Application of Spatial Calculating Analysis Model for Land Use Conversion in Colombo Urban Fringe

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Abstract:

Globally, the level of urbanization is rapidly increasing and metropolitan areas are growing fast, creating extensive land use changes and urban spatial expansion. In 2011, a total of 3.6 billion people were urban dwellers, accounting for 52% of the world population (UNDP, 2012). Simultaneously, it is important to access spaces to accommodate this growth. Ultimate results of that is urban fringe area gradually converting to provide access for this pressure demand. Hence it is important to study the conversion of land into urban uses as well as land use changing pattern, direction, and changing intensity. Specific reasons for land use conversion and also implication of land use conversion are very important to any party who is interested in this scenario. Land use changing information is more important to take the best decision when preparing land use management plans. In any situation, land use changes are very difficult to critically identify because of its complicated and dynamic nature. Therefore, Town planners, Real estate developers and all interested parties need to be aware of land use changes and its nature. Due to lack of advanced analytical tools for land use management, identification of land use changing pattern was a difficult task. Therefore it is required to use an accurate model to determine the land use pattern and its future trend. Present GIS analysis provides a more powerful platform for land based analysis. In this analysis it expects to use Spatial Calculating Analysis Model for land use analysis integrating GIS.

Key words: Land conversion, Urban land use, Urban fringe, Spatial Calculating Model

1. Introduction

The history of urban growth and urbanization reveals that urban areas belong to the most dynamic land cover types on earth. It forces to socio and economic development (Thapa & Murayama 2011) that leads to the land use and land cover change in the urban-rural fringe. Regardless of the regional economic importance, urban growth, particularly the expansion of urban growth towards the periphery of urban areas has an impact on the ecosystem (Hu et al. 2007; Thapa & Murayama 2010). It is evident that such trend of urban growth has an impact on natural resources and on land cover dynamics at large. (Thapa & Murayama 2010)

According to that land conversion in urban fringe area is a continuous process and it is of timely importance to analyze such a land conversion prior to making a decision to mitigate the above problems. Manual calculation of existing changes does not provide an exact picture of those changes. To obtain a clear picture it is needed to be analyzed in a scientific way. Over the last decade, GIS has grown dramatically and its sophisticated analysis tools provide a better insight for different kind of spatial analysis (Chang & Masser 2003). Most researches applied GIS for identifying land use changes. In 2008, Xinchang et al. developed a spatial calculation model for identifying land use changes in the urban fringe area.

Colombo suburban areas are highly dynamic areas, in terms of land development and usage. Indeed, land market has been boosted due to high demand for urban land during the last two decades. According to that illegal land filling, conversion of agriculture, marshy land and irregular land sub divisions and fragmentation are some of consequences of this process (Weerakoon et al. 2002). For instance, so far 1,600 hectares of

environmentally sensitive marshy lands have been filled by private developers. In some areas, nearly 50% of agricultural lands have been converted into urban uses (Ariyawansa 2008). Further, rapid increasing land prices and uncontrolled land markets stimulate poor land owners to sell their lands to private developers which is relatively advantageous with increasing land price than their existing land uses.

These rapid land use changes create some positive as well as negative effects to the society and environment. Different social, economical, political and environmental factors are causes for that. However, urban fringe areas are converted into urban uses at an alarming rate. This process threatens the sustainable development and its impact is unable to be measured. Hence, the land use changing pattern, intensity of changes and its consequence cannot be adequately measured due to lack of scientific methodology. So, it is very important to have a scientific, systematic and reliable technique to evaluate land conversion pattern of urban fringe area for decision making (Chang & Masser 2003). This study aims to develop some methodological approach for that.

2. Objectives of the Study

The General objective of this study is to develop a model to analyze and calculate land use changes using a scientific methodology during specific periods. For fulfilling this main objective, following specific objectives were developed.
- To analyze the land use changes during the 13 years period.
- To calculate the land use changing intensity using Spatial Analysis Model for Land use Change.

3. Review of Literature

3.1 Land use

Land use is a business between man and natural environment. Hence, Briassoulis (2008) stated that the land use change is the result of a complex web of interactions between bio-physical and socio-economic forces over space and time. The magnitude of land use change varies with the time period being examined as well as with the geographical area. Moreover, assessments of these changes depend on the source, the definitions of land use types, the spatial groupings and the data sets used (XinChang et al. 2008). However land uses pattern changes are different from area to area. Pattern of rural areas' land use changes totally different from urban land use change. Because land use types are different from area to area (Majeed 1996). For example while most rural areas land conversions are from forest lands to agriculture lands, urban agricultural lands being converted to residential, industrial uses etc. In any situation land use changes are very difficult to critically identify, because of its complex and dynamic nature (XinChang et al. 2008).

Growth of urban areas depends on both economic and non-economic factors (Harvey 2004). Economic factors are the nature of existing economic opportunities in a nation determined by the size and character of the future urban population, level of income, consumption need and land use etc. Non-economic factors are significantly interrelated with economic factors and vice versa; those are population changes, advanced in technology and policy changes etc. (Harvey 2004). Ultimately those two factors cause urban growth and simultaneously results in changing the existing land use pattern.

Land use changes are the result of complex interactions between human and biophysical driving forces that act over a wide range of temporal and spatial scales (Baker 1989).

Deriving those changes is a complex process due to its complexity. Modeling of land use changes (as a function of its biophysical and socio-economic driving forces) provides insights into the land use changes and its effects (Weerakoon et al. 2008).

