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MONITORING RESIDENTIAL QUALITY FOR THE ELDERLY USING A GEOGRAPHICAL INFORMATION SYSTEM

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MONITORING RESIDENTIAL QUALITY FOR THE ELDERLY USING A GEOGRAPHICAL INFORMATION SYSTEM

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Abstract

The population in Europe, and even more so in the Netherlands, is aging rapidly. Concurrently in the light of severe budget deficits, the Dutch government's elderly care service policy has decreased the number and capacity of elderly care services, such as old people's homes and nursing homes. The consequence of this national policy, with regard to housing for the elderly, is that the elderly need to remain independent in their own residential neighbourhood for more years than they did in the past. However, in urban and suburban areas, elderly who live independently face an increasing number and range of problems, such as poor quality of dwellings, disappearance of neighbourhood facilities, increasing fear of crime, etc..
In order to maintain the quality of the daily living environment of elderly, urban planners and policy makers need to have access to proper information about processes and developments in the residential environment of elderly. This information is related to physical and social characteristics of the residential area and its inhabitants. The use of modern information technologies to handle the associated multidimensional data, information and knowledge is therefore necessary.
The objective of this paper is to discuss some critical topics related to the development of a computer-based system for public policy making concerning the quality of the residential environment for elderly. Successful implementation of this system depends on a careful preliminary assessment of the type of system required to meet the demand of the end-user(s). The creation of accurate functional design is essential and should be discussed in both the context of the technical requirements and the context of the end-user(s). Therefore, perspectives of different people involved should be taken into account for the development of public policy analysis systems. This has resulted is a new information tool. In the paper this tool, corned RELEVANT (REsidential Location Evaluation and Analysis Tool), a GIS-based system for public policy analysis in the field of residential monitoring in the city of Amsterdam is presented. The essential components of this policy support system - data, models and user interface - will be outlined in more detail. The added value of the GIS-like functions in this system is assessed as well.

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1 Introduction

The population in Europe, and even more so in the Netherlands, is aging rapidly. An increase in life expectancy and a decrease in birth rates are leading to an explosive increase of persons 55 years of age and older, generally regarded as 'the elderly' (or the 'silver' generation). Within this group of elderly, 'double aging' also takes place, and the population of the 'old' elderly within the total elderly population increases even more rapidly (Vollering, 1991). Concurrently, the Dutch government's elderly care service policy has decreased the number and capacity of elderly care services, such as old people's homes and nursing homes. The consequence of this national policy, with regard to housing, is that the elderly need to remain independent in their own residential neighbourhood for more years than they did in the past. In this context also the increasing differentiation in housing demands among the elderly population is leading towards a growing demand for independent housing possibilities. However, in urban and suburban areas, elderly who live independently face an increasing number and range of problems. A notable shortage of suitable dwellings exists, especially in older urban areas. The quality of dwellings is often insufficient: poor technical quality, poor accessibility due to steep and narrow staircases, and sometimes lack of amenities like a shower or bath. Furthermore, a decent residential environment is often lacking. The gradual disappearance of small neighbourhood shops and post offices has a negative impact, especially for less mobile inhabitants who are often nearby oriented. Increasing fear of crime, threatening behaviour and violence in the streets diminish the interaction possibilities of the elderly and devalue their daily living environment.

In order to offer older residents a future perspective in a decent residential environment, urban planners and policy makers need to have access to relevant information regarding developments in the daily living environment of the elderly. A computer-based system that offers capabilities to assess urban and residential quality indicators may be useful to monitor dynamic developments in the urban environment and to evaluate future policy actions. Such a system should inform urban planners and policy makers about positive and negative developments both in time and space and offer possible directions for policy making.

GIS seems to be the technology that offers promising possibilities to integrate multidimensional data of the physical and social characteristics of the residential environment of elderly. GIS offers the capabilities to store, manage, integrate and visualise spatial and non-spatial data. Especially, exploring spatial or geographical patterns of locational suitability, equity, accessibility, etc. becomes easy through map display and interactive map use.

Remain objective of this paper is to illustrate some important aspects of the functional requirements, conceptual architecture and implementation of a GIS-based policy support system. Specific attention in this paper will be given to the integration of GIS technology and public policy analysis. This will be illustrated with an example of a GIS-based system for the assessment and monitoring of residential quality for elderly housing. This model-based GIS, called RELEVANT (REsidential Location Evaluation and Analysis Tool) offers interactive access to data and models and multi-perspective views on spatial and non-spatial information through visualisation by maps, graphs and tables.

This paper is organised as follows. First, some general remarks will be made according to residential quality assessment, indicators of urban and residential quality and urban planning concepts concerning residential planning for elderly housing in the Netherlands. Then, computer-based instruments that may support urban planning and policy-making are discussed with regard to monitoring residential quality. The perspectives of different (potential) users of such a system in public policy analysis is discussed as well. Next, basic components of the GIS-based system RELEVANT - data, models and user-interaction - will be discussed in more detail from a functional point of view. Finally, some concluding remarks will be made.

2 Residential quality assessment for elderly housing

Over the past decades, planning concepts of elderly housing in the Netherlands shifted from the planning of institutional housing - old people's homes and nursing homes - towards planning concepts of independent housing with a focus on the design of buildings and dwellings. Recently, Dutch urban planning and management emphasised the neighbourhood as the geographical unit to study and monitor the living environment of elderly and to obtain continuity of individual life-styles. Local government in the Netherlands has adopted a housing policy of independent housing of elderly households in their own neighbourhood. Therefore, from the perspective of urban planning, the quality of the daily living environment of elderly requires careful attention. The quality of living or 'life quality' has intensive attention in the social sciences (Pacione 1981, Rogerson et al. 1989). There is still a public and academic debate going on about the definition and measurement of quality of life. Various lists with social indicators exist, which refer to not only to the environment where people live (such as air and water pollution, poor housing), but also to the characteristics of individuals (such a health or educational achievement). As urban planning should provide a framework for the design and planning of residential places to live, it can only affect a part of people's wellbeing and the wellbeing of elderly. The residential environment does not only affect the physical well-being of the elderly, but also the social aspects of their lives (Burby & Rohe 1990). Satisfaction with the neighbourhood and the housing situation are examples of important factors that can be influenced by urban planners and policy-makers.

