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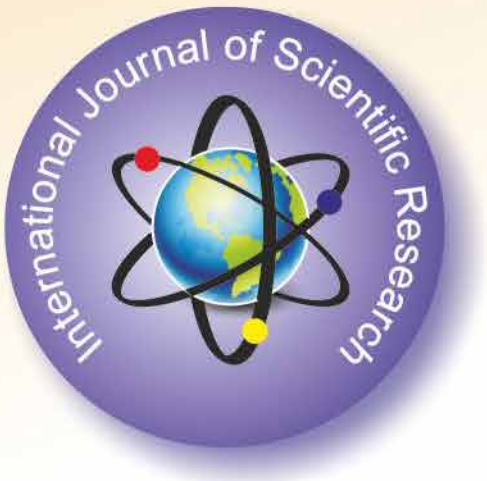

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INDEX

Sr. No.	Title	Author	Subject	Page No.
1	Ionic composition of a freshwater lake and its implications on aquaculture	Dr. Shankar P. Hosmani	Biotechnology	1-2
2	Growth and Performance of Mutual Fund Industry in India	Dr. M. K. Maru	Commerce	3-4
3	Waste Management: A New Paradigm of Contemporary Business	Dr. Vipul Chalotra	Commerce	5-6
4	Rural Financial Services in J&K (A study in the field of financial services sector development)	Tarsem lal	Commerce	7-8
5	Banyan, the National Tree of India	Dr. J.K. Sehgal	Commerce	9-10
6	Impact of Online Marketing on Customers with Special Reference to Coimbatore City	Dr. R. Ganapathi	Commerce	11-15
7	Customers' Attitude towards Housing Loan With Reference to Commercial and Rural Banks	Dr. R. Ganapathi, Mrs. B. VIDYA	Commerce	16-23
8	Consumer Behaviour towards Broiler Chicken Retail Stores With Reference to Madurai City	P. Easwaran, J. Gnanadevan, Dr. R. Ganapathi	Commerce	24-30
9	Data Security and Protection in Cloud Computing	Shameena Begum, V. Ratna Vasuki, K.V.V.Srinivas	Computer Science	31-34
10	Foreign Direct Investment in India – An Explanatory Study	Dr. K.Madhu Babu	Economics	35-38
11	Growth - Saving Causality in India: A Cointegration Analysis	Dr. Shradha H. Budhedeo	Economics	39-42
12	Constitutional perspectives on Labour Wages in India	Dr. Shankar Ambhore, Dr. Dilip Arjune, Manish Parshuram Pawar, Dr. Ashok Shankarrao Pawar	Economics	43-45
13	A Critical Study of Special Economic Zones in India	Dr. Shankar Ambhore, Dr. Dilip Arjune, Manish Parshuram Pawar, Dr. Ashok Shankarrao Pawar	Economics	46-48
14	Industrial Relations - Settlement of Disputes in India	Dr. Shankar Ambhore, Dr. Dilip Arjune, Manish Parshuram Pawar, Dr. Ashok Shankarrao Pawar	Economics	49-50
15	AMLA - ITS MEDICINAL USES	Manisha Gaur	Economics	51-52
16	The Role Of Total Quality Management In Higher Education	Ramesh B. Sakhiya	Education	53-55
17	Perceived Competencies Of Graduate Teacher Trainees In The Intensive Teaching Practice [I T P] Session	Dr M. Parimala Fathima, N.Sasikumar, M. Panimalar Roja	Education	56-58
18	Uchch Siksha Ki Rah Men Dushvariyan	Dr. Anup Chaturvedi	Education	59-60
19	Fault Diagnoses of Rotating Machinery with Advance Signal Processing Methods	Prof. Divyang H. Pandya, Prof. Ankit A. Darji	Engineering	61-63
20	A Hybrid Neural Network Approach for Wind Speed Prediction	S.N Deepa, K.gnana Sheela	Engineering	64-67
21	A Study on Phishing: Preventions and Anti-Phishing Solutions	V.Karamchand Gandhi, Prof R.Senthil Kumar	Engineering	68-69
22	The Killari 1993 Intracratonic Earthquake- a Comparative Study	S.S. Patil, K.L. Karkare, I.B. Ghorade	Environment	70-72
23	Cosmic Plants as Alternative Medicine	Dr. Sneh Harshendra Sharma	Environment	73-77

