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# Multifunctional land use in the city

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**Abstract**
The need for urban and spatial sustainability and for an efftcient urban land use has generated much interest in new forms of urban architecture. In The Netherlands, at present an intensive discussion is taking place on so-called multifunctional land use. This concept aims to concentrate and combine several socio-economie functions in the same area, so as to save scarce space and to exploit economies of synergy. In particular in densely populated countries like The Netherlands, we witness nowadays a shift in attention towards the development of integrated models and processes of multifunctional land use within given geographical boundaries. The present paper describes the concept of multifunctional land use in more detail, and outlines critically the underlying relevant backgrounds and related principles. Directions for new research ideas will also come to the fore, some of which will be dealt with in subsequent contributions to this special issue.

# 1 Introduction

Modern cities have to reposition themselves in a conflicting force field. On the one hand, cities have become important actors in an intemational competitive game and have to offer a keen survival strategy based on economic synergy. On the other hand, cities have to take the environmental quality issues very serious, as this will be decisive for their long-term approach. Multifimctionality of urban space might be a proper response to these challenges.

There is at present much discussion in The Netherlands on so-called multifunctional land use. Multifimctional land use can be seen as an empirical phenomenon, and be studied as such from a spatial economic perspective, but it can also be used as a planning concept, which addresses the planning challenge to concentrate and combine several socio-economie fimctions in the same area, so as to save scarce space and to exploit economies of synergy. For regions with a high population densely like The Netherlands, but also for many metropolitan areas elsewhere, we witness a shift in attention towards the development of integrated models and processes of multifunctional land use within given geographical boundaries. Multifunctional land use may be a useful concept to save the scarce space in The Netherlands, not only by differentiation of functions over time (e.g., sequentially over the day), but especially by seeking for a vertical combination of the functions (i.e., construction in multi-layer constellations). For this reaaon, it is an important and interesting concept to analyse in greater detail.

In traditional urban planning, complex multifùnctional land use projects in a free urban market system without scarcity of space are - without excessively high transport friction costs and with modest land prices - not likely to emerge since they make spatial planning more complex in a technical and organisational way (leading to high transaction costs) and they also make spatial planning more expensive in terms of land use prices. There is at present stil1 much uncertainty about the expected costs and benefits of multifunctional land use for the different parties involved. To stimulate the development of multifunctional land use it is important to analyse the most efftcient way to guide this process. One of the focal points is to create due support for potential (public and private) partners involved by making the opporhmities and the barriers involved transparent. Consequently, more understanding of the costs and benefits of complex multifunctional land use projects is required. Also, conflicting interests (competing spatial claims) among a large number of important actors play an important role and hence have to be addressed. Since the development of complex multifunctional land use projects is relatively new, there are several analytical and policy questions involved that still need to be answered.

In this paper, several background issues of multifunctional land use will be covered. In the next section a description of the spatial market will be given, in which the different land use functions are presented. Section 3 deals with competition in the spatial market since, as a result of the presence of market failures, there is no Pareto optimal situation in the land market. A description of different land use functions as well as different human activities and the relation between these two groups is presented in Section 4. This analysis leads to the definition of muhifunctional land use in Section 5, followed by a description of the relation between land use, infrastructure and transport in Section 6. Section 7 combines different land use functions in an urban context, whereas the concluding remarks and further research challenges are presented in Section 8.

## 2 The spatial market

Land is a scarce resource. It is mainly an input to production and consumption, and hence it mirrors - similar to transport infrastructure - a derived demand. Land use - as a parameter of socio-economie decisions - has to be deployed in an economically optimal way while respecting environmental conditions. The urban land use market is, however, extremely complex and subjected to many extemal forces.
There are many different forces that influence the organisation of land use in general. The most important drivers are geographic, economic, demographic, politica1 and social forces. The outcome of these forces and their interaction determine the spatial organisation of a certain area, be it a town, a region, a country, or even the world as a whole. Clearly, often these different forces cannot be seen in isolation, but will affect each other in various, complex ways. Spatial organisation is the result of the above mentioned forces. In this study, the focus will mainly be on the economic aspects of spatial organisation. Geographical, politica1 and social aspects will at times be touched upon, but, in principle, the spatial organisation will in this study be viewed from an economic point of view. Figure 1 shows the main (economic) forces that influence the spatial organisation of the land market.