In the Netherlands, the concept of 'residential zoning for elderly', developed by planners of the PPD Noord-Holland (1989), is a planning concept for residential quality assessment. This concept is offering a framework to monitor and guarantee the possibilities for elderly to live independently in a 'friendly' residential neighbourhood. Originally, residential areas for the elderly were defined as "areas with suitable and affordable dwellings, situated within 500 meters walking distance - or 400 meters as the crow flies - of services for elderly: shops, public transport, medical facilities, post office and green areas. At the same time, these areas have by no means a homogeneous population of elderly, but are built up heterogeneously" (PPD 1989).
Consequently, in considering housing for the elderly, planners need to focus their attention on both the physical and social characteristics of elderly residences (Burby and Rohe 1990). Residential zoning for elderly addresses this need, because it is

adapted to local circumstances and qualifies areas according to their suitability for elderly housing based on physical and social characteristics. Physical characteristics of the neighbourhood are measured with indicators of accessibility to several important shopping facilities, care services centres and recreational services. The availability of suitable dwellings, defined and selected on their physical characteristics such as ground floor accessibility, availability of an elevator, amount of floor space, number of rooms, the availability of amenities, rent level, house ownership etc., is another important objective policy variable for the measurement of elderly housing. These objective housing and neighbourhood characteristics - often translated into targets associated with policy objectives - should be considered together with social indicators regarding the satisfaction of elderly with housing and neighbourhood variables. Social variables include neighbourhood livability and satisfaction, fear of crime and potential for social interaction, which are linked to the location, design and management of housing for the elderly. The actual use of neighbourhood facilities and services, patterns of social interaction and the perception and fear of crime are indicators of housing satisfaction for elderly who are economically and physically limited, more vulnerable and less mobile. Interviews among the elderly population are necessary for planners to study the actual behaviour and their perceptions concerning their use of services and their existing and preferred housing situation.
The determinant factor for the perceived housing situation and actual interaction pattern is the household situation. Differentiation in household situation, in terms of age, mobility, cultural-ethnical background en socio-economic characteristics, cause individual households to perceive the housing environment differently and to weight objective policy criteria differently. This difference in perspectives demonstrates that residential zoning is a relative concept (see Figure 1). A range of friendly to unfriendly zones related to the demographic and socio-economic characteristics of the elderly population appear to exist.

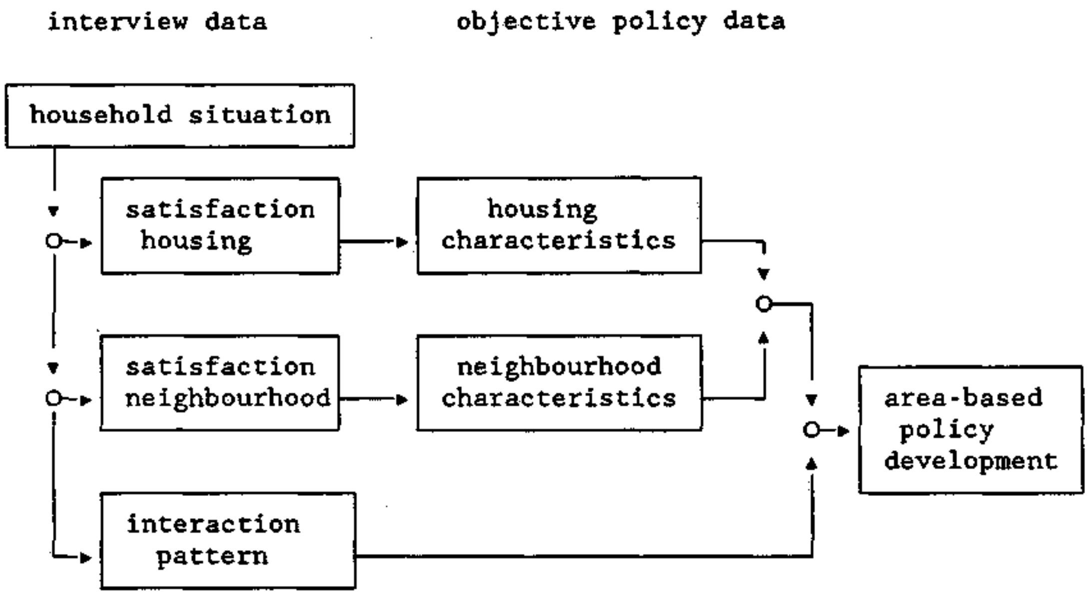

Figure 1 The policy variables are weighted using interview results and combined with other variables for the development of area-based housing policy.

In theory, the application of the residential quality concept for elderly housing in the Dutch - but also European - planning practice can perform several integrative functions, like:

1. a framework for new housing, housing renovation and allocation;
2. a framework for the integration and the adjustment of housing, care and service facilities to the needs of elderly;
3. procedures to handle the flow of elderly residents from large to small(er) dwellings;
4. a framework for management of the residential environment.

