

CITY GROWTH SIMULATION SHELL

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ABSTRACT:

CSS stands for City Simulation Shell. CSS is a menu driven shell for simulating the growth of the city, developed using Arc Macro Language (AML) of Arc/Info GIS. It generates different simulated city models in a semi-automated way.

Urban areas in the country are rapidly growing and thus there is a need to monitor the growth and changes in urban land use pattern over time. These inputs are helpful for planning the city in a sustainable manner utilizing natural resources and facilities optimally. While preparing the Master Plan of the city, one needs to do various projections related to population and physical growth of urban built-up land. It is in this context, the simulation exercises are helpful to predict the future growth of the city based up on the past growth. An attempt has been made in this study to simulate the future growth based upon the past growth of the city employing a multi-parametric approach.

In the present study, a semi-automated shell for city growth simulation has been developed. The concept behind the shell is to simulate the future growth of the city based upon the past growth of the city employing a multi-parameter approach. The input required for the shell is the composite layer having all the characteristics of physical parameters like existing land use pattern, slope, soil, water availability, transportation network and natural hazards etc. Since in order to predict the future growth, urban land requirement is needed and for that population for the required time is needed. This shell gives the user the flexibility to either give the population as input or user can give only present population and the shell will provide the population for the required time. Based on that projected population and population density, calculation of the land needed for the urban growth and the allocation of that land will be done by the shell automatically. Hence, the output of the shell is simulated city for the given period. Using this shell, growth of any city can be simulated by slightly modifying the parameters used and criteria. This shell also provides the facility to use either the standard criteria or user defined criteria. Also, there is an option to select the urban suitable classes for the land allocation process so that different simulated city models can be generated. The output of the shell also includes the land required for the city growth.

1.0 INTRODUCTION

CSS generates the simulated city for the given period in a semi-automated way. This shell gives user the flexibility to use either the standard criteria or the user defined criteria. Also, selecting the different urban suitable classes for the land allocation process can generate different simulated city models. The output of the shell also includes the land required for the given period for the city growth.

In an ever increasing urbanization, it has become imperative to have sustainable growth based upon optimal utilization of natural resources available. Therefore, it is necessary to monitor the growth of urban built-up land regularly and predict the urban sprawl based upon existing population growth and expected growth in future. It is in this context, a

simulation study is required to monitor the city's growth in future and suggest the remedial measures for the optimum utilization of natural resources in the region. In this paper, a semi-automated shell has been developed to simulate the future growth of the study based upon multi-parameter approach adopting RS and GIS techniques. The emulation of the city's growth in the past and simulation of possible change scenarios for the future would help planners and administrators to evaluate the proposed master plans and carry out mid course corrections in the proposed plans for implementation.

A procedure has been developed to simulate the future city growth (Shweta et al.). Based on this procedure a shell called "CSS" has been developed using Arc Macro language (AML) under Arc/Info GIS software. Since this shell is customized in the Arc/Info GIS software, to execute this shell Arc/Info GIS is required. Geographical Information System (GIS) is a

database management system used to capture, storage, retrieval, manipulate, analysis and display of spatial (i.e. locationally defined) and non-spatial (tabular) data in an integrated manner. (BurroughPA, 1986).

2.0 FUNCTIONALITIES:

CSS provides following functionalities;

1. Generation of simulated city for the given year.
2. Different simulated city models based on the selection of urban suitable classes.
3. Projected population for the given period.
4. Land required for the city growth for the given period.

All above functionalities can be accesses through menus and buttons provided by the shell as shown in Figure1.

3.0 METHODOLOGY

The methodology adopted in the present study is presented in Figure-2. The details of the methodology are as follows,

3.1 Population projection

Estimation of the population for a given period has been derived using different population projection methods (Pathan et al, ...). User can also give population as input to the shell.

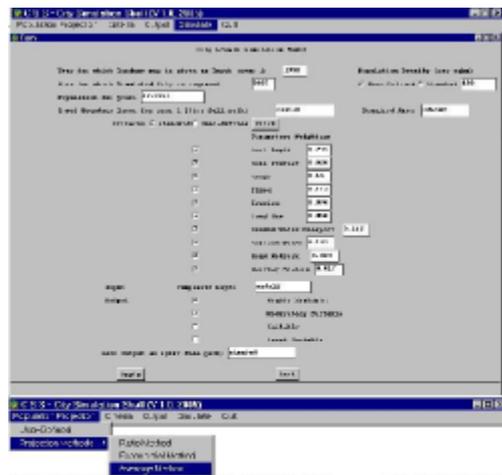


Figure1: Menu Functionalities of CSS Shell..

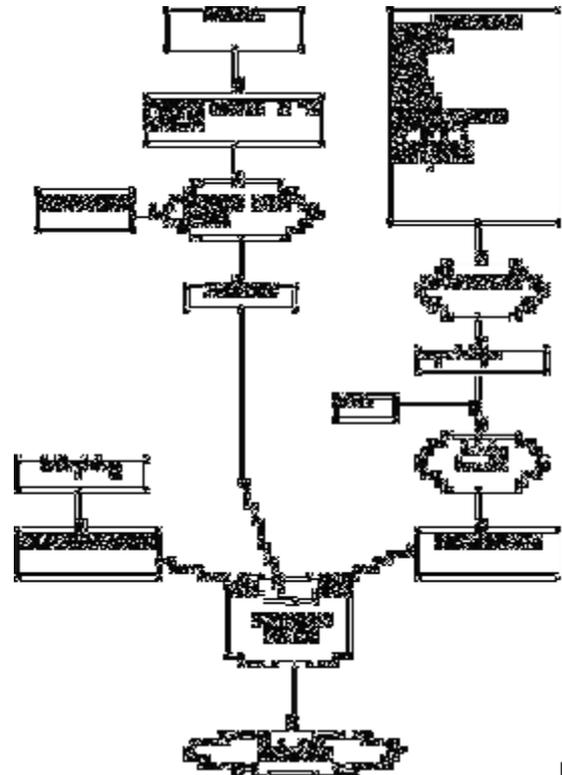


Figure2: Methodology for City Simulation

3.2 Calculation of area required

Additional area required for the given period has been calculated for the additional population considering the population density of 150 persons / ha.

