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PREFACE

This Collaborative Paper aims at providing a methodological framework for an international study on information systems for integrated regional development. This study focuses the attention in particular on concepts and approaches relevant for strategy in developing coherent regional information systems oriented on the planning needs of regional development.

The project is carried out by the Regional Development Group of the International Institute for Applied Systems Analysis (IIASA) in cooperation with the Department of Economics, Free University, Amsterdam.

Prof. Boris Issaev
Leader
Regional Development Group

June 1982

SPATIAL INFORMATION SYSTEMS - A RESEARCH STRATEGY

Peter Nijkamp*

1. PROBLEMS IN SPATIAL INFORMATION SYSTEMS

A regional information system is a set of data structured (for instance, by way of modeling, organizing or converting data) so as to increase the insight or level of knowledge regarding the regional dimensions (i.e., spatial structures or processes) of phenomena, especially from the viewpoint of forecasting and influencing these structures and processes. In the context of the present paper, much emphasis will be placed upon the significance of such information systems for regional planning and policy-making.

Regional information systems can be developed for several purposes in regional planning and policy-making (Nijkamp, 1982):

- description: a systematic analysis and representation of the characteristics of a spatial system (e.g., various kinds of causal structures), for instance, based on a multidimensional profile representation in a systems analytic approach (Nijkamp, 1979); evidently, a clear typology of targets, instruments, predetermined variables etc. has to be made. An example of a computerized information system can be found in Peters (1981).

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- impact analysis: a systematic assessment of foreseeable and expected consequences of changes in exogenous circumstances or of policy measures for the state of the system; impact analysis may be useful for making (conditional) forecasts of the endogenous development of a (multi-) regional system.
- evaluation: a systematic investigation of alternative policy plans, proposals or projects with the aim to identify their comparative advantages and disadvantages (for instance, by means of programming analysis or multicriteria analysis), taking into account prevailing external constraints.

As far as regional information systems are concerned, much emphasis has to be placed on the following aspects (cf. Willis 1972):

- the spatial interactions and spillover effects of a dynamic multi-regional open system.
- the spatial scale of measurement of the various variables and profiles included in the information system.
- the regional problems orientation of the information provided by the system concerned.
- the connection between regional information systems and regional planning and policy-making.
- the consequences of various spatial institutional policy levels (e.g., in a hierarchical setting, or in a bottom-up versus top-down structure) for the information system at hand.
- the consistency and the comparability of information systems across multiple regions.
- the contribution of regional information for integrated (multi-) regional planning and policy-making.
- the spatial diffusion patterns through which new technological, social and economic activities evolve.

- the linkages between data selected at different spatial levels, models developed for different spatial levels and policies designed for different spatial levels.

It should be noticed that in many studies, a less satisfactory specification or performance of regional models is ascribed to a *weak database*. Though evidently unreliable data may affect the quality of the results, it is at the same time also true that the structures of many models presuppose a database that does not fully exist in reality. Model users have to face and accept a situation of inappropriate information systems and of gaps in statistical data.

In addition to accommodating for *lacking* data, the possibilities of incorporating *qualitative* data have to be mentioned. Qualitative data are measured on a nonmetric scale (e.g., ordinal or nominal). Too often, qualitative data are left out of consideration, although such data may contain substantial pieces of information. The recent developments in the area of qualitative (and fuzzy) spatial data analysis may be a meaningful way of employing all relevant available information as well as possible.

In an ideal situation, one may expect the availability of a large data set for all relevant variables in a regional model. In reality, however, much information is missing. Examples of information that is often lacking in regional modeling are (see also Issaev et al., 1982):

(a) economic variables: stocks and flows of wealth, real and financial assets, and liabilities; scale and agglomeration advantages; capacity constraints; the value of public overhead capital; distributional effects;

(b) spatial variables: spatial interactions such as disaggregate migration and commodity flows; spatial spin-off and spillover patterns;

(c) process and state variables: technical progress, innovation, research and development, infrastructure, communication, energy productivity;

(d) sociopolitical variables: power groups, decision structures, interest groups, policy controls;

(e) basic variables: demographic structures, long-run regional dynamics.

