amount of green related tot the built-up area in the city. A city can have a low population density and therefore a large amount of green per inhabitant, but if the total built-up area is very large, because of industry for example, the area of green related to the total built-up area is smalt At first sight, looking at the average amount of

green per inhabitant, this city could be seen as a green city, but when we have a closer look and also include the amount of green related to the total built-up area, the city does not seem that green at all.

When we look at Figures 2 and 3, it appears that there are no big differences between the city groups for the average amount of green per inhabitant and the amount of green related to the total built up area for most of the cities

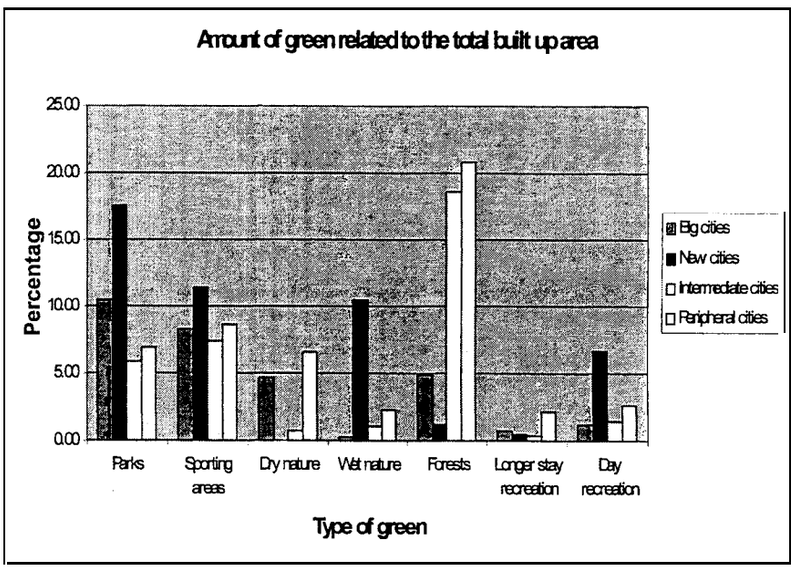

Figure 3: Amount of green related to the total built up area of the cities

Source: Statistics Netherlands (CBS)

When we consider the four city groups, we notice that the new cities and the peripheral cities have a relatively large amount of green space within their municipal borders. The differences between the amount of urban green in relation to the built up area (see Figure 3) are slightly bigger than the differences between the amount of green area per inhabitant (see Figure 2). Nevertheless, the new cities contain 'urban green' mostly in terms of parks, sporting areas, wet nature and day recreation areas, while the peripheral cities contain more 'natural green' in terms of forests, dry nature areas and longer-stay recreation areas. The intermediate cities accommodate both 'urban green' in terms of parks and sporting areas but also a relatively large amount of forest. It must be noted that the park area per inhabitant is the smallest for people living in the intermediate cities, Parks and sporting areas are also the most important green areas for the big cities. To a lesser extent the dry nature areas and the forests areas are also important. The amount of 'urban green' (Parks and Sporting areas), as shown in Figure 2 and 3, is still larger in the new cities. The natural areas, especially the wet nature areas, the day recreation areas and the longer-stay recreation areas are relatively poorly represented in the big cities.

In conclusion, we can see that the new cities accommodate a large number of green areas of which the largest part is urban green. The peripheral cities also offer their inhabitants a large amount of green space but these are mostly natural areas or sporting areas. The big cities incorporate urban green areas like parks and sporting areas and, to a lesser extent, forests and

dry nature areas but the total amount of green space is relatively small. The smallest amount of green space is generally found in the intermediate cities, although they do contain a large amount of forest area.

5. Conclusions

Cities may be seen as the centres of economic growth and human civilisation and the places where cultural and commercial ideas are born. But cities are also places which put a heavy burden on the environment and which can produce an unhealthy climate for their citizens. A wide-spread interest has, therefore, arisen in the concept of sustainable cities: cities which aim to meet the needs of their current population in efficient and responsible ways, without reducing the opportunities of the next generations. The three main interacting forces for urban sustainable development are social, environmental and economic forces. Urban green spaces may act as an important contribution to the sustainable development of cities. Against this background there is a need for an interdisciplinary catalogue which comprises proper criteria to evaluate ecological, economic, sociological and planning issues.

This paper has presented an evaluation of 24 Dutch cities and their urban green spaces on the basis of socio-economie indicators concerning the availability of urban green. The evaluation was accomplished with the help of factor analysis. The first factor related to data concerning the land use in and directly around the city described two components: man-made areas and natural areas. This analysis made clear that especially the big cities have a high value with regard to the man-made factor.