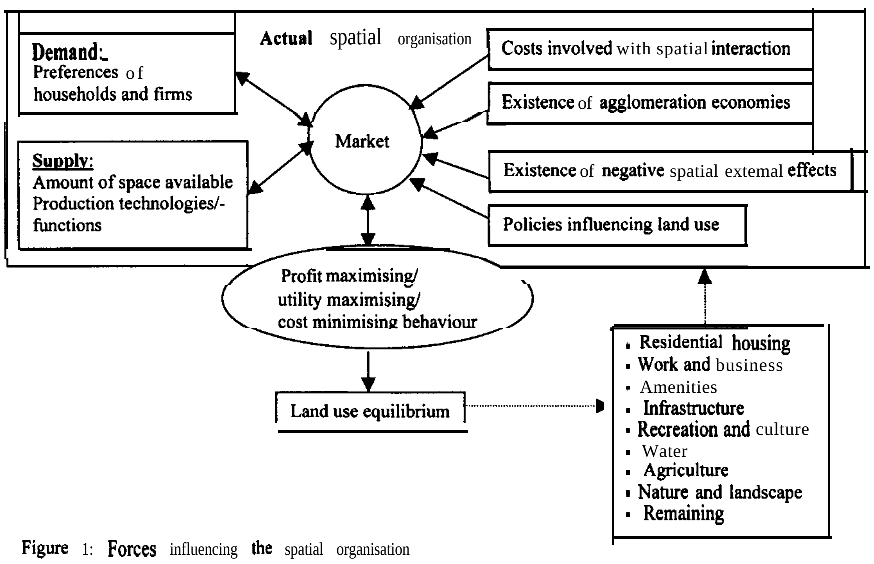


Figure 1: Forces influencing the spatial organisation

From an empirical urban planning perspective, it is important to take the actual situation of the spatial organisation into consideration. Current and future developments are often dependent on the past and actual functions of a certain area. The location of human activity usually has a long history that is reflected in rigid urban structures. This path dependency means that the actual spatial organisation is a logica1 starting point for analysing the future or potential land use of certain areas. The process of spatial organisation can be regarded as the functioning of a spatial economic market. This means that the major identiflable parts of the system are geographically differentiated demand and supply, as well as the interrelationships among these factors as a tìmction of their spatial location (Griffin et al., 1976). As an analytical starting point, we consider a rural region that has a uniform distribution of population and where city formation has not yet taken place. In this case the ***demand factors*** are represented by households and firms having certain preferences conceming the consumption of goods, among which are space, nature and time. The preferences of households are a result of utility maximising behaviour, whereas the preferences of firms are a result of profit maximising behaviour. Both kinds of preferences are influenced by emerging socio-economic developments, the public interest in certain land use functions and the current actors on the land use market.

The ***supply factors*** affect the total quantity of a commodity that can be offered within a given space and time. Examples are the availability of space and production technologies. The amount of space potentially available for a certain tünction is dependent on, among others, the current land use and the characteristics of the surrounding area (clearly, certain spatial functions are incompatible with others). For production, the area of land is obvious one of the inputs. It is evident that areas vary in their productive capacity as well as in the actual supply of the commodity demanded, since a given input of certain factors (given the other variables in the production function) produces a spatial variation in production Iìmctions of other areas. Those factors may originate from extemalities, indivisibilities and factor immobilities in resource use (Griffin et al., 1976).

It should be noted that the confrontation of supply and demand for various spatial goods and related land use prompt the formulation of a spatial equilibrium model through which the conditions for a balance on the good and land market may be investigated (see, e.g., Van den Bergh et al., 1996).

## 3 Competition in the spatial market

Taking for granted a situation in which competition in the 'spatial market' takes place there are several relevant factors to be considered. An important factor in land markets is the ***costs involved with spatial interaction*** between different locations. These can be transport costs or communication costs, since spatial interaction • in a more general sense • involves the movement of people, goods, production factors or services, or the transfer of ideas and information. These costs vary evidently with the accessibility of the location concemed; each activity seeks for an optimum spatial accessibility in order to save on transport and communication costs. The responses of the different actors towards these costs may vary according to characteristics such as trip purpose and distance to the central business district. A fundamental property of spatial interaction is that of distance-decay, which can be attributed to the cost, effort or time required to overcome the friction that distance imposes on interaction (Berry et al., 1976). Money, energy and time are limited resources. When more of these resources are allocated to interaction, fewer are available for other activities. Distance-decay reflects the relationship between the intensity of spatial interaction and distance.

A second main factor influencing competition in the spatial market is the existence of ***ugglomeration economies***, in the broadest sense. This means, for example, that by locating closer together (spatial juxtaposition), firms can produce at lower cost. Activities will compete for scarce space in case of agglomeration economies. There are various types of agglomeration economies, such as localisation economies, urbanisation economies and shopping extemalities (see, e.g., O'Sullivan, 2000).

Another factor is the existence of *negative spatial external effects* (*e.g.*, annoyance) between different activities in a given area (among others, diseconomies of density). These effects mainly arise in urban areas where the value of a location may vary strongly, dependent on the character of the area and the use of adjacent land. However, this is not exclusively due to extemalities (see also Verhoef and Nijkamp, 2002).

Based on a long-term perspective, the above mentioned factors will lead to cost minimising, profit maximising or utility maximising locational behaviour. This means that, in the end, the activity that can most successfully exploit the locational attributes of a given site will probably gain it through competitive bidding (see Fujita, 1989). This means that when extemalities or other market failures such as those mentioned above are present, the outcome of the free market process will typically not be optimally (Pareto) efficient. In general, if an allocation is such that no potential Pareto improvements are possible, it is called Pareto efficient (Varian, 1999). A Pareto improvement means that there is a way to make some people better off without making anybody else worse off. A Pareto inefftcient allocation has the undesirable feature that there is some way to make somebody better off without hurting anyone else, which means that in the equilibrium, resources are not used in the most effrcient way. So the market process of spatial organisation will result in an equilibrium solution, although not necessarily a Pareto-optimal equilibrium solution.