3.2 Land use change Models

Models are a formal representation of reality and also sometimes it represents theory of a system of interest (Briassoulis 2008). The representation of reality is expressed through the use of symbols and formulas (XinChang et al. 2008). Models of land use change can play an instrumental role in impact assessment of past or future activities in the environmental and/or the socio-economic spheres. Models of biophysical and/or human processes operate in a temporal context, a spatial context or both. When models incorporate human processes, the human decision making dimension becomes important. In reviewing and comparing land use change models along these dimensions, two distinct and important attributes must be considered: model scale and model complexity (Lambin 1994).

Time step or duration is the smallest temporal unit of analysis for change to occur for a specific process in a model. Duration is the length of the time that the model is applied. For example, in a model of forest dynamics, tree height may change daily. Hence, Model scale is very much important when preparing spatially explicit land use models and statistical models or any. Because it is always the reliability of the model depends on model scale (XinChang et al. 2008). There are important interactions possible between temporal complexity and human decision making (Ojima et al. 1994). For instance, some human decisions are made in short time intervals. The decision of which road to take on the way to work is made daily (even though many individuals do not self-consciously examine this decision each day). There are four main categories of

models distinguished like spatial interaction models (Spatially explicit land use models), statistical and econometric models, optimization models and integrated models. All these models can be identified as numerical models or conceptual models.

3.3 Numerical model for Land use changes.

Numerical models are one of the best methods that can be used to calculate land use changes. According to Bruce and Maurice (1993), Land-use changes during a certain period can be shown by calculating the average changing ratio of land-use model in the researched region. The principle of this theory is based on general mathematical calculation for finding some changes over time. For an example, calculation of Population growth rate, Death rate etc.

The mathematical expression for measuring land use change can be formulated as follows;

$$CR_i = (TA_{(i,\ t2)} - TA_{(i,\ t1)})/TA_{(i,\ t1)}/(t2\text{-}t1)*100\%$$

Where, CR is changing Rate, TA is Total Area, i is Land use type and t is time (year).

For instance when applying above expression for land use change of paddy during 1990 – 2000, it is as follows;

$$CR_{Paddy} = (TA_{(Paddy,\ 2000)} - TA_{Paddy,\ 1990})/TA_{(Paddy,\ 1990)}/(2000\text{-}1990)*100\%$$

The main advantages of the calculating model are shortness and simplicity and we can use it without complicated professional analysis. It is used in both professional and non-professional reports and academic papers.

But the disadvantage is obvious as well.

1) This model ignores the fixity and distinctiveness of land-use spatial position, and cannot reflect the spatial process and interrelated attributes of changing land-use dynamic.

For example, the following two changes is taking place

with spatial locations and attributes different, but acreage completely the same: On one hand, barren unused land is reclaimed far from the city; on the other hand, a field of high quality is converted into land for civil construction near the city. The two changing processes counteract each other and cannot reflect the actual condition when we analyze the dynamic changing of the region.

2) This model cannot calculate and compare the active degree of land-use changes, that is to say, it cannot distinguish the "hot" or "sensible" district, as it has no spatial characters.

3.4 Spatial Calculating Analysis Model

Spatio-temporal changes of land use analysis are significant for identifying dynamic changes in a certain period. "The general analysis of the quantity, structure and environment of land-use change is useful to perceive the trend and character of land-use spatio-temporal change", Xinhang et al. (2008). From time to time, the quantitative spatial information analysis is applied to identify different kind of spatial changes of land use (Hussain et al. 1996; Udayasena and Wijesekera 2008). For instance, some lands of adjoining industrial area change to paddy cultivation to arable land, other part of that area adjoin arable land converted to industrial purposes in the same extent. In this case land uses contradict with each other and cannot identify the real changes. Hence, most scientists in the last decade combine statistical calculations with geographic properties using GIS overlay analysis. Xinhang et al. (2008) mentioned to calculate land use changes using spatial calculation model. According to him land use changes contradict with other types of land uses, therefore we need to identify the unchanged part, converted part and increased part. Land uses can be categorized under these three categories using GIS overlay analysis. That research explained these three

categories as follows:

I. *Unchanged part-* Same land use pattern exists during case study period. This result in keeping the same extent of subject use as in the beginning.

II. *Converted part-*Some specific land use has changed into another use by the end of case study period. That conversion of use is considered as the converted part. This results in reducing the subject use extent and increase another use or uses.

III. *Increased part-* The accumulated area for subject land use pattern during the case study period. For example, Agricultural area might be increased by clearing the forest area. Then, it can be seen an increased area of agricultural land (Xinhang et al. 2008). Further study illustrated that situation in the following figure 1.

As a whole, land use changes are represented by either converted part or increased part. At the same time, there is a close relationship between these two. Because converted part results in increasing another use and vice versa.

Xinchang et al. (2008) state results obtained from spatial calculation model are used to find out why the situation can take place by combining social and economic situations. The result indicates the calculating analysis model of spatial information and can derive a more accurate procedure of spatial transference and increase all kinds of land from a microcosmic angle. By this model and technology it is easy to conduct the research of land use spatio-temporal structure evolution more systematically and more deeply, and can obtain a satisfactory result. And also in the case of application of these models GIS can be used as a tool.

