

**Planning Proposals And Land Value Change
-- A Case Study Of Singapore Using GIS**

by

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Bachelor of Engineering, (Computer Systems)
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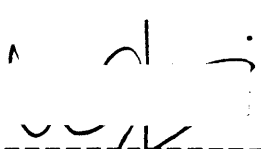
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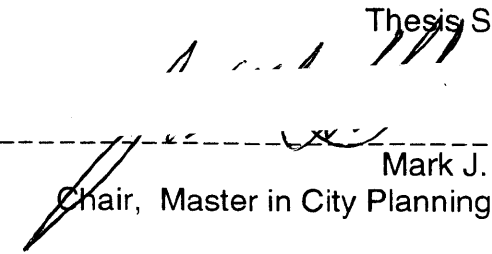
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PLANNING PROPOSALS AND LAND VALUE CHANGE

-- A CASE STUDY OF SINGAPORE USING GIS

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WONG KOK-WAI

Submitted to the Department of Urban Studies and Planning
on May 21, 1996 in partial fulfillment of the requirements for the
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ABSTRACT

The main objective of this thesis is to develop a framework using geographic information systems (GIS) to estimate changes in land value due to new planning proposals in Singapore. The impact of planning proposals on land value is an important consideration as the government owns about 80% of the land. Also, the Urban Redevelopment Authority (the national planning authority) has to be mindful not to introduce unnecessary economic hardship due to any downgrading of land value as one of the government's policy is to promote the economic welfare of the people. However, such a study is tedious and time-consuming to perform manually. A prototype GIS application was developed to automatically calculate land values using development charge rates and to produce land value maps. The usage of GIS technology significantly reduced the time and effort required to study the impact. The foundation for the framework is the development charge rates used in Singapore. These rates are a representation of the average market value per gross floor area of development in a geographic area. Planners in URA now have a tool to quickly evaluate land value changes due to their land use proposals.

GIS was also used to create a composite index of location factors that influence the value of commercial and industrial land. In its current form it indicates the presence of specific micro-neighborhood location attributes for every proposed residential and commercial land parcel. The index is simple and quick to construct. With proper calibration, the index can be used to adjust the land values calculated to better reflect reality. The process indicates how GIS can be used effectively and practically to aid planners in refining their analysis.

Thesis Supervisor: Qing Shen
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To Yew-Mui, the love of my life.

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INTRODUCTION

Background

The Urban Redevelopment Authority of Singapore (URA) is responsible for the physical transformation of Singapore into a tropical city of excellence. To carry out this task, the URA implemented a two-tiered approach to physical planning in Singapore. The first tier is the Concept Plan, which is a long-range plan that describes broad strategies for land use and transportation development. At the second tier, these strategies are translated into Development Guide Plans (DGPs) which are planning guidelines for specific areas.

An important consideration during the preparation of the planning proposals known as Development Guide Plans (DGPs) in Singapore is the impact on land value. In land scarce Singapore, a lot of attention and care are put into the physical planning process to ensure the best use of the land.

During the preparation of the DGPs, the planners are careful not to downgrade the existing land value unnecessarily. For state land, any downgrading in land value would translate to a loss in public assets. The problem can be substantial as the government owns about 80% of the land in Singapore. For privately held land, any unnecessary downgrading would result in strong resistance to the

proposals from affected land owners. The planners are also mindful not to give excessive windfall gains to private owners.

There are many factors that contribute to the value of a piece of land. Some of these are:

- Economic like the demand and supply of land available for development;
- Physical like the topography and shape of the parcel;
- Spatial like the parcel's location from the central business district (CBD) or undesirable uses;
- Institutional like the zoning and density restriction on the parcel.

At present, these factors are not given enough consideration when the planners in URA assess the impact of the DGPs on land value.

The use of Geographic Information Systems (GIS) in planning has grown tremendously over the last few years. Much has been documented about its capabilities and use in planning applications. However in our context, how can we use this technology to facilitate and improve the current process of estimating land value changes due the DGPs?

Thesis Objective

The two objectives of this document are:

1. To examine the current method of handling land value in the planning process and explore how GIS can be incorporated by developing a prototype;
2. To develop a framework that incorporates GIS and urban theory in the process of evaluating land value changes during the preparation of a DGP.

A frequent and often legitimate complaint about planners working in the context of planned development is that they do not have a good understanding of the market conditions that affect their plans. Therefore, incorporating some of the variables that the market deems important gives an added insight to the planners for their planning.

Organization of Document

Chapter 2 examines the current framework used for evaluating land value changes. It starts out by describing the physical planning environment in Singapore. Key concepts used in the process are described followed by an examination of the current process.

In Chapter 3, a prototype application that incorporates GIS technology and an index that is based on urban location theory are developed and described.

Chapter 4 describes the finished prototype and the result from using the proposed framework to estimate the land value for a DGP area in Singapore called Bishan.

Chapter 5 concludes this document. A discussion of further work required is included.

CURRENT FRAMEWORK

Physical Planning in Singapore.

The physical development of Singapore falls under the purview of the Ministry of National Development. The policies of the Ministry are carried out by various departments and statutory boards. The statutory board responsible for carrying out the urban development and regulatory functions is the Urban Redevelopment Authority (URA), which is the national planning and conservation authority. One of its main tasks is the physical transformation of Singapore into a tropical city of excellence. To carry out the task, URA uses two levels of plans: the Concept Plan and the Development Guide Plans (DGPs).

Key Terminology

Concept Plan

The Concept Plan is an integrated blueprint that outlines strategies for Singapore's long range land use and transportation development. It emphasizes economic growth while addressing the needs of the population. As Singaporeans enjoy increased affluence, quality of life issues become more important. Through the Concept Plan, URA aims to improve the quality of life by addressing social and economic needs like housing, commercial, industrial, community, leisure, environment and transport facilities. The Concept Plan

covers the country's future development in 3 stages: Year 2000, Year 2010 and an unspecified Year X when the population reaches 4 million.

Development Guide Plans (DGP)

The broad development strategies and policies of the Concept Plan translate into specific planning guidelines through the Development Guide Plans (DGPs).

They are plans at a local level, and provide development guidelines for individual areas of Singapore. Each DGP will address the housing needs for the population of the area and provide for community, commercial, industrial, transport and recreational facilities. The island is divided into 55 planning areas each with a DGP. The DGPs are also staged like the Concept Plan and have been proposed for the Year 2010 and Year X. To date, about a third of the DGPs have been started or completed.

Meanwhile, the development for the other areas is guided by the current Master Plan. The current Master Plan is a statutory land use plan covering the whole of Singapore. It forms the basis for specifying the permitted land use and development density allowed. The last major revision of the Master Plan was completed in 1985 and is referred to as the Master Plan 1985 (MP85). As each DGP is approved, it becomes the Master Plan for the specific area concerned. When all the 55 DGPs are completed, they will form the new overall Master Plan

guiding Singapore's development in more detailed terms. Therefore, it is obvious that the Master Plan and DGPs have an impact on land value.

The information in the current Master Plan and completed DGPs is available to the public for reference. Also, during the process of formulating the DGPs the plans are exhibited to the public using various media—like exhibition, display stands at the URA's office building, newspaper articles and press releases. As such, the landowners and developers have open knowledge of some of the factors that can influence the value of their property. These include the permissible land use, maximum density of development, location of commercial centers and industrial areas, alignment and location of future transportation facilities like mass transit lines and stations.

Land Value

Land has been described as a national asset and is therefore part of a nation's wealth¹. Since the government is the largest land owner in Singapore, they are naturally concerned about plans that can adversely affect the value of their assets. As good plans serve to improve and enhance overall land value, planners in URA take into consideration the likely impact of their planning proposals on land value during the preparation of the DGPs.

¹ DiPasquale and Wheaton, 1996.

Land value is influenced by a variety of factors. These can be grouped into macro-market factors and micro-market factors. Macro-market factors include the supply and demand for properties and the current macro-economic conditions of the nation. Some micro-market factors are physical characteristics of the site like shape and topography, allowable land use and density for development and its location relative to other uses and facilities.

Development Charge

Development charge may be looked upon as a form of betterment tax, intended to recoup from the land owner a part of his windfall resulting from a grant of planning permission over and above the normal intensity envisaged in the Master Plan². Also, to support the increase in development density or new land uses the government has to invest in more infrastructure such as roads, sewers, water supply, etc. In short, the government offsets the additional investment required (whether now or in the future) with the development charge collected.

Naturally, development charge increases or decreases along with land values. If the market conditions are good and land values are high, the development charge will correspondingly increase. If market conditions are poor, and land

² Urban Management Software, URA 1994.

values are depressed, any appreciation in land value will similarly be depressed and development charge will be lower. It is also 'optional' in the sense that the owner may choose to develop his land up to but not exceeding the Master Plan prescriptions and therefore not incur a development charge. In brief, development charge is usually involved when there is an alteration to the Master Plan zoning, an increase in plot ratio or a change of use of a building from a lower valuation rate to a higher valuation rate.

