MODELLING LAND USE FOR ENHANCE DEVELOPMENT CONTROL SYSTEM: INTEGRATION WITH GIS AND MULTI CRITERIA EVALUATION

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Abstract

The information revolution in the 21st century has put major pressures on land administration activities in urban context. As a result of the advanced information systems, a bond with land development activities is created in local authority level and an efficient system for urban planning and development control. But most Third World cities, unable to get this advantages due to poor mapping and land administration systems. This badly effects on manipulation of effective and efficient development control system in urban areas.

Therefore, the main objective of this study is to identify GIS related efficient development control system for Colombo Urban Area, using limited land data. Hence this study attempted to develop a proper platform for land evaluation, using multi-criteria evaluation and thereafter developed a system for development control process, based on land parcel based digital data. Data were collected using parcel based field survey and analyzed using ArcGIS software. Municipal GIS extension was used for the development of development control system for study area. Results summarizes land evaluation model indicating three different land values such as Market value, social value and ecological value. Development control system helps to simply find field data in the office without any delays. The outcome of research highlighted effective development control system integrates with urban planning and GIS.

Key words: GIS Modelling, Development control system, urban planning, Multi criteria evaluation, Analytic Hierarchy Process

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1. Introduction

The rapid urbanization is undeniably one of the most prominent spatial processes of the twentieth century. In the beginning of this century, the majority of world population will be living in towns and cities. Especially in third world countries this transition leads to a haphazard urban development and the effects call the need for developing a sustainable manner. Land is indeed an essential ingredient in employing various activities in the urban context. Thus it is needed to concentrate on getting a better regularization of the land due to its scarcity.

Firstly, in 1948 Town and country Planning Act in Britain introduced the town and country planning system to regulate the urban development and the use of urban land. After that most countries developed a broad range of land administration systems manually with weak linkages. The information revolution in the 21st century has put major pressures on these historical institutional activities especially in the urban context. As a result of the advanced information systems, a bond with land development activities is created in local authority level and an efficient system for urban planning and development control has been developed. Appropriate and efficient land information greatly improves the quality of planning. Nature of land information is descriptive, predictive or prescriptive and creation of accurate information with manual methods is difficult. GIS technologies address to avoid above difficulties and it provides numerous functions for efficient management of geoinformation. (Wegener, 1998).This has been evident in the areas associated with the management of spatial information which incorporates cadastral land and geographic information systems. Presently, it is widely recognized that GIS still needs focus on new analysis and modeling methods if it is to achieve as a tool for environmental and urban planning (Goodchild, 2000). Nowadays the technology plays a key role in the spatial infrastructure services for urban planning management and decision making. An efficient spatial information system adds a profound impact on the effective planning and development control system to address various urban issues.

Local authorities are the key players in the planning process, as decision makers and also as service providers. Development local control is one of the major activities in the local authority and it determines how planning principles should be applied. GIS based spatial information provides fast, strong and direct links with real world activities. The abstraction of the real world

to construct the conceptual model unavoidably results in differentiation between objects of the real world and their representation in GIS. (Burrough, 1990.) Land use analysis has been an important discipline of GIS applications since the inception of technology in the early 1970s. (Tomlinson,1967) GIS has also played a critical role in diverse types of land related applications in the late 19th century.

Given the dynamic nature of planning and management carried out at local level, it is not surprising that the local authorities become one of the largest users of GIS in advanced and developed countries. But, there are number of drawbacks of urban planning in most third world cities as a consequence of poor mapping and land administration systems. Most of the developing countries face problems in spatial data especially in cadastre maps, in creating their own information system for managing urban data.

In Sri Lanka, only a small number of urban Councils and Municipalities have already done maps in GIS. However, the previous reluctance of local authorities to accept the challenge to embrace the technology due mainly to lack of support from the management level, the lack of in-house expertise to make use of the system and the high cost of GIS has been countered by the support given directly by the Government in realizing the concept of e-planning.

Development control system in Sri Lanka imposes under Urban Development Authority Act No. 1978 it is regularized under planning regulations in Urban Development Authority. Urban Development authority introduced planning and building regulations for urban planning in Sri Lanka. It is completely based on manual method it create many delays in the approvals and controls. Hence this study aims to develop method to evaluate urban land with limited land spatial information for develop efficient development control system using GIS.

Therefore, this study mainly identified following questions to develop efficient user friendly system with limited resources. The theme that runs throughout the study is how could major land use processes in Local Government be improved with the support of an information system? It is decomposed to three areas of concerned as follows.

- How does local government conduct land use planning and evaluation?

- How should information system connected with land use with limited information?
- How would the system work when implemented through limited resources?

Based on that, the main objective of the study is to identify GIS related efficient development control system in Colombo Urban Area. For achieve above main objective following specific objectives were developed.

- To examine existing conditions and practices of land use planning and monitoring in local government.
- To develop GIS model as a basic guideline of development control
- To develop new system for development control in the case study area.

