

# Simulating Land Prices and Jobs in Aurangabad City through OPUS: Open Platform for Urban Simulation

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**Abstract**— The paper present study on the land use model using UrbanSim in Aurangabad city of India country, as a case study on urban planning project. This project aims at advancing the modeling of interactions between land use and transport and adapting the software OPUS (Open platform for Urban Simulation) under the Indian context. UrbanSim is open source software-based tool intended to be used by Washington University, governmental institutions and planning agencies. The report documents the data acquisition, processing and definitions of the Aurangabad case study. The technical approach to create a base year for running a “first run” of UrbanSim. The study area was divided into gridcell system. The basic model of spatial analysis is used as residential location, employment location, real estate development, land price models. The models were simulated for the period 2010 to 2020. This has provided information regard to changes in population, employment, land prices, population density etc..

**Keywords**— *Urbansim, Geographical information system (GIS), OPUS, Modelling, Simulation, Opensource.*

## I. INTRODUCTION

Urban planner has many problems to respond to the process of planning and constructing a new system. Metropolitan areas have challenges in the process of setting an urban boundary, changing tax policy, or modifying zoning and land use plans, transportation and environmental quality. In the citizen concerns about managing the side effect of growth such as sprawl, congestion, having affordability and loss of open space. Upcoming problems like land use, transportation and other environment issues will be faced by urban planner in future. The UrbanSim is software-based simulation model which is used to address these questions and systematically issues.

UrbanSim is more general software platform to support integrated modelling, and has been launched with international collaboration to use it and also for further development under the Open Platform for Urban Simulation (Opus). Researchers can use it at beginner level modelling system support for land, transportation and environmental planning in metropolitan areas. [1] It is an open source platform that has been continuously refined and distributed for planning applications around the world for over 15 years. The project was motivated for development in urban areas for these need the system is modelled for predict the future year to plan in urban areas. The system has been

developed in python programming language. It is open source as freely available on [www.urbansim.org](http://www.urbansim.org) and using the GPL license [2]. Opus is motivated from different urban simulation project, by lesson learned from the ILUTE, UrbanSim and MATSIM projects. A similar project that provides inspiration for the Opus project is the R project ([www.r-project.org](http://www.r-project.org)).

Aurangabad city is governed by Municipal Corporation which comes under Aurangabad Metropolitan Region. The Aurangabad city is located in Maharashtra state of India. As per provisional reports of Census India, population of Aurangabad in 2011 is 1,171,330 [3]. The main goal of the case study is simulation on Aurangabad on basis of grid cell version which implies a fundamental model structure. Further targets of the case study are to:

- Implement a more detailed data structure,
- Improve the existing models and extend them through new models,
- Implement a workflow based on open-source software.

This project is designed to attempt to reflect the interdependencies in dynamic urban systems, focusing on the real estate market, employment and population. Simulation results obtained for the Aurangabad City are also presented in the paper. There are two objective of this paper. The first is introducing the UrbanSim/OPUS framework, related to work done with reference to Urbasim and existing application in OPUS. The second one is describe data and model structure Aurangabad. Final section describes priorities in future research and development.

## II. LITERATURE REVIEW

This literature review considers only research that has involved the use of UrbanSim directly. The literature related to UrbanSim is as follows:

Assessing Uncertainty in Urban Simulations was developed. A method for assessing uncertainty about quantities of interest using urban simulation models is called Bayesian melding. It extends a previous method developed for macro level deterministic simulation models to agent-based stochastic models [4].

Borning and Waddell have described about decisions regarding urban transportation investments system such as building a new light rail system or freeway extension, or changes in land use policies such as zoning to encourage compact development and curb low-density urban sprawl. It has significant and long-term economic, social, and environmental consequences [5].

Hana and Liming have proposed the Open Platform for Urban Simulation (Opus). It is a general framework for agile modeling in dynamic urban and environmental systems. It has been developed as a generalization of UrbanSim to provide a common and productive platform to enable modelers to rapidly develop and renew component models that can be integrated within a model system [6].

Borning and his team have developed model that is unusual in the degree of disaggregation of space, time, and agents, and in the adoption of a dynamic disequilibrium approach. The objective was to describe the entire system at a sufficient level of detail to convey the key specification and design choices made in implementing the system[7].