In Singapore, development charge is implemented through a table that stipulates the rate payable (per gross floor area or GFA) for each type of land use in each geographic area. The rates are derived by the Chief Valuer from the average market value for the land uses within the group in a particular geographic sector. A certain percentage of this is taken to be the development charge rate. The percentage is currently set at 50%³. The rates are updated annually to reflect current market conditions. The whole island is divided into 47 geographic sectors with 8 land use categories. The development charge table was introduced to expedite the process of computing the charge payable and thereby speeding up the development process. Another intention was to open up the whole process of development charge calculation and make it transparent to property developers and the public.

³ Obtained from Head, Land Management Section, URA.

While the design of the development charge table was to facilitate the capture of the enhancements in land value, it is also used by the planners in URA to estimate the change in land value due to a planning proposal.

Estimating Land Value Change

It has always been desirable to quantify the increase or decrease in land value as a result of the new land use proposals in the DGP. The resultant change in value is politically significant because a net increase in overall land value means that the assets of the public would be enhanced. A deeper level of policy concern is that the government is very mindful not to introduce any unnecessary economic hardships due to downgrading of land use of private land parcels. At present, there is no system of compensation if the value of a parcel of land drops due to a change of land use. This careful consideration is in line with the policy of a caring government concerned with the promotion of the economic welfare of its citizens. It is also important from the planning viewpoint because it can be another criterion to judge the merit of a proposal.

Currently in URA, there are 2 ways of estimating land value change. One is to submit the land use proposals to Land Office in Singapore and request for a valuation. The valuation is done using the market comparison approach where the land value is derived from the sale of other comparable land parcels around

the study area. The assumption here is that the market value of a piece of land with a particular land use is closely related to the prices of similar parcels. The second method involves using the development charge rates to estimate the land value. This is possible because the development charge rates are also derived from the sale of land parcels within an area. However, the rates are an average of all the sales data for a particular land use group within the area.

The first method is preferred in situations where authoritative figures are required; for example the benchmark value for state land to be sold in a tender or auction. However, the process takes time and involves another agency which has their own agenda and priorities. Therefore, for cases where only an indication or estimate is required the development charge method is used.

The following are the steps in using development charge rates to estimate land value change.

For every land use parcel in the new proposal:

Find out the land area and the land use group that it belongs to in the charge table;

Calculate the land value using the formula⁴:

⁴ At multiplier of 2.0 is used as the development charge is currently set at 50% of the average market value of the land uses in a geographic area. PR refers to plot ratio and it is the ratio of gross floor area over site area and $rate_{ij}$ is the development charge rate for land use group i in area j.

$$\text{Land Value} = \text{rate}_{ij} * \text{site area} * \text{PR} * 2.0 \quad (\text{Equation 1})$$

Repeat the above calculation using the current land use intentions and density;

Take the difference between the values calculated.

The results are then tabulated and summarized to find out the net change in value.

Process Deficiencies

The process of estimating land value change using the development charge rates suffers from a few shortcomings. One, the process is tedious and time consuming as it is done manually. It is not responsive to the changing scenarios of land use and density patterns as the planners lack the resources to repeat it every time the plan changes. Secondly, it is difficult for the planners to visualize the impact of the results as it is only presented as a table. A land value map is too difficult and time consuming to do manually. Third, it is incapable of imputing the influences of micro-neighborhood location attributes on land value. For example, it is intuitive that the area immediately surrounding a transit station commands a higher value, whether zoned commercial or residential. However, this circumstance is neglected by the current method. Fourth, the land value estimates based on development charge rates might not reflect the most current market conditions as the rates are only updated annually.

PROPOSED FRAMEWORK

To overcome the shortcomings of the current method, the following framework is proposed:

- Automate the current process using Geographic Information System (GIS) technology;
- Build a composite index that accounts for micro-neighborhood location factors.

A prototype application and the index will be implemented and applied to an area called the Bishan Planning Area. It is situated in the heart of Singapore and at the fringe of the Central Area. The Central Area refers to an area encompassing the CBD of Singapore. Bishan was chosen because:

- It provides a good mix of land uses, though still predominantly residential;
- Has a good mix of residential use, from exclusive good class bungalows to public housing apartments;
- Data for Bishan is readily available;
- It has significant change to the land use proposals for the area.

Prototype GIS Application

Geographic Information Systems (GIS)

A GIS is described as a system of computer hardware, software and procedures that are designed to perform the capture, management, manipulation, analysis, and display of spatially referenced data. It has a unique database that allows us to model real world objects and phenomena such as cities, regions through a series of maps and data items. Some examples of such phenomena are land ownership, economic activities, soil type and quality, atmospheric quality and vegetation type. In fact, any real world object that is spatially referenced can be represented by a GIS.

Apart from modeling real world objects, a GIS also allows for the storage of statistical data for the analysis of spatial trends and developments. This information can be presented geographically and visually. Besides the data storage capabilities, most GIS also offers:

- arithmetic and geometric functions for the calculation of distance, area, and density;
- overlay analysis that allows common features to be identified and displayed;
- the ability to regroup geographic data based on specified common features or data items.

Some of the more advanced GIS packages also incorporate basic statistical analysis and impact analysis. For more complex modeling, it provides the necessary hooks to interface with other tools such as spreadsheets, database management systems, statistical software and analytic models.

One of the main benefits of GIS is that it provides a stable and consistent environment for the joining and analysis of data collected from disparate sources. New relationships between the data can be discerned and created using overlay techniques or by combining attribute information.

Methodology

A prototyping approach was used in the construction of a GIS application to estimate land value change.

Functional Requirement

The application must be able to perform the following:

- calculate land value using the development charge table and produce a land value map;
- calculate and map the difference in land value from two land value maps.

It should also provide functions for:

- feature editing so that different land use scenarios can be created;
- mapping of the results.

The idea is that the functions will facilitate planners in performing the repetitive and laborious tasks; thereby allowing them more time to analyze the results.

The proposed process flow is shown in Figure 1. The Edit Tools will allow the planners to create various scenarios of land use proposals. The Land Value Analysis Tools will take the land use scenarios and create land value maps using the development charge rates as the estimation method. It also can take two land use scenarios and evaluate the difference in land value by producing a land value difference map. Finally, the results can be displayed on the graphic terminal or printed using the Mapping Tools.

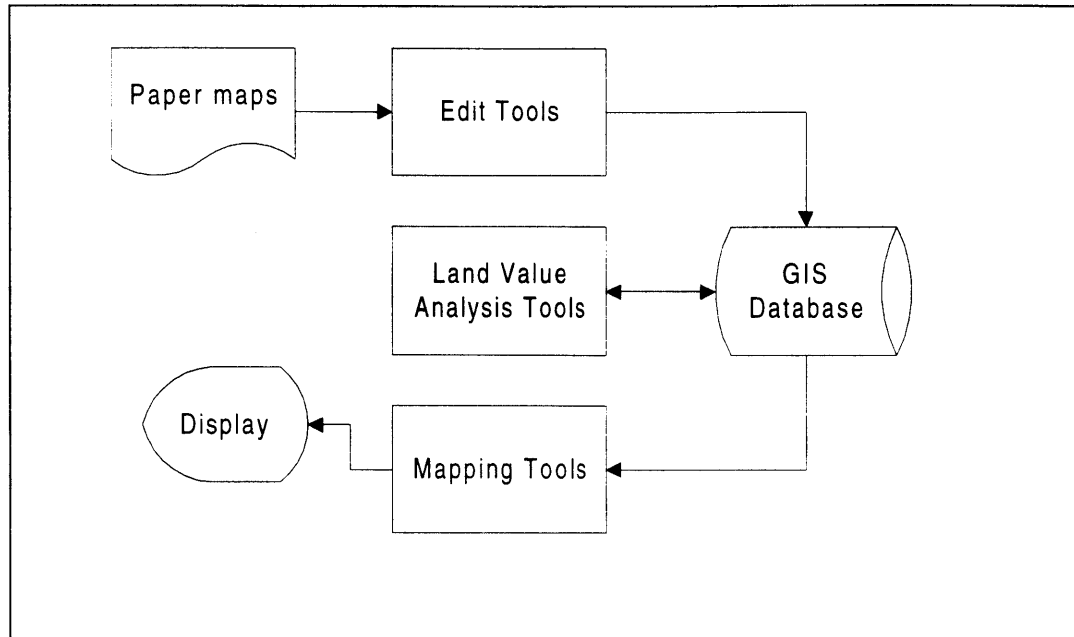


Figure 1: Proposed Process Flowchart.

The Land Value Analysis Tools will consist of two functions Calc_Value and Calc_Diff. The conceptual design for the functions are shown in Figure 2 and Figure 3 respectively.

The prototype will be developed using the ArcInfo™ GIS software developed by Environmental Systems Research Institute (ESRI). ArcInfo is one of the most sophisticated and popular GIS packages available on the market. It is also available on a number of hardware platforms.