2. Research Design

In the stage of development of research design, concepts of urban land use planning were concerned as a setting idea in the research. Urban land use planning and management is a principal guide be in command of haphazard development and enables optimum utilization of land.(Kaiser,et,al, 1995) With in this context, optimum land utilization plays an important role confirm the efficiency of cities. Therefore, the concept of the optimum utilization or highest and best use of land is, essential to be ensured by land planners so that a particular land is utilized establishing equilibrium between social and market highest and best use. Barlow (1986) pointed out "land is ordinarily considered at its highest and the best use when it is used for that purpose or that combination of purposes for which it has the highest comparative advantage and least comparative disadvantage." Further Kaiser et, al., (1995) introduces some interesting concept about land use change management process and it spotlight on conceptual model called "land use change management model". Land use change management model refer significance of balance between three sets of land values namely social use value, Market and Ecological values in particular land for achieving sustainable development. According to that a resolve of utilization of land in the urban area in sustainable manner is an urgent dialog in urban planning.

Setting of this land evaluation model is mainly based on the concept of land use change management model which was introduced on three land values appling to particular urban land. Thus combining this model to complex urban land evaluation is a tricky task and GIS minimizes

that gap via integrating multi-criteria evaluation. A number of steps follows for development of the model.

2.1 Development of Land evaluation map as a guide map

Land evaluation is mainly based on decision making in multi dimension scale. Also it focuses on multi disciplinary activity embracing environmental, socio economic and management related factors in different spatial scale. These decisions are conflicting with multivariate factors. Therefore effective coupling of these multiple factors in a spatial context is a key to land based decision making. Therefore, Multi-criteria evaluation (MCE) methods linked with geographic information systems (GIS) can be used to make such decisions. Mostly MCE called multi-criteria decision making includes both multi objective decision making and multi attribute decision making. (Janssen, 1992, Malczewski, 1996, Malczewski 1999, Malczewski 2006) These methods have an extremely wide range of applications such as urban and regional planning, land management, real estate management, natural resource management etc. Following the development of GIS diverse MCE methods have been applied to spatial dimensions. (Carver, 1991, Densham,1991, Eastman, 1997) Although numerous applications of MCE-GIS methods have been developed in the literature, very few research directly address the development of an MCE-GIS method for a same decision application(Zui, 1992, Bannai R,1989) . Among these applications a very few researches move toward urban land evaluation. In 1992, Zui developed Urban Land Evaluation Model Using Fuzzy set theory and Multi criteria decision making. This research is used as main literature of the development of the land evaluation model. However this research concerns it in different aspect.

2.2 Modeling Procedure

(a) To identify multiple criteria for decision making process

Set of suitability criteria needs to be discussed and formulated. Accordingly, following criteria are considered for this study.

Table 1 Criteria based on Land evaluation

Criteria	Definition of criteria
Land use	Land uses potential to develop
Land value	Land apply with less land value
Proximity to shopping center	Lands less proximity with shopping centers
Proximity to Main road	Lands less proximity with main road

Population density	Lands with less population density
Flood areas	Lands within flooding areas
Storm water catchments	Lands within storm water catchments areas.
Proximity to green area	Lands less proximity with green area

(b) The judgment of a Land evaluation modeling structure

It is focused to determine the factors affecting the land evaluation on the basis of an analysis of existing studies and knowledge. Here, judgments made by discussions with experts on urban planning can be applied. A criterion is a basis for a decision that can be measured and evaluated. Map Layers representing the each criterion as criterion maps.

(c) Producing Map Layers

A GIS application is used for managing, producing, analyzing and combining spatial data. The data needed in this study are produced from collected or existing data by using different kinds of spatial functions and analysis. Proposed here are only vector data structures. Figure 1 describes those map layers. Those criterion layers are based on available data in the study area. All these data descriptions have been able to be applied to each spatial unit in Colombo urban area. But, to apply of this model to other urban area, criteria must be revised according to the features in those areas.

(d) Cartographic Modeling

Cartographic modeling is applied in producing and combining spatial data describing the causing factors.

(e) The design of multi-criteria environment for Criterion weighting

Criterion weights are an imperative part of the MCE. There is a wide range of methods used in various researches. In this research use a Pair wise Comparison Method for determine the weights for each criteria. In 1980 Saaty incorporated it to the Analytic Hierarchy Process (AHP). It is used as a mathematical method of translating this matrix into a vector of relative weights for the criteria. By evaluating the criteria, the values of the criteria were classified to explain the opinions and preferences. Therefore preference elicitation for scoring is based on a mixture of implicit knowledge, personal experience and individual opinions.

First this method needs to compare evaluation factors with each other (pair wise comparison), including comparing the factor with itself. Secondly it will use a nine-degree scale to transform

the comparison judgments into numerical values. The nine-degree scale based on AHP is explained in Table 2

Table 2 Importance comparison of nine-degree based on AHP method

Degree	Description of pair wise comparison judgments
1	Factor i is equally important as factor j, or comparing i with i, or j with
3	Factor i is moderately more important than factor j.
5	Factor i is strongly more important than factor j.
7	Factor i is very strongly more important than factor j.
9	Factor i is extremely more important than factor j.
2,4,6,8	The importance is between the upper degree and lower degree.
Reciprocals	It is contrary to the above importance, namely factor j is more important than factor i.

