GEOGRAPHICAL ASSOCIATION of ZIMBABWE

Proceedings of 1979/80

Number 13 December, 1980

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MODELS AND THEIR USES IN GEOGRAPHY AND PLANNING - A REVIEW PAPER

by

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INTRODUCTION

The third quarter of this century saw an increasing interest among geographers and planners in quantitative methods and modelling. In Geography this has been referred to as the 'quantitative revolution' and quantitative models are part and parcel of this revolution. It should be noted, however, that models have been in geography and planning for a long time. As Minshull (1975) states, with particular reference to Geography: "Many theories and principles . . . in the past were never called models, but models in fact they were". Quantification meant a rigorous examination of principles and theories which would initially have to be formulated into hypotheses and quantitative models, and then tested thoroughly before their acceptance as structured concepts rather than as narrative and descriptive concepts. This is perhaps what revolutionized the discipline and also influenced planning methodology. Models are essential tools in this revolution because they facilitate properly organized and directed research. The careful formulation and testing of hypotheses is central to most present-day geographical research. This approach i.e. stating hypotheses in a manner sufficiently precise for anyone else to test their validity, is what distinguishes 'modern quantitative geography' from the 'old qualitative geography.'

It is worth noting that models and model building are only a small part of geography (see Harvey, 1969). Similarly in planning models represent only a small part of planning methodology. Furthermore, geographers do not necessarily build models for purposes of predicting (some do), but planners necessarily build models in order to predict and hence plan.

The purpose of this paper is to highlight some of the more important issues concerning models and their uses in geography and planning. To this end the discussion will examine briefly why models are devised, what models are, what types of models there are, how models are used, and finally, the role of quantitative techniques in relation to models.

WHY MODEL?

The fundamental argument is that modelling helps the researcher to understand, explain and thereafter predict the behaviour of the system that is under examination. Modelling requires the researcher to:

1. recognise and identify the problem clearly;

2. examine the composition of the problem, identifying and defining the elements, subsystems, processes etc.;
3. know how the system works or functions by examining the inter-relationships, interactions, etc. within the system, and between the system and its environment;
4. hypothesize about the structure of the system and how it might function;
5. gather data which is employed to test the model;
6. test the model to see whether it corresponds to the 'real world system' it is supposed to represent; this might necessitate subsequent modification of the model; and
7. use the model to predict the future state(s) of the system, once the model has been tested successfully.

There are fundamentally three basic parts to modelling procedures:

1. Identification of the elements, members or parts of the system which facilitate the description, identification and definition of the composition (structure) of the system.

2. Formulation of hypothetical functional relationship (based upon theory, conjecture, experience, observation, etc.) as a possible explanation of how the system functions.

3. Establishment of a precise representation of this functional relationship in mathematical, graphical or other form such that it can be tested and used to demonstrate the functioning of the system-and hence aid in explanation and prediction.

Once an acceptable model is established it can be used to monitor and evaluate the impact of any one or more desired future states of a system; this is the end product of a model in the planning process whereas explanation normally marks the end product of the model in geography.

MODEL DEFINITION

Different definitions of models have been proposed by various authors and in many cases the definitions reflect particular approaches adopted by these authors. While this can be misleading and is sometimes erroneous, it is inevitable because individuals can model the same phenomena differently depending on the objectives of a given study. Minshull (1975) provides an extensive list of different definitions of models which demonstrates that the context in and the purpose for which a model is developed have influenced some definitions (and uses) of models.

