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THE LAND USE PLANNING PROBLEM OF NEW TOWNS

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ABSTRACT

The land use planning process of new towns is unique in that all land use activities are simultaneously being distributed at the planning stage. This presents a major planning problem to the land use planner and, consequently, a need for a planning paradigm from which an optimal land use allocation plan can be generated. Upon presenting the major aspects of the land use planning problem of new towns the paper outlines a general planning model which is capable of producing optimal land use plans and then proceeds to examine the model's main components and the essence of its operation.

Introduction

In general, the land use planning process of new towns is distinguished from planning activities which take place in established urbanized areas in that *all* land uses can freely be manipulated, with respect to location and density, at the initial planning stage. Furthermore, the planning for urbanized areas is ultimately a piecemeal process which, characteristically, tends to hinder the attainment of optimality in the overall distribution of land uses. That is not quite the case in new town planning since, as indicated above, the planner can concurrently allocate all land uses and, consequently, achieve the desired optimality. As it is presently shown, these circumstances present a severe problem to the planner of new towns regarding the generation of optimal land use plans.

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The principle objectives of this paper are first, to examine the land use planning problem of new towns and then to sketch a planning model (presented in the form of a block diagram) whose purpose is to generate optimal land use plans for new towns.

Unfortunately, there is very little in the literature on new towns which is of direct relevance to the work undertaken in this paper[2] and, therefore, the schematic model described below should be considered primarily as a first attempt to tackle the problem. Despite its generality, however, it is believed that this model contains the major analytical elements which should be incorporated into any quantitative operational model of a similar nature. Attempts to develop such a functional model are currently being undertaken as a part of an ongoing research on new towns planning.

The Unique Land Use Planning Problem of New Towns

The literature on urban land use planning has long recognized that the actual planning process of urbanized areas is step-wise or incremental in nature.[3] That is, at any given point in time major land uses like residential, commercial and intrastructure are fixed with respect to location, intensity of use and their interdependencies. Consequently, land use plans are usually devised such as to mainly affect the existing spatial distribution of *one* land use–city wide, (e.g., the transportation system) or some land uses at *one* area (e.g., urban renewal projects), while accepting as constraints the state and location of all other activities. Moreover, even comprehensive or master land use plans which focus upon the entire distribution of land uses at some distant point in time has to accept the existing capital stocks and the current state of all land uses as given inputs if not as constraints upon the final desired distribution.[4] The overall result of this state of events is a planning process which overtime tends to alter the current distributions of land uses–incrementally.

This characterization, however, is not quite applicable to the planning of new towns since the argument concerning the invariable state of all major land uses does not hold. In other words, new town planning is unique in that the distribution of *all* land uses can, and should, be determined simultaneously at

[2] Most of the literature on new towns deal with three main topics. A descriptive analysis of the major elements of new town planning–with reference to some case studies (see, for example, Hoppenfeld [1967]); attempts to critically evaluate the special roles new planned communities play in the continuous process of urbanization. (See, for example, Downs [1970], Alonso [1970]) and, finally, discussions of some architectural and design aspects of implementing new towns (see, for example, Pillorgè and Brents [1971]).

[3] A critical evaluation of this concept is provided by Braybrooke and Lindbloom (1970).

[4] It is interesting to point out that some researchers argue that the present observed spatial form of urbanized areas, which undoubtedly were also influenced by past planning efforts, are mainly the results of historical stocks and distributions of private and public land use activities. See for an interesting study, Wheaton (1972).

the initial planning stage and the constraining effects which the state of existing land uses usually have upon the planning process, do not prevail here.[5]

This essential difference between the land use planning activities of urban areas and that of new towns come into sharp focus when we consider the efficiency and optimality aspects of land use plans. It is rather a well known fact that as the number of constraints (or bounds) increases, the size of the space of all feasible solutions diminishes and the chances of finding an optimal solution, at a given number of steps, increases. Hence, the case of new town planning–where the number of such restrictions is much smaller–presents a far more complicated optimization problem than the case of planning urbanized areas.

Another equal significant problem in land use planning is the theoretical and empirical definition and identification of the interdependencies between various land use activities–many of which do not pass through a market system and, therefore, register on markets.[6] Yet such interdependencies have significant impacts upon obtaining social optima in general and optimum distribution of land uses in particular. Again the complexity of these phenomena is largely increased (with respect to the planning process) when all land uses are distributed concurrently. On the other hand, considering the relatively small size of new towns (in terms of their physical boundaries and expected number of land use activities) it is all the more critical that the planner will strive toward attaining optimality in the overall land uses allocation.