Source: Saaty, 1980

Then a structural judgment matrix is generated by every factor's numerical value. After the normalization, the eigen-vector of the largest eigen value derived from the structural judgment matrix is the corresponding factors' weighting vector. (Saaty,1980)

(f) Sensitivity Analysis

The main purpose in sensitivity analysis is to examine how sensitive the choices are to the changes in criteria weights. This is useful in situations such as where uncertainties exist in the definition of the importance of different factors. Different decision makers may apply different criterion and assign different weights for each criterion according to their preferences. The decision maker selects the criteria and compares them in a comparison matrix. The weights of the criteria and the consistency ratio of weighting procedure were calculated in interface module.

(g) Standardization

Considering standardized criteria as fuzzy measures, where fuzzy set theory was emphasized, held the uncertain knowledge in multi criteria decision-making.

3. Methodology

In the research methodology, first it pays attention to the urban planning context, for developing a model. It concerned about the land use change management model and three different land values namely, market, social use and ecological. Secondly it needs to propose the desirable

criteria. After the stakeholder analysis for suitability, eight suitability factors in each main criterion will be selected to develop urban land evaluation model.

As such, two suitability scenarios will come out according to different sets of scores and weights, and certainty factors. It uses MCE to carry out the ranking among the above two suitability scenarios (alternatives). Sensitivity analysis is then used to test the validity of scores, weights and the ranking of alternatives. Thus, study makes a conclusion based on all the above analyses. If the model is satisfied, we can take the final best suitability factors into application. Otherwise, we have to turn back to select another set of suitability factors, repeat all the above steps and try to get a satisfied conclusion.

4. Development of GIS based system for efficient development control

Based on above guided land evaluation map develop a small information system based on numerous extension plug in for ArcGIS software known municipal GIS extension. MainStreetGIS has streamlined the GIS needs of town, city, and county governments with a turnkey approach that tackles the key components of a successful municipal GIS. Following prominent features can be easily identified through the program.

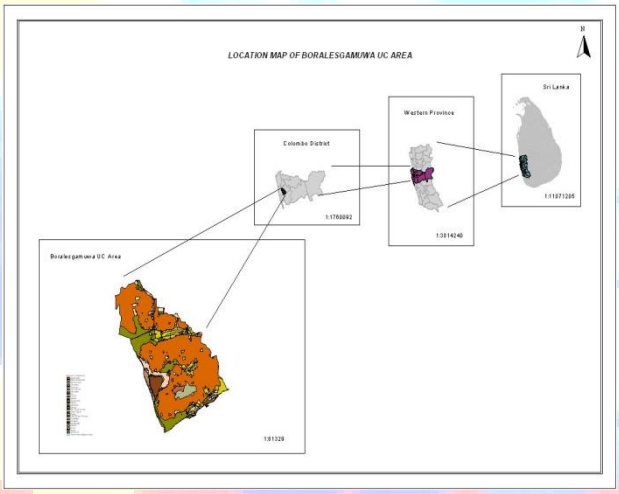
1. Main street attributes
2. Main Street Parcel Search
3. Main Street Spatial
4. Main Street Address Search
5. Main Street Search
6. Main Street Visibility
7. Main Street Bookmarks

Hence this extension is used to develop the information system t efficient development control system.

5. Study Area

After end of the civil war in 2009 urban development in Sri Lanka growing faster and Colombo Urban Area has been a massive urban growth. This growth has exited pressure on surrounding sub urban area. According to 2012 census total urban population in Sri Lanka is 14% and In western province consist of 70% out of total urban population in the country. Hence urban council located in the Colombo urban Area is selected as a case study area for test the applicability and feasibility of the GIS modeling process. Boralasgamuwa urban council is a medium sized urban council is close proximity to City of Colombo selected as a case study area. It is located in the Western province of the country and major transportation roots connected with three municipalities. Figure No 1 indicates the location of the study area.

Figure 1.



2001 Census figures stated that total population of Boralasgamuwa U.C. area is 56362. It has 5.37% of the total population in Colombo district. This town can be mainly identified as a service centre and also a commercial centre.

6. Analysis

6.1 Land evaluation Model

Development of GIS model is mainly based on multi-criteria evaluation process. Multi-criterion decision analysis is a process that transforms evaluation criteria into a preference ranking over a set of possible courses of action. Multi-criterion decision analysis techniques combine well with GIS and can contribute in the transformation of data into information. The data comes from a series of measurements concerning a variety of phenomena. These measurements enter into the definition of criteria, which influence the preference of the decision maker. Typically, a decision

maker involved in a problem of locating an obnoxious facility will use many different criteria to evaluate different options. The criteria are organized in two groups related to high ecological value and high development potential value. Multi-criteria analysis is used to establish a weighting of the preferences related to each of the criteria. Pair wise comparison method was selected for calculating weights and ranking of the criteria are important for comparisons.

The application of multi criteria evaluation process in this research explains as follows. MCE procedure consists of the following steps:

a) Define the Relevant Quality Parameters
b) Establishment of the Geographic Database of the Input Layers and identify relevant main criteria and sub criteria
c) Weighting process using pair wise comparisons
d) Calculate composite weights and apply to input layers

a) Definition of the Relevant Quality Parameters

An important criterion for defining relevant parameters is that they may be conveniently quantified in a geographic framework. The land evaluation model, which was developed in the chapter three, considers several quantified criteria under high ecological value and high development potential value. All above criteria have to be considered in the case study area except slope and soil factors. These criteria, which will be analysed are in Table 3

In the weighting process all these criteria are defined in a positive sense; thus, for example, less the noise pollution in a particular geographic location is, the higher will be the environmental quality; that land can be add high ecological value. Similarly, the proximity criterion means that, the land is not closer a location is to main shopping center; that land indicates high development potential value. After evaluation of those 2 factors following criteria was developed.