In general, *systematic information systems* are a prerequisite for the construction of appropriate regional models. Input-output matrices (especially the commodity-by-industry or rectangular form), capacity and bottleneck variables, social overhead capital and interregional interactions make up basic ingredients of a satisfactory spatial information system. Absence of up-to-date information limits the ability of modelers to adequately represent regional systems. The construction of input-output models based on very old date is not a satisfactory activity, although several models sometimes use 10- to 15-year-old data. Of course, data availability varies from country to country, and often within countries, but one of the crucial gaps is in the area of regional stocks and their interregional flows. Apart from the problem of measuring these data as such, a major problem is also that the responsibility of collecting and structuring data is sometimes shared by several offices, so that incomplete databases may be created. Databases sometimes include investment data for manufacturing, but very little else (except in some countries such as Japan). This unsatisfactory data situation is regrettable, especially as the movements of capital are very important in long-term regional developments in market economies.

A similar situation exists for interregional *money* flows (social insurances, old-age pensions, entrepreneurial profits, etc.). These flows have a direct distributive impact on a system of regions, while they are neglected in many regional models.

As mentioned in a previous study (Nijkamp, 1982), it will not be possible to design an information system that is in agreement with all above mentioned issues, but it is still meaningful to undertake a rigorous endeavour to design a framework for information systems in a geographical, socio-economic and institutional context characterized by:

- a structure based on a generalization and an evaluation of international experience regarding the linkage of information systems to (multi-) regional planning.
- an inventory of the most progressive trends and elements in designing operational regional and multiregional information systems.

- an assessment of the prospects and a formulation of research recommendations regarding various aspects of regional and multiregional information systems.

These aspects will be further explored in subsequent sections of this paper.

2. AN INTEGRATED INFORMATION SYSTEM FOR REGIONAL PLANNING

Regional planning may be regarded as any activity (or set of activities) that aims at achieving certain goals for a regional or multiregional system. In this broad respect, regional planning (territorial planning, planning of territorial production complexes etc.) may encompass various components like:

- economic and industrial planning
- land use planning
- manpower and labour market planning
- housing planning
- transportation planning
- infrastructure planning
- financial planning
- environmental planning
- energy planning
- social planning
- facilities planning, etc.

This illustrative (and by no means exhaustive) list reflects already the fact that regional planning is addressing a broad set of issues. In the framework of the present study, it is not meaningful to focus the attention simultaneously on all kinds of information systems that might be designed for the above mentioned issues, as this would lead to a desintegrated methodology for regional information systems. Instead, a more distinct focus will be strived for by presenting a systematic but simplified picture of some key components of a regional system. This representative system will be referred to later as the reference system, as this system will provide the basis for the methodology of information systems for regional planning. This reference system is by no means meant as a normative system, but as a framework for arriving at a logical and integrated view of the necessary information base for regional planning.

The main focus of this reference system for integrated regional development planning is on the spatial interactions between various basic activities taking place in a regional or multiregional economy. In this way, geographical activity patterns (labor and settlement patterns, e.g.), land use, transportation and infrastructure, and natural resources may be taken into consideration in a coherent framework. This reference framework is represented in Figure 1, where the main emphasis is placed on the (direct or indirect) linkages between the household sector and the production sector. Evidently, a more extensive version might be developed (see the illustrative spatial system from Figure 2), but for the ease of international comparability of regional information we will mainly use the reference system from Figure 1. The blocks and circles of the reference system will be denoted as components.

Now the following questions may be raised:

- which information is necessary (or should be generated) to describe the components of the reference system presented in Figure 1?
- which information is necessary (or should be generated) to model the linkages between the components of Figure 1 (entirely or partly)?
- which information is necessary (or should be generated) in order to employ the information system as an effective tool for regional planning with regard to the spatial system at hand?

It should be added that this reference system may relate to both a single or a multiple region system, so that also interregional commodity flows, migration flows etc. may be taken into account (cf. van Est and de Vroege, 1981).

Now various issues may be raised regarding the structure, characteristics and use of information systems for regional planning. This will be elaborated on in the next section by means of a systematic and coherent matrix representation.