$$\text{Area Req.} = \text{Additional Population} / \text{Population density}$$

3.3 Identification of suitable area for future city growth

Urban land use suitability analysis encompasses physical characteristics, constraints and socio-economic possibilities. Basically it refers to the potentiality of the land for development. The land suitability designates land according to its physical capability regardless of any planner's conceptual interest. Identification of suitable areas for urban development is one of the critical issues in the preparation of a development plan. The land suitability is thus not only based on a set of physical parameters but also very much on the economic factors. The composite effect of these parameters determines the degree of suitability and also helps in further categorizing the land into different classes of development. Moreover, the process of suitability

assessment is very much dependent upon the prevalent conditions such as pressure on land. If the pressure on land is too high, it may give rise to a high order of speculation and may lead to development of land, which is otherwise not suitable from suitability point of view. This clearly states that the level of inputs would be high due to the market forces. Hence, suitability analysis has been attempted for prioritization of land for urban development. The parameters considered for the land use suitability are a) soil depth, b) soil texture, c) slope, d) flood, e) erosion, f) land use, g) groundwater prospects, h) surface water, i) road network and j) rail network.

The assessment of physical parameters gives an identification of the limitations of the land for urban development. The concept of limitation is derived from the quality of the land. For ex, if the slope is high the limitation it offers is more than for a land, which has gentle slopes for a flat terrain. Practically, this would mean that the development of the high slope land would require considerable inputs and thus may be less suitable against the flat land where the inputs required are considerably less. This concept is true for all the land parameters that are assessed. All the above-mentioned physical parameters have been considered for analysis towards the identification of suitable areas for the urban development in the town as well as its environs. Each category within the parameters has been ranked according to its significance towards the urban development. Each parameter has been given weightage according to its importance. A multivariate index analysis of these parameters has been carried out by integrating them in GIS environment. Rank and weightages has been multiplied to get the Composite Suitability Index (CSI). This CSI has been classified into four categories based on mean, maximum, minimum and standard deviation. These four classes indicate highly suitable, moderately suitable, less suitable and not suitable.

Area allocation

For allocating the areas for urban development, AML (Arc Macro Language) based programme in GIS environment has been used. As per this programme, the process of area allocation for different types of urban land use development comprises the search of ideal and suitable areas within and in the proximity of the city. As per the procedure, buffer zones have been generated with different distance criterions around the existing city limits. These buffer zones have been utilized as a search radius for identification of the additional areas required in the proximity of the city for urban development. Finally, the procedure searches for the areas ideally suitable for urban development till the allocated area becomes nearly equal to the additional areas required for the future development. While allocating the land for urban development, a provision is also provided to the user to select the suitable areas which are generated for

urban development based upon physical characteristics of the terrain as city simulation process depends on the selection of the suitable categories to be used. The simulated built-up land density will be directly proportional to the number of the suitable classes selected by the user.

4.0 RESULTS

City growth models have been generated for Ahmedabad city in Gujarat state by selecting different suitable classes.

The simulated growth of the city is validated with respect to the actual growth of the city and the results are shown in **Figure 3**.

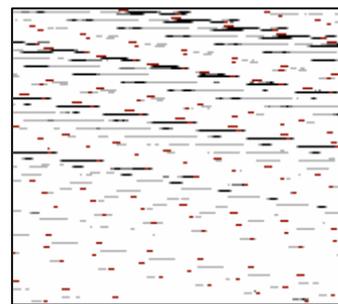


Fig. (3a) Actual Development During 1996 – Nov 2004

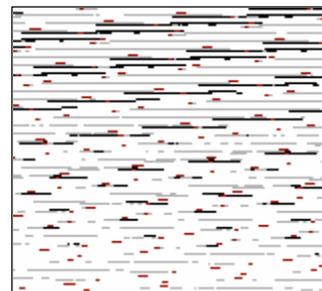


Fig. (3b) Simulated growth of the City (Suitability Classes used: 1 & 2)

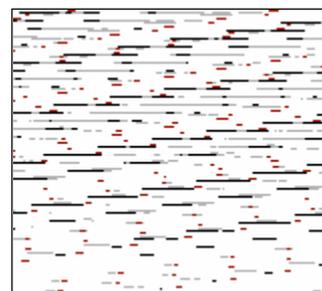


Fig.(3c) Simulated City (Suitability Classes used: 1,2 & 3)

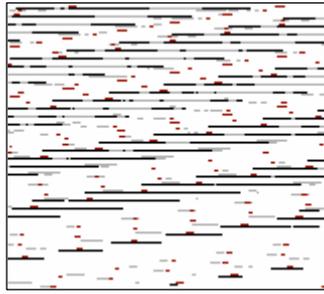


Fig. (3d) Simulated City
(Suitability Classes used: 1,2,3 & 4)

It was found that the city growth simulated by the shell using the standard criteria and actual city growth has a correspondence of approximately 65%. The accuracy of the city growth simulation can be improved further by giving the criteria derived based on the actual growth of the city by past data sets and development trends of the city as input to the shell.

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