24	Green Initiatives for Reducing Carbon Footprint	Dr Mahalaxmi Krishnan	Environment Science	78-79
25	Prediction of Urban Sprawl in Hyderabad City using Spatial Model, Remote Sensing and GIS Techniques	S. Indhira Gandhi, Dr. V. Madha Suresh	Geography	80-81
26	Tectono-Provenance and Reservoir Rock Characteristics of the Tipam Sandstones in Parts of Upper Assam Basin	Dr. Pradip Borgohain	Geology	82-84
27	(Jansanchar Aur Bharatiya Samaj)	Dr Subodh Kumar	Journalism	85-86
28	An Overview of Industrial Disputes Settlement Authorities in India	Manish Parshuram Pawar, Dr. Ashok Shankarrao Pawar	Law	87-88
29	Innovative Method of Role Play for Developing English Language Teaching and Learning	K Rajkumar	Literature	89-91
30	Impact of Workers Participation in Management on Industrial Relations	Anuradha Averineni	Management	92-93
31	Consumers Preferences , Behaviour and Satisfaction with respect to banking services quality in Ghaziabad(NCR Region)	Prof(Dr.)H. P. Pandey, Mr. Ashish kumar Singh	Management	94-96
32	Factors Influencing Employee Branding in Higher Educational Institutions: A Special Reference to Management Institutions in Virudhunagar District in Tamilnadu	Jegadeeswari. Mani, Dr. S. Franklin John S.	Management	97-98
33	Evaluation of Service Quality in Internet Banking: An Empirical Study in Coimbatore	Ms. R. Gokilavani, Dr. R. Ganapathi	Management	99-101
34	To Study the Relationship Between Gender & Banking Preferences of Management Graduates at Ibmrd, Ahmednagar	Rajendrasingh Pardeshi, Gadekar Vithal Laxman	Management	102-103
35	FCB model of Advertising Strategy	Prof. Arvind Rathod	Management	104-107
36	Assessing Beneficiary Satisfaction with Service Delivery of Non Governmental Organizations (NGOs)	Dr Papori Baruah, Bhaskar Jyoti Barthakur	Management	108-111
37	Current Trends in Human Resource Management	Dr. Kalyani Kenneth, Mrs.R.Aruna jayamani	Management	112-113
38	“Indian Banking – A Future Ahead”	Haresh B. Barot	Management	114-116
39	Financial Inclusion-Banking Services to the Common Man	Dr. M. Venkata Subba Reddy, Mr. M.s.udaya Banu	Management	117-118
40	A study of Service Marketing Mix w.r.to b-schools in Mumbai	Dr. Balaji S. Mudholkar	Management	119-120
41	A Study on the Customers Opinion on the Benefits of the Credit Cards Around Combatore District	Mrs. G. Murali Manokari	Management	121-123
42	A Study on the Job Satisfaction of the Employees at Sri Kannan Departmental Stores, Coimbatore	Mrs. G. Murali Manokari, Mrs.r.kanaka Rathinam, Mr. G. Lenin Kumar	Management	124-126
43	Foreign Direct Investment In Indian Retail Sector: A Critical Evaluation	Dr. Raghavendra Dwivedi, Ram Kumar	Management	127-128
44	Emerging Challenges to Cyber Security-Internet Monitoring with Specific reference to National Security	Triveni Singh	Management	129-131
45	An Empirical Study of Consumer Impulse Buying Behavior in domestic Markets (special reference to Ahmednagar, (M.S) India.)	Gadekar Vithal Laxman	Marketing	132-135
46	Insomnia and the performance of general population: Results from the Insomnia Survey	Miss Ketaki Sathe, Dr G S Shekhawat	Medical Science	136-137
47	Transition in Human Resource for Health: Challenges Ahead	Dr. Pawan Kumar, Dr. Abdul Majeed Khan	Medical Science	138-139