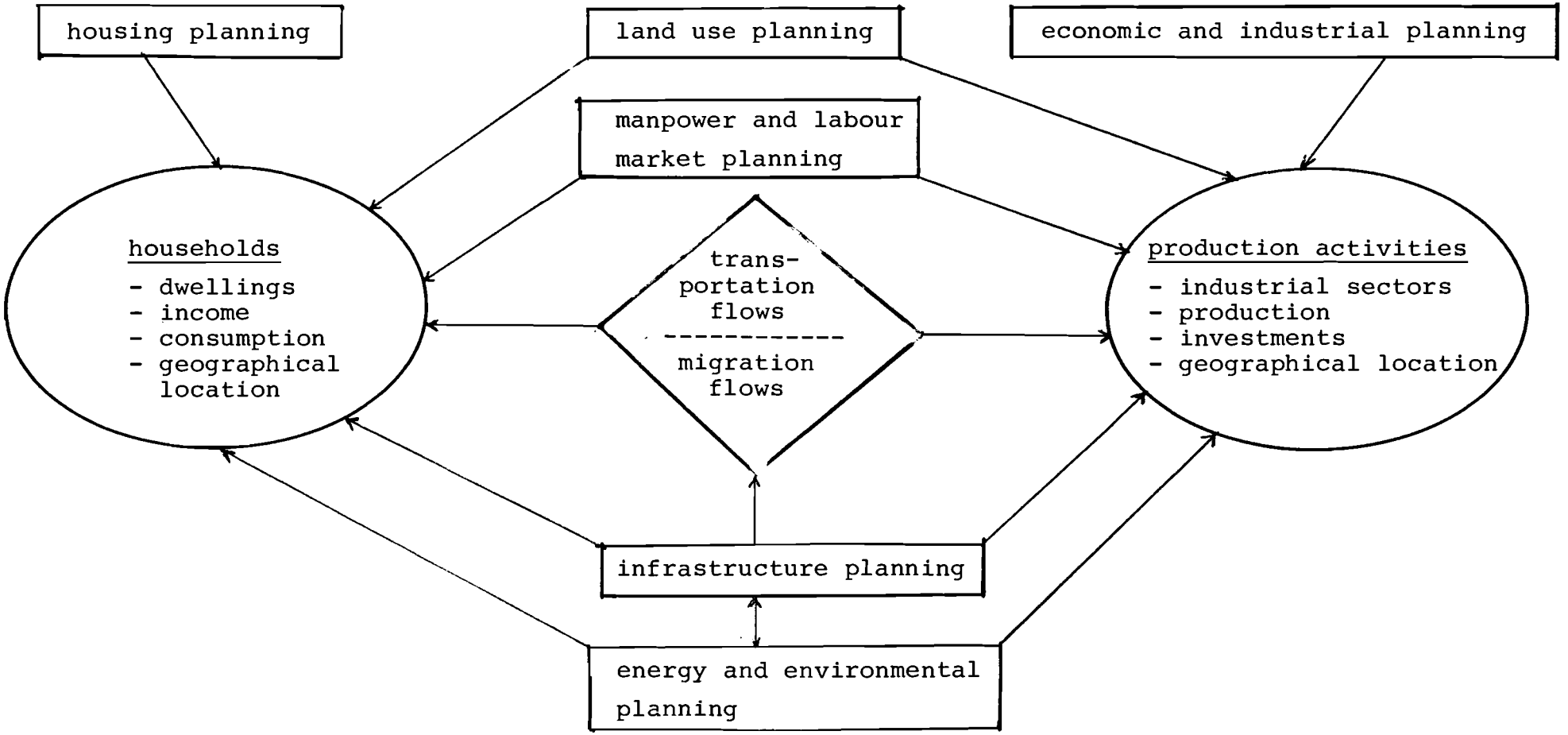

Figure 1. A spatial reference system

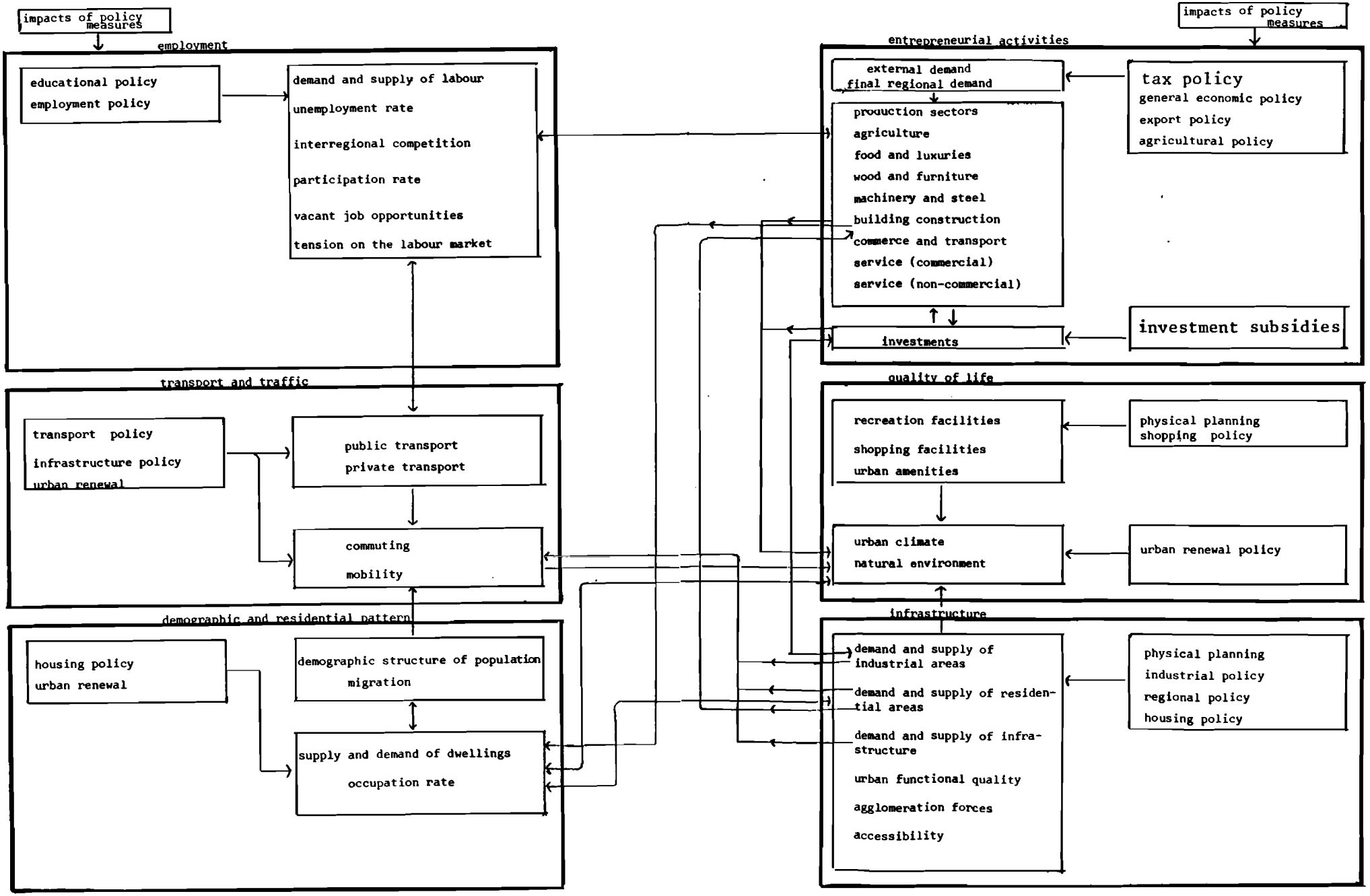

Figure 2. An integrated spatial system

Source: Nijkamp 1981

3. A MATRIX STRUCTURE FOR A RESEARCH STRATEGY ON INFORMATION SYSTEMS

In this section a two-dimensional matrix representation of attributes and components of regional information systems will be given, based on the spatial reference system from Figure 1. In a vertical direction, the various attributes of information systems for regional planning are listed, while horizontally the successive components of the information system associated with the reference system are represented.

Each cell of this matrix may be regarded as a unit encompassing briefly the most relevant aspects of an information system for the component listed at the top of the matrix. Thus, each row of the matrix reflects the way in which all components of the spatial system at hand can be characterized by one particular attribute. Each column represents a profile of attributes of a given component of the system at hand.