In practice, however, various obstacles may restrict the application. First, it is essential to define the elements of residential quality. Indicators can be provided with different methods (Pacione 1981). A list of indicators may be established using social planning theory. However, there does not exist a social theory that offers precise conditions defining the residential needs of people. In this context, planning concepts like 'residential zoning for elderly' can only offer some guidelines for measurement. The second approach is to ask people how they view their residential environment using surveys. This direct method is probably the 'best' method to collect the necessary information; however, it is often time consuming and costly. The third approach involves the collection of 'expert opinions' or the judgements of scientist or representatives of public views. Here, it is possible that the opinions do correspond to the concern of the population under consideration. In fact, the specification of the elements of residential quality should be adapted to local circumstances and the priorities of the local population and organisations. All three methods may support the development of a suitable and comprehensive list of local residential indicators.
The next topic that deserves practical attention is the data collection and data integration. Residential quality indicators can have different data sources, such as statistical data, survey data, data generated by objective (spatial) models. Another data issue is that objective and subjective indicators can be distinguished (Pacione 1981). Objective indicators are hard measures which describe the environment in which people live and work, such as health care provision, crime, education, leisure facilities and housing. Subjective indicators are less hard to measure and describe the perception and evaluation of the conditions around people. This might result in weights of the criteria and objectives of individuals or groups (see Rogerson et al. 1989). The integration of objective and subjective indicators needs specific attention. Many individual factors, such as social and socio-economic characteristics, influence the evaluation of the objective environment. Individual experience leads to different perceptions of objective measures.
Furthermore, indicators and the associated data consist of a different spatial resolution. For residential quality assessment the daily living environment of elderly consists of the housing location. This implies that the residence, represented by the address or postal code location, is the most disaggregated level of measurement. As such, this does not only require large amounts of spatial and non-spatial data, but also the interpretation of this kind of information for policy making requires new methodological considerations, like aggregation into policy variables. The aggregation of indicators into one element can be employed with different models, such as statistical, mathematical or logical models. The type of measurement technique may also influence possible outcomes.

Thus, measurement of residential quality for elderly remains an exercise that deserves careful consideration. The choices made regarding the selection of indicators, the aggregation into one index, the weighting or non-weighting of indicators can easily lead to a bias in the results (Pacione 1981).

In the sequel of this paper we will now describe a case study for Amsterdam. The Departments of Gerontology and Regional Economics of the Vrije Universiteit Amsterdam started a research project in the field of residential zoning and elderly housing (Grothe and Blom 1992). In several pilot studies conducted in residential districts in the Amsterdam urban area the research framework illustrated in Figure 1 has been applied for the definition and measurement of residential areas for elderly to support policy development for elderly housing. GIS was applied as data integrator and visualiser in various elements of the research framework, such as qualifying neighbourhood areas based on accessibility indicators, selection and display of suitable dwellings, integration of data on elderly social interaction and attractiveness of collective areas. The next section will outline some important aspects of such a computer-based support for monitoring residential quality.

3 Computer-based support for monitoring residential quality

In information technology many types of computer-based systems exist that have the intention to support operational and managerial decision making tasks like Data Processing systems (DP), Management Information Systems (MIS), Decision Support Systems (DSS), Expert Systems (ES) and Executive Information Systems (EIS). The differences between these systems is often explained by the level in which policy and decision making is supported. For the purpose of this paper a DSS approach is adopted as being a computer-based instrument that offers policy- and decision-makers access to indicators and strategic information based on data and various models. These indicators can be compared with the dashboard of a car or the identifiers in a cockpit: they support the driver in making decisions concerning vehicle navigation. The literature on DSS is rich and many definitions of DSS exist. In the context of this paper the functional definition of Mittra (1986) offers a consistent framework: " A Decision Support System, DSS for short, is a computer-based information system that helps a manager providing him or her with all the relevant data in an easily understandable form. As the user of a DSS, the manager formulates the problem by using an interactive and probably menu-driven front end. The system then accesses a data base to locate the necessary data, utilizes a repertoire of mathematical and/or statistical models and finally produces the desired information at the user's terminal" (Mittra 1986). An important component of this DSS definition, besides models and user-interaction, is the database. Especially for locational planning problems, a DSS should offer possibilities to represent geographical space and the objects in geographical space in order to analyze spatial relations and patterns. The technology that handles spatial data is known as GIS (Geographical Information Systems). GIS is an information technology that offers capabilities to store, maintain, analyze and display spatial data. The geometric and attribute characteristics of the objects in locational planning can be integrated using specific GIS data structures. These data structures give easy access to the construction of geographical measures and concepts like distance, connectivity, contiguity, accessibility, etc., that form part of locational models. At the same time map display capabilities of GIS have led to possibilities for interactive modelling and exploratory data analyses through computer graphics (Haslett et al. 1990). As such, GIS can be considered as a DBMS for spatial data. The combination of DBMS, DSS, ES and GIS has resulted in the development of Spatial Decision Support Systems (see Densham and Rushton 1988; Densham 1990), as the spatial equivalent of DSS.

Computer-based systems may also play an important role in assisting urban planners, policy- and decision-makers in handling large amounts of data and models involved in residential policy analysis (see also Aybet 1986). Such an automated instrument should offer the users efficient access to data, methods and models, needed to generate the necessary information for solving residential planning problems. An essential requirement is the supporting role of the system in all stages of the public policy and decision making process. First, ongoing monitoring of the significant characteristics of the urban system should be provided. Monitoring provides information concerning the effects of past public policy and problem situations that may call for new policies or actions. The second stage of policy analysis has an input from the monitoring process and specifies the problem, policy objectives, decision criteria and alternative solutions. The final step considers the alternative solutions and evaluates their costs and effectiveness. This three-level rational paradigm of policy analysis forms a continuing process with feedback and iterative procedures of monitoring significant measures and indicators (Calkins 1992).