1. Land value
2. Land use
3. Proximity to main road
4. Proximity to shopping
5. Proximity to green area
6. Storm water catchments
7. Flood sensitive area
8. Population Density

It is important that all criteria are defined in the development potential sense. It means that, lands which are including high development potential values, put in high weights. Because,

- It is easier to make multiple comparisons when the evaluation scales have a similar orientation.
- The addition of various values to obtain an overall value is straightforward when "better" corresponds to a positive sense.

b) Establishment of the Geographic Database of the Input Layers

The qualitative perception of the criteria given earlier must be translated into a more precise quantitative definition in order to establish the geographic database of the data layers corresponding to the input criteria. Table 5.1 indicates available data sets for analysis. The Maps of different criteria presented Figure 2

c) Preference elicitations for pair wise comparisons.

The pair wise comparison is mainly based on preference elicitation, and every criterion under consideration is ranked in the order of the decision maker's preference. To generate criterion values for each evaluation unit, each factor was weighted according to the estimated significance for land evaluation and the AHP based evaluation scale was used to the nine degree pair wise comparison judgment, which is indicated in Table 2

Firstly, it is essential to demarcate the basic hierarchical structure. In this regard collect public and experts views based on structured interviews with a 100 sample survey. It includes 25% of expert's and 75% of public's covering the whole UC Area. All their opinions are considered in the demarcating basic hierarchy and it indicates in Table 4 Apart from that research conduct some reconnaissance survey for better clarification of the area. These judgments are used for the evaluation of sub criteria.

Table 3 Selected Development Potential Criteria for Land Evaluation

Criteria	Map layer	Description	Measureme	GIS
Land use	Land use map	Category 1 Category 11 Category 111	Nominal	Polygon overlay
land value	Land value map	Less than Rs 100,000 per perch Rs. 100,000 – 300,000 per	Interval	Surface analysis

Proximity to Main road	Road buffer map	Distance Less than 250 meters 250-500 meters	Interval	Buffer Analysis
Proximity to shopping	Shopping center map	Distance Less than 250 meters 250-500 meters	Interval	Buffer Analysis
Population density	Population density map	Less than 30 persons per ha. 30-60 persons per ha. 60-120 persons per ha	Interval	Selected polygons
Proximity to green area	Green buffer map	Distance Less than 100 meters 100-200 meters	Interval	Buffer Analysis
Storm water catchments	Storm water catchment	Water bodies Catchment area	Nominal	Polygon overlay
Flood sensitive area	Flood map	Water bodies Flood sensitive area	Nominal	Polygon overlay

d) Calculating weights by hierarchic analysis of nine-degree

After the preparation of basic hierarchy, it is needed to compare hierarchic analysis of nine-degree. The user first has to make a comparison for every pair of factors: first qualitative and then quantitative. As such, the experts including urban planners, environmentalists, and local government officials were invited to make the pair wise comparison according to the nine-degree scale. But local residents were excluded for that just because of their weak sense, which would make it difficult for them to use the nine-degree scale to make the pair wise comparison among the 14 suitability factors. The method then creates a structural judgment matrix based on the pairwise comparison judgments of these experts.