Hereafter a brief description of the meaning and relevance of the successive attributes will be given.

I. Description of planning system

Each country has its own regional planning system, depending on the political and institutional conditions of the country. Some countries may have a bottom-up planning structure, others a top-down or a mixed structure. In some countries, regional planning may belong to the responsibility of a single public agency (e.g., a Ministry of Regional Development), in others various ministries are involved in regional policy-making. In some countries, regional planning is mainly oriented toward physical planning, while in others regional planning is almost exclusively economic and industrial planning. In general, there is a tremendous variation in planning activities, varying from so called facet planning (characterized by emphasis on one single component without considering the other components) to comprehensive planning (characterized by an all encompassing master plan). Integrated planning may be regarded as an intermediate way of planning by aiming at coordinating various planning activities without however the high ambitions of a comprehensive master plan.

COMPONENTS / ATTRIBUTES	spatial reference system as a whole 1	individual components									
		actors		planning components						interactive components	
		household 2	production activities 3	housing 4	land use 5	economic/ industrial 6	manpower & labour market 7	infrastructure 8	energy & environment 9	transportation 10	migration 11
I Description of planning system	I.1	I.2	I.3	I.4	I.5	I.6	I.7	I.8	I.9	I.10	I.11
II Policy issues and purposes of information system	II.1	II.2	II.3	II.4	II.5	II.6	II.7	II.8	II.9	II.10	II.11
III Data sources and responsibilities	III.1	III.2	III.3	III.4	III.5	III.6	III.7	III.8	III.9	III.10	III.11
IV Characteristics of information system	IV.1	IV.2	IV.3	IV.4	IV.5	IV.6	IV.7	IV.8	IV.9	IV.10	IV.11
V Level of measurement of data in information system	V.1	V.2	V.3	V.4	V.5	V.6	V,7	V.8	V.9	V.10	V.11
VI Accessibility of information system	VI.1	VI.2	VI.3	VI.4	VI.5	VI.6	VI.7	VI.8	VI.9	IV.10	IV.11
VII Use of information system for modelling	VII.1	VII.2	VII.3	VII.4	VII.5	VII.6	VII.7	VII.9	VII.9	VII.10	VII.11
VIII Use of information system for regional planning	VIII.1	VIII.2	VIII.3	VIII.4	VIII.5	VIII.6	VIII.7	VIII.8	VIII.9	VIII.10	VIII.11
IX Bottlenecks in information systems	IX.1	IX.2	IX.3	IX.4	IX.5	IX.6	IX.7	IX.8	IX.9	IX.10	IX.11
X Perspectives and recommendations	X.1	X.2	X.3	X.4	X.5	X.6	X.7	X.8	X.9	X.10	X.11
XI New trends	XI.1	XI.2	XI.3	XI.4	XI.5	XI.6	XI.7	XI.8	XI.9	XI.10	XI.11

Table 1. A matrix representation of an integrated information system for regional planning.

II. Policy issues and purposes of information system

Planning may be focusing on incremental changes or on integral changes in a spatial system. It is of course especially important to know the problem orientation of the information in relation to regional planning. Clearly, the depth and scope of planning activities determine the required amount and accuracy of an information system. In addition, the structure and purposes of information systems are also determined by the aims of the planning activities at hand, e.g. description, impact assessment (including modeling and forecasting) or evaluation (including decision-making).

III. Data sources and responsibilities

Data may come from different sources (primary and secondary sources, e.g.), from extensive survey techniques or censuses or from sample techniques, from direct observation or from interpolations or extrapolations. If different institutions are involved in collecting data, the spatial scales may not be in harmony with each other. This holds especially true if statistical offices are independent from planning agencies. Similar problems may emerge if the spatial scales of models for the successive individual components are different. Finally, different centers for statistical information may exist, so that the various components are provided with uncoordinated or unintegrated data.