It is for these reasons that the planners of new towns face a unique land use problem which might be summarized as the following:

> Given the variable state of all land uses at the initial planning stage and given the unknown relationships between the various land use activities how to produce a land use plan which will, simultaneously, be feasible and optimal.

The Proposed Planning Model

The purpose of this model–like that of any other planning model–is to generate land use plans for new towns. As alluded to previously, the term land use plan is used here to indicate a set of specifications concerning the spatial location, intensity of use and the overall level of various land use activities like residential units, commercial outlets, public facilities, etc. Obviously, there is almost an infinite number of possibilities for construction of such a plan and the

[5] There are, of course, some other constraints (e.g., the region's economic development) which might affect the planning process of new towns. These, however, are less restrictive in nature and are briefly discussed later in the text.

[6] These include non-internalized externalities in the form of agglomeration economics and all sorts of neighborhood effects. The analysis of such factors, which fall within the domain of public economics, is beyond the scope of this paper, the burden of which is not to deal with this particular aspect.

problem is, therefore, to establish a procedure which will generate the "best" plan. A related requirement is that this process will be an efficient one, i.e., generating this "best" plan in a reasonable number of steps.

As it is presently shown the two criteria used for the selection of the best plan are feasibility and optimality.[7] In its narrow sense the concept of feasibility simply imply that the resources necessary for carrying out any selected plan would not exceed those available to the planning organ. In a more broader sense feasibility may also imply that the selected plans should comply with some non-monetary requirements like the preservation of natural habitat, minimum level of community interaction and the desired socio-economic make up of the new community.

The concept of optimality, which is a much more complicated one, will be discussed in section 4 below, following the presentation of the model which is diagramatically exhibited by figure 1.

The model starts at the INITIAL PLAN step which, as indicated above, is a technical enumeration of the various land use activities–including their spatial, economic and social attributes. In general, there is no particular rule which tells the planner how to formally present a plan, or what to include in it–except that the planner should explicitly consider the unavoidable trade offs between comprehensiveness and generality in presentation. A more severe question, however, is how to extract from the vast possible alternative initial land use distributions one which will be a good "first approximation." A partial answer to this question can be obtained from recognizing at this point the possible interactions between the planned new town and the surrounding region.[8] That is, to a certain extent the future shape of the new town depends upon the mixed characteristics of the region in which it is to be implemented and, in particular, the region's economic and physical structure, its prevalent employment opportunities, the existing infrastructure and the socio-economic make up of adjacent communities. Hence, by making some plausible assumptions regarding the level, or degree of importance, of these and similar exogenious factors, the number of such possible initial land use distributions (i.e., the new town's spatial form) can be substantially reduced.

Once the initial plan has been defined it is desired to obtain an analytical picture of the system it comprises–including the behavior of its various components and their interrelationships–which, essentially, is a simulation step. To illustrate, suppose that a matrix which enumerate the various land use activities and their locations has been introduced at the initial stage. It is desired,

[7] These concepts are discussed elsewhere in the planning literature and they are briefly presented here mainly to highlight their special inference in this context of new town planning. In general, all planning processes, at least implicitly, relate somehow to these factors. See, for example, the planning model suggested by Harris (1967).

[8] An example of an analysis of the relationships between a new town and the surrounding region can be found in Batty (1969).