Figure 2: Criterion Maps

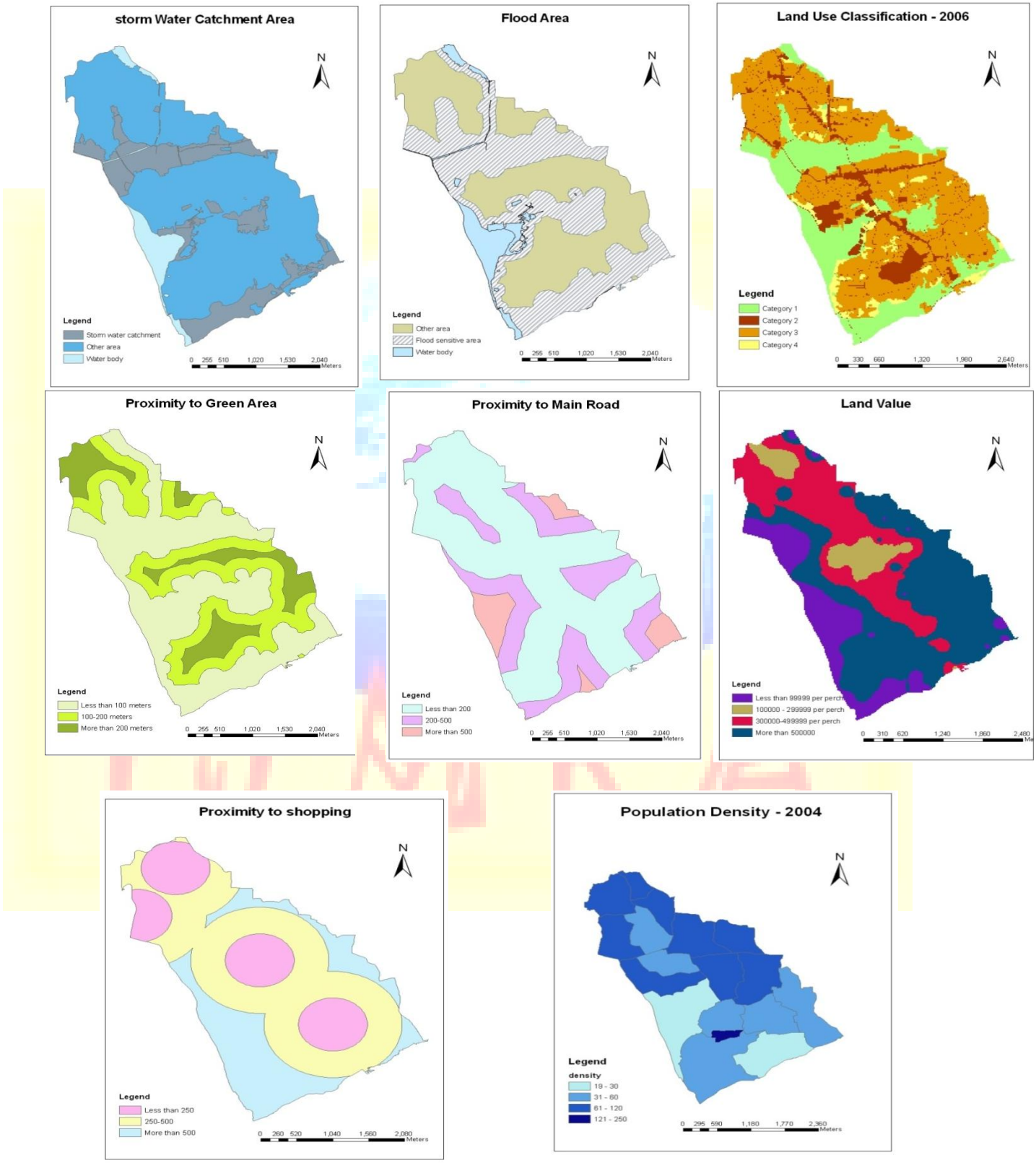


Table:4 Summery of field survey

Percentage of people interviewed					
		more	fairly	not	Priority
Flood Areas	54	35	9	1	2
Storm water drainage	35	38	25	2	3
Land use	56	27	10	7	1
Land value	36	42	13	9	4
Proximity to main road	45	26	26	3	3
Proximity to green area	35	38	22	5	7
Population density	24	52	23	1	6

Weights resulting from pairwise comparisons using AHP were derived for a group of variables by comparing pairs of alternatives, just like the name implies. Each variable was compared to all other variables in pair sets assuring that all alternatives were included in weight development. The weights derived using the AHP pair wise comparisons determined the strength individual goals exerted on the final suitability layer. The overall structural judgment matrix are stated in Table 5. The values in the following matrix were determined by using the rule of 'the minority should obey the majority'. Each criterion followed a pair wise comparison methodology using Expert Choice[@] software (www.expertchoice.com) (Malczewski 1999, Saaty 1980).

Table 5 Deriving relative Weights for Development Potential criteria

Suitability Criteria	Land use	Land value	Proximity to main road	Proximity to shopping	Storm water catchments	Population density	Storm water	Flood area facilities	Weight wi
Land use	1	3	3	3	5	5	7	7	**0.325**
Land value	1/3	1	1	3	5	5	7	7	**0.207**
Proximity to main road	1/3	1	1	3	5	5	5	5	**0.194**
Proximity to shopping	1/3	1/3	1/3	1	2	3	5	5	**0.103**
Population density	1/5	1/5	1/5	1/2	1	2	5	5	**0.072**
Storm water catchments	1/5	1/5	1/5	1/3	1/2	1	3	2	**0.046**

Flood area	1/7	1/7	1/5	1/5	1/5	1/3	1	2	**0.028**
Proximity to green area	1/7	1/7	1/5	1/5	1/5	1/2	1/2	1	**0.025**

The weights applied to sub criteria or second branch of hierarchy are now examined. All of above main criteria consist with sub criteria. Those sub criteria again classified as suitability classes namely high suitability, moderate suitability and no suitability. The description of suitability classes within factors are in Tables 6 to 12. The weights of every sub criteria are calculated using multi criteria evaluation based AHP method. Those basic judgments are based on my experiences among this research, reconnaissance survey and various discussions with several experts. Each criterion followed a pair wise comparison methodology using Expert Choice[@] software (www.expertchoice.com) (Malczewski 1999, Saaty 1980).

Table 6 Deriving Relative Weights for Proximity to green area

Criteria	High	Moderate	No	Weight
High	1	2	5	0.559
Moderate	1/2	1	5	0.352
No	1/5	1/5	1	0.089

Table 7 Deriving Relative Weights for Flood Areas

Criteria	High	Moderate	No	Weight
High	1	5	7	0.740
Moderate	1/5	1	2	0.167
No	1/7	1/2	1	0.094

Table 8 Deriving Relative Weights for Land Use

Criteria	High	Moderate	No	Weights
High	1	3	5	0.627
Moderate	1/3	1	4	0.280
No	1/5	¼	1	0.094

Table 9 Deriving Relative Weights for Land Value (000, per perch)

Criteria	High	Moderate	No	Weight
High	1	2	4	0.558
Moderate	1/2	1	3	0.320
No	1/4	1/3	1	0.122

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Table 10 Deriving the Relative Weights for Population Density persons per ha.