## 4 Land use by spatial functions and activities

The above mentioned factors will result in a spatial equilibrium (whether unique or not) in which the different functions of land are the result of market processes. There are several spatial functions and many activities to be exercised by the location at hand. The question thus arises which functions and activities can (or should) be exercised at a specific location, and against which cost levels. Therefore, the different functions and activities should be analysed, but first of all defmed. For the definition of these fuzzy and vague terms, Webster's Dictionary (1961) has been consulted. It defines spatial functions as; 'a special duty or performance required of land in the course of work or activity'. Human activities, on the other hand, include all activities that humans carry out in (24-hour) daily life, and are defined by 'any specific action or pursuit' in which taking action is defined as 'to become active; start to move, work, etc.'. The different functions followed by the activities will now be analysed in more detail, after which a combination of both will be addressed.

An important question in determining the possible spatial functions on a spatial unit or location is: what is the choice one has in determining the destination of the location? The result is a division into locations that are relatively more suitable for residential housing, work and business, amenities, infrastructure, recreation and culture, water, agricuhure, and nature and landscape. The definitions of these functions are given in Table 1. However, there will always be parcels of land that cannot be classified under anyone of the other land use functions. These will be clustered under the heading of 'remaining'. This classification of spatial functions defines the total land use in a certain region. This observation means that the sum of the total land cannot be exceeded by the sum of the land use of the different functions; i.e. the initial starting point deals with mono-functional land use in which each type of land use has its own characteristics of demand and supply. Infrastructure, for example, demands land with such characteristics that it is possible to build roads on it, whereas agriculture needs fertile land. The spatial functions will, in first instance, not be subdivided into sub-functions in order to simplify the spatial analysis of making combinations between functions and activities.

The different spatial functions and land use claims will, in an equilibrium market, be in accordance with the activities an urban population carries out. These activities depend on the choices people make among altemative uses and satisfactions, given their own set of preferences. For instance, they have to choose a certain mixture of work and leisure. The chosen mixture will mainly be dependent on the income people derive from work.

Table 1 provides an overview of the match between the land use by different spatial functions and human activities. The category of 'remaining' land use functions is left out of the table, since different land uses can be assigned to this type of land, dependent on the requirements for specific fimctions. The human activities are subdivided into work and leisure activities and travel time. The different colours of the boxes indicate the possibility to combine spatial functions and human activities from an economic point of view. The black boxes indicate principal human activities that can quite easily be carried out on a location with a certain spatial function. For example, on a location with a work and business function, production, distribution or storage can take place. Nature, on the other hand, can be used for recreation and social activities as a principal activity. The grey boxes indicate activities that can to a certain extent be carried out on a location with a certain spatial function, for example, agriculture can also be used for recreational activities (e.g., camping on farms, landscape tours). However, recreational activities are a minor tûnction (exception) and for this reason marked with a grey shaded box. The final category, the white boxes, indicates the spatial functions and human activities that are (almost) impossible to combine, such as agriculture and shopping. It is important to note that the colours of the boxes used here have a tentative character.

This table may be used as a frame of reference to give a complete coverage of the spatial system and activities that take place. That means to make a combination of all possible fimctions that a certain location can have with all activities that people can carry out in (24-hour) daily life. This match provides the possibility to make a clear distinction between the different functions (mono-functional land use), but, next to that, provides also opportunities to check whether it could be possible to practise more than one function on a certain location (i.e., multifunctional land use).

Table 1: The relation between land use by spatial functions and human activities.

| | | Human activities | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Work / Labour | | | Leisure | | | Travel time/Transport | |
| | | Production | Distribution | Storage | Living | Shopping | Recreation and social activities | Commuting | Social mobility |
| Land use by spatial functions | Residential housing | | | | ■ | ▒ | ■ | | |
| | Work and business | ■ | ■ | ■ | | | | | |
| | Amenities | ■ | ■ | | | ■ | ■ | | |
| | Infrastructure | | ■ | ▒ | | | ■ | ■ | ■ |
| | Recreation and culture | | | | | ■ | ■ | | |
| | Water | ■ | ■ | ■ | | | ■ | | |
| | Agriculture | ■ | | | | | ▒ | | |
| | Nature and landscape | | | | | | ■ | | |

■ Quite easy to carry out ▒ Can be carried out to a certain extent ☐ Almost impossible to carry out

FUNCTIONS:

- *Residential housing* is defined by the space that is needed for living. This includes houses that are in use for permanent use only.
- *Work and business* refers to the space that is needed to facilitate commerce and industry. This includes, for example, office locations and industry locations.
- *Amenities* include non-profit organisations (hospitals, schools, etc.) as well as shopping facilities.
- *Infrastructure* refers to the space that is needed to facilitate movements of goods and persons. This includes transport infrastructure (roads, railways, terminals, ports, and airports), communication infrastructure (data-communication networks), energy facilities (electricity network) and water infrastructure (dikes, bridges, locks, sea walls, etc.). It includes also the canals and rivers when they are used for transport purposes.
- *Recreation and culture* is a broad denomination. However, benches along public roads are not included, bot areas that are a destination of day trips, campings, stadiums and amusement parks are included, as is space consumed by museums and other cultural functions.
- The *water* function refers, on the one hand, to the space used by rivers, watercourses, lakes and territorial waters having a 'water management' function, whereas, on the other hand, this includes those areas that have a drinking water function, e.g. storage of drinking water, and infiltration areas.
- *Agriculture* refers to the space that is needed for cropland, pasture, orchards, vineyards, and horticulture, but also the space needed for intensive, not land-constricted cattle breeding.
- *Nature and landscape* means, in the case of a broad definition, the space needed to maintain or guarantee the current quality of nature (bio diversity). With a more narrow definition, thii may refer to the Main Ecological Structure (Ecologische Hoofdstructuur): a policy concept used in The Netherlands for a spatially connected network of larger units of nature (including water). The broad definition will be used here.
- *Remaining* includes the use of land that can not be classified onder one of the land use functions as described above.