4. Methodology

On the basis of literature review and analysis, a model will be proposed that will be able to improve to analyze the Land use

changes in urban fringe area using GIS (Geographical Information System). On this basis GIS plays a major role to analyze existing situation compared with the past situation. Further, field survey data collection (Discussion with villagers) is used to correct doubtful areas of existing data. Hence, this study consists of the following areas.

Study area consists of several GN divisions. And also land use changes differ from each GN division. Hence all GN divisions are selected to study. Therefore, Selected Sample is the total area of Homagama Pradeshiya Sabha (HPS).

General objective of the research is to calculate the land use changing rates for each use during 1981 to 2004. According to the literature review, basically it requires collecting secondary data and in case of the need, primary data for verifying the secondary data. Therefore, based on availability of secondary data, it has selected land use data in 1981 and 2004, where 1981 data has to be moderated so that it is compatible with 2004 data structure. Because in 1981 HPS area was different from 2004 PS limits. Study is mainly based on field survey for identifying land use changes and boundary differences.

Though both data sets are past in 1981 and 2004, those are different in extent and boundaries. And also 2004 data are in digital format and in 1981 data are abstracted from a paper map. Therefore, 1981 data has to be converted into digital format using GIS and doubtful areas need to be checked. Because, some Paddy land which appeared in 1981 has changed into Rubber land. Generally, Paddy lands are not used for Rubber cultivation. Likewise, general overview of accuracy of the data should be rechecked and updated by using a field survey. 1:2000 land use map prepared by the survey department of Sri Lanka was use as a base map for analysis.

4.1 Development of Spatial Calculation Model
As discussed in the literature review, a Spatial Calculating

Analysis model is a modification of numerical model for measuring the land use changes. Hence, disadvantages of using a numerical model can be minimized. Because it concerns not only the state of beginning and end of a particular use but also the variation of such uses throughout the study period.

The spatial calculating analysis model is based on GIS overlay. It compartmentalizes the case study area land (Homagama PS Area) into three spatial parts: like unchanged, converted and increased areas. Following figure 4.1 illustrates the concepts of Converted, Unchanged and Increased areas, where LUi means the selected land use category. For example Agriculture, Built up areas etc.
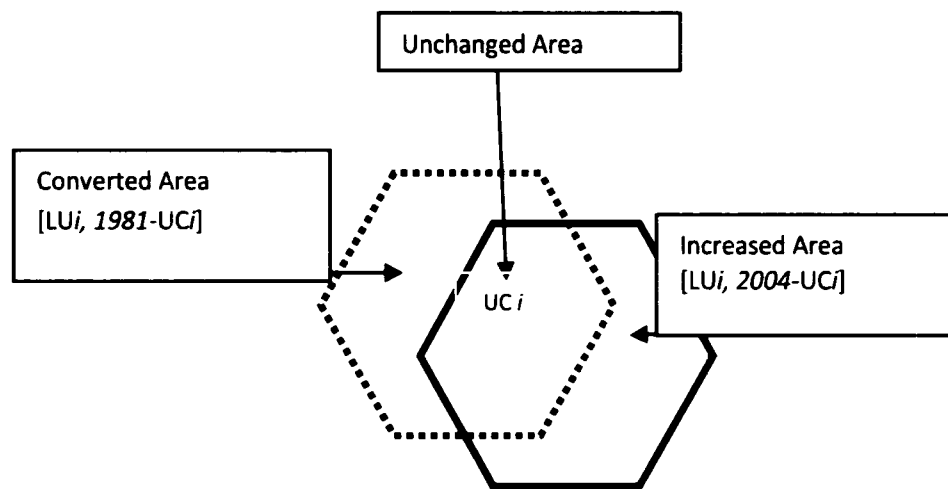

Figure 4.1 Land use classification according Spatial Calculating analysis Model
Source: Developed based on spatial calculation model, XinChang et al, (2008)

By this model it is possible to evaluate the numerical model and dynamic degree model for existing calculating changing speed of land use. Furthermore the result rise reviving the calculating analysis model of spatial information in order to predict the dynamic changing level of all sorts of land. More concretely speaking, the model is mainly to know the changing area and changing speed (increased or decreased) of different land classifications to clearly show the spatial distribution of

changing urban lands. The result will benefit the planning and management of land-use of HPS area in the future.

I. ***Unchanged part***-Here, it can be seen that a particular use remains unchanged during the case study period. This results in keeping the same extent of subject use as in the beginning. For example, unchanged Agricultural land area during 1981-2004. GIS is used as a tool to select this unchanged area. Accordingly, each similar land use categories from 1981 and 2004 are taken and overlapped to select the common area of each and it is called the unchanged area of each category during 1981 to 2004, because these common areas are constant during the study period.

II. ***Converted part***- Some specific land use has changed into another use by the end of the case study period (1981-2004). For example, Agricultural land in 1981 has converted into residential use by 2004. That conversion of use is considered as converted part area of Agriculture use. This results in reducing the subject use extent and increase another use or uses.

4.2 Calculation of dynamic land use change rate for converted area

Converted area means the area that has changed into another use during the study period. For example 977.76 ha of Coconut land has changed into another type of use by 2004. Hence, the intensity of such a change can be measured by the following formula.

$$CR_i = (TA_{(i,\,1981)} - UC_i)/TA_{(i,\,1981)} / (2004-1981)*100\%$$

In that model CR is converting rate per year, *i* is a particular land use type, UC is unchanged area of relevant land use type and TA is total area of that land use type.