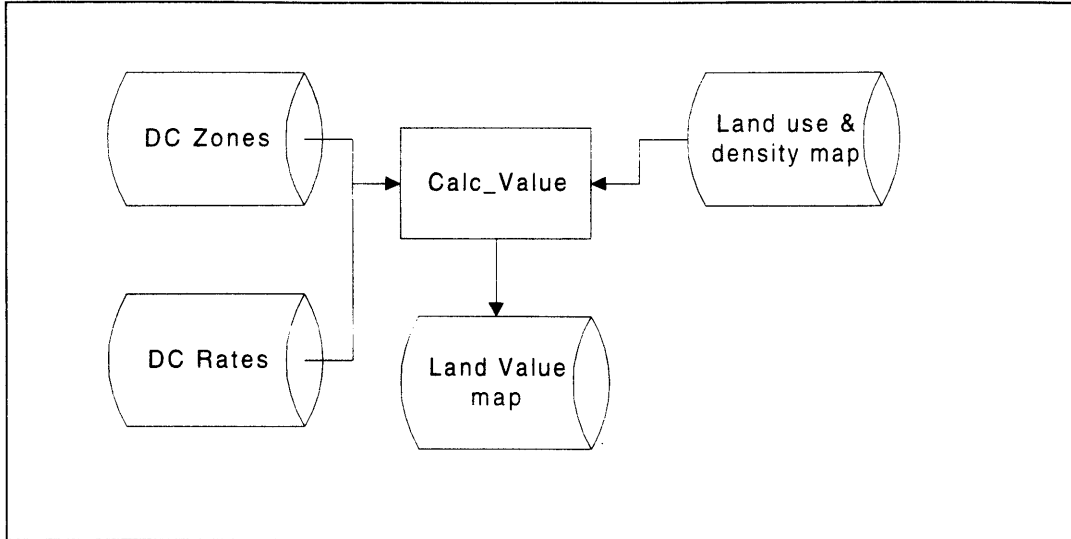


Figure 2: Conceptual design for function, Calc_Value.

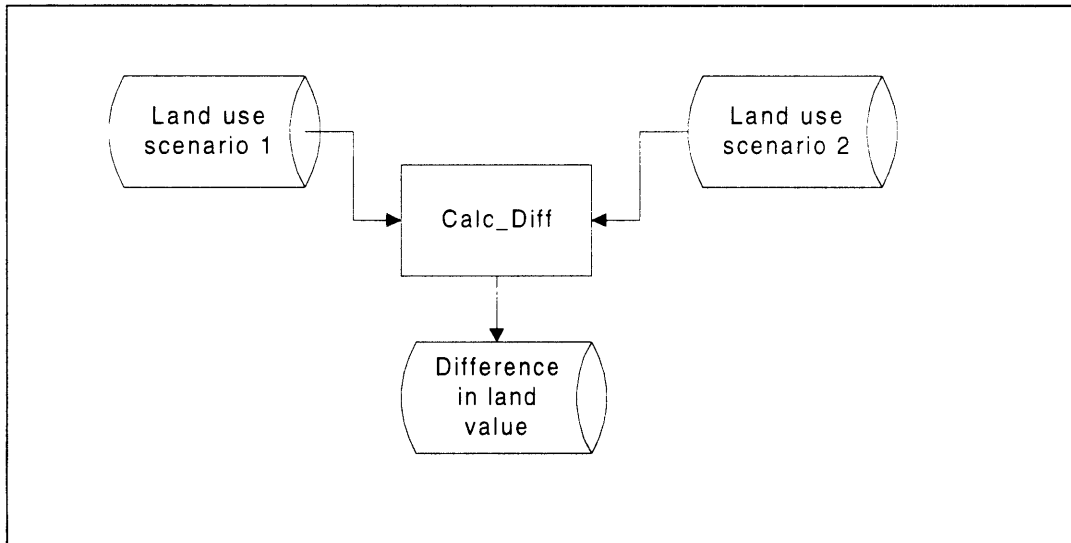


Figure 3: Conceptual Design for function, Calc_Diff.

Data Requirements

The following data are required to support the application:

- development charge zones (an ArcInfo coverage)
- development charge rates (stored as a database table in ArcInfo)

For the demonstration, we want to look at the difference in land value between the new land use proposal and the current intentions for Bishan Planning area. Therefore we also need both proposed and current land use in digital form in ArcInfo.

Building a composite index.

Objective

We are interested in building an index to estimate the effect of location at a neighborhood level. It should incorporate location-specific attributes such as proximity to commercial establishments, major interchanges, recreation area and industries. Such an index can be used to enhance the land value map computed using the development charge rates. The index should also be simple enough to be understood and used by planners and technical officers in URA. Another criterion to consider is ease of implementation.

While it is possible to create an index to cater for all the major land uses, this exercise will only consider the effects of commercial, residential and industrial use. To understand how location can influence the value of a piece of land, we can look to location theories developed by urban economists.

Location Theory

In neo-classical urban economics, land price is derived from land rents that result from an economic activity supported. The argument is that there exists a trade-off between land rents and transportation costs to the center of the city or CBD⁵. This relationship gives rise to a rent gradient with the rents being highest in the CBD (as zero transportation costs is incurred here) and falling away with distance from the CBD. This explains why similar parcels of land with identical uses in different locations can have different prices. Studies had been conducted where distance to the CBD was used as one of the variables to explain the variations in housing and land prices in cities. A variation of the distance to CBD is travel time. The longer the travel time, the lower the land value⁶. Other literature suggests different measures and proxies for location. They include accessibility to transportation facilities, recreation facilities (Palmquist 1980), employment centers (Johnson 1982) and undesirable use

⁵ Alonso, 1964.

⁶ Chen, 1993.

such as landfills or heavy industries (Michaels & Smith 1990). The effect of location also depends on what type of activity is been conducted. Table 1 summarizes some of the location attributes that can influence land value.

Proximity to:	Residential	Commercial	Industrial
sources of employment	+	+	+
sources of labor	na	+	+
undesirable uses	-	-	na
major transport facilities	+	+	+
good schools	+	na	na
commercial centers	+	na	na
frontage to main road	-	+	na
leisure facilities	+	na	na

Table 1: Summary of some location factors that influence land value.

Apart from location, other factors also influence land value. The most important is land use and regulations governing it like permitted land use, maximum density of development and floor area ratio. Physical attributes such as size of parcel and the topography also affects the pricing of land. Likewise the condition of the land, whether it is raw land or prepared land is important in Singapore because prepared land means that roads and utilities like telephone exchanges

and electrical sub-stations have been provided. Some of the other determinants include the physical, social, and the cultural qualities of the neighborhood where the land lies, crime rates, level of crowding, type of people living in the area, and level of education and income in the neighborhood. Aesthetic qualities like panoramic views, bad odors, and noise level can influence land value too.⁷

Multivariate analysis techniques such as regressions are often used to estimate land value as a function of the factors that might influence it. The variables are quantified and a regression model is used to specify how these factors might affect land price. Then the model is tested and calibrated using sales data. In general, such models are used as exploratory tools to understand what shapes land value in a particular setting rather than accurate predictors of land value.

While multivariate analysis seems to be the only tool to quantify many of the variables thought to influence land value, it is often not very successful. A major weakness is that some of these variables cannot be properly observed and measured. Also, un-included variables will often bias the estimates of the coefficients. Moreover, the model cannot account for interactions between variables easily. Another shortcoming is that some models that result do not have a solid theoretical foundation. Nevertheless such techniques usually

⁷ Dubin and Sung, 1990.

provide a useful starting point for land value assessment and provide an insight into the dynamics of land pricing in an area.⁸

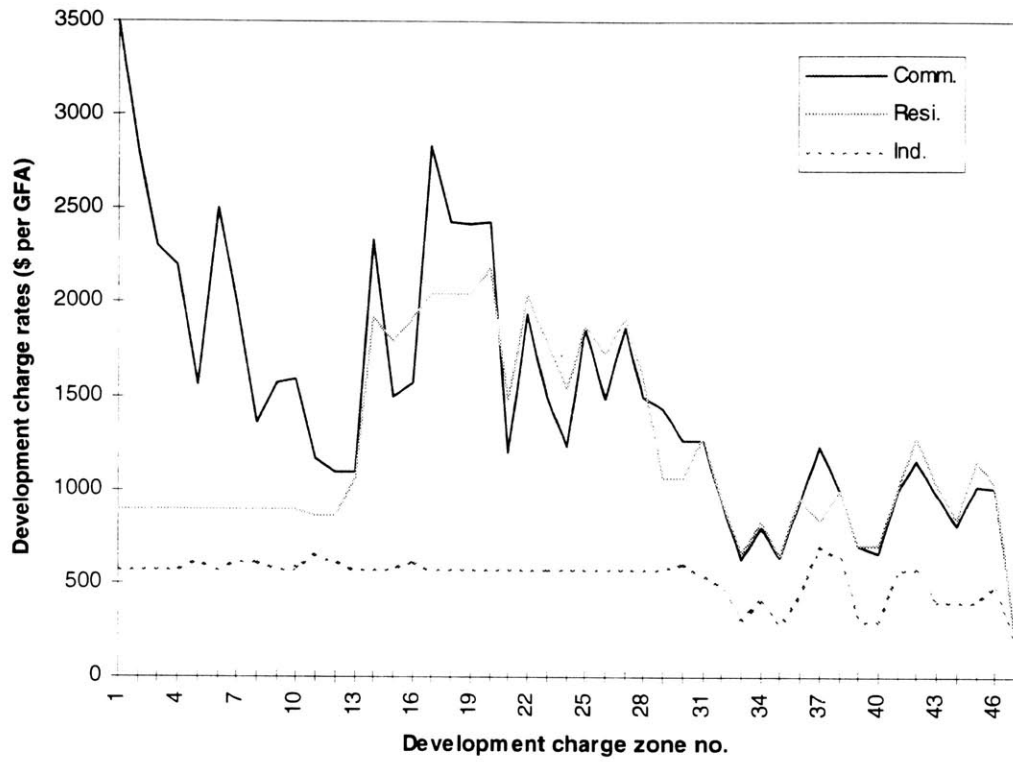
Methodology

Again, the objective of the index is to provide a balance to the pattern of land value estimated using the development charge rates. The idea is to detect the presence of specific micro-neighborhood factors and assign a number indicating the sum of these factors to each land use parcel. We will examine the development charge rates in detail to determine the variables used in the index.