Waddell has describes the model system and its application to Eugene-Springfield, Oregon[8].

Paul Waddell and team have found contexts as varied as Detroit, Honolulu, Houston, Phoenix, Seattle and San Francisco and there were common elements to the tensions of appropriating a model system for their own use.[9]

Paul Waddell has provided an introduction to urban simulation, which are interpret broadly to mean operational models that attempt to represent dynamic processes and interactions of urban development and transportation.[10]

Hand and their team have described uncertainty using Bayesian melding, yielding a full predictive distribution of average commute times on 22 deferent routes in 2020. Of these routes, 14 did not include the viaduct and eight did. For each of the eight routes that did include the viaduct, the 95% predictive interval for the deference in average travel times between the two scenarios includes zero.[11]

David Simmonds has discussed options of modelling dynamics and argues for recursive or quasi-dynamics as a rational trade-off between theory and operationally in spatially disaggregate urban models. This has been illustrated by comparing how three existing recursive or quasi-dynamic urban models addressed temporal dynamics and pointed to applications of the three models in which the consideration of dynamics significantly added to understanding relevant policy issues.[12]

Liming Wang has worked on models predicted whether a worker would choose to work at home on a long-term basis by using census which have data. [13]

David Socha has studied on building simulations of land use, activity-based travel demand, and dynamic traffic assignment.[14]

An interactive agent-based behavioral modeling system as well as adaptive geometry generation algorithms for roads, parcels, and building envelopes. It was demonstrated interactive design and editing with a variety of examples of synthetic urban were reported spaces spanning over 200 square kilometers.[15]

Zachary and Mitchel have evaluated UrbanSim on two applications (Brussels in Belgium and Lausanne in Switzerland). The paper described a procedure to develop a prototype UrbanSim model and how to use it to evaluate UrbanSim for application to a new region.[16]

Pinjari and Bhat have described the significance of residential sorting or self-selection effects in understanding the impacts of the built environment on travel choices. Land use and transportation system attributes are often treated as exogenous variables in models of travel behavior.[17]

The advent of microsimulation approaches in travel demand modeling, wherein activity-travel patterns of individual travelers are simulated in time and space, has motivated the development of synthetic population generators. These generators typically use census-based marginal distributions on household attributes to generate joint distributions on variables of interest using standard iterative proportional fitting (IPF) procedures.[18]

A synergy of urban simulation, urban visualization, and computer graphics to automatically infer an urban layout for any time step of the simulation sequence. The method gathered data of the original street network, parcels, and aerial imagery and uses the available simulation results to infer changes to the original urban layout. The method produced a new and plausible layout for the simulation results [19].

### III. SOFTWARE PLATFORM

Opus is easy to integrate with other system that provides complementary facilities, such as estimation, Data visualization, data storage and GIS etc. This application requires some tools like ArcGIS, Hawth's tool; and databases MySQL, postgres, MS SQL server, SQLite and other as given below.

#### A. ArcGIS

ArcGIS Desktop is comprised of a set of integrated applications such as ArcCatalog, ArcMap and ArcToolbox. ArcMap is the main mapping application which allows users to query attributes, create maps, and analyze spatial relationships and layout final projects. ArcCatalog group spatial data contained on computer and various other locations and allows searching, previewing, and adding data to ArcMap as well as managing metadata and setting up address locator services (geocoding). ArcToolbox is the third application of ArcGIS Desktop. It is not accessible from the Start menu, it is easily retrieve and used within ArcMap and ArcCatalog. ArcToolbox contains tools for data projections, conversion, geoprocessing, coordinate systems and more. [20]. In this Aurangabad application, we have done zoning map in Arc Map as shown in fig.1.