III. ***Increased part***- The accumulated area for subject land use pattern during the case study period. For example,

Agricultural area might be increased by clearing the forest area. Then it can be seen an increased area of agricultural land. Similarly, increased area is accumulated or adjoined area of selected land use category into another use during the research period. For an example, some Paddy area in 1981 has been converted into Residential use by 2004. That area is called as increased area of Residential use etc.

As a whole, land use changes are represented by either converted part or increased part. At the same time, there is a close relationship between these two. Because converted part results in increasing another use and vice versa.

4.3 Calculation of dynamic land use change rate for increased area

Dynamic land use changes the rate of increased area of a particular use, which measures the intensity of increase of a particular land use type. This is also calculated using following formula and result is in a percentage.

$$IR_i = (TA_{(i, 2004)} - UC_i)/TA_{(i, 1981)}/(2004-1981)*100\%$$

Here, IR_i means the increasing rate percentage of a particular land use pattern. All other variables are similar to converted rate calculation formula.

4.4 Aggregate model for land use change analysis

To get a reasonable conclusion about land use changing speed of a selected use, it is important to consider both conversion and increasing parts. Therefore, Total changing speed or aggregate land use change percentage is calculated as follows;

$$AR_i = (TA_{(i, 1981)} - UC_i)/TA_{(i, 1981)}/(2004-1981)*100\% + (TA_{(i, 2004)} - UC_i)/TA_{(i, 1981)}/(2004-1981)*100\%$$

$$\boxed{AR_i = CR_i + IR_i}$$

5. Data Analysis

5.1 Case study area

Homagama Pradeshiya Sabha (HPS) is situated in the Western Province of Sri Lanka within the Colombo district. It is located 21 Km away from the City of Colombo along the High level road. The high growth in the City of Colombo during the past decades has made an impact on Homagama to be developed as a service center. Location of residential clusters, the Industrial parks of Katuwana, Panagoda and Meegoda, Diyagama International Sports Stadium, Main interchange of Southern Highway, Nano Technology Park, Information technology park, Godagama economic development center are the main service centers attracted to the growth of this area. In the Colombo core area plan, Homagama has been categorized as a fourth order township. Further, Godagama, Habarakada, Meegoda and Polgasowita are important sub-centers in the area. Homagama is also linked and has interrelationship with the surrounding service center of Athurugiriya, Kaduwela, Malabe, Maharagama, Kottawa, Piliyandala, Horana, Padukka, Ingiriya and Hanwella.
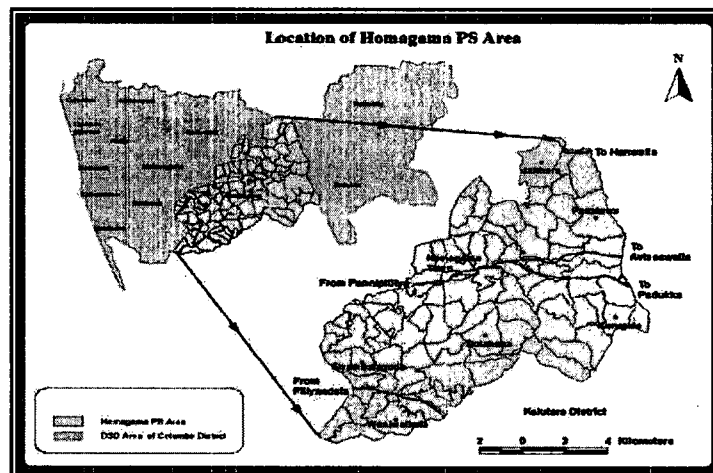

Figure 1: Location of case study area

This area is predominantly an agricultural area and it consists of a low residential density of 14 persons per Ha. During the last inter censual period, population growth rate has been increased up to 2.92% per annum. This growth rate is higher when compared with the other local authorities in Colombo district.

5.2 Existing Land Use Pattern

According to Homagama Development Plan, the land extent of Homagama Pradeshiya Sabha area is 13,820 ha. Out of the total land extent 48% (6572 ha.) is under residential use. Agricultural use is 36% (4949 ha.) The agricultural land use is decreasing with the growth of population. However, agricultural sector is dominant in the local economy. The existing land use pattern is shown in the following table 1 and figure 1.

Land Use	Extent (Ha)		Percentage as a total land	
1. Residential		6,572		47.56
2. Commercial		92.5		0.67
3. Industrial		379.5		2.74
4. State & Institutional		471		3.41
a)Security	220		1.59	
b)Religious	64		0.46	
c)Education	158		1.14	
d)Parks & Play grounds	7		0.05	
e)Cemeteries	22		0.15	
5.Roads		756		5.47
6. Agriculture Lands		4,949		35.81
a. Paddy Fields	1,996		14.74	
b. Coconut	744		5.38	
c. Rubber	1,960		14.18	
d. Other	249		1.8	
7.Water Bodies		344		2.49
a. Reservoirs	40		0.28	
b. Marshes	304		2.19	
8. Excavations/ Quarries		93		0.67
9. Bare lands		163		1.17
Total Land Extent		13,820		100