The objective of a policy and decision support system is to support public policy through analysis. The evaluation and monitoring functions in policy analysis are often vulnerable elements in policy analysis due to the long-term period involved in implementation of social and economic policies. Long-term implementation asks for a continuing process of data collection to support these activities (Calkins 1992).
Besides the fact that a policy support system should consider all stages of policy analysis, it should meet the condition of quantification of the significant policy attributes. Some of the methodological and data-oriented difficulties of quantification of the urban residential system have already been outlined above. An important condition for the acceptance of a policy support system is the willingness of planners, policy- and (political) decision-makers to accept quantified targets in policy making. The transformation from general policy statements into direct measurable policy indicators requires often a process of acceptance and adoption. It should also be noticed that public policy-making might be influenced by private organisations. Public decision-making can only affect private actions indirectly and therefore the effectiveness of a monitoring system may be limited.

User perspectives towards computer-based systems for urban policy analysis

A (S)DSS approach may play an important role in model-based planning like residential quality monitoring and planning. A vital issue here is how various models can be integrated in a computer-based system that offers a multi-perspective view on the urban residential system. For this purpose it is necessary to consider the requirements of (potential) users of such a system (Scholten and Padding 1990; Nijkamp and Scholten 1993). Expertise regarding the specific characteristics of the problem environment, data requirements, modelling methods and political decision making are often not combined in one individual. Although it might be not a comprehensive classification, three types of users can be distinguished:

1. the policy or/and decision maker;
2. the analyst or/and modeller; and
3. the information technology specialist.

The three types of users have different information and system demands (see Figure 2). The information technology specialist is a professional user of methods and techniques applied in raw data processing. Knowledge of conventional DBMS and GIS technology is essential for the tasks performed by information technology specialists. The information technology specialist does not necessarily use a DSS, but supports raw data processing concerning the underlying DSS databases and provides the analyst or/and modeller with adequate and up-to-date data. The analyst or/and modeller has often a well-defined task: to search for laws in observed choices made by the actors involved in locational choice. The analyst or/and modeller needs easy access to models and procedures that generate information for policy and decision-making. Modelling is an iterative process of model specification, calibration and testing. A model-based GIS supports the central elements of the modelling process; data set selection, model specification, calibration (estimation and testing) and model use. The analyst or/and modeller is often an intermediate actor who preprocesses data for policy or/and decision makers. Policy or/and decision makers need a system that generates key information for strategic policy and decision making. Good accessibility of model-based information and a user-friendly interface are key elements for handling a computer-based system by a policy or/and decision maker. The use of computer (geo)graphics is generally acknowledged, as it can be considered as a decision aid in itself. GIS technology can play an important role in visualising georeferenced data and making graphical interaction through maps accessible to the user.

TYPE OF USER	INFORMATION DEMAND	USER DEMAND	TYPE OF SYSTEM
information technology specialist	raw data	analysis and flexibility	DBMS / GIS
analyst / modeller	raw and preprocessed data (= information)	analysis and good accessibility	model-based GIS
policy /decision maker	strategic information	good accessibility to various models	(S)DSS

Figure 2 Types of users and their demands concerning (S)DSS use

The interaction between information technology specialists, analysts or/and modellers and policy or/and decision makers in the planning process is essential for the quality of choices and decisions. The policy or/and decision maker might need the analyst or/and modeller (or another intermediate) to feed the critical stages of the policy decision process with relevant information. This information is handled by the policy or/and decision maker to make final choices or to start a reiteration of the process. This relationship between analysts or/and modellers and policy or/and decision makers has impacts on the demands both users have regarding the development of computer-based support systems. As mentioned, above the analyst or/and modeller is interested in a flexible modelling system, whereas the policy or/and decision maker is interested in a system that generates strategic information for policy and decision making tasks. In this context, the analyst or/and modeller should have access to a model-based GIS and the policy or/and decision maker to a (S)DSS. A model-based GIS is basically a tool for the analyst or/and modeller to explore and construct spatial models in a visual interactive way. The analyst/modeller is capable to select, query and visualise data and model estimates through geographical views (maps). The model parameters and estimates generated using a model-based GIS may then be an input for a policy and decision making process. This process is supported with an overall (S)DSS that incorporates various views on the urban residential system. As such, a model-based GIS can be considered as a subsystem of a larger (S)DSS that performs a well-defined task. Thus, a model-based GIS forms part of a larger Spatial Decision Support System which allows direct interaction between the policy or/and decision maker and the available data, models and procedures. The policy or/and decision maker no longer needs to communicate with data and models through the intermediate analyst or/and modeller. This function of (S)DSS gives the policy or/and decision maker the opportunity to play with the planning and decision problem environment (see Figure 3).

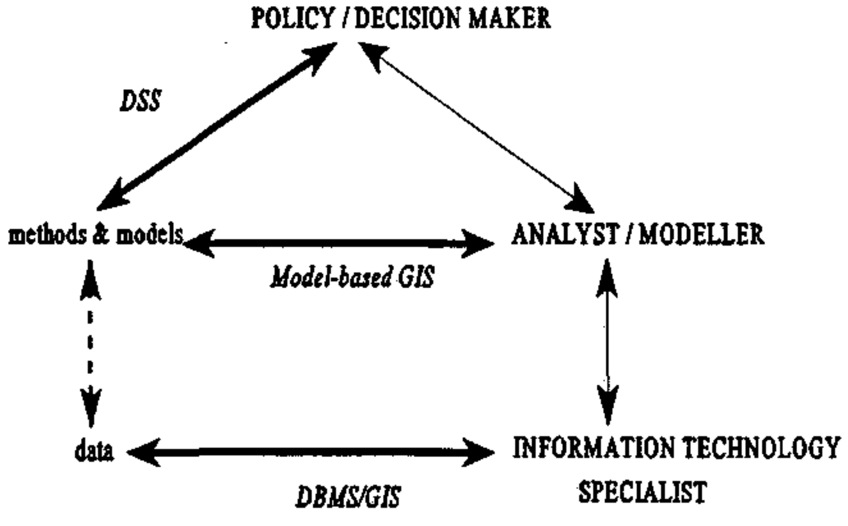

Figure 3 Interaction between users and the role of DBMS, GIS, models and (S)DSS

The next section presents an integrated system for residential quality assessment and monitoring. This GIS-based system offers strategic decision making functionality for the policy or/and decision maker as well as flexible modelling functionality for the intermediate analyst or/and modeller. As such, it might be considered as a hybrid system; the functionality covers the demands of two types of users. The integration of data, models and user-interaction capabilities will now be illustrated within the context of urban planning for elderly housing.

