INFORMATION SYSTEMS FOR INTEGRATED REGIONAL PLANNING

Edited by

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and

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INTRODUCTION TO THE SERIES

This series consists of a number of hitherto unpublished studies, which are introduced by the editors in the belief that they represent fresh contributions to economic science.

The term "economic analysis" as used in the title of the series has been adopted because it covers the activities of both the theoretical economist and the research worker.

Although the analytical methods used by the various contributors are not the same, they are nevertheless conditioned by the common origin of their studies, namely theoretical problems encountered in practical research. Since, for this reason, business cycle research and national accounting, research work on behalf of economic policy, and problems of planning are the main sources of the subjects dealt with, they necessarily determine the manner of approach adopted by the authors. Their methods tend to be "practical" in the sense of not being too far remote from application to actual economic conditions. In addition they are quantitative rather than qualitative.

It is the hope of the editors that the publication of these studies will help to stimulate the exchange of scientific information and to reinforce international cooperation in the field of economics.

The Editors

PREFACE

We should all be concerned about the future
because we will have to spend the rest of our lives there.

Charles F. Kettering
Seed for Thought (1949)

The period after the Second World War has been marked by a wave of information that has flooded many societies, east and west. Information systems have become indispensable for planning and decision making in both private and public agencies. Recent advances in microelectronics, in particular, have offered enormous potential for using information in a logical and well structured way for handling complex problems of choice and decision.

Usually, however, information systems in public policy making are oriented toward either the national level or the detailed local level. So far, the *regional* dimensions of socioeconomic development have not been adequately represented in information systems for regional planning.

This book is the result of an endeavor to fill the gap by addressing key issues of information systems for planning regional development, by evaluating trends in the progress of information systems, by identifying the greatest difficulties in their use for aiding long-term regional development, and by focusing attention on the possibilities of new operational tools in modern information systems.

The study, based on a joint effort of several experts on information systems for regional planning, was initiated by the Integrated Regional and Urban Development Group at the International Institute for Applied Systems Analysis (IIASA) in Laxenburg, Austria and the Department of Regional Economics at the Free University in Amsterdam. This cooperation led to a network of scholars who were interested in contributing to a comprehensive survey of the subject. Several results of the project were also discussed at a workshop held at IIASA in December 1982.

The aim of the book is to show that planning-oriented information systems are powerful tools in regional decision making and policy making. Some of the issues discussed are mentioned here:

- Is there a unifying methodology for integrated information systems that will adequately represent regional systems as a whole, as well as specific parts and aspects of a regional system?
- How can one secure the complete and coherent representation of a regional economy, so that it may be regarded in planning as a socioeconomic system interacting with the national (or international) economy and with other regions?

- How can intraregional socioeconomic, demographic, and political mechanisms be included in information systems so as to identify the key forces of change in the structure of a regional economy?
- What should be done in the design and use of information systems to enhance the understanding and cooperation between the "actors" in regional planning and regional development analysis: the planners, model builders, systems analysts, statisticians, and data-processing specialists?
- Which new developments in information technology promise to improve regional information for planning and decision making?

Altogether, this study has a strong methodological and practical bias. Technical aspects will be touched upon only insofar as they are consistent with this approach.

Finally, we wish to express our gratitude to Dr. Manfred M. Fischer of the Department of Geography, University of Vienna for his outstanding help in making constructive comments on the first draft of the book; to Dr. Geoffrey J.D. Hewings for his suggestions on parts of the final chapter; and to Professor Börje Johansson, Acting Leader of the Integrated Regional and Urban Development Group at IIASA, for his continuous support, especially after the death of the former Leader, Professor Boris Issaev.