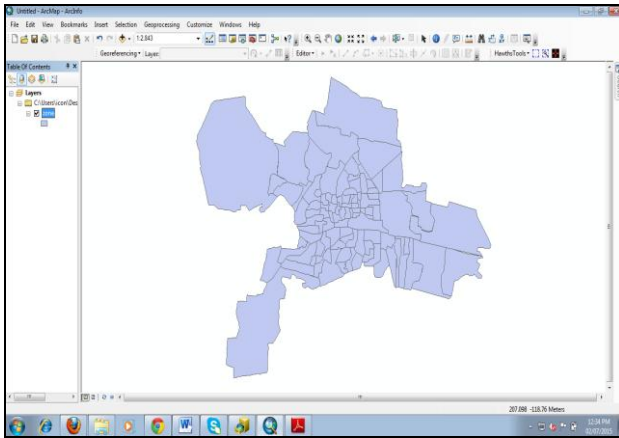


Fig 1. Zoning Map of Aurangabad city in ArcMap

### B. Hawth's Tools

Hawth's Tools is an add-on created for ArcGIS that provides a set of spatial analysis tools not included in the ArcGIS software. It's very helpful to have ArcGIS to calculate distances between points; In this project we used Hawth's tools to create grid on shapefile. Aurangabad\_Gridcell application has more than 15000 grid created by using this tool shown in fig 2.

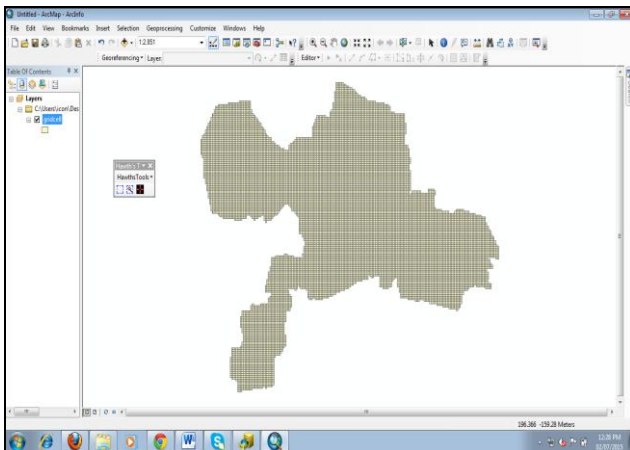


Fig 2: Gridcell map of Aurangabad by using Hawth's tools

### C. Opus/ UrbanSim

Open platform for urban simulation (OPUS) executed in the Python programming language. Python is high-level programming language. It has become widely popular in the modeling and GIS communities, due to its relatively rapid learning curve, development productivity, and the steadily increasing availability of specialized open-source libraries [6]. Model management includes creating, configuring and estimating models; Scenario simulation includes running and configuring a system of models. Figure 3 shows a typical work flow with Opus.

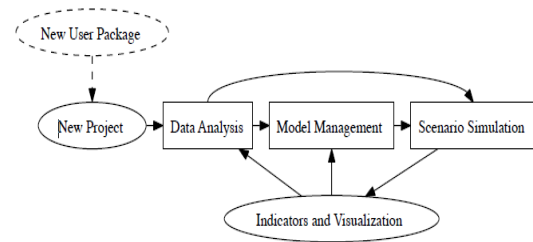


Fig 3: Opus work flow.

### D. Storage types

The storage of data in OPUS is as follows:

- ASCII, tab or comma delimited (CSV) files;
- SQL storage, which supports various relational database systems such as MySQL and Postgres;
- Dbase formatted files;
- ESRI formatted files;
- Numpy (Python) arrays on disk

### IV. APPLICATION ON AURANGABAD CITY

The Aurangabad metropolitan city is in Maharashtra state at south west of India country and a fertile agricultural region that contains most of the economic activity in the state. Aurangabad city is a rapidly developing as metropolitan area with population 1,171,330 as per the year of 2011[3].

The procedure is used to develop Aurangabad\_gridcell application is illustrated in fig 4. We can follow the following procedure to develop new application in Urbansim. The procedure we refer there as iterative improvement and can be divided into two parts: familiarization and implementation as shown in fig. 4.