The development charge rates are determined for 8 major land use groups for each of 47 separate geographic areas (called development charge zones) in Singapore. They are based on the average market value for each type of land use. Figure 4 shows the development charge rates for three major land uses in the development charge zones. Figure 5 shows the corresponding z-scores⁹. We can discern the following patterns by examining these graphs.

⁸ Holland, 1970.

⁹ Z-scores measures how many standard deviation from the mean is the observation.



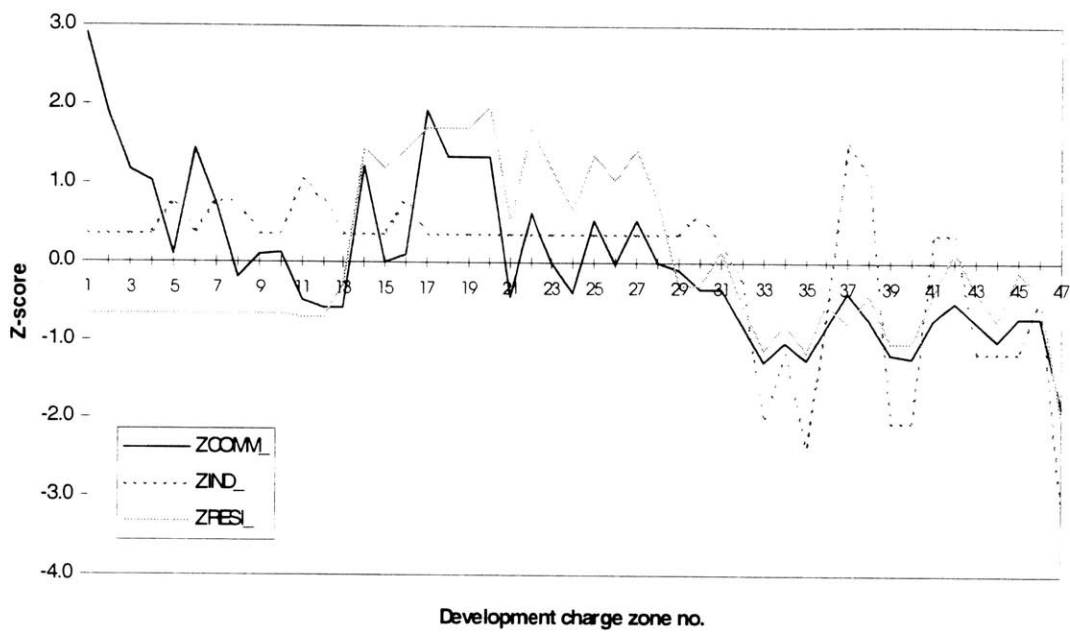
GFA = Gross Floor Area

Data source: The Planning (Development Charges) (Amendments) Rules 1995, Singapore.

Figure 4: Development charge rates for commercial, residential and industrial land use type by area.

Note: Bishan is located in parts of zone 36, 38 and 46.

The monetary unit used and in subsequent figures and tables is Singapore dollars.



Data source: Calculated from The Planning (Development Charges) (Amendments) Rules 1995, Singapore.

Figure 5: Standardized Development charge rates for commercial, industrial and residential land use type

Note: Bishan is located in parts of zone 36, 38 and 46.

Industrial use—The pattern of land value is quite uniform throughout the island. There are a few areas within the Central Area where the value is much higher than normal. An examination of the areas revealed that this is due to the presence of certain industrial uses that have high commercial quantum like motor showrooms. Also, rates for industrial land are higher in the Central Area due to a supply constraint as the amount of land available for industrial use is small. The areas that exhibit very poor rates (with z-scores less than -2.0) are actually water catchment areas or reservoirs with little or no habitation. Consultation with valuation officials in URA also confirmed the premise of uniform land value for industrial use. Therefore, we can assume that micro-location attributes are not so important here.

Residential use—The rates show quite a bit of variation in value among the areas. Land value is low in and around the CBD while it is very high in the prime residential districts of Singapore. This is because people prefer to live in the suburbs where the lot sizes are bigger rather than in the center of the city. Also, mixed use developments with residential component are generally preferred in this area as the location commands greater value for commercial activities. However, such uses are grouped under the commercial land use type. Another land use that is grouped with residential use is hotel. The majority of hotels in Singapore cater to the tourism industry and therefore prefer locations in the main

retail belt outside the CBD. Other hotels that cater to conference and exhibition delegates are also located at the fringe of the CBD.

Commercial use—There is quite a lot of variation in value among the areas, the highest being in and around the CBD and the main retail belt of Singapore (area surrounding the famous Orchard Road). This observation concurs with urban land theory and other observations of office rents in other cities¹⁰.

From our observations, we can conclude that though certain micro-neighborhood effects of location are lost in the process of averaging, the development charge rates still manage to capture the effect of macro-location attributes. Also, we will ignore the impact of micro-neighborhood location on industrial use in building our land value index as the land value is uniform throughout the island.

The work done by Li and Brown¹¹ in the late 70s was used as a foundation for the component on residential land. They found that proximity to certain non-residential uses affects housing prices by having a positive value for accessibility and a negative value for external diseconomies (congestion, pollution, and unsightliness). While their dependent variable was housing price, the result is also applicable to land price.

¹⁰ DiPasquale and Wheaton, 1996.

¹¹ Li and Brown, 1980.

In their work, the authors found that the structural attributes of housing were the least affected by introduction of micro-neighborhood variables. They argued that this is plausible as construction costs are basically independent of location. Empirical evidence also points out that housing units with similar physical characteristics will vary enormously in price by location with the location characteristics accounting for more than half of the overall value¹².

In their study of sample sales data taken from 15 suburban towns located in the southeast sector of the Boston metropolitan area, Li and Brown found that a property located about 550 meters from industry commands the highest premium. The net effect of accessibility and externality increased rapidly and then tapers off gradually indicating that after 550 meters the negative impact of industry is small. The research also suggested that accessibility to commercial establishments is more important than the externality imposed by them. The data indicates that the effect of proximity to commercial area is the highest within 250 meters. Both of these results seem to be quite applicable to our study area (Bishan) as it also exhibits some of the characteristics of a suburban town:

- It is mainly a residential area with a variety of housing types;
- It has a good mix of industrial and commercial uses.

¹² DiPasquale/Wheaton, 1996.

- It is considered to be at the fringe of the business and commercial district of Singapore.

The other proximity variables that are significant in the study are closeness to express interchange, recreation area, ocean and rivers. The results that they obtained suggest that there is a higher net value near major thruways and they postulated that it reflects the potential for conversion to a more intense and higher valued use. This argument however is not valid in Singapore as land use is pre-determined through planning and therefore there is no opportunity for the type of conversion mentioned by the authors. Another possible explanation for the positive impact is the relative ease by which commuters can get onto the major interchanges and on to their destination. Buyers are willing to pay more for the reduction in commuting time. Anecdotal evidence also suggests that proximity to major interchanges and expressways carry a premium in Singapore. The authors' results indicated that at properties located at 300 meters from a major thruway is least valuable.

Observations also suggest that proximity to recreational area, ocean and rivers play a vital role in determining the price of a residential property. This premise is validated by the authors in their research. Here, they had separate measurements for proximity to recreation area, distance to ocean and distance to rivers; of which the coefficients were all significant and had large values. As

the study area is confined to Bishan which is in the heart of Singapore, proximity to the ocean or sea is not a big factor in the overall pattern of land value here. The percentage of open space, recreation and green spaces within a 400 meter buffer is used as a proxy for proximity to recreation area¹³. In Singapore where land is scarce, land located in well-established low density housing estates can fetch above-average prices as such estates are very exclusive. Table 2 summarizes the variables used in the index.