The second factor related to data about green areas in and directly around the cities encompassed three constituents: parks and public gardens, dry nature areas and forests, and daily recreation and wet nature areas. This analysis showed that the big cities have an especially high score on the urban recreation factor. These are older cities with high population densities. a situation which may explain their need for urban green areas. The new cities, which were planned and built more recently, have higher scores on the daily leisure areas.

Concerning the amount of green per inhabitant and the amount of green in relation to the built-up area, the new cities accommodate a large number of green per inhabitant as well as in relation to the total built-up area, of which the largest part is urban green. The peripheral cities also offer their inhabitants a large number of green spaces, but these are mostly natural areas or sporting areas. The big cities include urban green areas like parks and sporting areas, but the total amount of green space per inhabitant is relatively small.

Our final conclusion from the economic assessment of the 24 Dutch cities is that, when we focus on the availability of green areas in and directly around the cities, the new cities and the peripheral cities appear to be the most sustainable ones. The new cities, which were planned and built afler the awareness of the importance of urban sustainability and the quality of life, are furnished with a large number of green spaces, mostly urban green spaces. The peripheral cities, with low population and housing densities, also contain important amounts of urban green as well as natural green spaces. In contrast, intermediate cities show medium-value scores for the different factors. Their average area of urban green is relatively small, especially in terms of parks and natural areas, although they do contain rather large amounts of forest area. The group of big cities contains fewer green spaces and, especially, fewer natural green spaces. However, since big cities have high population and housing densities, the urban green spaces there might even be more important than in new or peripheral cities. Therefore, in future research, more attention should be paid to the analysis of urban green spaces in (big) cities with high population and housing densities. Such an analysis should not only focus on the availability of urban green spaces, but also on the importance of urban green spaces for citizens.

6. Literature

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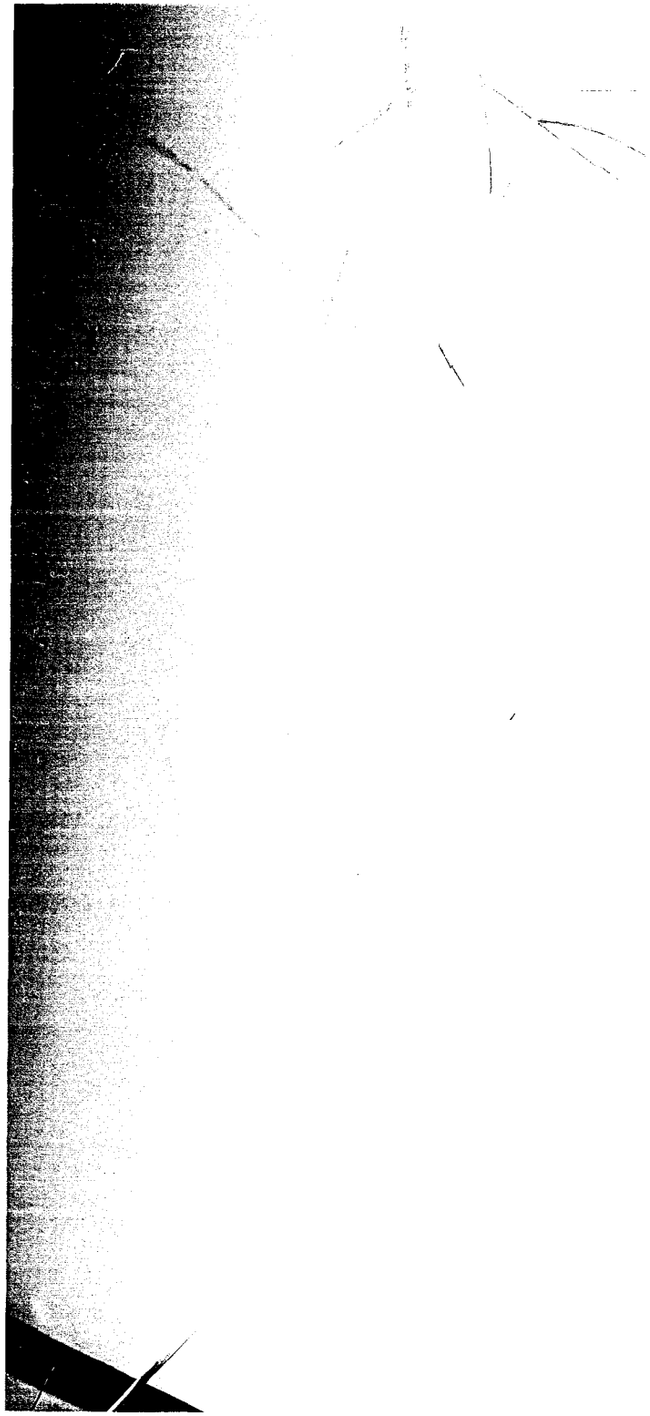
Appendix I