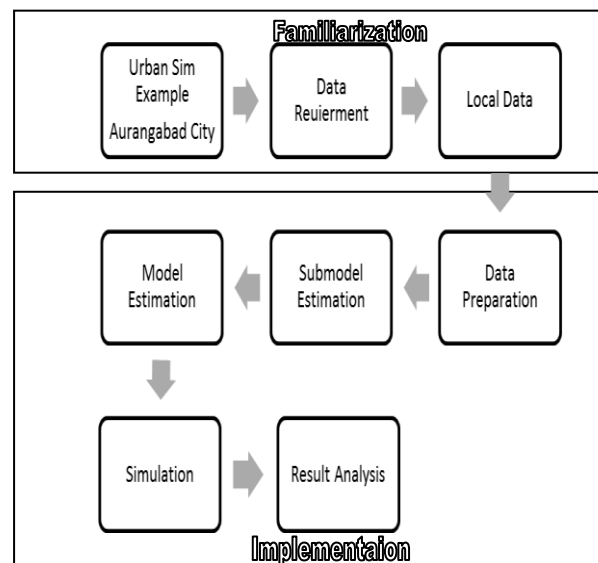


Fig .4: Procedure to develop Aurangabad Urbnsim Models

### A. Familiarization

In the case of Aurangabad, no data on buildings were available. Because buildings could be “created” to house the jobs and households for which we did have data. The study region includes ward-wise data; the following figure 5 shows the 98 ward in Aurangabad city. Some necessary data were not available, that is: land prices, improvement values or surface area requirement by job.



Fig 5: 98 ward in Aurangabad city.

### B. Implementation

In this stage tables are prepared to be put in the database, the various location choices and land price models are estimated. Simulations are performed and analyzed.

#### a. Data preparation

In the case of Aurangabad, there was no readily-available land-price data so gridcell population and employment density were used as proxies. This seems to have worked quite well with “land-price” consistently being statistically significant with the “correct” sign in all of the models to be estimated. The actual data disaggregated population, employment land-price and building etc. would have been ideal, obtaining these data would have mostly lengthened the time needed to develop a preliminary model. In gridcell application is focuses on the six tables: the gridcell, jobs, buildings, and development event history and development constraint tables. These are tables which required most data and iterative in construction shown in fig 6.

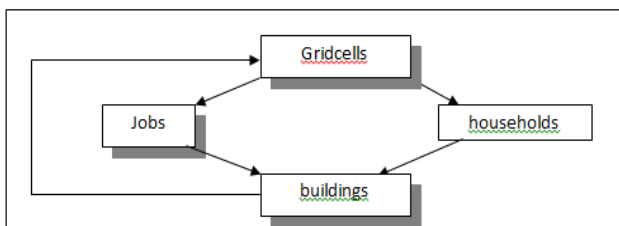


Fig 6: Iterative construction of gridcell

#### b. Model Estimation

Once basic data has been designed, the land-price models, household model, employment model and location choice model must be modified to the new region. These models are estimating using the baseyear database done relatively easily. Appropriate developing models need some analysis on parameters such as the distribution of jobs and households in the region. Some part of this analysis can be done directly in UrbanSim which uses Matplotlib to produce maps for variables of interest [16]. The quality of the models is hard to evaluate without seeing simulation results so it is good to estimate these models relatively quickly knowing that they can be enhanced after analysis of simulation results.

TABLE I. LAND PRICE MODEL ESTIMATED RESULT.

Coefficiant_name	Estimate	Std. Error	t-value
constant	9.901	0.073	135.456
bflood	-0.208	0.035	-5.852
bldhw	-0.040	0.009	-4.409
bwet	0.316	0.057	5.491
cbdtrvl	-0.077	0.002	-28.254
hwy	-0.422	0.057	-7.375
ln_duw	0.160	0.006	24.926
ln_impval	0.092	0.001	49.241
lru	0.174	0.009	19.332
pctdevwal	0.011	0.0004	24.791
pcthiwa	0.002	0.0004	5.631
Number of observations:	14771		
R-Squared:	0.762		
Adjusted R-Squared:	0.762		
Suggested  t-value  >	3.098		

In the case of Aurangabad\_gridcell application, we have considered residential location, employment location, real estate development, land price models. The table 1.1 shows the result for land\_price\_model.

In the table 1, Coefficiant\_name is Unique name of a coefficient, estimate is the estimated value of this coefficient, Std. Error is the standard error of this estimated value and calculated by using formula (1). t-value is The t-statistic of this coefficient for the test of significance from 0 and can be calculated by using formula (2) asgiven below. These both are reference only and is not used by UrbanSim.

$$SE_{\bar{x}} = \frac{s}{\sqrt{n}} \quad (1)$$

Where, S is the sample standard deviation (i.e., the sample-based estimate of the standard deviation of the population), and n is the size (number of observations) of the sample



$$t = \frac{|\bar{X}_1 - \bar{X}_2|}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}} \quad (2)$$

Where, n is number of items in each data set (n), X represent mean, S represent variance.