48	Kartageners Syndrome- A Case Report	Dr. Ramakrishna Ghubde, Dr. Archana Shekokar	Medical Science	140-141
49	Perceptual challenges in auditory neural processing in neurodegenerative conditions like Fredereich Ataxia	Mr. Ayas Muhammed, Ms. Archana, Dr. Rajashekhar	Medical Science	142-143
50	Transient Auditory Dysynchrony Due to Non-Maturational Causes Evidenced by ABR – A Case Report	HariPrakash. P, Sangeetha. G, Bhargavi P.G	Medical Science	144-146
51	Study on Sphenoid Sinsuses Variants in Magnetic Resonance Imaging of South Indian Population	Suresh Sukumar, Sushil Yadav	Medical Science	147-148
52	A Study to Find out the Prevalence and Effectiveness of Occupational Therapy Intervention for Pain and Activity Performance in Mobile Users with Risk of Repetitive Strain Injury	KR.Banumathe, V.Guruprasad, Leena Ann Lukose	Medical Science	149-151
53	Modified Falls Behavioral Scale for Indian Community Dwelling Older Adults	V.Guruprasad, Sebestina A D'Souza, KR.Banumathe	Medical Science	152-154
54	The Essence of Employees Training and its Impact on the Work Force in an Industry	Dr. Mohan Singhe	Organization Behavior	155-156
55	Scientific Behaviourism of Watson and Hull : A Philosophical Perspective	Dr. Jatinder Kumar Sharma	Philosophy	157-158
56	The growth of manganese oxide thin films by spray pyrolysis technique	M.Sudha, P.Duraisamy	Physics	159-161
57	Terrorism and Competitive Terrorism in India	S. Sreejith, P. Sakthivel	Political Science	162-164
58	Kuposhan Se Karahta Bachpan	Dr. Anup Chaturvedi	Social Science	165

Volume : 1 | Issue : 2 | July 2012 • ISSN No 2277 - 8179

Research Paper

Prediction of Urban Sprawl in Hyderabad City using Spatial Model, Remote Sensing and GIS Techniques

Geography

KEYWORDS : Urban Sprawl, SLEUTH, GIS and Remote Sensing

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ABSTRACT

This paper presents a study that integrates Remote Sensing, GIS, and dynamic spatial modelling for predicting urban spatial growth, given the different development conditions. The prediction is based on SLEUTH, a modified Cellular Automata model consisting of an urban growth and land cover change transition sub models was chosen to calibrate urban growth in Hyderabad city. The calibrated model allows us to fill gaps in the discontinuous historical time series of urban spatial extent, since maps and images are available only for certain period between 1950 and 2004. Using the model a spatial forecast of urban growth is done till 2055. The predicted mode of growth in Hyderabad is organic or edge growth and road influenced growth due to very high coefficient of spread and road gravity. This study reveals that there will be increase in urban growth of 120% between 2005 and 2055.

1. INTRODUCTION

The urban sprawl refers to the areal expansion of urban concentrations, it refers more to the pace and magnitude of land conversion to urban use and areal expansion of the city. As the city expands in area with more population growth the land use gets changed with the hitherto non-urban areas like forest, agricultural lands, other vegetative areas, water bodies etc., getting replaced by concrete structures and black-topped roads (Strahler, 1975). The main aim of this study is to apply spatial modeling for urban growth prediction from 2005 to 2055 using Remote sensing and GIS.

2. STUDY AREA

Hyderabad, the historic beautiful city is the capital of Andhra Pradesh, India and extends from longitude 78° 23' to 78° 33'E and latitude of 17° 17' to 17° 31' N. The study area shown in Figure 1 covers about 217 km2 and encompasses the administrative districts in the integrated town and city planning scheme which are greatly influenced by urban sprawl.

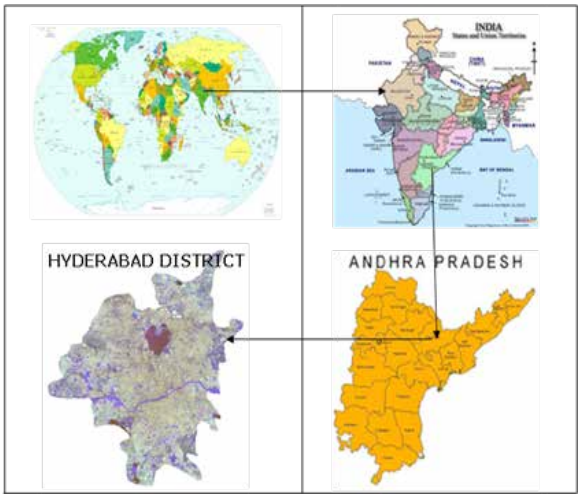

Figure 1: Study Area

3. THE SLEUTH MODEL

SLEUTH is a modified cellular automata model which consists of an urban growth sub model and a land cover change transition sub model (Clarke, 2002). The urban growth model is the main component of SLEUTH which is tightly coupled with the land cover change transition model (Silva and Clarke, 2002). SLEUTH simulates four types of urban land use dynamics: Spontaneous growth, New spreading center growth, Edge growth and Road influenced growth (Clarke et al., 1997). The growth rules are applied sequentially during each cycle and are controlled by five coefficients, namely: Diffusion, Breed, Spread, Slope Resistance and Road Gravity.