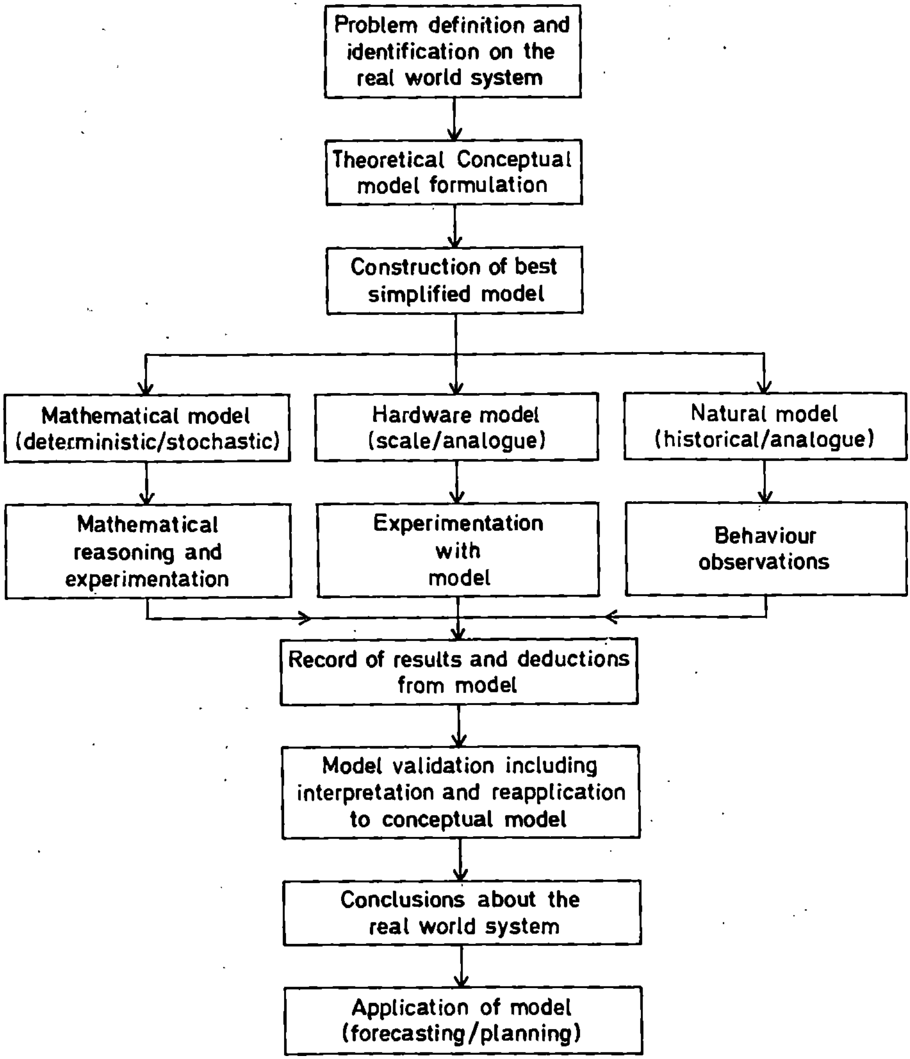

Figure 1 : Construction and use of models in Geography and Planning

Basically a model is a formal representation of the behaviour of a system as understood by the modeller. In general terms, it is an idealized or simplified representation of reality; hence a model might be criticised for its simplicity and for being unrealistic, because the underlying assumptions (including the constraints) behind the model and the purpose for which the model is built are not fully appreciated. Generally the greater the complexity in a model, the lesser the number of and rigidity in the underlying assumptions and constraints of the model; there appears to be an inverse relationship between these. Simple models may not be as powerful tools as complex ones for planning and other purposes but, in practice, they are very attractive to users because of the relative ease with which they can be applied, and also the results can be interpreted easily. Despite these limitations and variations in interpretation as to what constitutes a model it appears that a common structure can be identified in the majority of models including:

> a description of the phenomena in question; an explanation of the functional relationships among the phenomena; and a 'precise' representation in mathematics, graphics, or hardware on which certain tests or demonstration procedures may be carried out.

These three elements are consistent with the definition of a model given by Ackoff et al (1962) where it was stated that a model is "an idealized representation of reality in order to demonstrate certain of its properties".