### c. Simulation and Result

The simulation on Aurangabad City was done using the tool. The simulated result corresponding to jobs and land prices are shown in fig. 7 and 8, respectively for the year starting from 2010 to 2020. The simulated result corresponding to land price are in excellent agreement with actual land price during 2010 to 2020.

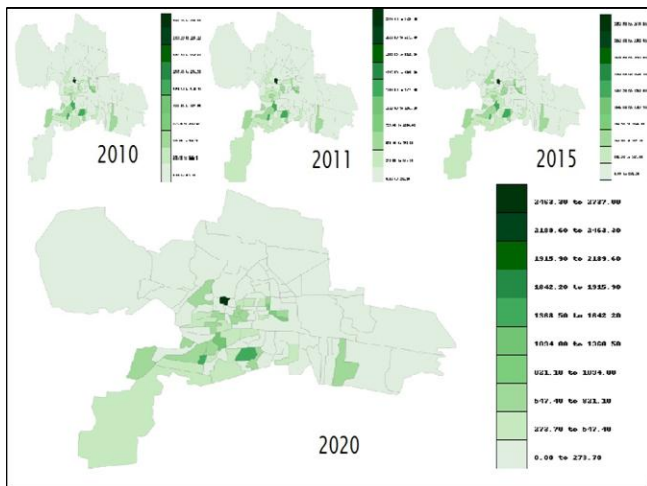


Fig 7: simulating Number of Jobs 2010-2020 in Aurangabad City

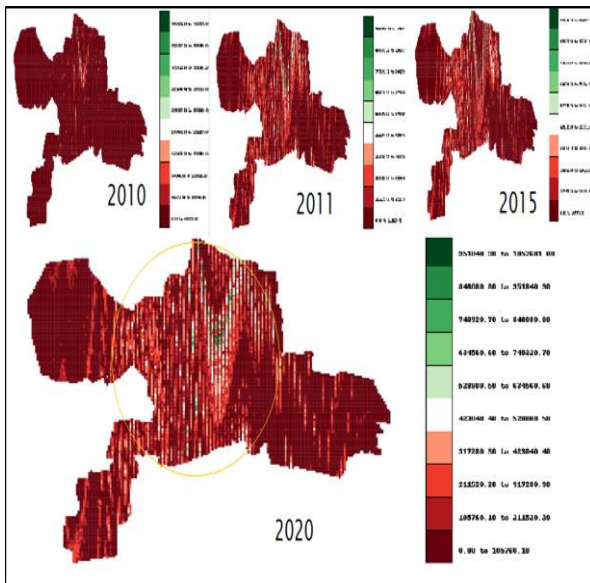


Fig. 8 : Simulating Land prices 2010 - 2020 in Aurangabad city.

Figure 9 shows the simulated price of the land in the year 2020 along with the base price of 2010. It can be seen from the figure 9, the price at some grid drastically by 125% and some region, the price also decreases. This is due to development of some region, and some region have not developed during simulated period.

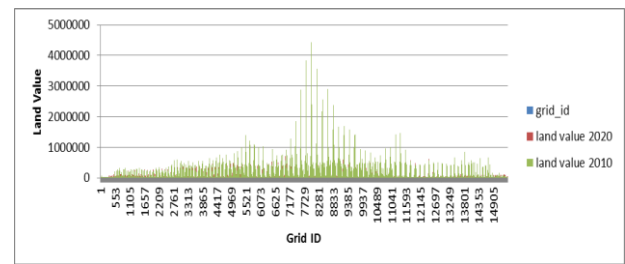


Fig. 9: Difference between land price 2010 and 2020.

### V. CONCLUSION

The purpose of this paper was to describe a procedure to develop prototype UrbanSim models and describe how to use these models to evaluate UrbanSim for planning or research purposes. The six tables which correspond to data related to various parameters of Aurangabad for the base year 2010, have been prepared and used to simulate these parameters for the consecutive year upto 2020. The simulated results found to be in excellent agreement with the available result. It can be seen that the urbansim tool is very useful for urban planning.