IV. Characteristics of information system

As mentioned before, information systems for regional planning are usually multidimensional in nature, so that an enormous variation across regions or countries may occur. Some relevant features of an information system are:

- the frequency of measurement of the data (yearly, quarterly, etc.)
- the relationship between the frequency of observations and the degree of detail of observations
- the verifiability of the information provided
- the uncertainty or unreliability of some data (including stochastic or probabilistic elements)

- permanent use or ad hoc use of data
- the adaptability, flexibility and versatility of the information system (e.g., based on computerized systems)
- the costs of designing the information system and of providing the information (in manpower or money)
- the period over which experience regarding the design and use of the information system exists
- the extent to which data in information systems are up-to-date and can be used in new planning situations.
- the way in which a regional information system is capable of taking into account spatial interactions and linkages
- various kinds of variables, for instance, stock variables, flows in time, flows in space, longitudinal variables, etc.

V. Level of measurement of data in information systems

Data can be measured in various ways:

- on different scales (cardinal, ordinal, nominal, qualitative, etc.)
- at aggregate or disaggregate levels (also at varying spatial scales).

It may be very important to explore whether the data are precisely measured and collected at the appropriate regional planning level and on the appropriate measurement scale, so that the information system fits exactly into the regional planning system concerned. Otherwise, various aggregation or disaggregation techniques have to be carried out, or adjusted statistical techniques have to be applied (e.g. qualitative statistical and econometric methods).

VI. Accessibility of information system

Some information systems are easily accessible for a broader public, others are computerized in a complex way (with unknown codes) so that the only real experts can get the data at their disposal. Sometimes the accessibility to information systems is restricted to a few agencies only (especially planning agencies). This of course evokes the problems of the timely availability of an information system. It is also interesting to observe that very often data are available at statistical offices, but have never

officially been published. Finally, it is meaningful to observe that in some cases the contents of an information system is determined by the users (planners, e.g.), while in other cases the research needs of experts and analysts determine the contents of an information system.

VII. Use of information system for modeling

One of the aims of a regional information system is to provide a satisfactory empirical basis for operational (multi-) regional models. If the data base is unsufficient, simulation methods may be used. In other cases, only simple statistical techniques may be applied. Thus it is a very interesting question whether the effectiveness of an information system for regional modeling in a specific context can be gauged (see also Issaev et al., 1982).

VIII. Use of information system for regional planning

Especially in a planning context, it is very important to make a clear distinction between various kinds of variables considered, such as endogenous regional variables (inter alia regional objectives) and exogenous variables (inter alia exogenous data and policy instruments). Clearly, the impact of problems and policy-makers on the contents of such a regional information system may be significant. In this respect, also conflicts among regional planning agencies that have an effect on information systems may be mentioned.

IX. Bottlenecks in information systems

Various bottlenecks may be envisaged while using information systems in a regional planning context, such as:

- different spatial scales for different components (e.g., administrative versus functional demarcations)
- lack of coordination at various regional planning levels leading to inefficient use of information systems
- the existence of latent variables or indirectly observable variables in a spatial system
- lack of information on regional capital variables and money flows.
- lack of comparability and consistency of a single region information system with another single region information system.

X. Perspectives and recommendations

After the extensive description of attributes of information systems for various regional planning purposes, it may be very helpful to formulate research recommendations on the basis of a prospective view on the use and value of information systems for regional planning.

XI. New trends

These remarks may, for instance, pay attention to the various gaps that exist between the available data and the requested data in a regional planning setting and to strategies developed for bridging these gaps. Discriminating features or special (dis)-advantages of the information system at hand compared to other information systems may be mentioned as well, especially in light of future information needs for regional planning.

Having discussed now the general relevant attributes of information systems, we will now pay attention to specific aspects of the successive components of a reference system.

4. COMPONENTS OF THE REFERENCE SYSTEM

The various components of the reference system also deserve closer attention, especially because the accelerating pace of development of cities and regions places an increasingly heavy burden upon urban and regional management. These components will now successively be discussed.

1. The spatial reference system as a whole

A single region system is seemingly an attractive unit to deal with, but - given the many spatial interactions and the openness of a spatial system - it is usually far more reasonable to deal with multiple region systems. In this respect, it is important to know the number of regions (countries, provinces, administrative units, etc.) included in the system. Also further relevant spatial subdivisions (local, regional) may be outlined with a special emphasis on the consistency problem of aggregating different spatial units.