Peter Nijkamp
Piet Rietveld

Amsterdam, May 1983

THE INTERNATIONAL INSTITUTE FOR APPLIED SYSTEMS ANALYSIS

is a nongovernmental research institution, bringing together scientists from around the world to work on problems of common concern. Situated in Laxenburg, Austria, IIASA was founded in October 1972 by the academies of science and equivalent organizations of twelve countries. Its founders gave IIASA a unique position outside national, disciplinary, and institutional boundaries so that it might take the broadest possible view in pursuing its objectives:

To promote international cooperation in solving problems arising from social, economic, technological, and environmental change

To create a network of institutions in the national member organization countries and elsewhere for joint scientific research

To develop and formalize systems analysis and the sciences contributing to it, and promote the use of analytical techniques needed to evaluate and address complex problems

To inform policy makers and decision makers of how to apply the Institute's methods to such problems

The Institute now has national member organizations in the following countries:

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CHAPTER 1

Information Systems: A General Introduction

Peter Nijkamp

1. Introduction

Since the Second World War almost all countries of the world have experienced an information explosion. The introduction of computers, microelectronic equipment, and telecommunications services has paved the way for an avalanche of information, not only for scientific research but also for use by a broader public and by planners and policy makers (Burch *et al.* 1979, Debons and Larson 1983).

There are several reasons that may explain the information explosion in planning and policy making. First of all, the complexity of modern society has led to a general need for adequate insight into the mechanisms and structures determining intertwined societal processes.

Secondly, to avoid the enormous risks and costs incurred by taking wrong decisions today requires careful judgment, based on sufficient information about the consequences of all alternative courses of action.

In the third place, public policy institutions themselves adopt complicated positions arising from conflicting interests. In negotiations between such agencies information can be used as a powerful tool.

Next, in recent decades many statistical offices (national, regional, and urban) have produced a great deal of data that are available for further treatment or analysis.

Another factor that has stimulated the present information wave is the progress in statistical techniques and in econometric modeling, which has permitted data of different kinds to be manipulated to suit the needs of planners, decision makers, or politicians.

Finally, modern computer hardware and software (decision support systems, for instance) have made possible the quick and flexible treatment of a wide variety of data relevant to policy analysis. The data storage capacity that is available today favors a much better organized use of

information than was possible previously.

All these factors have led to the widespread use of appropriate and manageable information for decision making, not only by the individual but also at the level of social and economic organizations (Sowell 1980). In the developed world and in developing countries, proper and systematic information is regarded as a prerequisite for successful planning (Casley and Lury 1981).

It should be emphasized here that, in principle, there is a substantial difference between *data* and *information* (Burch *et al.* 1979). Data are numerical representations, or other symbolic surrogates, that characterize people, organizations, objects, events, or concepts. Information means data that are structured (by way of modeling, organizing, or converting data) so as to improve insight or knowledge regarding a certain phenomenon. Thus an information system is based on a systematic data transformation that aims at providing analytic support to planners and decision makers (Rittel 1982). An information system should be judged by its contribution to solving, organizing, or rationalizing complex choice and decision problems.

The purpose of this book is to present a scientific reflection on information systems for planning and policy analysis. Because of the information explosion, there is a need for a closer investigation of information systems for public policy making. The following arguments may justify this endeavor.

Firstly, information systems (especially those having many kinds of information) may provide an integrative framework for multidisciplinary work, since they include the features necessary for communication between such disciplines as geography, planning, economics, ecology, demography, regional science, and public management.

Next, data and information systems contribute to the foundation of operational analysis. Without this empirical and testable foundation, we may run into misinterpretations of complex mechanisms, especially if the long-term dynamics of social or spatial systems are to be taken into account.

Thirdly, data and information systems determine the actual relevance of scientific analysis for society, for planning, for management, and for policy making. They act as a filter for identifying and specifying empirically a precisely demarcated policy or choice problem.

Furthermore, data and information systems are also a prerequisite for building, testing, and using models. Data are necessary for judging the validity of a model and provide an empirical test of model behavior. A model does not have absolute validity, for its purpose is to describe a subsystem of a complex reality. Consequently, a "good" model derives its value from its empirical basis; it cannot be used to test the reliability of data. In a provocative article published recently, Leontief (1982), the Nobel Laureate in economics, discussed the friction between theory and application in social sciences. He found that, at least in economics, only a small proportion of scientific analysis was rooted in reality and empirical

observations. The majority was just theory. He strongly criticized this "theorizing on non-observed facts." In his view, many scientists are making assumptions instead of collecting data and using them. He showed convincingly that a substantial operational foundation based on facts is necessary for mature scientific analysis.