Table 1 Land use in Homagama PS Area-2007
Source: Urban Development Authority

In 2007, HPS area was updated and boundaries were changed. So, 2007 land use map cannot be compared with the 1981 map. Therefore 1981 and 2004 maps were selected for application of spatial calculation model. The model illustrated the land use changes of a 13 years period. But land use categories are different in those two years; hence before applying the model it should be converted to common land use categories. According to that land use categories on two different years can be classified as follows in figure 2.
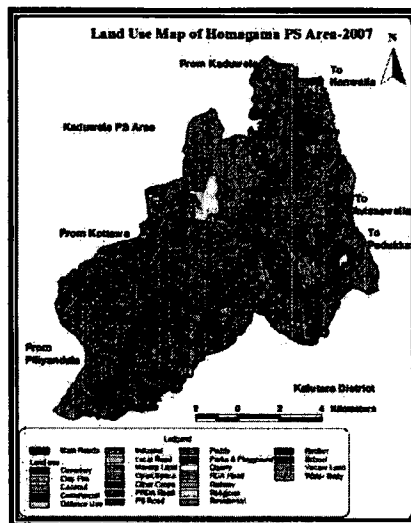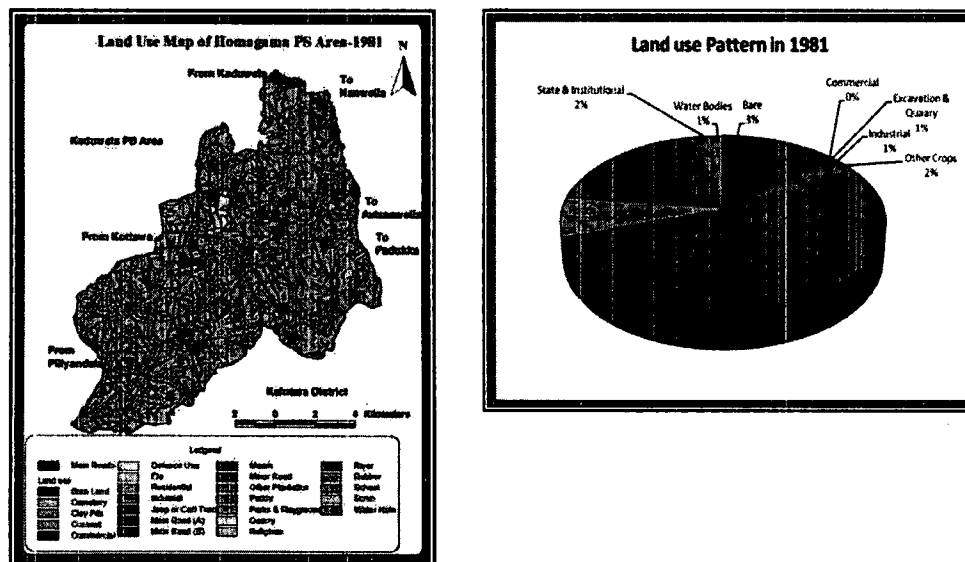

Figure 2: Landuse Map Homagama
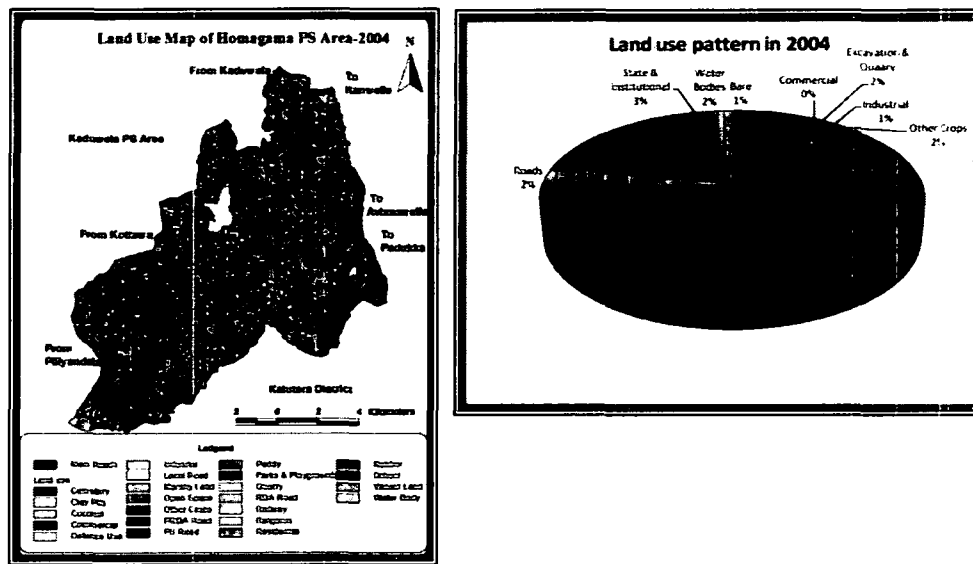Source: Urban Development Authority

Figure 3: Land use pattern of Homagama PS Area in 2004.