4 RELEVANT: Residential location evaluation and analysis tool

RELEVANT (REsidential Location EValuation and ANalysis Tool) is a computer-based system developed to support policy making for elderly housing in the Netherlands. RELEVANT has a GIS-like vector-oriented data model for the storage of spatial data regarding the urban residential environment. Furthermore, procedures for selection, aggregation, classification and display of spatial and non-spatial data are available. Location and decision models offer possibilities to create new information from existing data and evaluate the outcomes. A Graphical User Interface (GUI) using multiple windows views is offered to the user to interact with data and models. This section outlines the GIS-like vector-oriented data model, modelling capabilities and user interface in more detail.

Data model and data integration

Indicators of residential quality can be referred to various spatial levels and resolution. The most disaggregate level for indicators assessment is the house or residence. The associated address and the 6 digit postal code is the basic georeferencing level of spatial objects in the urban residential system in the Netherlands. The address and postal code georeferencing system is based on the centroid (in x-y coordinates) of the underlying parcels. For postal code data different spatial levels of resolution exist, depending on the number of digits (6, 5.5, 5 or 4) digits. At this moment the 6 digit postcode is the lowest aggregation level representing an average of 15 households. Besides the parcel-centroid georeferencing system, there also exist a grid-based referencing systems.

Data concerning the residential environment also consist of other spatial entities. Besides housing all kinds of other located activities should be taken into consideration. Shopping, recreation, transport, social interaction and crime are activities that influence residential quality. These activities are geographically bounded and the associated indicators have different spatial impacts.

The representation of spatial phenomena in RELEVANT is build upon a two-dimensional Euclidean space with three types of spatial objects: points, lines and polygons. The three spatial objects are represented in a vector-oriented data structure. A vector-oriented data structure handles points as one-dimensional, lines as two- and polygons as three-dimensional objects. Table 1 shows examples of data for spatial objects in RELEVANT.

In order to support the integration of data of different spatial resolution two methods of spatial data integration are available in RELEVANT. The spatial objects can be linked using a point-in-polygon operation and a network topology building facility with a shortest path algorithm.

A point-in-polygon operation establishes a relation between the object points and the area or polygon with which the point is locationally associated. For instance, for integration of house and neighbourhood indicators, the house indicators should first be transformed into a aggregated neighbourhood index. A point-in-polygon facility identifies the area or neighbourhood that geographically encloses the point.

entities	identifier	position	object
house	address	coordinates for parcel centroid	point
stores	address, name	coordinates for parcel centroid	point
households	postal code	coordinates for parcels centroid	point
street	name	coordinates for endpoints	line
railways	ID number	coordinates for endpoints	line
district	ID number	coordinates for perimeter	polygon
neighbourhood	ID number	coordinates for perimeter	polygon

Table 1 *Examples of data for spatial objects in RELEVANT*

With a network topology building facility, it is possible to model flows between point locations in discrete space. The discrete space is represented by a graph or network of nodes that are connected through intermediate arcs. Real-world elements in the urban system, like houses, stores and transportation costs, are represented as nodes and links in this network. In order to measure costs and impedance measures between two point locations, a network topology building facility is available. This facility links the location of a selected set of point locations (stores, consumers) to a street network by adding a link from the initial point locations to the nearest position on the network. This results in a network data file which might be used to measure accurately transportation costs between origin-destination locations using a shortest path algorithm.
An additional facility in measuring origin-destination transportation costs is that is able to take physical barriers into account. Especially interactions of elderly might be influenced by the occurrence of physical barriers like railroads, waterways, highways , etc.. To restrict interaction flows in the network, nodes can be defined as barriers. As a result impedance will increase or become infinite.

User interaction

An important aspect of SDSS development and use is the accessibility of data and models through a computer-based system. Clear presentation of data, modelling estimates and results make models, which are often difficult to access, easier accessible and understandable. RELEVANT is accessible through a Graphical User Interface (GUI) using multiple linked windows. Computer interaction through graphics and symbols, e.g. icons, buttons, graphs, maps and linked windows, characterise this approach. The idea of offering multiple views on data and modelling results is implemented through visual display of data through maps, graphs, tables and graphical, mouse-driven specifications of system variables. Figure 4 shows the user interface and main menu of RELEVANT. The main idea of behind RELEVANT is that data can always be accessed through maps. Selection, query and display of data through a mapping facility, the 'mapview' is always available to the user. A 'legend' window controls the display in the mapview and visualises the selection of data sets. All operations seek automatically whether the necessary data sets are available. Selection of data can be achieved in two ways. First, data can be selected geographically using the view 'toolbox'. This toolbox offers instruments to zoom in/out geographically by dragging the mouse in the mapview. This will automatically select all spatial features of the data sets selected in the 'legend' window. The second method to select data sets is combining geographically selected data with selections on the attributes of features. This is implemented under the menu control options.