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### REFERENCES

- [1] Nilesh shingne, Sagarkumar meshram, Deepa ramteke, "Simulation of Urban Area through OPUS: Open Platform for Urban Simulation", IJCSIT in 2015.
- [2] www.urbansim.org/background viewed at 3-6-2015.
- [3] http://www.census2011.co.in/census/city/360-aurangabad.html viewed at 7-6-2015.
- [4] Hana, Adrian E. Raftery, Paul A. Waddell (2007), "Assessing Uncertainty in Urban simulations Using Bayesian Melding", Transportation Research Part B: Methodological, Volume 41, Issue 6, Pages 652-669.
- [5] Alan Borning, Paul Waddell, Ruth Forster, "UrbanSim: Using Simulation to Inform Public Deliberation and Decision-Making" Digital Government Integrated Series In Information Systems Volume 17, 2008, pp 439-464.
- [6] Hana, Liming Wang, Paul Waddell, Alan Borning. "Agile Modeling for Urban and Environmental Systems: The Open Platform For Urban Simulation" in 2012.
- [7] P. Waddell, A. Borning, M. Noth, N. Freier, M. Becke, G. Ulfarsson, "Microsimulation of Urban Development and Location Choices: Design and Implementation of UrbanSim", Networks and Spatial Economics, January 2003, Volume 3, Issue 1, pp 43-67.
- [8] Waddell, P. (2002), "UrbanSim: Modeling urban development for land use, transportation, and environmental planning", Journal of the American Planning Association 68(3), pages 297-314.
- [9] Paul Waddell (2004), "Introduction To Urban Simulation: Design And Development Of Operational Models", Handbooks in Transport series, Volume 5, pp 203-206.
- [10] Waddell, "Integrated Land Use and Transportation Planning and Modelling: Addressing Challenges in Research and Practice", Transport Reviews, in 2011, 31: 2, 209 - 229
- [11] Hana Sevcikova, Adrian E. Raftery, Paul A. Waddell (2011), "Uncertain Benefits: Application of Bayesian Melding to the Alaskan Way Viaduct in Seattle", Transportation Research Part A: Policy and Practice, Volume 45, Issue 6, Pages 540-553.

- [12] David Simmond, Paul Waddell and Michael Wegener, (2011) ,“Equilibrium v. dynamics in urban modelling the Symposium on Applied Urban Modelling”, Innovation in Urban Modelling" at the University of Cambridge, page 23-24.
- [13] Liming Wang, Paul Waddell, and Maren L. Outwater (2010), “Incremental Integration of Land Use and Activity-Based Travel Modeling Workplace Choices and Travel Demand”, Transportation Research Record: Journal of the Transportation Research Board, DOI: <http://dx.doi.org/10.3141/2255-01>.
- [14] Paul Waddell , Alan Borning , Hana Sevcikova , David Socha, (2006), “Opus (the Open Platform for Urban Simulation) and UrbanSim 4”, Proceedings of the 2006 international conference on Digital government research, May 21-24, 2006, San Diego, California
- [15] Carlos A. Vanegas , Daniel G. Aliaga (2009), “Interactive Design of Urban Spaces using Geometrical and Behavioral Modeling”, International Conference on Computer Graphics and Interactive Techniques.
- [16] Zachary Patterson and Michel Bierlaire (2008),“Development of Prototype UrbanSim Models” ,Association for European Transport.
- [17] Pinjari, Pendyala, Bhat, and Waddell (2007) “Modeling Residential Sorting Effects To Understand The Impact Of The Built Environment On Commute Mode Choice”, Transportation September 2007, Volume 34, Issue 5, pp 557-573.
- [18] Ye, Xin, Konduri, Karthik Charan, Pendyala, Ram M, Sana, Bhargava Waddell, Paul,(2009)“A Methodology To Match Distributions Of Both Household And Person Attributes In The Generation Of Synthetic Populations”, Transportation Research Board 88th Annual Meeting, 09-2096.
- [19] Carlos A. Vanegas, Daniel G. Aliaga, Benes, Paul Waddell “Visualization of Simulated Urban Spaces: Inferring Parameterized Generation of Streets, Parcels, and Aerial Imagery”, IEEE Trans Vis Comput Graph. 2009 May-Jun;15(3):424-35. doi: 10.1109/TVCG.2008.193.
- [20] “Introduction to GIS Using ArcGIS Desktop 10”
- [21] <http://www.drew.edu/wp-content/uploads/sites/82/Hawths-Tools-Tutorial.pdf> vied at 25-6-2015.