It is unfortunate that the development charge rates categorized office and retail use together. Each of these uses has its own set of theory on how location influences the economics of its activities and hence land value. Also, there are not many studies conducted of the impact of location on retail and office use at the neighborhood level. For our purpose here, we shall simplify the location factors to distance to MRT (Mass Rail Transit) station and frontage to main roads. These correspond to locations that have the potential to serve a larger segment of the population (see Table 3). A check with officials in URA revealed that prices for neighborhood shopping lots are generally uniform lending credence to our simplification.

¹³ A distance of 400 meters is the standard threshold walking distance used for planning in Singapore.

Proximity to:	Nature of Effect	Model parameter
commercial establishment	positive impact	within 250 meters
industry	negative impact	within 550 meters
major thruways	positive impact	within 300 meters
river or waterbody	positive impact	adjacent
good class bungalow area	positive impact	inside
recreation area (park, open spaces, etc.)	positive impact	within 400 m

Table 2: The variables and their parameters used in the index for residential use.

Proximity to:	Nature of Effect	Model Parameter
major road	positive impact	adjacent
MRT station	positive impact	within 100 meters

Table 3: Variables and parameters used in the index for commercial use.

In order to keep the computation of the index simple, we used dummy variables for each of the factors identified. For example, if a parcel is within a 'good class bungalow' district, the variable, GCBA will have a value of 1. If it is not inside, a value of 0 is assigned.

The index for residential land use is implemented as follows:

$$R_idx_i = a*COM + b*IND + c*RDS + d*WTR + e*GCBA + f*REC \quad (Equation 2)$$

where R_idx_i = index for residential parcel i.

COM = 1 if within 250 m from commercial land use; 0 otherwise.

IND = 0 if within 550 m from industrial land use; 1 if otherwise.

RDS = 1 if within 300 m from major road; 0 otherwise.

WTR = 1 if adjacent to waterbody or river; 0 otherwise.

GCBA = 1 if inside a good class bungalow district; 0 otherwise.

REC = 1 if within 400 m from recreation land uses; 0 otherwise.

The index for commercial use is as follows:

$$C_idx_i = x*MJR + y*MRT \quad (Equation 3)$$

where C_idx_i = index for commercial parcel i.

MJR = 1 if adjacent to a major road; 0 otherwise.

MRT = 1 if within 100 m from a MRT station; 0 otherwise.

At this stage, it is not possible to assign any coherent and justifiable weight to each of the coefficients above as we do not have access to enough data

regarding land transaction. Without data like sales price for land, we cannot perform a regression to estimate the impact of each independent variable. However, to demonstrate the conceptual framework we assigned equal weight to all the factors that compose the index. For each parcel, the factors' coefficients are then summed up to form a numerical index. Therefore, for residential land use the maximum value is 6 and the minimum 0. Likewise, for commercial land use the maximum is 2 and the minimum is 0.

RESULTS

Estimates of land value for Bishan

To test the prototype, data was collected for the Bishan planning area in Singapore (Appendix A). The data came in different formats and had to be converted before being loaded to the ArcInfo database.

Data	Format
MP85 land use map (Figure 6)	Intergraph Exchange format (IGDS)
proposed land use and density map (Figure 7)	Arcview 1.0 shape files
development charge zones and rates	paper map and table

Table 4: Data used and its' corresponding format.

We used Arcinfo's data conversion commands to convert the data in Arcview 1.0 and Intergraph exchange format. The commands were able to convert the shape files into arcs (which had to be polygonized later on) and the IGDS files into raw polygons (another command is used to build topologically correct polygon structures). Then the attribute data like land use and density was manually linked as 1) the data downloaded from the Internet had no relevant attribute information and 2) the linkage for the attribute data cannot be directly exported and imported using IGDS format.

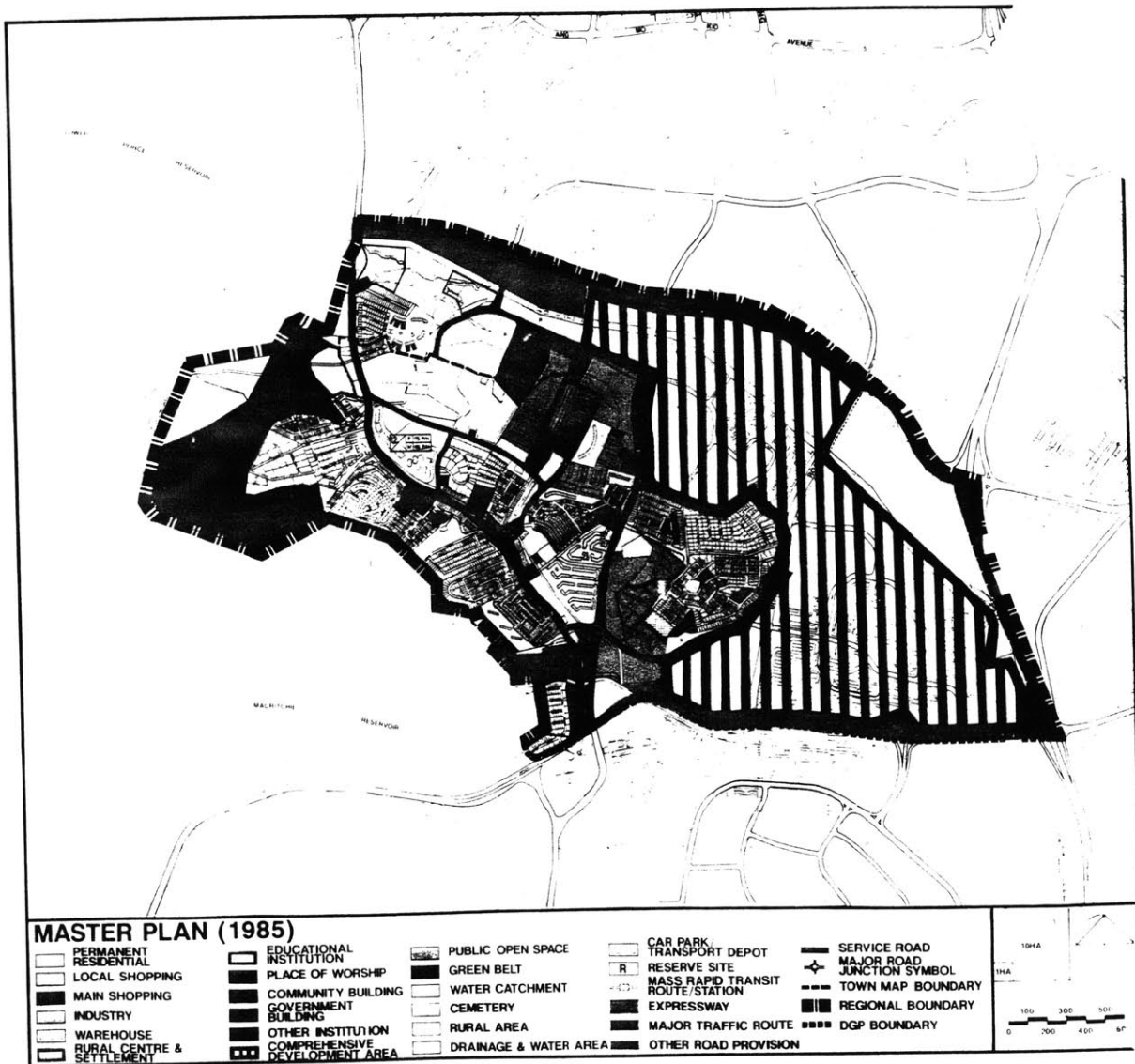


Figure 6: Master Plan 1985 (MP85) land use map.