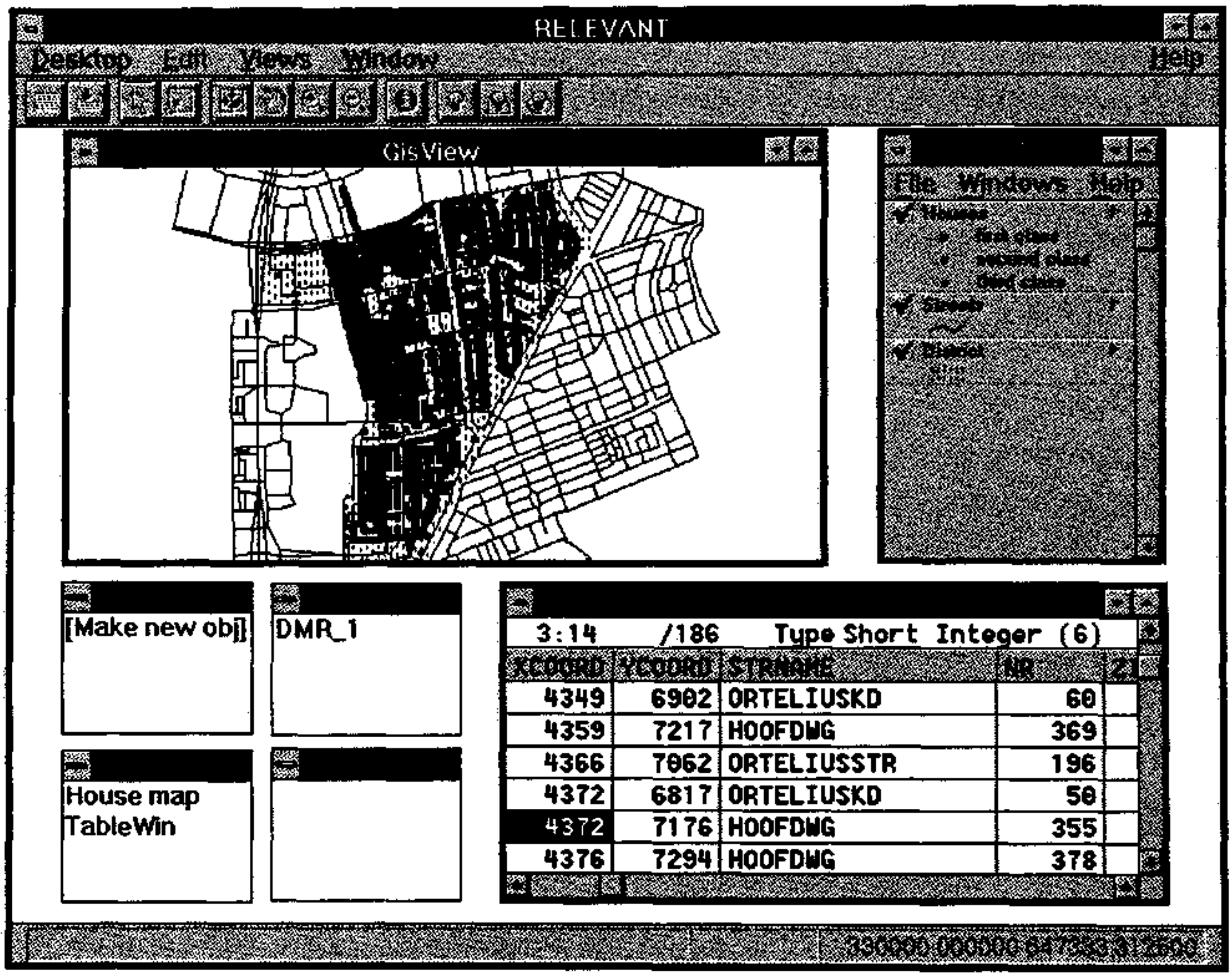

Figure 4 User interface of RELEVANT

An important feature of the user interface of RELEVANT is the formal specification of system functions and control options. System functions like selection, aggregation, classification of data are functions that often have to be specified in order to generate the necessary information. Formal specification of these functions into system objects make it possible to recall a specification any time the user would like to do so. If a formal specification is changed or another specification is selected, automatically the information in all windows (mapview, table view, business graphics view) will be updated. This facility offers the user an easy to handle tool to change views of the urban system without being concerned about specification issues all the time. Modern computer technology offers the possibilities to link views which offers also possibilities for interactive exploratory data analysis (Haslett et al. 1990; Batty and Xie 1994). User interaction through a GIS-like interface is further illustrated in the next section.

Models

Thus, decision support for investment decisions concerning the residential environment is only efficient if the planner and policy-maker have (easy and fast) access to reliable information regarding the impacts of decisions on the quality of the residential environment. To reduce the risks and uncertainties involved in residential planning and to help planners and policy-makers in supporting decision making, several analytical methods and models have been developed. From a practical point of view, the main use of analysis and modelling methods is adding value to information (Clarke 1990). This can take many different forms (see figure 5). The most common function of a model is providing a framework for data transformation.