2. The household sector

As far as the household sector is concerned, information on their locational patterns (urbanization, density, etc.) is very

important, while also information on some general socioeconomic features are necessary (such as income and consumption levels). An evident special characteristic of the household sector is the housing situation. In regard to this topic, the situation on the housing market (demand and supply of various kinds of housing rents etc.,) deserves sufficient attention. Finally, also the way in which this information can be used in housing market models has to be set out.

3. The production sector

Apart from elementary data such as sectoral production and investment levels, also information on the employment situation in each sector is very important, especially because regional policy tends to become increasingly regional employment policy. Evidently, also the spatial dimensions deserve a closer attention (e.g., industrial location, size of industrial parks, large-scale plants, input-output linkages, etc.).

4. The housing planning component

This component should focus the attention on various goals of housing market policies (like regulation, urban renewal, etc.), and instruments involved, so as to indicate the kind of information needed for effective planning.

5. The land use planning component

The land use planning component should address the physical aspects of location and allocation patterns, especially as far as household and industrial location is concerned.

6. The economic and industrial planning component

In this component, various objectives and instruments of regional economic and industrial policy are to be considered (e.g., investment subsidies, wage subsidies). Special attention may be paid to the relationship between regional economic and industrial planning on the one hand and physical, housing and labour market planning on the other hand.

7. The manpower and labour market planning component

This component includes information on relevant aspects of the labour market (demand and supply, duality or segmentation etc.), while special attention should be given to unemployment

situations, labour force participation rates for different age-sex groups, and 'discouraged labourer' effects. Demographic aspects have to be considered as well, while also educational and occupational elements have to be included.

8. The infrastructure planning component

The regional infrastructure component may of course be defined in a very broad sense as regional public capital, but for the scope of the present study it is more appropriate to regard infrastructure especially as physical and space-opening (network-related) public capital, such as roads, railways and other transportation systems. Information on infrastructure planning should then focus on objectives and measures of public policy on transportation networks (roads and railway construction, long-run physical planning etc.).

9. The energy and environmental planning component

This component relates to energy use and environmental decay emerging from the spatial distribution of activities. Elements of an associated information system may be: energy consumption by various kinds of transportation modes and pollution from transportation flows. The planning aspects of this component relate to energy savings measures and environmental regulations.

10. The transportation planning component

Information systems on transportation may focus on the spatial transportation patterns according to different traffic modes, division of transportation flows into commuting, business traffic and social interaction traffic etc. Information on transportation planning may then relate to traffic regulations, price and tax measures etc.

11. The migration planning component

This spatial interaction component is essentially the result of frictions between the residential location and entrepreneurial location patterns. Information systems on migration flows may relate to (aggregate and disaggregate) volumes and motives, taking into account age-sex groups. Migration planning may also need information from housing and industrial planning.

5. FINAL REMARKS

The research strategy outlined in the previous sections aims at providing a coherent and practical insight into methodologies of achieving a better presentation of regional systems and a better adaptation to needs of planners by outlining the structure and components of integrated information systems for regional planning. It is expected that the above mentioned approach to information systems will lead to an adequate reflection of the space dimension of socio-economic development in regional planning.

REFERENCES

van Est, J., and F. de Vroege, 1981 Het Kader van een Ruimtelijk Georienteerd Informatiesysteem, Research Centre Physical Planning TNO, Delft.

Issaev, B., P. Nijkamp, P. Rietvelf and F. Snickars eds., 1982, Multiregional Economic Modeling: Practice and Prospect, North-Holland Publ. Co., Amsterdam, 1982.

Nijkamp, P., 1979, Multidimensional Spatial Data and Decision Analysis, John Wiley, New York/Chichester.

Nijkamp, P., 1981, Urban Impact Analysis in a Spatial Context, Research Memorandum no. 1981-5, Dept. of Economics, Free University, Amsterdam.

Nijkamp, P., 1982, Information Systems for Multiregional Planning, IIASA, Laxenburg, CP-82-27.

Peters, A., 1981 Die Verstäterung in den Niederlanden nach 1950 und seine Raumordnungspolitischen Implikationen, Ph.D. Thesis, Technische Universität, Berlin, W. Germany, 1981.

Willis, J., 1972, Design Issues for Urban and Regional Information Systems, Centre for Environmental Studies, London.