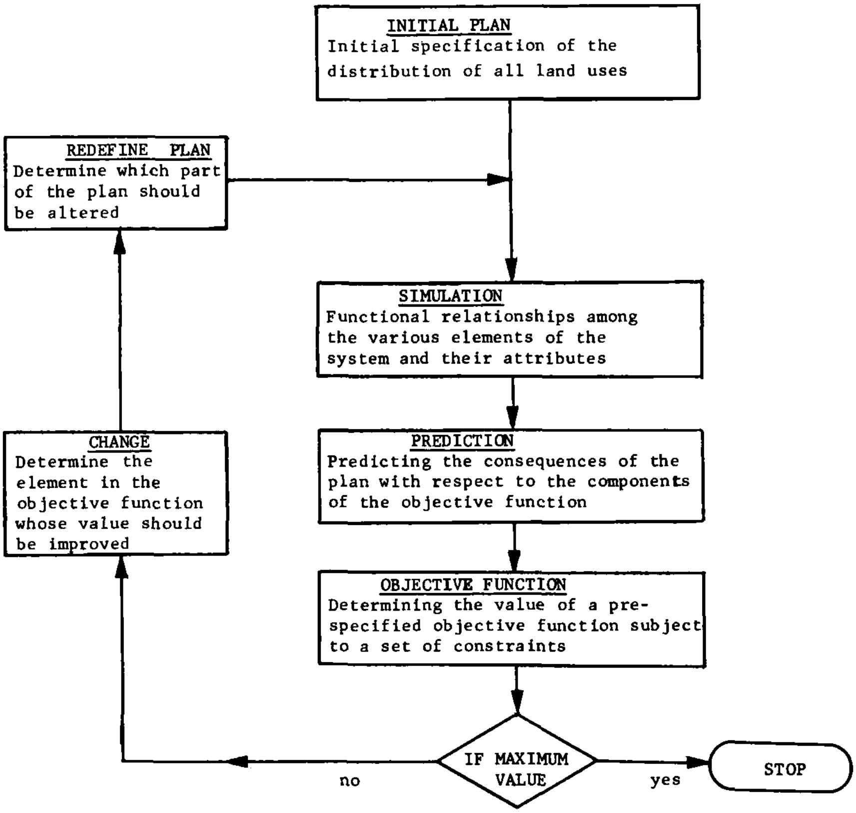

Figure 1. Diagramatic exposition of the planning model.

however, to determine the overall accessibility level which this particular land use system insinuate. This, in turn, calls for the introduction of some, theoretically determined, accessibility factors (e.g., distance and traveling time between any two zones) and, subsequently, the simulation of the spatial behavior, of the various groups of locators. Thus, the SIMULATION stage fundamentally puts together the various components of the initial plan into one system by analyzing the nature and the level of interrelationships of these elements. It is important to point out, however, that this step is strongly dominated by some previously made theoretical assumptions, regarding the economic and spatial conduct of the various land use activities. These assumptions (or considerations) are exogeneous to the entire planning process and they are based upon the planner's conjectural knowledge of urban land use systems.

The completion of the simulating step still does not provide the analyst with the important information concerning the performance of the system, in terms of the variables which constitute the predefined objective function, and a PREDICTION stage becomes necessary. For example, suppose that community welfare and developer's revenue are the two central components in the objective function. Hence, it is vital that the previously simulated system will be manipulated such as to determine its performance with respect to these two elements. In sum, this stage of the model generates conditional predictions of the consequences of the initial land use plan with regard to the variables which compose the objective function.

The output of this stage when fed into the OBJECTIVE FUNCTION stage will produce a numerical value of that function which, in turn, provides a quantitative appraisal of the previously constructed land use plan.

The intrinsic assumption here, of course, is that the objective function used has some desired analytical properties and, as shown in the following section, there is a number of conceptual problems in defining such a function.

Assuming, for the moment, the existence of such a function it is possible now to determine the desirability of a given plan and eventually the generation of the "best" or optimal plan. Schematically, this is being done by keeping redefining the initial plan and generating, along the process, the corresponding values of the objective function. This iterative process is kept in motion until convergence occurs in the form of either a plan whose value (in the objective function) cannot be improved any further or that a marginal improvement of the plan's value is economically unattractive. Also, it is virtually impossible, due to the internal complexity of the system of the land use activities, to *a priori* ascertain which plan will ultimately yield the highest value of the objective function and, therefore, the iterative process becomes necessary.

In the following section the objective function, its major desired characteristics and its essential role in the recursive model are examined.

The Objective Function and The Optimization Process

As can be easily seen from the above diagramatic exposition, a critical component in the model is the objective function and its analytical structure.

Conceptually, the elements which compose the objective function should reflect some basic, predetermined goals which the planner wish to achieve. For example, a profit element or a rate of return on the investment, which reflect the developer's enterprenual motive, may be included in the function.[9] Similarily, if residential amenities or community welfare are explicit goals of the planner, then some factors which reflect these aims should also be incorporated into the objective function which then attempts to maximize (or minimize) the integrated value of these factors.

[9] An example of a formula whose purpose is to determine the present value added by land development in new towns and from which a profit factor can be computed can be found in Ricks (1970).

It is important to note that this key component of the iterative model contains not only the objective function but also some predefined constraints like an upper bound for the available resources or a lower bound for the accepted level of residential amenities. Technically, these constraints can be integrated with the objective function (thus defining a Lagrangian expression) or remain as a separate set (thus defining a feasible region with some necessary mathematical properties) over which the original objective function is optimized. Independent of the mathematical method used, the planner is required to properly identify and specify these constraints which, by and large, are the product of the unique economic, social and political environment in which he operates. Needless to say, both the objective function and the constraints set remain unchanged during the entire iterative process even though, redefined land use plans are successfully being introduced.

Having these background remarks, there are two major reasons for making the adequate specification of the objective function a critical step for the entire process.