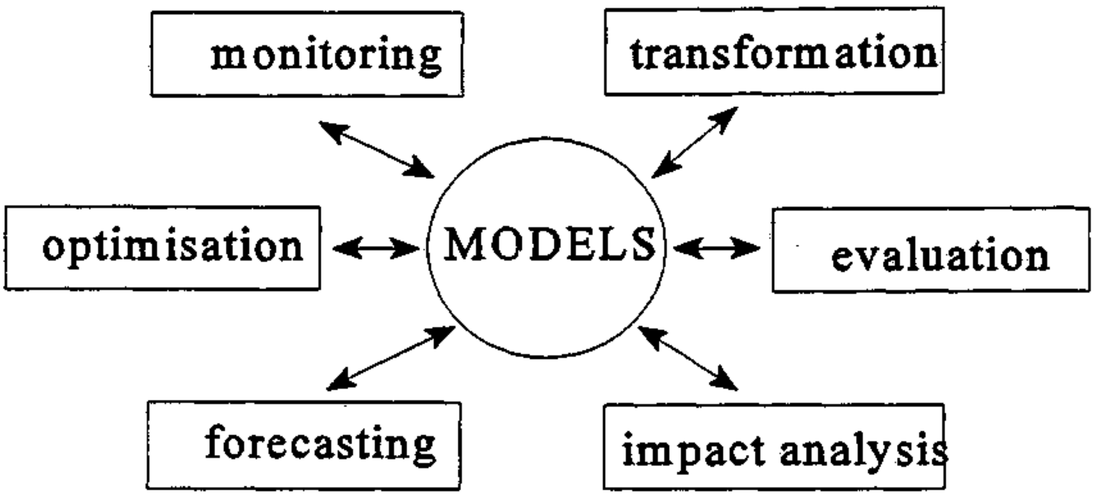

Figure 5 Relation between models and planning functions

These models generate performance indicators using some kind of (simple) arithmetic operation. Data synthesis and updating refers to procedures to merge and link different data sets, to estimate values of missing variables or to update data sets. Monitoring models have a task to monitor system performance in time and to give a warning in case the performance of system components is exceeding predefined performance levels. Forecasting models generate data on future trends (for instance, population forecasts). Optimisation models can be characterised with problems of finding optimal solutions by maximising an associated objective function considering a priori defined constraints. Impact analysis is a function that models perform in order to solve 'what-if' questions. Through changes in the characteristics of the urban system, impacts of (potential) actions can be explored. Evaluation models help decision makers to develop and evaluate different scenario's. Using multi-criteria evaluation methods the generated scenario's can be ranked according to the objectives, criteria and weights of the decision maker.

The results from various analytical methods and models will provide the local government with additional relevant information for decision-making. This multi-method perspective offers management the information needed to take decisions concerning location problems.

RELEVANT includes several model-based systems that interact with the existing databases. Each of the models or systems covers a different perspective on the urban system. Examples of (model-based) systems in RELEVANT are: a accessibility indicator system, a site suitability system, a residential quality monitoring system and a multi criteria analysis system. These subsystems perform functions that can support various locational planning problems:

1. a system to measure various accessibility indicators;
2. a system to assess subjective and objective indicators of residential quality;
3. a system to monitor residential quality;
4. a system to rank spatial alternatives and scenario's using multiple criteria decision analysis.

RELEVANT supports several functions of public policy analysis.

Application of RELEVANT in Amsterdam

The objective policy indicators of elderly residential situations in the Netherlands were applied in the urban areas of Amsterdam. From the standpoint of accessibility, the following retail and recreational facility and care services are important to the elderly, according to Dutch planning objectives (in descending order of importance):

1. daily visited retail facilities (bakery, green-grocery, butcher's shop, dairy, supermarket and daily market);
2. public transport (bus, tram, metro);
3. financial services (postoffice or bank);
4. recreational facilities (park and green areas); and
5. care/welfare service centres.

Accessibility for elderly has been defined as a walking distance of 250 meters for less-mobile elderly and 500 meters for mobile elderly. Suitable elderly housing was defined as:

1. being on the ground floor, first floor or in a building with an elevator;
2. dwellings with 2, 3, or 4 rooms;
3. dwellings with more than 32 square meter of floor space and a low rent- level.

Data about the location and type of facility and care services centres, and the location and characteristics of the housing supply been collected and stored as point data in RELEVANT. A transportation network is used for distance calculation between all residential locations and every single retail facility and care service centre. Using policy variables and weights, this information is processed and displayed in suitability maps (see Figure 6).

On the basis of interviews among elderly residents, the weighting was adapted to local circumstances. Elderly expressed their preference and the frequency of use of the different types of facilities and service centres. Using different weighting methods and the weighted summation method of multiple criteria analysis, a classification was derived, based on the products of weights and the distance between residential location and facility location. Shopping and recreation facilities available to elderly in the neighbourhood were measured by counting the number and type of shops within variable distance zones from residents' dwellings. Using the average distance, a qualification of dwellings according to the neighbourhood service level was generated.

The relationship between the household situation and the spatial component of activities of older individuals was examined, using the behavioral analysis of elderly. Data about places that elderly regular visit, socalled "habitats" have been collected from individual elderly to establish commonly visited areas in the neighbourhood. Data concerning spatial and social interaction by type (shopping, visiting friends etc.), origin-destination and frequency was collected, stored and analyzed in RELEVANT. Using spatial data integrating operations, the interaction maps were combined and collective areas of interaction have been defined (see Figure 7) and differentiated for the household situation (age, mobility etc.). Measuring the habitat of elderly is important to understand the actual interaction which was used to correct policy variables of accessibility to the local circumstances.
At the same time, this information is combined with information about "attractive" and "less attractive" areas gained during interviews among governmental, care and welfare institutions and elderly inhabitants. As a result, maps of attractive and less attractive areas, based on the perception and occurrence of crime, were compiled and stored. These maps reflect the mental and social perception of elderly individuals and indicate the parts of the neighbourhood they perceive as decent living environments. In combination with objective policy variables, these maps aid in the development of new local plans to improve the housing environment of the elderly. Some of these plans have already been implemented.

Although RELEVANT is still in the development stage, applications in the urban areas of Amsterdam clearly illustrate the potential of GIS technology for residential zoning, behavioral analysis and policy development and support (Grothe and Blom 1992). Not only local government authorities, but also care service institutions, housing corporations and real estate owners can benefit from this concept and gain support for their elderly-housing policy. GIS use in this regard is inevitable. Based on these experiences and the results in several districts of Amsterdam, discussion is now going on for a large implementation of the system in the cities of Amsterdam and Utrecht.