ACTIVITIES

- *Work* is defined by 'bodily or mental effort exerted to do or make something' which is broader than employment, thus including doing the housekeeping as well
- *Leisure* is defined by 'freedom from occupation or business; idle time; time free from employment, during which a person may indulge in rest, recreation, etc.'
- *Travel time* is defined by the time needed to move from one location/activity to another. This includes, among others, commuter time and time needed to travel from home to sporting clubs, music lessons and so on.

N.B. the definitions of work and leisure are based on Webster's Dictionary (1961)

## 5 Multifunctional land use

To define the concept of multifunctional land use adequately, it is important to identify time dimensions and scale levels. The longer the time-span the higher the extent of multifunctional land use: in one year, more functions will take place on a spatial unit than in one day. The same counts for the scale dimension: the higher, for example, the geographical scale-leve1 the higher the extent of multifunctional land use. In general, the geographical scale leve1 is more determinative for the extent of multifunctional land use than the time-span. If a high scale leve1 is chosen (e.g., a city or a region), it is inevitably that several hmctions will be undertaken within this area. If a low scale leve1 is chosen (e.g., single square meters) mono-functional land use is usually the case, except if the third or fourth dimension is used. The third dimension means a combination of fimctions by seeking for a vertical combination of functions (i.e., a construction in various layers), whereas the fourth dimension means that different functions can be combined by introducing the time aspect: functions can be combined by differentiating them over time (e.g., sequentially).

There are several current definitions of multifunctional land use. That of Lagendijk and Wisserhof (1999) is the most commonly used in the Dutch literature. It states that one can speak of multifunctional land use if at least one of the following four conditions are satisfied: (1) intensification of land use (an increase in the efficiency of land use by a function); (2) interweaving of land use (which they define as the use of the same area for several fimctions); (3) using the third dimension of the land (the underground along with the surface area), and (4) using the fourth dimension of the land (use of the same area by several functions within a certain time-frame).

However, there are some remarks to be made conceming this definition. In comparison with the other elements of the definition, intensification is a process, whereas the others represent a state. This means that intensification itself cannot be observed in a static sense, but only in relation to developments over time or between different land use altematives or areas. Interweaving as well as the use of the third and fourth dimension can be observed as being present or not, at a certain moment. Furthermore, intensification is not only observable in the case of multifunctional land use but can also be a characteristic of monofunctional land use. Besides, intensification may be a result of multifunctional land use or a goal in itself. We therefore argue to leave this aspect out of the definition of multifunctional land use.

The second element, interweaving of land use, is defined by Lagendijk and Wisserhof as 'use of the same area by several functions', but we prefer to call this '*diversity*'. Figure 2a depicts the case of multifunctional land use by diversity: two land use hmctions are present in the demarcated area (indicated by the numbers 1 and 2). Figure 2b shows an increased degree of diversity: the number of land use Iùnctions in the area increased from two to five.

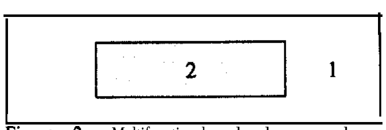


Figure 2a: Multifunctional land use by diversity: two land use functions

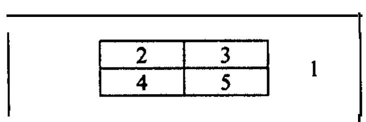


Figure 2b: Multifunctional land use: increased degree of diversity

The degree of *interweaving*, then, can be defined as the number of territories divided by the number of functions, in which a territory is an enclosed monofunctional area (which can be positioned in a two- or three-dimensional setting). Interweaving measures the degree of dispersion of functions over the demarcated area. This will be explained with the help of Figure 3. For example, a large area used for a grocery store (see Figure 2a) will be divided into four single units scattered over the area (see Figure 3). The individual areas consist of a bakery, a greengrocer's shop, a butcher, and a drugstore. In this case, where all four individual shops still belong to the land use fùnction of amenities, the interweaving of functions in the areas will increase, since, compared to Figure 2a, the number of territories increased (5 instead of 2), whereas the number of functions remained the same.

Next to interweaving, there is the issue of ***spatial heterogeneity*** of functions, which is slightly different from interweaving. Spatial heterogeneity can be seen as the degree in which a given territory touches upon other (different) functions. It can be measured as the sum (over territories) of the number of other functions touching a territory divided by the number of territories. This will be illustrated by an example. If four different land use tünctions are concentrated together (see Figure 2b), the degree of spatial heterogeneity will be higher than if these functions are individually located in an area with a single land use function (see Figure 4). In the first case, each territory touches upon four different land use functions, whereas in the second case, each function only touches upon one other land use function and only function 1 touches upon 4 different functions.