4. MATERIALS AND METHODS

4.1 Data sources

This study utilized data from various sources, including GIS digital data, satellite images and topographic maps. The satellite data for the study area were received from NRSC and topo maps from Survey of India.

4.2 Data Preparation

The input data requires by the SLEUTH model includes Slope, Land use, Exclusion, Urban extent, Transportation and Hillshade. Data preparation depends greatly on GIS and remote sensing techniques, for example, data conversion, reclassification and data import/export. The software used for preparing the input data includes ERDAS Imagine version 8.5, ArcGIS version 9.1 and Adobe Photoshop version 7.0

Input data for the study area is prepared at three resolutions to calibrate the SLEUTH model. The cell size of images 200m, 100m and 50m corresponds to the resolutions of 120 m, 60m and 30m. The selection of these spatial resolutions was based on Dietzel (2003) and Candau (2002).

4.3 Calibration of SLEUTH Model

The calibration has been carried out based on SLEUTH version 3.0 beta program. The code is written in C programming language, and supports three modes: test, calibration, and prediction. For this study, all three modes viz. test calibration and prediction modes are used. The model is operated by a Linux Redhat version 9.0 on PC microcomputer. All input grey scale .gif images at different resolutions are verified in the SLEUTH test mode. Brute-force calibration involves fitting the model to historical data on land use, transportation, and urban extent. Using the best coefficients derived from calibration, SLEUTH is run for the historical time period to initialize forecasting. Coefficient values are shown in table 1 which is derived from forecasting mode to predict growth of the study area.

Table 1: Coefficient values to predict growth:

Coefficient Type	Prediction Best Fit Value
Diffusion	1
Breed	1
Spread	79
Slope	31
Road Gravity	49

5. RESULTS AND DISCUSSION

When the calibration mode is completed, the results are used for forecasting studies in the prediction mode. SLEUTH forecasts rely on replicating growth trends from the past. Once a coefficient set is found that can best describe how urban change has occurred over time, these values are used to forecast future growth.

Volume : 1 | Issue : 2 | July 2012 • ISSN No 2277 - 8179

The urban expansion in Hyderabad City is a mixture of spread and road gravity expansion. The urban expansion is mainly by spread (about 79), but is resisted by slope. The reason for the urban expansion is due to IT industries, educational institutes and historical/tourist places. The high Road Gravity coefficient value derived from final calibration (49) indicates the abundance of urban growth along the road side and as a result many new buildings or urban centres are being developed on road side. The spread value is adjusted to the local characteristics at the final calibration.

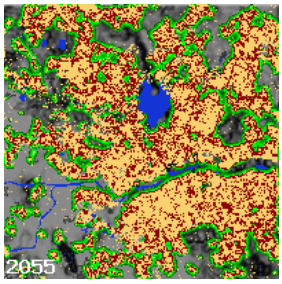

Figure 2 Predicted Urban Growth of Hyderabad City

The predicted urban area change in Hyderabad City is shown in Figure 2 between 2005 and 2055. The prediction of the city continues to expand more and more rapidly. Much of the growth in Hyderabad is now taking place due to the growth of the Information Technology (IT), Business Process Outsourcing (BPO) and other software services, which are increasingly concentrating in the outer areas that are designated for them by the State Government. Besides, large manufacturing and integrated Special Economic Zones (SEZs) are expected to be coming up in these areas. Film industry is also a major driver of the various services and of the employment generation. Recently, large real estate and construction activity has been playing a major role in the economic development and employment generation, and much of it is occurring in the areas outside the urban agglomeration.