Criteria	High	Moderate	No	Weight

High	1	3	5	0.618
Moderate	1/3	1	5	0.297
No	1/5	1/5	1	0.086

Table 11: Deriving Relative Weights for Shopping Convenience

Criteria	High	Moderate	No	Weight
High	1	3	5	0.637
Moderate	1/3	1	3	0.258
No	1/5	1/3	1	0.105

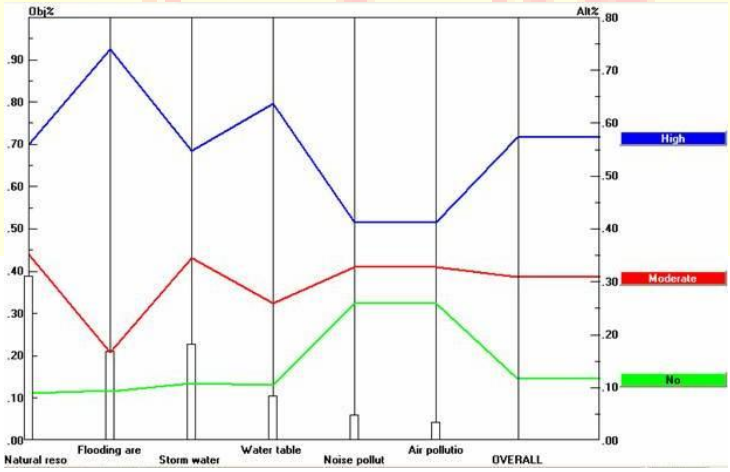
Table 12: Deriving the Relative Weights for Proximity to main road

Criteria	High	Moderate	No	Weight
High	1	3	5	0.637
Moderate	1/3	1	3	0.258
No	1/5	1/3	1	0.105

Sensitivity Analysis

Sensitivity analysis depends on the error in the input data as criterion weights and criterion attributes. The sensitivity between the Main two goals with its criteria was analyzed and it indicate figure 3. Analysis results indicate that those two goals and its main criteria are not so sensitive for this analysis. When the sensitivity of criterion values was analyzed, it was also seen that there were no significant changes in the ranking with small perturbations on the gradient of the main channel criterion.

Figure 3: Sensitivity Analysis



The final output of the land evaluation map shown in below incorporating various criteria**.** To arrive at the final suitability map composite weights were given calculated above. The degree of suitability

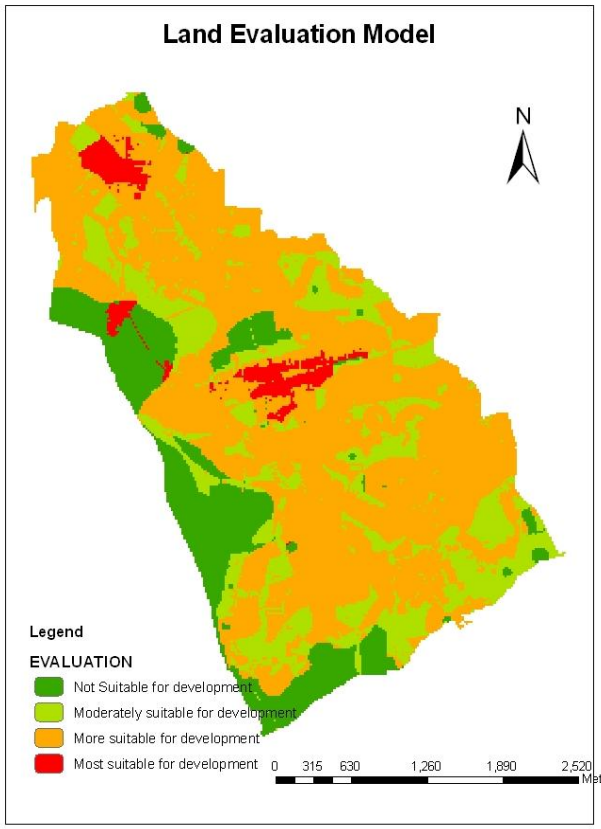
determining on those calculated composite weights are applied to each layer related to land evaluation. Finally fuzzy operation, union (A∪B) performed to overlay above seven digital files and obtained the final Land Evaluation map (Figure 4). The overlaying process was done according to the fuzzy maximum value concept. The composite values are ranged from 0.2135 – 0.0096. According to that land evaluation classification (Table 13) is as follows.

Table No 13: Classification of Land Evaluation

Weight Range	Classification
More than 0.2000	Highly suitable for development
0.1500-0.1990	More suitable for development
0.0926 – 0.1490	Moderately suitable for development
Less than 0.0926	Not suitable for development

The above four categories describe the status of urban land evaluation. Within these categories, highly suitable land for development and highly suitable land for conservation are very clear for planning. In particularly, the moderate category of lands is very important in decision-making process, because those are the areas with transition land uses. Therefore, planning decisions of these areas are essential to review in carefully. At this instant, study built superior platform for investigate overall background of the area. It is good observations for develop a system for setup efficient development control.