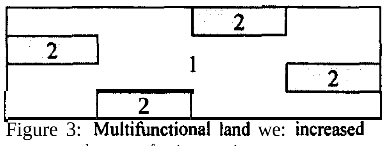

Figure 3: **Multifunctional land** we: **increased** degree of interweaving

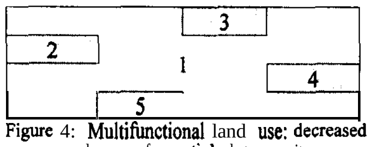

**Figure** 4: **Multifunctional** land **use: decreased** degree of **spatial** heterogeneity

The concept of multifunctional land use is very broad. It can range from a combination of hvo economic functions to the combination of all nine economic functions, depending on the chosen scale level. In this paper, the project level has been chosen as the scale level. The boundaries of the project will be taken as given and define the area that will be analysed. A practica1 definition of multifunctional land use should therefore reflect that the concept is best understood as a relative, non-binary one: it is better to define a degree of multitìmctionality then to make a strict demarcation between mono- and multifunctional land use pattems. Therefore, a more suitable definition of multitûnctional land use in a dynamic context is:

*A land use pattern is said to become more multifunctional when, in the area considered, the number of functions, the degree of interweaving, or the spatial heterogeneity ìncreases. An ìncreased degree of multifunctionality may therefore result from the addìtion of functions to the area (multifunctionality by diversity), from an ìncrease in dispersìon of the number of functions over the area (multifunctionality by interweaving), orfrom an ìncrease in the number of otherjünctions touchìng a territory (multijiunctìonalìty by spatial heterogene@).*

Multifunctional land use can be seen as an empirical phenomenon and can be studied from a spatial economic perspective, but multitünctional land use is also used as a planning concept in order to attain (urban) sustainability. In the case of multifunctional land use as a planning concept it is important to identify specific focal points in order to design an operational definition of multifimctional land use in actual situations (case studies). Nijkamp et al. (2000) have carried out an electronic interactive consultation about the definition of multifunctional land use. The consultation made clear that when applying the definition of multifunctional land use to actual situations, the time dimension and geographical scale leve1 must be specified, but also the following aspects need explicit consideration:

1. The *efficiency* of the multiftmctional land use project, compared to the current use of the land, not only as far as the costs of space and space-saving are concemed, but especially, as far as quality of space and sustainability are concemed;
2. The *diversity* of the project's appearance: this can be an extension, such as a new development, or an intensification, which means a change in the organisation of space;
3. The *synergy* of the economic and spatial functions that are brought together, leading to increasing returns to scale.

From an economic point of view, synergy is a very important aspect, since it is interesting to see if and if so where, different functions can strengthen each other if they are combined: added value will arise. Nijkamp and Reggiani (1995) describe network synergy. If we adapt this formulation for multifùnctional land use, one may define synergy as a situation of positive user extemalities through (spatial) interactions - in the form of transportation or communication - between various operators (actors, users) as a result of an efficient interconnectivity of the functions concemed, which generates value added from scale advantages - and hence increasing marginal benefits - for all users involved. This means that with a combination of fûnctions, resulting in synergy, the sum of the economic value of the combined functions exceeds the sum of the economic value of the separate functions. Therefore, multifunctional land use becomes very interesting for all different parties involved in development and exploitation of a location. However, as opposed to the implicit assumption that synergy would always be positive, it has to be said that synergy as a result of multiftmctional land use can also strengthen harmful effects. This will be called 'negative synergy'. An example is the nuisance that could arise as a result of the combination of housing and infrastructure. An example of a classification of positive synergy effects is the following (Iversen, 1999):

1. Sharing of activities subject to size economies (economies of scale and scope);
2. Performing mutually adjusted (complementary) activities.

The first type of synergy may be obtained if assets/activities are shared between businesses if production based on these assets/activities is subject to declining average unit cost, that is if economies of scale or scope can be obtained. For multifunctional land use, this means that synergy may emerge if different land use tünctions are combined such that all individual functions are favoured (e.g., by sharing a high-tech environment). The second type of synergy can be divided into vertical complementarities and horizontal complementarities. Complementarity can be achieved in a succession of activities where different steps in a chain are adjusted to the preceding and/or proceeding steps. Vertical complementarities are the effects of obtaining complementarity between activities performed in succession. Translating this to multifunctional land use and activities, an example is the development of fast food chains nearby shopping malls. Horizontal complementarities, on the other hand, are achieved by combining activities to perform a single task. An example for multitîmctional land use is a parking garage under an office building or theatre, etc., enabling people to seamlessly combine activities.

To be able to estimate the value added as a result of location synergy, it is important to know who contributes to and benefits from this synergy, or, in other words: who is involved as share- or stakeholder in the process of realisation and exploitation of multihmctional land use projects. There are three main parties to be distinguished: investors (in infiastructure and real estate), operators (users of infrastructure and users of office/retail space) and users (who make use of the offered transport and service possibilities). Examples of investors are government, municipalities, landowners, speculators, real estate developers, banks, brokers and real estate agents, whereas examples of the operators are railway companies, housing associations, and retailers. The users are the people who make use of the different land use functions and related activities offered.

The presence of different stakeholders leads to organisational complexities. Not only because each stakeholder has its own interest, but also because there is a dependency of govemments with regard to the infrastructures elements of the location. Since there is often infrastructure involved in multifunctional land use projects, in many cases there is a certain form of public private partnership necessary in order to develop the site. Such a partnership should lead to the realisation of value added and efficiency gains. This should be realised by a more proportional distribution of means between public and private parties, the use of market knowledge in the early stages of the process and by carrying out the project more efftciently. However, in practice, the uncertainty about the character of the co-operation, the juridical and financial consequences for both public and private parties and the participation of govemments often leads to more complexity without evidence of the value added and the efficiency gains.