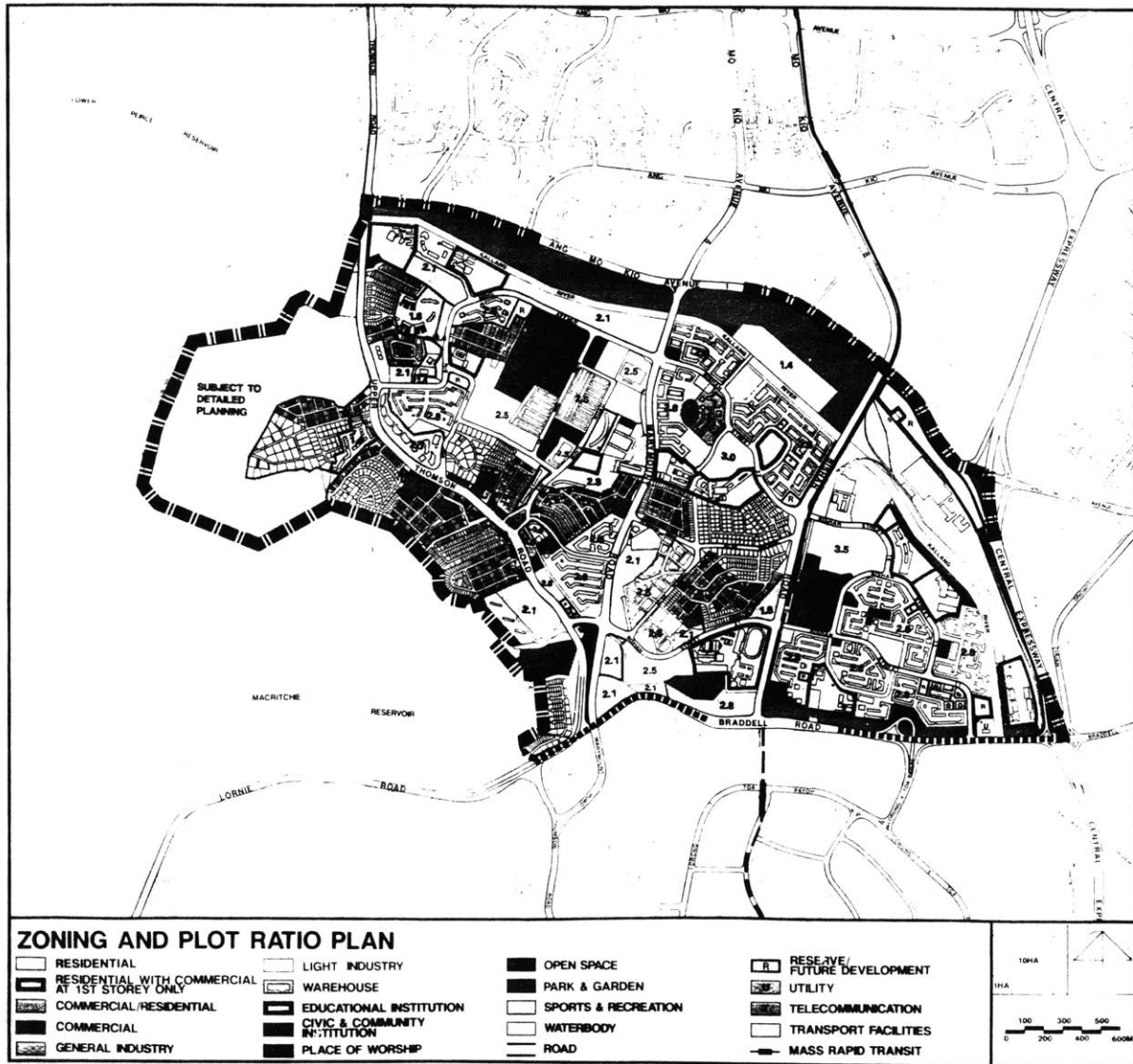


Figure 7: New proposed land use and density map.

The user interface for the application is shown in Figure 8 and Figure 9. The prototype is easy to use as it is mouse and windows-driven.

Figure 10 shows the map of land value per square meter calculated using the MP85 land uses and density. Table 5 shows the distribution of land area by land value classification.

Land value per sq. meter (\$) ¹⁴	% of land area in Bishan
0 - 1000	73.9
1001 - 2000	21.1
2001 - 3000	4.7
3001 - 4000	0
4001 - 5000	0
5001 - 6000	0.3

Source: Calculated from land value map for MP85 land uses.

Table 5: Percentage of land area in each land value classification (for MP85 land use).

From the above table, we can see that most of Bishan (~74%) falls into the 0 to \$1000 per square meter range. This is due to the fact that all of east Bishan was previously zoned as cemetery and open space which have very low value.

¹⁴ Calculated using Equation 1 (development charge rates).

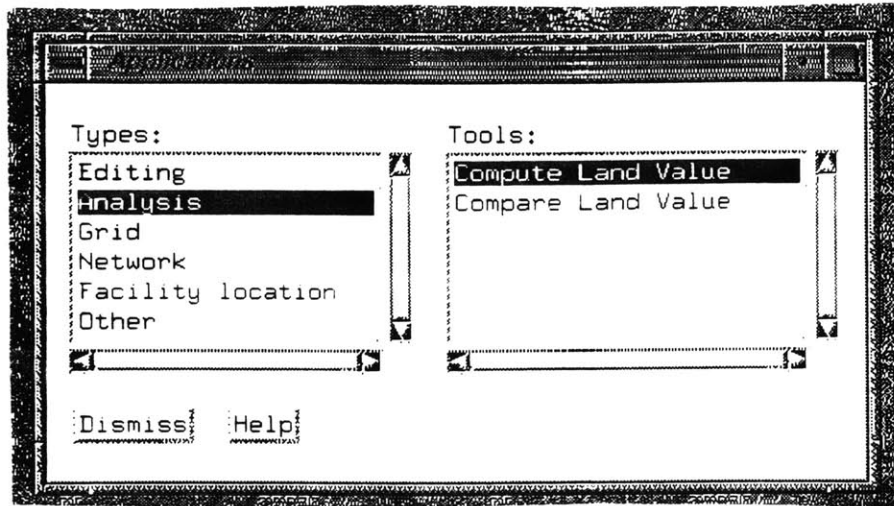


Figure 8: Interface for module Calculate Land Value.

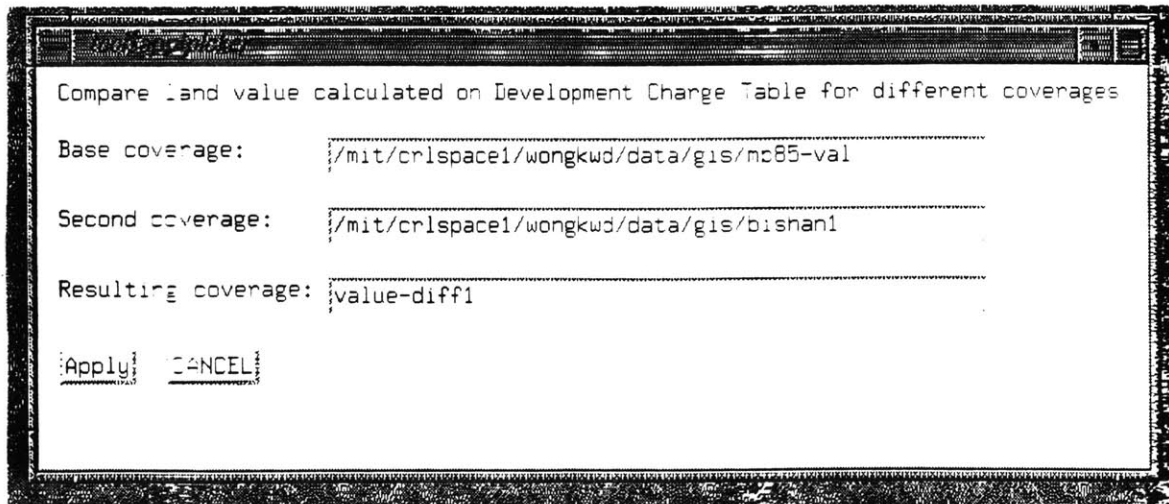


Figure 9: Interface for module Compare Land Value.

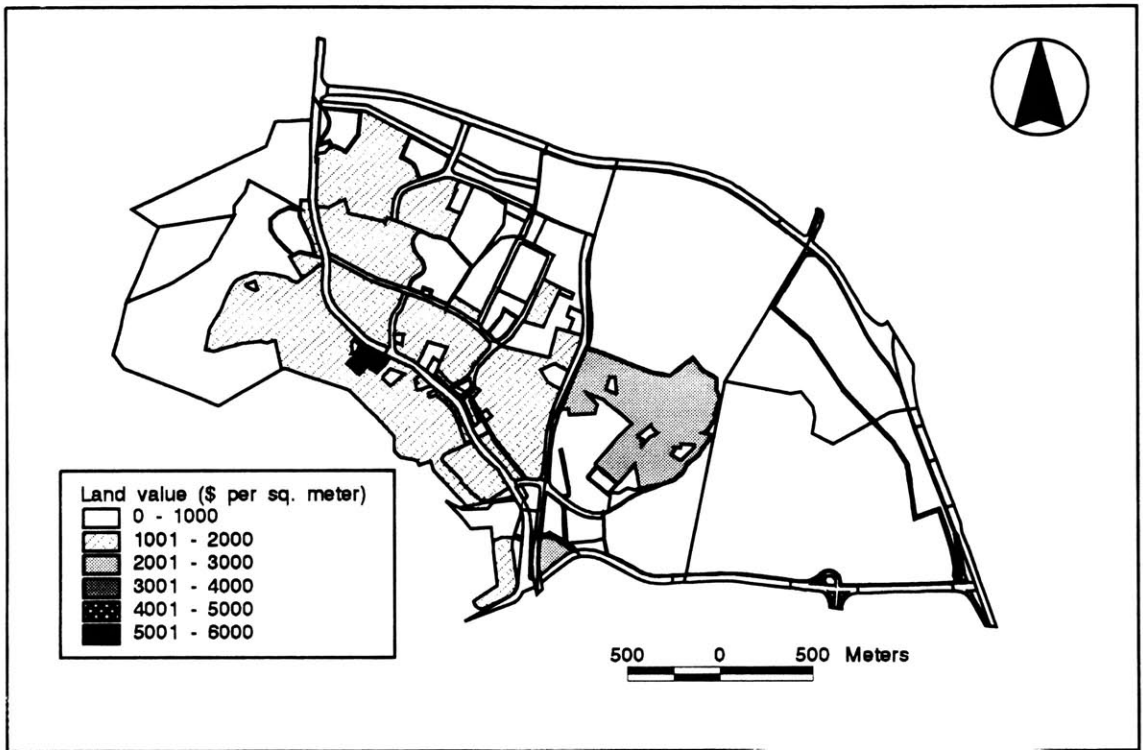


Figure 10: map of land value per square meter (based on MP85 land use and density).