Figure 4 Final Result Map

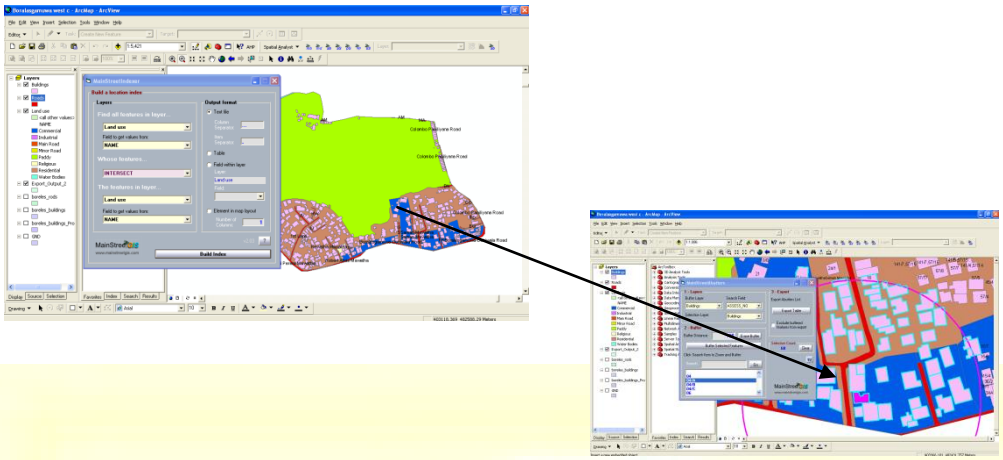


6.2 Land Information System

MainStreet GIS has been used for streamlined the GIS based system in the urban council area using ArcGIS. It used building and Road layers which are in the scale of 1:2000 digital data from Survey department. Field data are collected according to GN Boundary. Field data sheet was prepared for collection of data. Following features were developed based on above extension.

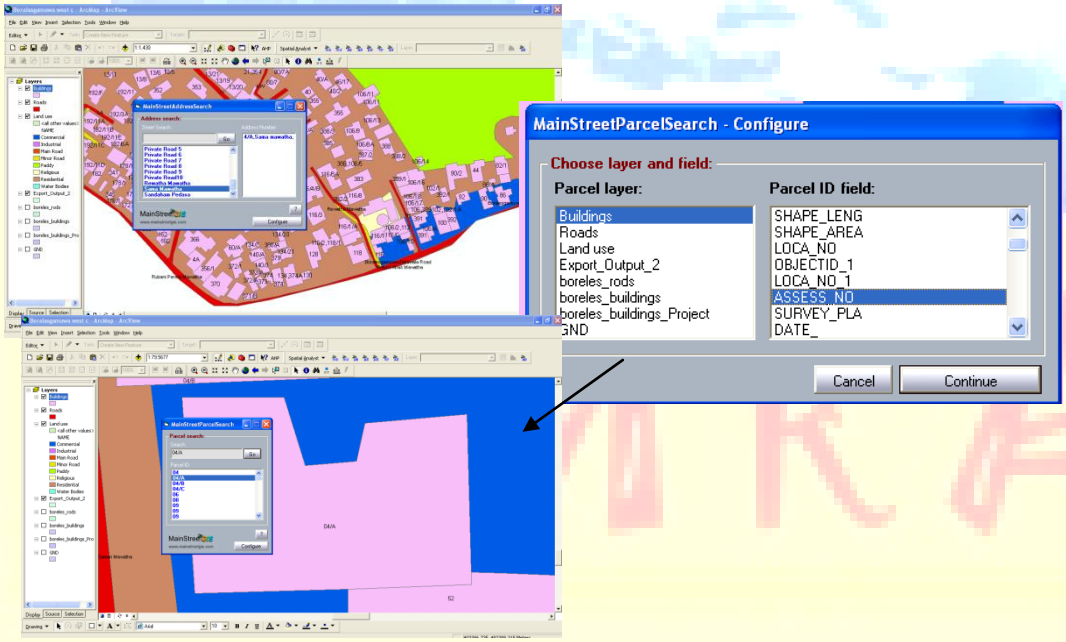
(a) Main Street attributes

Using MainStreetAbutters tool**,** that is easy to buffering and selection of map features. Also it is an amazing advantage for the development control system. The other advantage is Attributes from the selected features are exported to a table or viewed as mailing labels, envelopes, letters, and other customizable documents



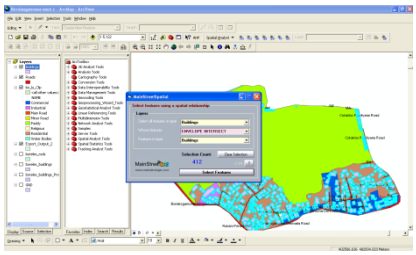
(b) Main Street Parcel Search

In the Configuration window, when we asked to select a Parcel Layer and a Parcel ID field from that layer. It helps to gather information without any delays.



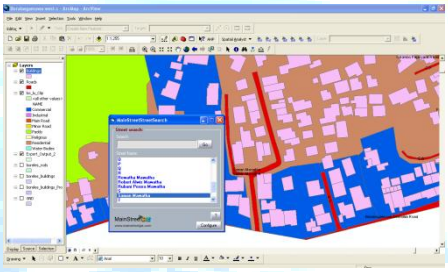
(c) Main Street Spatial

That selects features in one layer based on their spatial relationship to features in another layer. For example, select all Parcels that are contained within features from a Watershed layer.