Redevelopment of Dutch railway station sites shows erratic results due to the former mentioned complexity. To realise a program that meets the needs of every party involved is difficult. The emphasis on financial feasibility of the projects on the leve1 of co-operation between municipalities and real estate developers often leads to a homogeneous program with emphasis on office development. Aims such as improving the social safety and contributing to the stimulation of the use of public transport are often not realised.

## 6 Relation between land use, infrastructure and transport

The centra1 issue with multihmctional land use in cities is to deal with the scarce space as wise as possible. If the population density is growing, the price of using scarce space will increase, conform economic theory. An important issue in cities is that the scarcity of space (especially in the CBD) is so big that several spatial functions have to be combined on one-and-the-same location. If the spatial claims are high on a specific location, the readiness to pay of potential users will be high. The land price is determined by a multitude of considerations (originating from demand and supply factors). The complexity of the price for multifimctional land use is also caused by the huge amount of actors involved and their different backgrounds: most land use functions are developed by private parties, but, in general, infiastructure will be developed by govemment institutions. Therefore, especially the infrastructure component is interesting to analyse since there are not only differences in ownership, there also exist strong interdependencies between the land use system and the transportation system (regarded here as the system of transport infrastructure), according to the fundamental assumptions regarding urban structures and location behaviour. Briefly stated, locational decisions made as a result of land use activities are, to a large extent, the result of the relative costs of travel to various spatial opportunities. Given the structure (layout, capacity, geographical position, etc.) of the transportation system, the pattem of trips generated by these activities affects the costs of travel in the region. It can be said, therefore, that the spatial organisation of land use detennines and, at the same time, is being determined by the design and characteristics of the transportation system.

Not only spatial functions and land prices are influenced by demand and supply factors, the same factors have their influence on transport as well. Transport infrastructure itself has no other initial fimction than to provide transport opportunities in order to bridge possible discrepancies between demand and supply in different regions. Since the different functions of spatial organisation are in genera1 geographically separated, one needs to move from one location to another to make use of the different spatial fimctions. This immediately shows that the different spatial functions lead to a demand for transport, which is a derived demand, resulting from the geographical separation of the initial spatial tünctions (see Figure 5).

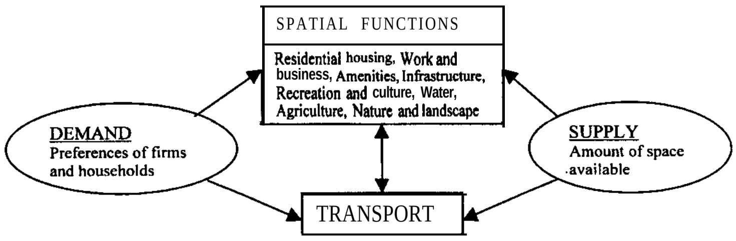


**Figure 5: Relation between demand and supply factors, spatial functions and transport**

There are at least two important questions witb regard to transportation (Dijst, 1995). The first is *when* people will make movements. People have to move from one location to another to participate in activities. This means that a movement is a derived demand in stead of a goal in itself. The second question is *why* people move. In transport and traffic science it is assumed that a movement to a certain location to participate in activities only takes place if the subjectively judged benefits of the activity at least counterbalances the costs involved with the movement. It is assumed that people will minimise these costs (expressed in time, money and/or effort) as much as possible.

Transport is often not desired for its own sake, its value derives from the access it provides to other goods and services. Transport can even be regarded as having a negative utility for the most part: the less of it one has to consume, the better it is. Since transport is derived from the initial ftmctions of spatial organisation, transport infrastructure has more than one single function of spatial organisation in itself. The reason why people use the infrastructure (work, recreation, etc.) defines the derived tünction. This means that there is no single specific spatial activity related to infrastructure, not even on a certain location.

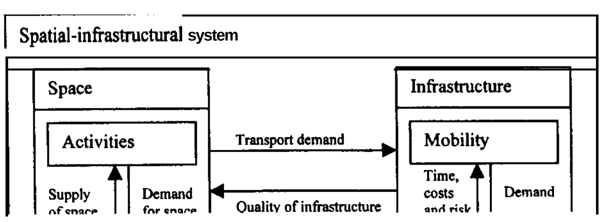

Figure 6: The spatial-infrastructural system
Source: based on Geurs (2000)

The relation between tbe spatial organisation and the demand for transport is presented in Figure 6. The spatial-infrastructural model shows (a) the spatial developments (land use in relation to human activities (see also Table 1)), (b) the location, size and quality of infrastructure as well as the use of it (division of traffic over the network), and (c) the mutual relation between space and infrastructure, i.e., the location of activities determines also the demand for transport and the quality of infrastructure.
For example, transport between a housing and an office location (i.e., commuter-trafftc) arises as a result of the geographical separation between those two functions. This traffic serves the housing as well as the work function. This means that, as a consequence of mutuality, infrastructure has a multifunctional structure, in contrast to the mono-lìmctionai structure of the spatial organisation (residential housing or work, and business or recreation, etc.).
Another characteristic of infrastructure is that, with the provision of infrastructure, network effects arise since regions are connected by infrastructure links providing transport opporhmities between neighbouring regions, but also connecting regions further away. This shows that infrastructure is an important factor for economic development, since it provides opportunities to bridge possible discrepancies between demand and supply.