TYPES OF MODELS

Minshull (1975) provides an extensive discussion on definitions and types of models suggesting a classification which embraces all the features that different authors try to show. For brevity his classification is adopted here followed by a brief description of the sub-models. The classification is outlined below:

1. Submodels of structure - iconic or scale, analogue, symbolic.
2. Submodels of function (used for simulation and experiment) - mathematical, hardware, natural.
3. Submodels of explanation or theoretical conceptual models.

1. Submodels of structure

The iconic or scale models are simple scaled-down representations of reality. In analogue models the real propertise of what is being modelled are represented by different and more manageable properties (e.g. the map). In the symbolic model reality is represented by abstract mathematical expressions (e.g. $y = A + bX$).

2. Submodels of function

These models are designed to perform experiements with and/or to simulate changes in variables and their inter-relationships. Mathematical models can be deterministic in that they can be used to represent processes of reality which show that certain changes are the result of some given causes. Mathematical models can also be stochastic; in this instance they have a probabilistic element where, if certain changes take place, one cannot be sure about the exact consequences. Hardware models consist of apparatus in which experiments and simulations about reality can be carried out. Materials taken from the field may be used in hardware models. Natural models involve a comparison between the phenomena being studied with something better known or easily accessible for study or experiment.

3. Submodels of explanation or theoretical conceptual models

These models are probably the most versatile and comprehensive of all. They provide the rules and framework which a given study will follow. Furthermore, they not only help in simplifying the conceptualization of complex reality, but also assist in structuring modes of explanation.

Recognizing that models may have to meet different requirements Lowry (1965) structured models according to the tasks for which they might be used. He suggested three categories of mathematical models; briefly these are:

1. Descriptive models which are designed to represent an existing situation in a simplified more coherent mathematical form. Their scientific value is in providing concrete insights into the structure of the situation under study.

2. Predictive models which are used to simulate future situations as accurately as possible. They have a forecasting accuracy.

3. Planning or normative models which are extensions of predictive models. The emphasis is on their effectiveness in meeting and satisfying given goals and constraints. Clearly defined objectives are essential in order to assess the range of their performance.

HOW MODELS ARE CONSTRUCTED AND USED

Developing upon the work of Harris (1965), Lowry (1965) and Steger (1965), Wilson (1974) suggested a useful checklist of questions to facilitate the design and construction of a model. These are:

1. What is the purpose behind the particular model building exercise?
2. What should be represented as quantified variables within the model?
3. Which of these variables are under the control of the planner?

4. How aggregated a view can be taken?
5. How should the concept of time be treated?
6. What theories are we trying to represent in the model?
7. What techniques are available for building the model?
8. What relevant data are available?
9. What methods can be used for the calibration and testing of the model?

Clearly it is necessary to define the purposes of the research before attempting to answer these questions since the construction of the models and the use to which they are put are conditioned mainly by the purpose and objectives the model builder has in mind. Generally in geography and planning, models are used as aids in research and explanation; as aids in exposition; as analogue, model building and 'black box' tools; and as aids in planning and plan implementation.

Geography models typically focus on the description and explanation of spatial distributions and areal differentiation. Their construction and uses normally begin and end with phenomena in the real world. In planning the concern is with the application of models in the planning process and the construction of planning models is directed towards this end. The gist of these observations are summarized in Figure 1; this diagram also incorporates some of Chorley and Haggett's (1967) ideas on the use of models in geography.

MODELS AND QUANTITATIVE TECHNIQUES

A discussion of models and their uses would not be complete without an examination of the role of quantitative techniques in relation to models. Quantitative techniques are complementary tools to models. Their role is a very special one in that they not only give greater factual and numerical accuracy to research but, and more important, also serve to rigorously test and analyze the validity and degree of usefulness of the results and deductions arising from a model.