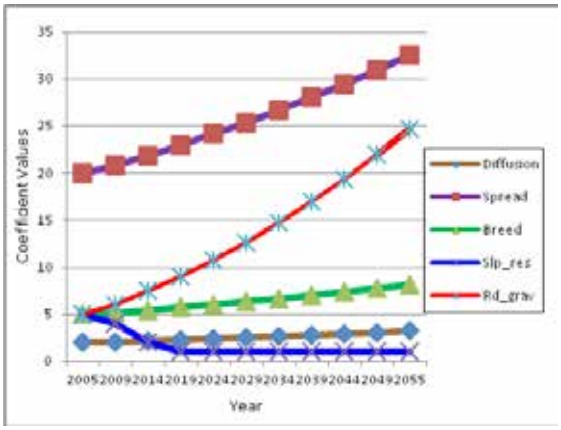

Figure 3 Modelled Future Urban Growth

It is seen from figure 3 that the spread coefficient is continuously increasing which indicates the Organic Growth of the city is continuously spreading. In the same way Road Gravity coefficient is also progressively increasing which indicates the Road influenced growth more along the road side. However, the rate of increase of Road Gravity coefficient is more than that of Spread coefficient. Therefore, the urban sprawl would be more influenced by the road than the organic growth in Hyderabad city beyond 2055.

The extension of urban sprawl of Hyderabad has been inhibited. The hitherto unoccupied area of places like Banjara hills and Jubilee hills are occupied. The boulders and tors which are lying protected are broken to be used for foundation stones of buildings coming up on the sites. In the northern direction the sprawl have crossed Bolaram and reached Hakimpet. As observed the pull factor is the Poultry farms and grape gardens, especially around Shamirpet. Some of the measures taken by the transportation department to develop Shamirpet lake as a holiday resort has been attracting people along the transportation artery linking the city with the lake. The areas along the Highway are being built up. The urban sprawl in Hyderabad city is not only in radial direction that is from the core of the city but also in linear along road sides.

6. CONCLUSIONS

SLEUTH provides key functionalities like interactive scenario development and the ability to visualize and quantify outcomes spatially. The availability and consistency of historic data sets, especially those that are earlier than satellite availability, is a potential issue for some applications. Empirical calibration of the model using Landsat TM image maps of past change aides the model predictions of future change. Calibration at high level of spatial detail remains a computationally intensive process, requiring sufficient use of a parallel computing environment and may prevent the use of the model by local or nongovernmental agencies where computing resources may be a limiting factor. Despite these considerations, we find SLEUTH to be a useful tool for assessing the impacts of alternative policy scenarios.

Calibration of the SLEUTH model for Hyderabad indicates a very high spread coefficient, which means that the predicted mode of growth in Hyderabad is organic or edge growth. Hyderabad has been experiencing organic or edge growth and road influenced growth due to very high coefficient of spread and road gravity. Among Hyderabad Urban Agglomeration (HUA), Municipal Corporation of Hyderabad is the major area that drives the population and urban growth in HUA.

The quality of the input data and the selection of optimal parameter ranges should be considered carefully to improve the calibration result. Since the calibration of SLEUTH is computer intensive, it should be implemented on a super computer or to be run on a parallel processing and high performance computing methods (e.g. cluster computer) in order to obtain the result in a timely manner. In conclusion, applying the SLEUTH model to Asian countries has just started and this being the first attempt in India, there is still a need for modelers to explore in more aspects of using this model. This calibration experience has provided us some insights to SLEUTH model and more understandings on how the Cellular Automata adapted to the urban environment in India.

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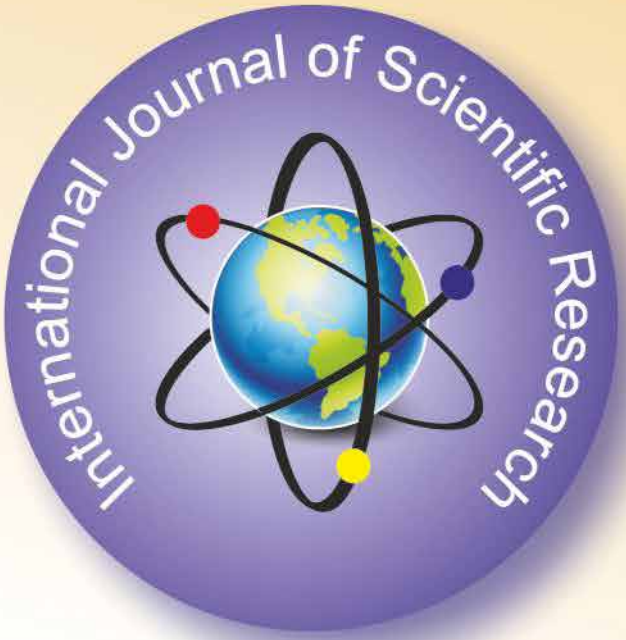

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