## 7 The combination of different land use functions in an urban context

After giving an impression of underlying factors behind land use and, more specific, the concept of multifunctional land use, the opporhmities and threats influencing multifunctional land use can now be analysed in more detail. Therefore, considering certain combinations of functions could be a good starting point. If we use the functions as presented in Table 1 and we focus on the functions representing urban multifunctional land use (i.e., residential housing, work and business, infrastructure, amenities, and recreation and culture), the following combinations of functions can be made:

1. Residential housing - Work and business
2. Residential housing - Infrastructure
3. Residential housing - Amenities
4. Residential housing - Recreation and culture
5. Work and business - Infrastructure
6. Work and business - Amenities
7. Work and business - Recreation and culture
8. Infrastructure - Amenities
9. Infrastructure - Recreation and culture

With these five land use fùnctions, also combinations of more than two fimctions can be made (10 combinations of *3* functions, 5 combinations of 4 functions, and 1 combination of 5 functions). Not all these possible combinations will be dealt with in this paper. For reasons of simplicity, we will focus on the combination of two fimctions. This is justified by the fact that these already give a good reflection of the kind of problems that could arise as a result of the combination of different land use functions. But one has to keep in mind that the more fimctions will be combined the greater the number of obstructing factors and the greater the call for creativeness of developers and architects will be. On the other hand, the combination of two functions also gives a first indication for possibilities for the rise of synergy effects. However, the relation between the number of land use functions combined and the chances for the rise of synergy effects are still unclear. There is no optimal number of land use functions defined yet that is necessary to create the highest synergy benefits.

For now, the focus is on the combination of two land use functions. The lower left part of Table 2 shows the possibilities to apply the above mentioned combinations of land use functions in a two-dimensional world, which means that different functions exist next to each other. The right side of the table presents the possibilities to apply the above mentioned combinations of land use functions by using the third and fourth dimension.
The grey colour indicates that these land use functions can to a certain extent be combined, whereas the white colour indicates that it is less preferable to combine these land use fimctions (although not impossible). It is important to note that again the colours of the boxes have a tentative character.

Table 2: **Relation between** different **spatial functions** in tbe **second,** third and **fourth** dimension.

| | Residential housing | Work and business | Infrastructure | Amenities | Recreation and culture |
|---|---|---|---|---|---|
| Residential housing | | | | | |
| Work and business | | | | | |
| Infrastructure | | | | | |
| Amenities | | | | | |
| Recreation and culture | | | | | |

The ***lower left*** part of the **table presents** possible combinations of **functions** in a ***two-dimensional*** **world.**
The ***upper right*** part of the **table presents** possible combinations of fùnctions in the ***third and fourth dimension.***

Almost all combinations seem to be possible in a two-dimensional world as well as in using the third and fourth dimension. The only combination that seems to fit less well is the combination of infrastructure and residential housing in a hvo-dimensional world. This can be explained by the fact that infrastructure causes several negative external effects such as noise and pollution. Therefore, people do not prefer to live close to a highway or a railway. By using the third dimension, this problem can be solved if the infrastmcture will be brought underground. For almost every possible combination of infrastructure with other land use functions the use of the third dimension is recommendable, but not a prerequisite per se for the development of a certain functional mix.
Another remark conceming the combination of different land use functions with the specific land use function of infrastructure is that infrastructure has the character of a

public good in contrast to the other land use functions as specified in this paper. A major part of the spatial investments in infrastructure are public investments for which decision making takes place at high politica1 levels. For the introduction of multifunctional land use co-operation between public and private parties is necessary and desired (Nijhof and Stuip, 1998).

Since this paper deals with multifunctional land use containing the third and fourth dimension as well, the possible combinations of land use functions as presented on the right side of the table will be described in more detail.

- Residential housing - Work and business

Traditionally, different land use functions have been developed spatially separated. Nowadays, however, there are good reasons to combine residential housing and work and business (Priemus, et al., 2000):

- To avoid car mobility, especially commuter traffic;
- To increase the work and business function of houses and neighbourhoods (80% of the people starting a business start from home; teleworking, teleshopping, etc.).

Nevertheless, one has to reckon with the effects that the combination of these functions could have on transport flows. Barriers in the combination of these two functions are environmental legislation (especially if housing would be combined with industrial activities), development plans and the current situation in the built environment.

- Residential housing - Infrastructure

As mentioned above, residential housing and infrastructure can be combined, but preferably by using the third dimension. If this is not the case, there have to be compensating elements or positive synergy effects that more than compensate the negative extemal effects in order to get people to live next to infrastructure. From a spatial planning perspective, a high density (containing a minimum amount of houses within a circle with a given diameter from a (public) transport stop) is desirable around public transport stops. In this way, real estate development can influence the rate of cost recovery of public transport if houses and public transport infrastructure are strongly integrated (Priemus et al., 2000). The substantial losses in the public transport market could be a stimulus for multifunctional land use. Conceming private transport the accessibility of houses and residential areas as well as the integration of parking in residential areas is important. To guarantee the quality of public space certain requirements have to be determined within the relation between residential housing and infrastructure. However, environmental legislation and the non-cooperativeness between different govemment institutions being responsible for spatial planning could hamper the realisation of these positive symbioses.