First, a properly defined objective function will guarantee that the recursive process will eventually converge into a unique optimum (optimurum) solution which is another way of saying that there will exist one, and only one, land use plane whose value–in terms of the objective function–is higher than that of any other alternative plan. In general, and given the analytical structure of the objective function, it is quite possible that in addition to the point of global optimum there will be a number of points of local optima. Under these circumstances it is rather likely that the process will halt at one of these points producing a land use plan which is not overall optimal. Furthermore, by starting with different initial plans the process might eventually converge into different points of local optima without ever reaching the global optimum. This general problem of global vs. local optima is known to be a complicated one and of crucial importance for sound land use planning.[10] However, given the scope of this paper, nothing more will be said here on this matter except to notice that any empirical version of the presented schematic model should be supported by a formal proof regarding the existence of an optimum solution and the ultimate convergence of the process into that point.

A second reason for the key role of the objective function is that it can be shown that its structure together with the constraints set affect the efficiency of the recursive process, i.e., the number of iterative steps necessary for convergence. In some instances this number can be extremely large marking the whole process as uneconomical from the planner's view. In such cases the planner might try to restructure the objective function or, alternatively, estimate the opportunity costs–in terms of the value of the objective function–of accepting a plan whose value is less than that of global optimum. Moreover, efficiency as defined here may also be affected by the structure of the initial

[10] For a good discussion of this and related subjects, see Harris (1970a) and Harris (1970b).

plan which determines the entry point to the optimization process. This will happen if in fact we face a case of multiple optima, and, consequently, each entry point will imply a different number of steps necessary to achieve a global optimum (if at all). Thus, a properly defined objective function (and its set of constraints) can largely increase the efficiency of the iterative process and, therefore, the acceptability of the final selected plan.

Once a value for the objective function is obtained for the kth iteration the question still remains of how to redefine the land use plan (evaluated at this iteration) such as to improve the objective function's value at the (k + 1) iteration. In terms of the diagramatic model we refer here to the CHANGE and REDEFINE PLAN components.

The general answer to this question is that the analytical properties of the constructed mathematical expression (produced by the objective function and its set of constraints) will ultimately determine the direction the analyst should follow. That is, knowing on the hand, the analytical conditions (in terms of this constructed expression) necessary for achieving global optimum and, on the other, obtaining at each iteration the intermediary values of the elements which compose this expression enables the planner to determine which of these elements should be improved upon and at which direction. Since we also know–from the simulation and prediction stages–which part of the land use plan affect which element in the objective function, it becomes possible to determine that part of the plan which should be altered (thus, redefining the plan) at the next iteration.

To amplify a point made earlier, it is imperative to understand that in lieu of the general complexity of land use systems and in particular the nonlinear interrelationships between various activities it is impossible to decide, on a *a-priori* basis, which specific plan would generate those values (of the arguments of the constructed expression) which are necessary for optimality, or by how much a certain modification in the initial (and the successive) plan will advance us toward that point. Thus, the planner is forced to follow the iterative process where at each iteration he attempts to improve the overall value of the optimized objective function according to the scheme which is outlined above.

A prime modification in this general scheme might be unavoidable if, in fact, the analytical structures of the objective function and its constraint are such that it is impossible to mathematically derive the above mentioned theoretical conditions necessary for optimality. Under these circumstances, some sort of optimum seeking algorithms should be employed (with regard to present schematic model–at the CHANGE stage) to virtually direct the analyst toward the point of optimum.[11]

[11] A good review of such algorithms can be found in Himmelblau's (1969) book.

Conclusion

As indicated at the outset the main objectives of this paper were to present the special land use planning problem of new towns and to sketch a planning model (diagramatically exhibited in Figure 1) which is capable of producing optimal land use plans for new towns.

It is important to note that this model was presented as a "static" model in the sense that it implicitly assumes that all the relevant information is initially known to the planner and no additional applicable information, enters the system throughout the process. If so wished, another component might be added to the model to reflect some changes which, are likely to occur over time in the real-world, and which might affect the structures of the objective function, its constraints or the theoretical assumptions which underlie the simulation and the prediction stages. Such a component will essentially create a feedback mechanism which links the constructed system with eventual transformations which occur in the economic, social and physical dimensions of the external environment. However, in many cases this feedback might be so slow that its impacts might be of negligible value—at least over a substantial period of time.

Another equally significant point is that the planner should not be engaged in developing an operational version of this model unless he is equipped with some theoretical postulates concerning the relationships between various land use activities in general and human spatial behavior in particular. Both the simulation stage and the prediction stage are fundamentally based on such theoretical postulates.

Finally, and as alluded to earlier, an attempt is currently under way to construct a quantitative version of the outlined model. Such an endeavor essentially requires a detailed mathematical specification of the model's various components and in particular that of the objective function and its constraint set.

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