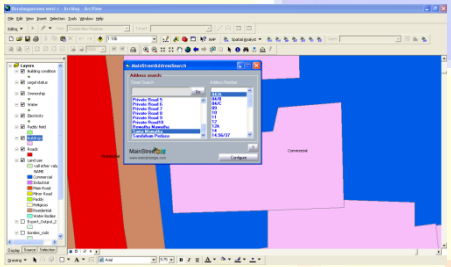
(d) Main street search

In the Configuration window, you are asked to select a streets and a Parcel of the streets from that layer. Then easily identified specific streets and parcels.



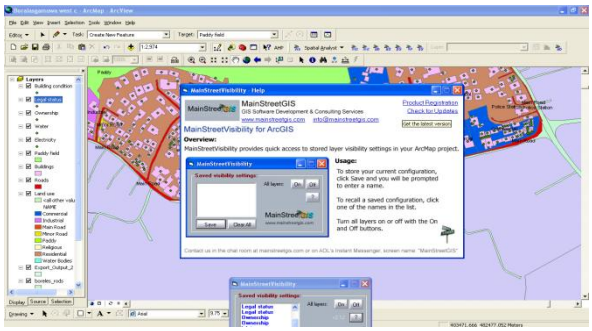
(e) Main Street Address Search

In the Configuration window, you are asked to select a Parcel Layer, a Street Name field, and an Address number field from that layer.



(f) Main Street Visibility

Save your current settings and apply them at a later time by clicking a name in the list.



The GIS database developed could be used by many parties involve in the process as reference point in evaluating a planning submission. Having access to the database will provide the flexibility in assessing a development and deciding on the overall urban growth management program in the most cost-effective manner. The development of Geospatial and Planning Information Subsystem consist of eight main data element, which contain 10 layers.

This ensures transparency and consistency in the development control procedure. The database developed is expected to enhance the overall process of planning and building approval through providing appropriate information for the specified purposes, while at the same time support strategic planning and rational decision making.

7 Conclusions and Recommendations

All factors directly concerning to the urban land have been taken into consideration for this Land Evaluation Model (LEM). Therefore this model is much closer to the concept of sustainable development. This model has been specially proposed for urban lands with the view to minimize the negative consequences of urbanization. The criterion adopted herein is common to Colombo Urban Area. This model also can be applied any sub urban center. Even though, the considerations to certain criteria such as location, natural resources and functions it would be changed. On such occasions, new factors, which have to be considered, should be added into the model. For an example in the case of the scared city of Anuradhapura, its lakes and reservations will have to be taken into consideration.

Secondly, the application of weights for this model is important. Computation of weights by expert choice computer package is easy. But lots of cases have to be exercised in the criterion of the pair-wise comparison matrix. Here the preference elicitation is a vital factor. In the pair-wise comparison system, each sub criterion should be compared and preference given.

Here the system followed to obtaining social factors, was the preference of people through a questionnaire survey. In this case it had to be exercised to collect well-balanced facts. Sample has to be selected to cover the whole area, all sectors of the society and on non-bias basis, since actual weights cannot be revealed. In the other hand where ecological factors are concerned the above-mentioned system cannot be applied to find the preference. Always it should based on scientific factors and such data have to be elicitation logically. Hence for calculating of weights in this model, these two methods had been applied. Although the manner mentioned earlier in this model, it can be applied similarly for any general urban area. To give weights for preference elicitation, based on data of the area is compulsory, since the weight relevant to study cannot be applied for another area. Taken into consideration of these facts, this model can be used subject to certain amendments to determine of any urban area in the future urban scenario. Obtaining the land evaluation map is the final result of this model.

In that context urban land has been identified under four categories. Mainly two parts have been identified; one is "highly suitable for future development" and the other is "highly suitable for conservation or environmentally sensitive zone", and other two have been identified is, "moderately suitable for future development" and "moderately suitable for conservation or environmentally sensitive zone."

The system that has been developed provides planners with new tools to implement their work more efficiently especially with support of the interactive and user-friendly interface developed to ease the use of the sophisticated system without the need of advanced technical skill. Nevertheless, the application of the system will inevitably influence the existing structure and practice of urban planning and management in case study area. With issues of smart growth and sustainability unlikely to fade, policy makers, local officials, and interested citizens will continue to look for workable approaches to understanding and directing urban growth. For this system, the implementation of GIS, however, involves far more than hardware and software decisions. Effective implementation rests on a thorough and systematic evaluation encompassing planning, operational, organizational, institutional, personnel, financial and technical aspects. To optimize GIS use, more research and attention need to be directed toward organizational and institutional issues, as well as developing GIS for planning and management purposes.

Lack of cadastre data is a major difficulty in developing a data information system for development control. But study focuses on building layer to collect data. The system that has

been developed provides planners with new tools to implement their work more efficiently especially with support of the interactive and user-friendly interface developed to ease the use of the sophisticated system without the need of advanced technical skill. In addition, the web-base GIS applications developed provides meaningful public participation apart from better data integration and sharing through effective data dissemination techniques.

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