Data on land use in and directly around the city (ha)

Cities	Total surface	/Built-up area	Agricultural area	Forest	Residential area	Infrastructural area	Recreation area	Nature area	Other grounds	Water
Almere	248771	18411	53947	22939	13864	7580	9588	3548	15606	117152
Alphen a/d Rijn	57678	10076	36920	85	6689	2074	3928	0	2048	2547
Amsterdam	212353	76523	29248	1169	47989	12744	22238	507	16553	53371
Breda	76408	25413	29699	9773	16254	4764	3556	229	1561	1413
's-Gravenhage	82604	39650	4890	3998	30177	3160	9094	5734	1397	14681
Den Helder	178834	12777	20567	448	7238	2191	4140	3949	1344	133418
Deventer	36860	12093	15560	1636	7680	1969	2385	202	1123	1892
Ede	320481	22213	117362	1050311	14204	9295	5940	59411	843	386
Eindhoven	87948	40311	19936	8668	27688	6870	6892	873	3441	957
Emmen	280524	29859	200284	16256	22222	10562	4341	9299	5139	4784
Enschede	141467	28167	74366	21470	19831	6205	6437	1591	1808	1423
Groningen	82761	29986	33122	1409	18537	5214	5920	213	3476	3421
's-Hertogenbosch	90458	26338	41691	3348	17487	5403	4464	961	1994	6259
Leiden	23157	13392	3271	73	9637	1923	3116	0	388	994
Maastricht	58920	21783	23982	1806	14063	3106	4007	41	1435	2760
Middelburg	32858	7709	20550	84	5633	1804	1546	0	351	814
Nijmegen	48198	28016	7095	2178	19718	3240	3614	39	1090	2926
Roermond	41667	12602	16055	604	6453	2355	2999	3	874	6175
Rotterdam	304129	100851	30523	3681	46178	18341	20709	4461	29934	95629
Tilburg	80191	31161	24285	11382	20661	3878	4940	449	3068	1028
Utrecht	64095	30023	15121	1212	18469	7513	6612	18	919	2677
Zaanstad	83047	21577	37223	450	15012	4452	4109	4864	1828	8544
Zoetermeer	37048	14216	11564	91	10729	2279	6206	0	1230	1462
Zwolle	101168	20819	58714	2672	13814	5482	4637	1030	1992	5822

Source: Statistics Netherlands (CBS)



Appendix II
Data on urban green in and directly around the city (ha)

Cities	Parks and public gardens	Sporting areas	Daily recreation areas	Longer stay recreation	Dry nature areas	Wet nature areas	Forests
Almere	4343	2562	1767	-215	7	3541	22939
Alphen a/d Rijn	1417	1427	809	58	0	0	85
Amsterdam	10435	7337	779	250	0	507	1169
Breda	1292	1865	83	59	1711	108	9773
Den Helder	1128	1421	34	1202	3867	82	448
Deventer	1046	1190	60	21	0	202	1636
Ede	146	1036	142	4484	59314	97	105031
Eindhoven	2431	3680	345	31	516	357	8668
Emmen	312	2303	1286	124	4864	4435	16256
Enschede	1959	2872	594	726	1514	77	21470
Groningen	2844	1724	698	107	0	213	1409
Leiden	1340	1008	121	96	0	0	73
Maastricht	1132	2101	446	162	41	0	1806
Middelburg	789	605	15	13	0	0	84
Nijmegen	652	1852	939	70	39	0	2178
Roermond	593	807	1102	433	0	3	604
Rotterdam	10885	5924	773	416	4184	277	3681
's-Gravenhage	3468	3214	842	560	5734	0	3998
's-Hertogenbosch	1172	2241	798	81	474	4871	3348
Tilburg	2425	2095	31	0	342	107	11382
Utrecht	2619	2843	245	167	0	18	1212
Zaanstad	1509	1443	695	0	0	4864	450
Zoetermeer	3674	1565	786	0	0	0	91
Zwolle	2008	1705	442	192	0	1030	2672

Source: Statistics Netherlands (CBS)