Figure 11 shows the land value map calculated for the proposed land use and density. Table 6 shows the distribution of land area by land value classification.

Land value per sq. meter (\$)	% of land area in Bishan
0 - 1000	38
1001 - 2000	22
2001 - 3000	12
3001 - 4000	6
4001 - 5000	2
5001 - 6000	17
> 6001	3

Source: Calculated from land value map for proposed land uses.

Table 6: Percentage of land area in each land value classification (for proposed land use).

The distribution of land area amongst the classifications reflects the proposed land use pattern. All of east Bishan has been rezoned as high density residential with plot ratios up to 3.5. Apart from the changes in land use, the maximum density has also been increased. Under the MP85, most of Bishan has a plot ratio of 1.036. Under the new proposal, this has gone up to greater than 2.0. Holding land use and site area constant, the increase in plot ratio will result in an increase in land value (Equation 1). This explains why there is a

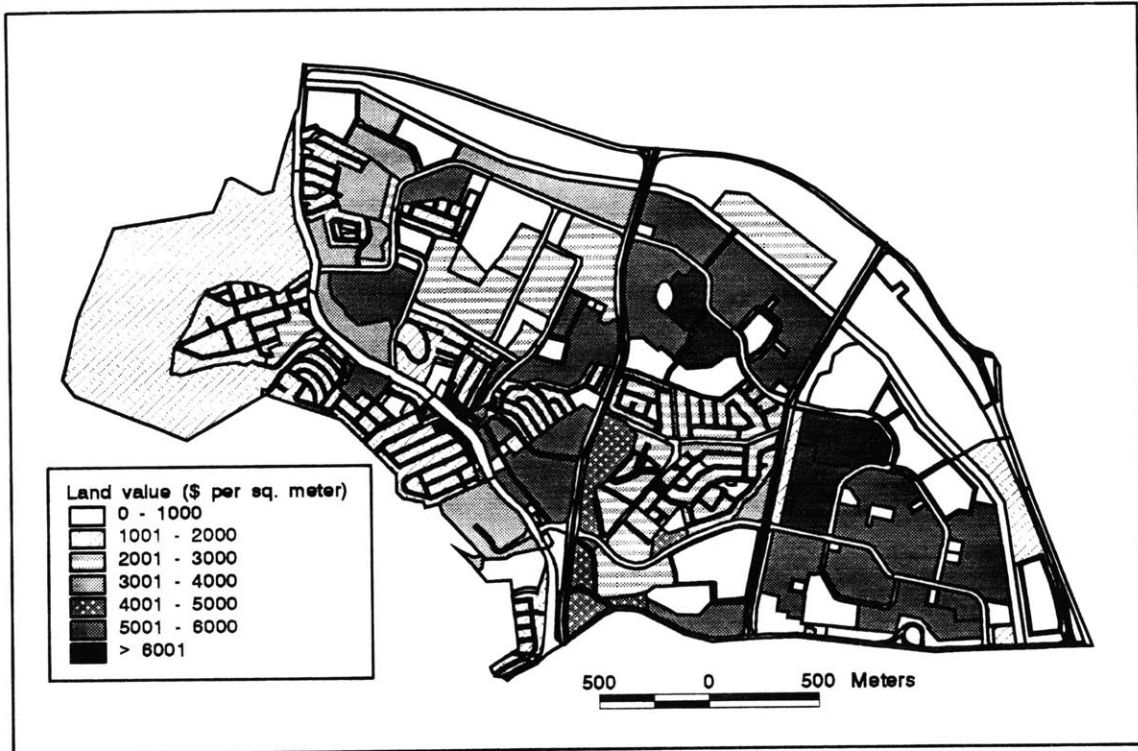


Figure 11: Map of land value per square meter (based on proposed land use and density map).

great difference between the land value maps for the new proposal and the MP85 planning intentions.

Figure 12 shows the changes in land value per square meter between the new proposal and the MP85 intentions. The areas that had a net loss in value of greater than \$2000 per square meter (less than 0.1% of the total land area) are those whose land use was downgraded from residential to park. The cause of the other significant loss in land value per square meter is the downgrading of plot ratio. The summary statistics are tabulated in Table 7. Overall, the new proposal resulted in a net increase in land value of 250% (~\$17.1 billion compared to ~\$4.8 billion) as compared to the land uses and density allowed in the MP85.

How well the land values calculated here reflect reality depends on the development charge rates. Rough estimates of land value in Bishan were obtained from the valuation experts in URA. These were based on the sales evidence of three to four comparable sites for each type of land use. They represent the experts' opinion of the land value per square meter per plot ratio of development¹⁵. Table 8 shows the comparison for the three major land uses (commercial, residential and industrial).

¹⁵ If the maximum plot ratio is 2.0, then a value of \$2800 per sq. m/PR would translate to $2800 \times 2 = \$5600$ per sq. m.

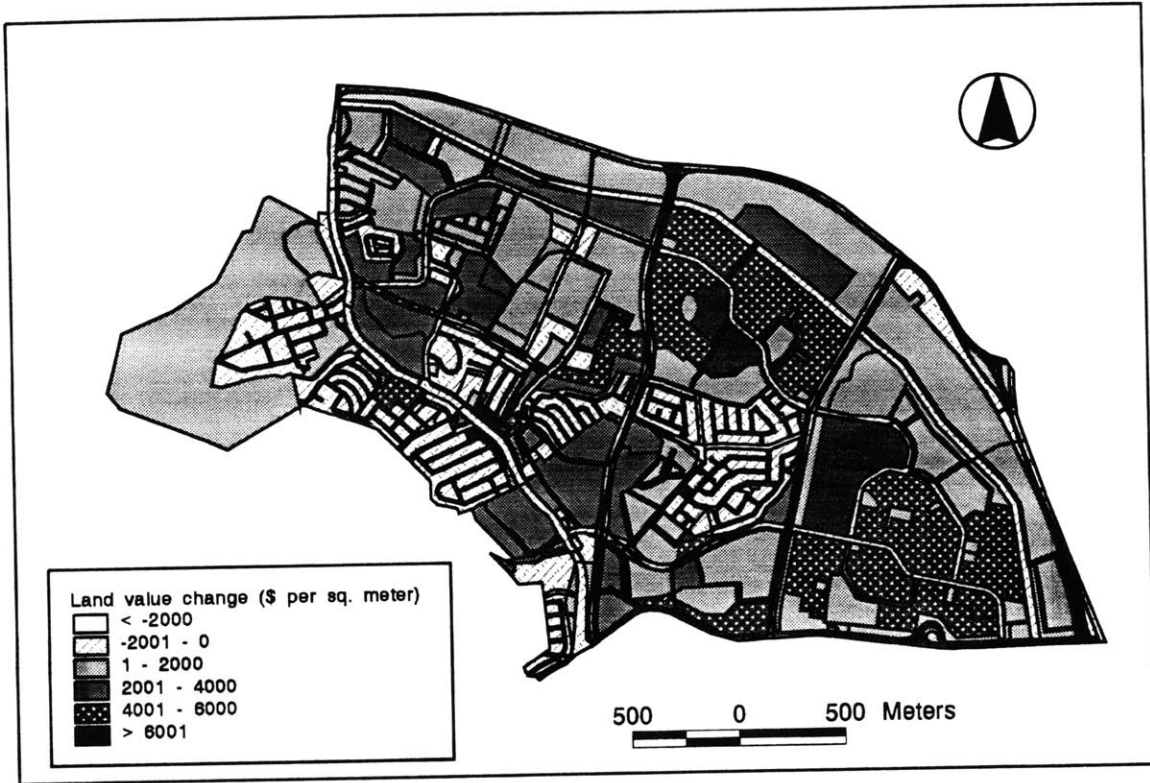


Figure 12: Map of change in land value per square meter between the new proposal and the MP85.

	Based on MP85 land uses & density	Based on proposed land uses & density
Minimum land value per sq. meter	2	2
Maximum land value per sq. meter	5,610	8,400
Mean value per sq. meter ¹⁶	566	1,682
Total land value (all in \$)	4,851,732,721	17,167,127,102

Table 7: Summary statistics for land value calculated for the MP85 land uses and the proposed land uses.

Land use	Land value (\$ per square meter per plot ratio)	
	From development charge rates ¹⁷	From valuation experts in URA
Commercial	1963	3200
Residential	1983	2800
Industrial	1053	930

Source: Calculated from Planning (Development Charge Amendments) Rules, 1995 and from estimates obtained from URA.

Table 8: Land value per sq. meter per plot ratio from development charge rates and from URA.

¹⁶ Calculated as total land value divided by total land area.

¹⁷ As Bishan straddles 3 development charge zones (zone no. 36, 38, 46), the rates from the 3 zones were averaged.