Land use pattern in1981			
Description	Area Ha	Category	Area Ha
Coconut	1345.42	Agriculture	7682.13
Other Plantation	261.54		
Paddy	3287.27		
Rubber	2787.90		
Commercial	24.26	Built up Area	5587.63
Industrial	110.96		
Residential	4185.39		
Jeep or Cart Track	370.31		
Main Road (A)	50.34		
Main Road (B)	43.48		
Minor Road	552.15		
Defense Use	214.93		
Religious	8.96		
School	26.87		
Ela	30.18	Environmentally sensitive areas	166.86
Marsh	106.74		
River	27.76		
Water Hole	2.18		
Bare Land	470.92	Other uses	583.21
Clay Pits	16.93		
Quarry	60.03		
Scrub	18.05		
Cemetery	15.27		
Parks & Playgrounds	2.00		
Total Area			14019.82

Land use pattern in 2004		
Description	**Category**	**Area Ha**
Coconut	Agriculture	6400.83
Other Crops		
Paddy		
Rubber		
Commercial	Built Up Area	6979.60
Industrial		
Residential		
Local Road		
PRDA Road		
PS Road		
Railway		
RDA Road		
Defense Use		
Religious		
School		
Marshy Land	Environmentally sensitive areas	290.73
Water Body		
Open Space	Other uses	348.62
Vacant Land		
Clay Pits		
Quarry		
Cemetery		
Parks & Playgrounds		
Total Area		14019.78

Land use Pattern in 1981 & 2004

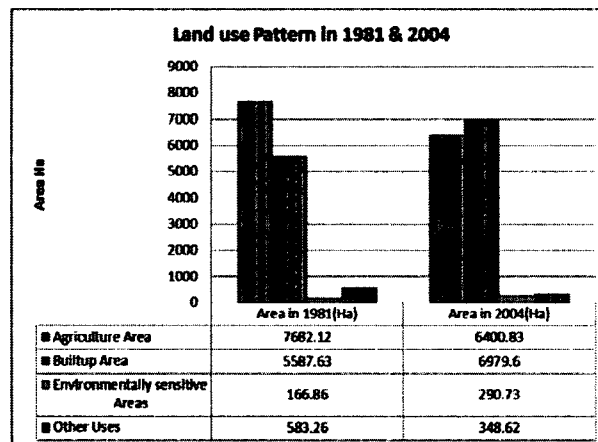|	Area in 1981(Ha)	Area in 2004(Ha)
Agriculture Area	7682.12	6400.83
Builtup Area	5587.63	6979.6
Environmentally sensitive Areas	166.86	290.73
Other Uses	583.26	348.62

Figure. 4: Changes of four major land use categories during 1981-2004

According to the above figure 4.3, in 1981 Agriculture was the major land use category in Homagama PS area which was about 54.8% of total area. However Agriculture use has reduced

up to 45.54% of the total area by 2004. Secondly, Built up area consists of 5587.63 Ha or 39.85% of total area in 1981 and it has increased up to 49.78% by the year 2004. Hence, it is obvious that the trend is to convert agricultural land into built up areas like residential, commercial and industrial etc.

In addition to those, environmentally sensitive areas and other uses like bare land, scrubs etc are 1.19% and 4.16% respectively in 198. But by 2004 aforesaid other uses have reduced and environmentally sensitive lands have increased. Construction of new irrigation systems and declaration of irrigation reservation areas caused to increase the areas which are environmentally sensitive by 2004.

As in the above figures, it is only possible to determine the changes of each category. For example agriculture uses are being converted into built up areas etc. But it doesn't give a clear index to determine the conversion trend accurately. As described in the literature review numerical models are not reliable and accurate. Therefore "Spatial Calculating Analysis Model" can use be used as follows;

6. Application

Data analysis is basically done by using GIS and MS Excel. Here, when analyzing data, GIS is used as an analytical tool, data processing tool and data presentation mode. Therefore, it is possible to obtain reliable data so that it can be used to prepare maps, charts etc.

6.1 Data Modification using GIS
In this study 2004 land use information are compared with the 1981 land use information. Basically, Spatial data are used to calculate the spatial land use changing rates. Hence, both year data should be in same area extent. Therefore, in 1981 data need to be selected and a GIS data set has to be created similar to 2004 area extent.

And also in 1981 paper map doesn't indicate the declared area for Defense use. But actually that area should appear in 1981 data too. So such modifications are done prior to data analysis.

6.2 Data analyze using GIS

At first it needs to identify separate themes for each land use category from both 1981 and 2004 data sets. For instance, Agriculture uses themes in 1981 and 2004 etc. There are four different themes for each land use category so that it is able to compare one another.

Those are

- Agriculture use
- Built up areas
- Environmentally sensitive areas
- Other uses

6.3 Comparison of land use changes 1981-2004 in HPS Area

When taken the whole built up area into consideration, an important category of the land use change is residential. Other land uses in built up area are not significant.

Total Land use changing rates during 1981-2004

When considering all the above information land use changing rates for each category can be calculated using Spatial Calculation Model. Hence it is easy to identify not only the total conversion rates or intensity of land use changes but also Converting rates and increasing rates for each land use category. And also based on aggregate land use changing rates (AR), it is possible to predict the future trend of each land use changes in Hectare. Therefore, both extent and changing rate need to be considered to get a comprehensive idea of changes.

For example by 2004 total agriculture area is about 6400 Ha and its changing rate is 3.86% p.a. Therefore, it can be assumed that by 2005 agriculture use might change by 247 Ha.

Further, this result can be analyzed according to converting rate and increasing rate. In that scenario 146 Ha of agriculture land is to be converted into another use by year 2005. Accordingly, Figure 3 indicates the land use changing pattern of major four categories Agriculture, Built up Areas, Environmentally sensitive area and other uses. However land use changing pattern of main four categories (Figure 3) doesn't give a clear idea about its use. Hence, Table 3 indicates the detailed analysis of each land use with Converting rates and increased rates and ultimately aggregate land use changing rates (AR) for each land use category. Therefore it is easy to identify and predict the most endangered Agriculture use etc. for example paddy land is more sensitive to change-66 Ha per annum. Accordingly, changing pattern of each use can be predicted using AR rates.