6 Concluding remarks

Residential planners requires fast and easy access to large amounts of subjective and objective (spatial) indicators for monitoring the impacts of private market developments and public policy. In this paper a GIS-based policy support system has been presented that can help urban planners and policy makers to support decision making regarding residential location problems. Although the system is originally developed to support planners and policy makers in the field elderly housing, it offers a much greater generality and applicability.
This monitoring system does not offer exact solutions to the problems that urban planners are facing, but gives them a set of automated tools and decision aids to explore and structure locational planning procedures in order to maintain residential quality.

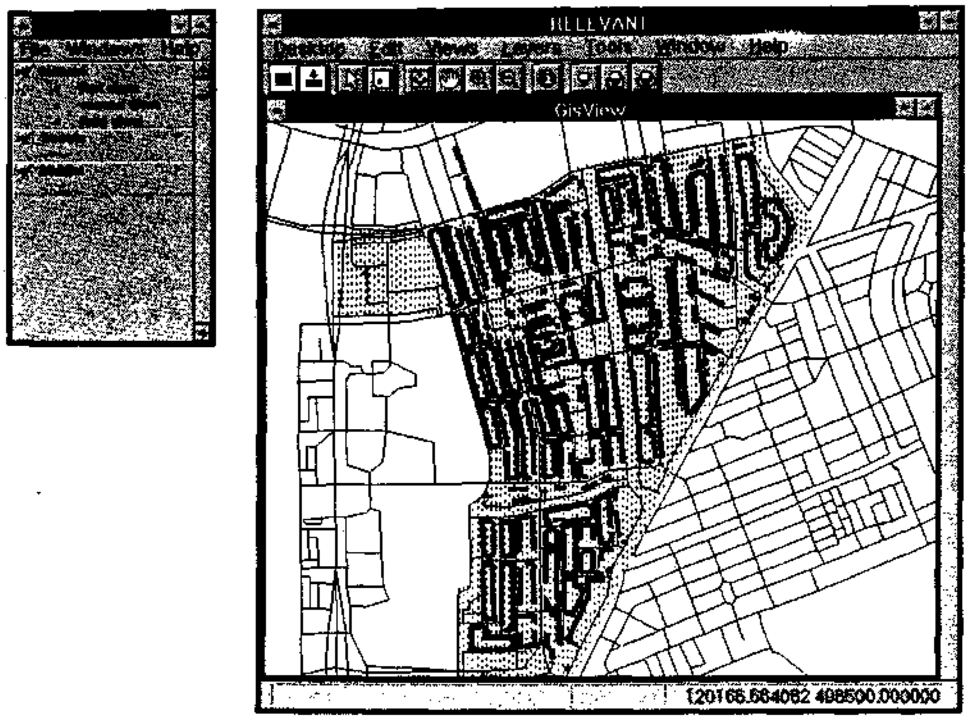

Figure 6 *Residential suitability for elderly housing of residential zones in district de Baarsjes in Amsterdam*

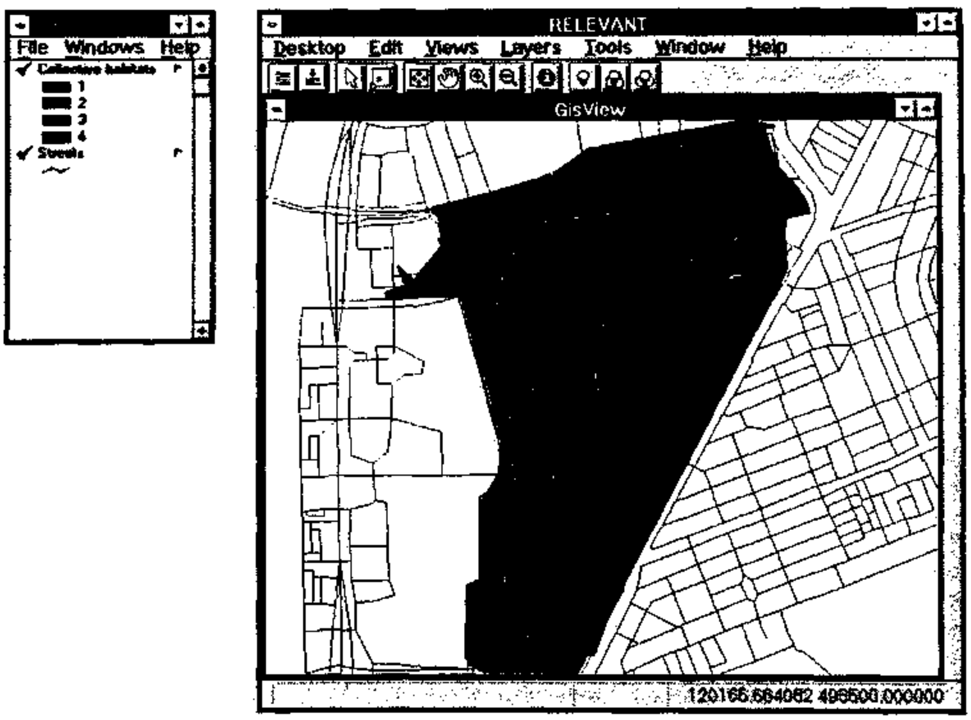

Figure 7 *Collective areas of interaction in district de Baarsjes in Amsterdam*

Several advantages may be expected from the integration of large spatial databases, modelling systems and GIS technology. First, various databases concerning the urban residential environment are linked and integrated through their geographical reference. This may provide new insights and information.
Second, decision makers may have faster access to strategic information to deal with locational planning problems. Third, the integration of GIS technology and urban planning models, like accessibility models, make models become (more) available and accessible for the urban planning practise. Finally, not only planners and policy makers in local government can have effective support, but also policy makers and individuals of private and public organisations may benefit from it. Access to information for all groups involved in urban planning may improve negotiations and consensus making and hence the quality of decision making.

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