Finally, public policy making is increasingly evolving into conflict management, in which each interest group or decision agency uses its own arguments based on a specific information system. A careful analysis of information systems may provide a rational framework for judging different, sometimes conflicting options.

Clearly, there are many trade-offs involved in collecting data and developing information systems: accuracy, adaptability, and availability have to be weighed against the consequences in terms of financial benefits and costs. In this regard, special attention has to be given to the benefits and costs of user–surveyor interactions. A necessary condition for manageable exchange of information is a permanent user–surveyor dialogue that will guarantee meaningful coordination of the various tasks in a planning process.

Because of the wide variety of urgent problems in the world (from global to local), there is a need for a coherent framework for information systems, as almost all technological, socioeconomic, spatial, and environmental processes develop together. The provision of reliable, manageable, and up-to-date information, structured according to a sound methodology, is essential in order to understand and to influence such processes in a rational and systematic way. Coherent information systems for regional planning should contain the necessary data on the elements of a socioeconomic system, on their properties, their linkages, and their dynamics. But, as will be indicated later, the *spatial* dimensions of socioeconomic development have not yet been considered adequately in information systems for public planning and decision making.

In general, information is the integrative basis to all planning and decision activities. The inadequacy of information often renders economic models ineffective or inoperable, leads to a misunderstanding of the real mechanisms of socioeconomic systems and to inconsistent decisions, and hampers communication between planners and model builders. It is, therefore, important to determine whether current trends in planning-oriented information systems are promising and, if they are not, to indicate the steps to be taken to adapt them better to the needs of planners. It may be particularly useful to identify bottlenecks and failures in the use of information systems, so that new strategies for designing and applying coherent information systems can be developed. In this process the attention of persons and institutions responsible for the design of decision support systems for planning may be directed also to various qualitative issues crucial to development planning. Such issues can often be included in modern information systems, because entirely new possibilities for data storage and data treatment have arisen. Therefore, information systems may act as a vehicle for identifying systematic patterns in a complex,

dynamic world.

Our era is indeed the era of information. But, at the same time, the identification of meaningful structures and patterns in the mass of information that confronts us is fraught with many problems. The need for better information for planning has evolved into the need for better planning of information.

2. Information as a Process

As stated in the introduction, information is more than a set of data, as its aim is to provide analytic support to a decision maker. An information process takes place when the insight of the decision maker into a choice problem is improved by access to logically organized data. This process can have two effects, namely an increase in knowledge about a phenomenon, or a decrease ("misinformation"). The latter aspect is extremely relevant, as very often scientific analyses may lead to a removal of certainty that a decision maker had regarding the expected outcomes of his decisions. Thus, a rise or a decline in the degree of certainty about the occurrence of a particular phenomenon may be called "information" (Rittel 1982). Information in a planning framework may have an impact (positive or negative) on various types of knowledge (Rittel 1982): conceptual (theoretical), factual (descriptive), deontic (normative), explanatory (causal), and instrumental (goal-oriented).

A specific kind of uncertainty emerges if different information systems (e.g. models) lead to different outcomes. In that case, a decision maker might use the contradictory results of two information systems to create more public uncertainty (i.e. confusion) so as to achieve an expansion of his own decision space. This so-called *strategic* uncertainty may emerge especially if the foundations, definitions, data, and purposes of the information systems are not clearly specified.

Information can thus also be linked with *surprise*. A message contains more information as the discrepancy between prior (expected) results and posterior (realized) results increases. Theil (1967) used the latter viewpoint to develop his conception of information theory, in which Shannon and Weaver's classic measure of information is one of the elements used for judging the relevance of information for decision making. The input of organized data (information) brings more order to an otherwise less organized complex system (Scheele 1983). Raising the information content (or *negentropy*) removes uncertainty and reduces the entropy of a system. This information process will depend on the capability of the system to incorporate the extra information (Webber 1982).

As mentioned before, a restructuring and interpretation of data is a prerequisite for generating information. This treatment may be for various purposes (Burch *et al.* 1979). Examples are:

capturing	recording data systematically
verifying	confirming the validity of data
classifying	sorting data into specific classes
arranging	placing data in a predetermined sequence
summarizing	aggregating data into new sets
calculating	manipulating data arithmetically
forecasting	extrapolating data into the future
simulating	assessing and manipulating lacking data
storing	placing data on to storage media
retrieving	selecting data from storage media
communicating	transferring data to other users.