- Residential housing - Amenities

The integration of residential housing and amenities is not as successful as has been hoped for. In the last decades the increase in scale in distribution pattems has been the major reason. The local shops suffer from a lack of customers, whereas big, monofunctional concentrations of amenities are realised in the city as well as at the edges of cities. This development will be difficult to curb. By developing services close to houses (day nurseries, personal services, physiotherapists, etc.) residential housing and amenities can become more integrated. The higher the density of an area is the higher the desirability of such an integration of functions. Difftculties in realising this integration can be found in distribution pattems, the structures of services and also environmental legislation. Solutions might be found in the realisation of urban centres and junctions in which these functions will be integrated.

- Residential housing - Recreation and culture

A growing part of (car) mobility is a result of the increase in recreational motives for transport (Priemus et al., 2000). More importance is being given to the fact that people should be able to recreate close to their homes. If 'urban recreation' is regarded, the combination of residential housing and recreation and culture could be profitable, decreasing car mobility and increasing visitor numbers.

- Work and business - Infrastructure

The accessibility of offices and firms is an important location factor. A strong spatial relation between work and business and infrastructure is important for the accessibility by car, public transport and freight transport. If multifunctional land use has to be realised on work and business locations at the edges of cities but also in the city centres, the area will have to be opened up by means of infrastructure. The synergy between these two functions could be realised by developing urban interchanges/junctions, designing public transport networks and logistic solutions for urban distribution.

- Work and business - Amenities

The integration of these land use functions is evident in those situations where there are a sufficient number of employees present that could make use of amenities such as shops and services. The combination of work and business with amenities such as hospitals and schools is less evident. A genera1 remark in combining the work and business functions with other functions at inner city locations is that there are hardly any possibilities for expansion of firms.

- Work and business - Recreation and culture

There is not a very close connection between 'urban recreation' and work and business. Urban recreation is in general practised during free time, whereas work and business is dealt with in business hours. The chance that office workers will use the recreational facilities after office hours is very small. Nevertheless, an interesting aspect of the combination of these functions could arise if, for example, urban green is developed close to work and business environments, providing employees the possibility to have lunch outside. Another example is the presence of a concert hall, enabling employees to visit a lunch concert.

- Infrastructure - Amenities

It is important that the accessibility of amenities is provided by means of infrastructure. A hierarchical structure of the transport system in which there are coherent junctions to be found offers an ideal starting point for the spatial integration of amenities and infrastructure in and around transfer points (Priemus et al., 2000). To realise this, a better integration of spatial planning, real estate development and infrastructure as well as transport policies is necessary.

- Infrastructure - Recreation and culture

The combination of infrastructure and recreation and culture is more problematic if open-air recreation and recreational areas are considered. However, in this analysis we deal with the combination of infrastructure and urban forms of recreation and culture for which the same applies as for the combination of infrastructure and amenities. Also for recreation and culture, it is important that the accessibility is provided by means of infrastructure. A difference between amenities and recreation and culture is that for the latter it is not as important to be located on infrastructure junctions, since they are less dependent on people who by chance make use of the facilities. For recreation and culture, people decide beforehand if the trip has a recreational goal. In contrast, the consumption of amenities such as shopping is more often not intended.

. Amenities - Recreation and culture

On inner-city locations, the combination of amenities and recreation and culture can create an attractive ambience for visitors. By applying urban intensitïcation, this combination can be encouraged and could lead to multipurpose trips, which have a positive effect on car mobility and on the time (and money) spent in the area.

With this discussion of the opportunities and threats influencing specific combinations of urban land use functions, the concept of multitünctional land use has been illustrated in more detail. However, the concept should be tested on case studies in order to see the real consequences of multifunctional land use in terms of opportunities and threats. The next section will give some concluding remarks as well as directions for new research ideas on the issue of multifunctional land use in tbe city.

## 8 Conclusions and challenges

Modem cities have to find a balance between becoming an actor in an intemational competitive game based on economic synergy and dealing with environmental quality issues, which will very much influence their long-term approach. Multifunctionality of urban space might be a proper response to these challenges. The concept of multifunctional land use has tumed out to be a very interesting one in urban planning. Moreover, it can also be regarded as an empirical phenomenon and analysed from a spatial economic perspective. Economic research has traditionally put great interest in mainly monofunctional land use based on issues of efficiency and (more recently) sustainability. Multifunctional land use, however, attempts to combine several socio-economic functions in the same area, so as to conserve scarce space and to exploit economies of synergy. After an analysis of the spatial market and the presentation of the different land use functions, the description of multifunctional land use in this paper showed that it is no unambiguous concept, which makes it important to use/develop a clear definition. Based on such a definition, the synergy effects of multifunctional land use projects could be analysed. However, to be able to estimate the value added as a result of location synergy, it is important to know who contributes to and benefits from this synergy. In practice many elements lead to more complexity without evidence of the value added and the efficiency gains. Examples are the uncertainty about the character of the co-operation, the juridical and financial consequences for both public and private parties and the participation of governments as was illustrated by the combination of combines different land use functions in an urban context.

Although this paper already described the concept of multitûnctional land use in more detail, and outlined critically relevant backgrounds and related principles, it is interesting to analyse the concept of urban multitünctional land use in further detail. Issues that are not yet dealt with in this paper and that could form interesting directions for new research are, among other things, spatial dilemma's that arise in the discussion on compact cities vs. urban sprawl, the development of multifunctional land use as a result of market processes or planning, the position of multifunctional land use in the city as a production or consumption system, the design of multifunctional cities, and the future impact of multifunctional design. Some of these issues will be addressed more extensively in subsequent contributions to this special issue.

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