Also table 4 and 5 indicate detail land use changes according to spatial calculation model.
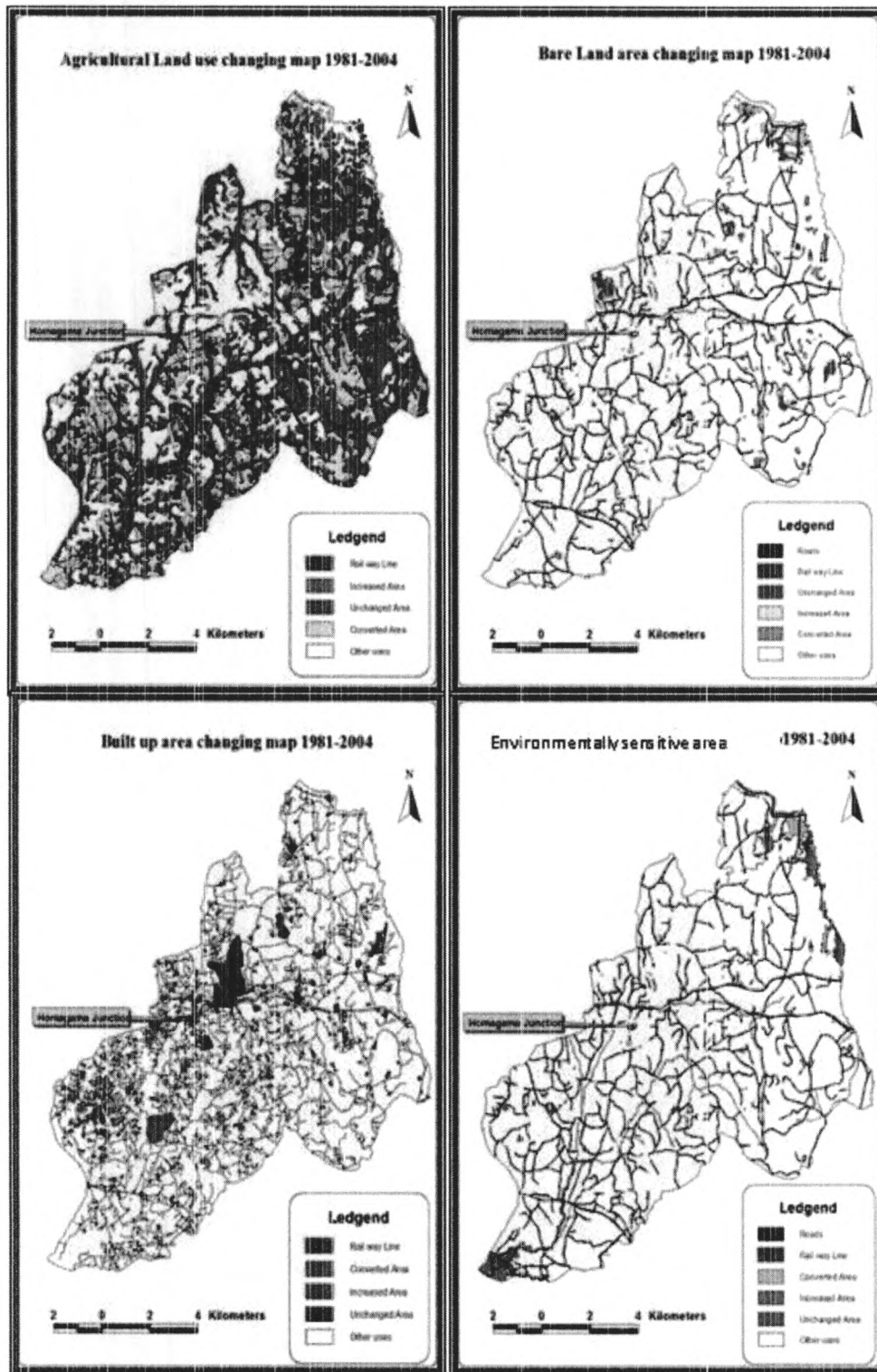
Figure 5: Main Categories of Land use changing during 1981-2004

Following table suggests the predicted land use changes in the future. Therefore, it is easy to identify the highly converting uses, highly increasing uses etc. So, these results can be used to prepare plans, policies, and regulations to make comprehensive and sustainable development of Homagama PS area.

Land Use Type	Land area 2004 (Ha)	Converting rate %	Predicted area to Convert (Ha)	Increasing rate %	Predicted area to Increase (Ha)
Bare land	108.71	3.34	3.63	0	0.00
Coconut	1001.48	3.16	31.65	2.05	20.53
Commercial	55.39	0	0.00	5.58	3.09
Excavation & Quarry	202.24	0.64	1.29	5.54	11.20
Industrial	169.12	0	0.00	2.28	3.86
Other Crops	221.38	3.95	8.74	3.28	7.26
Paddy	2792.42	1.52	42.44	0.86	24.01
Residential	6005.52	1.59	95.49	3.48	208.99
Roads	335.11	4.05	13.57	1.14	3.82
Rubber	2385.54	2.63	62.74	2.01	47.95
State & Institutional	452.13	0	0.00	2.99	13.52
Marshy area	290.73	1.79	5.20	5.02	14.59

Table 3: Predicted land use changes per annum based on changing rates

Above table mentioned the predicted land use changes in the future and it will add more understanding to decision makers about changing pattern of the area.