All these operations are determined by the contribution of the information system at hand to solving planning and policy problems. The choice of operations very much depends on the related costs arising *inter alia* from personnel requirements, the modularity, flexibility, and versatility of the information system, and the processing speed and control. The benefits of an information system depend *inter alia* on its accessibility, comprehensiveness, accuracy, appropriateness, timeliness, flexibility, verifiability, freedom from bias, and quantifiability.

Clearly, a system with redundant information may result in inefficient decisions, to which *lack* of information may also lead. Theoretically, an *optimum* level of information will be reached if the marginal value of information equals its marginal cost. In reality, such costs and benefits can hardly be expressed by one common denominator, so this marginality rule has only a limited practical relevance. The various aspects involved in judging the value of an information system normally require to be treated in a multidimensional trade-off (to be discussed later).

An information system may also be useful for identifying the *minimum* requirements for making a decision. If the information level is too low, it may be appropriate to postpone a decision in order to collect more reliable data, unless the costs of postponing would be higher than the expected benefits of gathering better information. This principle of *trichotomous segmentation* is extensively discussed by Roy (1981). In conclusion, information systems may not only serve as decision support for making actual choices, but may also indicate the *margins* within which choice may be justified on scientific grounds.

3. The Nature of Data

The importance has already been mentioned of the trade-off between the costs of producing relevant information and the benefits of using it effectively in planning procedures and policy decisions. Therefore, we should pay attention to the nature of data that are appropriate for information systems.

Phenomena that are studied using social sciences can be described in various ways; for instance, by means of theoretical constructs (e.g. the level of welfare or the quality of life) or by means of operational concepts (e.g. the level of income or the amount of pollution). In the phase of theorizing on problems to be analyzed, the theoretical constructs are usually called *latent variables*. These variables do have a certain (sometimes intuitive) meaning, but cannot be directly measured. However, during hypothesis testing, empirical analysis, or model building one needs observations of *operational variables*, which are often proxy measures for latent variables. The literature on latent variables is fairly rich (e.g. Goldberger 1972, Goldberger and Duncan 1973, Aigner and Goldberger 1977, Folmer 1983).

More recently a great deal of attention has been given to explanatory analyses of latent variables; for instance, by means of indirect methods, like path analysis (e.g. Duncan 1975, Leitner and Wohlschlägl 1980, Jöreskog and Wold 1982), or by means of partial least squares (e.g. Wold 1975, 1983) or by means of linear structural equation models (Jöreskog 1977). The state of the art demonstrates that both latent and observable variables can be dealt with in empirical statistical and econometric analyses.

It should be added, however, that even operational and measurable variables may pose validity problems, as they have to be adjusted to specific analytic issues. For instance, if one has to examine the relationship between regional value added and the availability of transport infrastructure, the variable representing transport infrastructure has to be *standardized* in a meaningful way, for instance by relating it to the actual use of infrastructure, to the number of regional inhabitants, or to the regional activity density (Nijkamp 1983). Thus, each standardization includes a certain arbitrary or subjective value judgment that may have a substantial impact on the final results. In conclusion, even apart from measurement problems *per se*, defining an operational concept or variable in data analysis is far from easy.

Data for use in planning can be collected at various levels and according to various viewpoints. From an ideal point of view, the nature of data is determined by the aims of the analysis (e.g. impact analysis or plan evaluation), but in reality one very often has to use an existing data base in the most efficient way to extract the most relevant information for a specified use. For instance, it appeared from a recent international survey of multiregional economic models that specific data bases were not developed for the majority of the models, but instead the existing data provided by various statistical offices were employed in most cases (Issaev *et al.* 1982).

In general, data can be measured on different scales (Harvey 1969, Roberts 1979). Two major measurement scales are the *qualitative* (nonmetric) and the *quantitative* (metric) scale. (A thorough formal treatment of measurement theory can be found in Roberts (1979).)