Models and quantitative techniques are thus complementary. Quantitative techniques can be used to test the reliability of a model, and the validity of deductions drawn from the model; they might also serve to establish the degree of confidence in the conclusions about real world phenomena which are based upon the findings of a model. Indeed such techniques can be used to test and analyse models for their explanatory and predictive power and efficiency. In every case modification and reformulation of a model may result. Clearly then a model is much more complex than the various quantitative techniques which are structurally part of the model and which play a role (crucial though it can be) at some stage in the function of the model (Fig. 2).

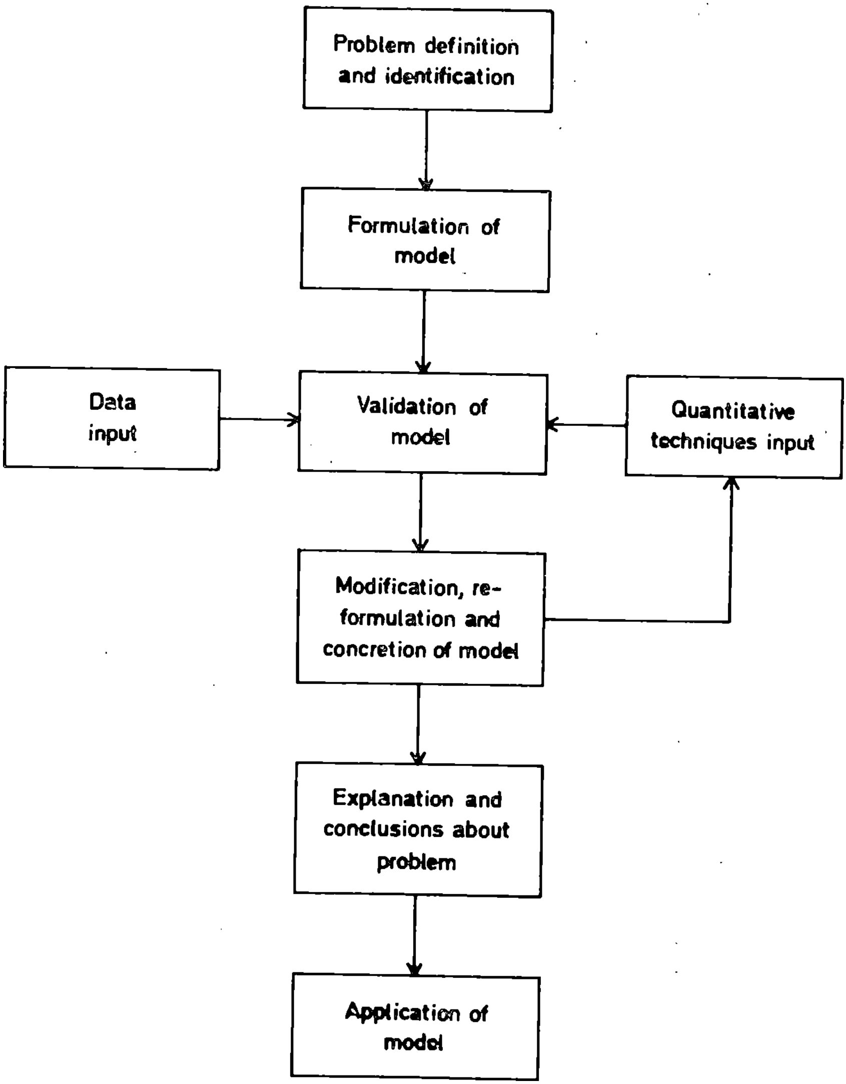

Figure 2 : The model and the role of quantitative techniques

CONCLUSION

The literature on models in geography planning is extensive (Minshull, 1975; Lee, 1973). The literature demonstrates how complex the world of models is and the kind of debate which surrounded the adoption of models in the disciplines of geography and planning.

The purpose of this paper was not to provide another extensive and detailed discussion of models but to examine briefly models in the context of their uses in geography and planning. Implicit in this was an attempt to show the mutual interest of geography and planning in models and to identify the role that models play in linking the two disciplines (see Hardwick, 1978).

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