Land Use Type	Area in 1981 (Ha)	Area in 2004 (Ha)	Unchanged Part		Converted part			Increased part			Changing Rate(AR)%	Intensity of Changing per Annum (Ha)
			Area	Total Area %	Area	Total Area %	Converting Rate	Area	Total Area %	Increasing Rate		
Agriculture	7682.12	6400.83	3630.2	25.89	4051.91	28.9	2.29	2770.59	19.76	1.57	3.86	247.07
Built up Area	5587.63	6979.6	3123.9	22.28	2481.01	17.7	1.92	3873.05	27.77	3	4.92	343.40
Water Bodies	166.86	290.73	98.14	0.7	68.72	0.49	1.79	192.59	1.37	5.02	6.81	19.80
Other uses	583.26	348.62	189.77	1.35	234.65	0.87	2.93	0	0.86	1.18	4.12	14.36
Total Area	14019.87	14019.77										

Table 4: Land use changing rates based on Spatial Calculation Analysis Model 1981-2004

According to the above table 4.3, Agriculture land use changing rate is only about 3.86% per annum. Which is the lowest changing rate compared with other uses. And also highest changing rate of the water bodies are 6.81% per annum. But the impact of these rates depends on the total area of each use. Therefore that impact on each land can be identified in "Intensity of Changing per Annum (Ha)" column in table 4.3.

Land Use Type	Unchanged Part		Converted part			Increased part			Changing Rate(AR)%	Intensity of changing Ha p.a
	Area	Total Area %	Area	Total Area %	Converting Rate	Area	Total Area %	Increasing Rate		
Bare	108.7	0.78	108.7	0.78	3.34	0	0	0	3.34	3.63
Coconut	367.64	2.62	977.76	6.97	3.16	633.81	4.52	2.05	5.21	52.18
Commercial	24.26	0.17	0	0	0	31.14	0.22	5.58	5.58	3.09
Excavation & Quarry	81.07	0.58	13.95	0.1	0.64	121.18	0.86	5.54	6.18	12.50
Industrial	110.96	0.79	0	0	0	58.16	0.41	2.28	2.28	3.86
Other Crops	23.92	0.17	237.62	1.69	3.95	197.47	1.41	3.28	7.23	16.01
Paddy	2139.91	15.26	1147.36	8.18	1.52	652.51	4.65	0.86	2.38	66.46
Residential	2651.9	18.92	1533.48	10.94	1.59	3353.3	23.92	3.48	5.08	305.08
Roads	68.75	0.49	947.53	6.76	4.05	266.35	1.9	1.14	5.19	17.39
Rubber	1098.73	7.84	1689.17	12.05	2.63	1286.8	9.18	2.01	4.64	110.69
State & Institutional	268.03	1.91	0	0	0	184.1	1.31	2.99	2.99	13.52
Marshy area	98.14	0.7	68.72	0.49	1.79	192.59	1.37	5.02	6.81	19.80

Table 5: Separate Land use changing rates based on Spatial Calculation Analysis Model 1981-2004

7. Conclusion

The spatial calculating analysis model can be used to analyze the land use changes from a microcosmic aspect, taking the converted and increased parts of land use changes into account as well, which can actually reflect the land use changing degree, especially the land use category that is increased and

converted actively. At the same time, the model can calculate the dynamic changing degree of all kinds of land use categories. Based on the spatial calculating model, combining with the regional characters in HPS area in the past twenty three years 1981-2004, the following conclusions can be made;

The spatial changing of land use and urbanization are synchronous processes, and the urbanization agrees with the principle of the spatial distribution. Most obviously agricultural lands tend to convert to Residential and Commercial uses. Hence, in HPS area both Residential and Commercial land uses have increased by 5.58% and 3.48% per annum respectively. Where the most significant scenario is Commercial land use in 1981 has not converted in to another use during the past twenty three years. Hence, Converting rate of Commercial use is 0%.

Paddy, Coconut and Rubber are the main agricultural uses in Homagama PS area. However, the trend is all such crops being converted into other uses like Residential, Commercial etc. their converting rates are 1.52%, 3.16% and 2.63% per annum respectively for Paddy, Coconut and Rubber. Meanwhile those uses are being increased by 0.86%, 2.05% and 2.01% per annum. Net result is again to decrease such uses. Hence, self-sufficiency of the area is being diminished. Specially, rise of paddy and coconut prices are seriously harmful for the living standard of the poor.

Land use changing rate of other crops is 7.23% per annum in which Converting rate is 3.95% per annum while increasing rate is 3.28% per annum. Hence, the ultimate result is to decrease the land use for other crops. This badly affects on environmental as well as economical sustainability.

As far as the spatial land use changes are concerned, the nature of land use in urban fringe is the most complex and unstable. It has a great trend to be changed into land for constructions. Without systematic control the built-up area will be extended to a large scale, which will lead to the sharp

decrease of greenery. In short, the utilization of land for construction and the decrease of the greenery in the suburb will arise numerous ecological and environmental problems. Therefore it is important to reinforce the regulation of land use control.

According to the analysis, different actions should be taken to manage land use areas during the planning and management of the land in the future. In Homagama area where land use is much dynamic, town planners, local authorities and property developers need to enhance the land-use efficiency to make the best use of land when land-use development, sustainable development, ecologic and environmental protection are considered.

This model can be used to predicate land use changes in the urban fringe. Its advanced numerical calculations suggest improvement for future research.

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