The figures obtained from URA differ by about 60% for commercial use and 40% for residential use when compared with those calculated from the development charge rates. The difference for industrial use is about 11% and is acceptable as an approximation. The big difference can be due to a number of factors. One reason could be that the development charge method was not able to capture the premium associated with the presence of an MRT station and an established housing estate. As we can see from the map of development charge zones (Appendix A), Bishan straddles 3 development charge area. Zone 36 mainly consists of water catchment area and has very little development except for Bishan West. Furthermore, even though Bishan Central is more developed than the area north of zone 46, the rates do not reflect this. This is in contrast to the estimates that were taken from comparable sites in Singapore; that were located in established housing estates and close to a MRT station.

Even though the land values calculated using the development charge rates are low in comparison with estimates, the methodology is still useful in URA as it is easy to perform quickly and gives a fair approximation of land value.

Composite index of location factors

The composite index was calculated using a GIS package, Arcview 2.0. Arcview is also developed by ESRI and can run on personal computers and UNIX workstations. The main difference between Arcview and ArcInfo is in the user interface and functionality. Arcview is easier to learn and use because of its graphical user interface but has less GIS functionality than ArcInfo. Nonetheless, it is sufficient for computing the index.

The buffering capability of Arcview was exploited here. Figure 13 shows the buffers polygons around the variables used for the location index. The buffer polygons are used to determine the parcels affected by its corresponding location condition. Figure 14 shows the result which is a map of the location index for the proposed residential land use. It shows that most of Bishan's residential parcels have attractive location characteristics. The mode value is 3 while the average value is 2.4. This agrees with market observations that indicate Bishan has a very sought-after residential property market.

Within Bishan, the index revealed that residential land located in the east is most attractive in terms of the location factors. This result also agrees with recent observations of property prices in Bishan. The rate of increase in property prices in this area is among the highest in Singapore. While there are many other

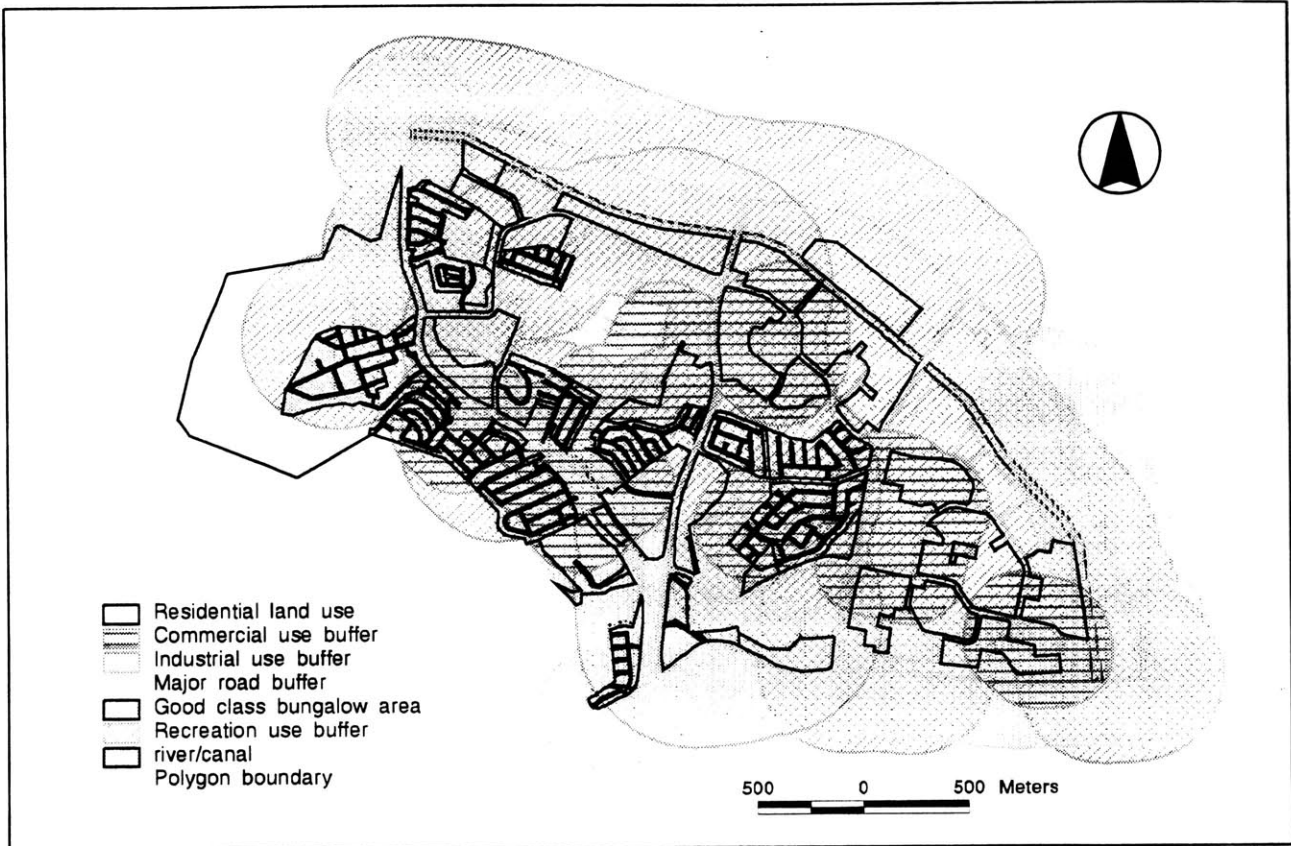


Figure 13: Buffer polygons for variables in index for residential uses.

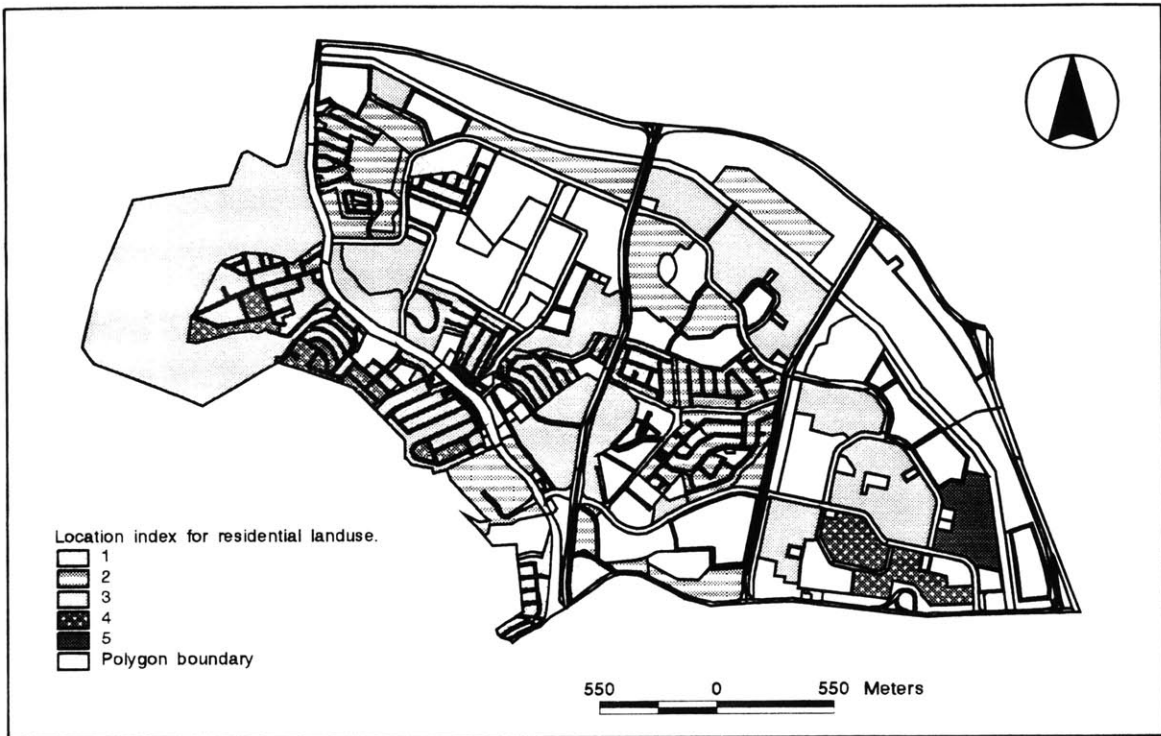


Figure 14: Map of location index for residential land use using equal weights.

factors that contributed to the rate of increase (like the existence of prominent schools in the area), some of the increase definitely is due to the location factors.

The index for commercial land use is shown in Figure 15. It suggests that the land value of the main commercial center in east Bishan should be rated higher. This goes for the commercial zones along Upper Thomson Road too.

To demonstrate how the index can be easily fine-tuned, the residential component was recalculated using different coefficients for the location factors. The effort took less than an hour to complete and demonstrated the ease of generating the index. The result is shown in Figure 16. The coefficients are based on the following observations and are summarized in Table 9. The rationale is as follows. The weight for location inside a good class bungalow district is increased as such land is most desirable. Distance to major thruways does not influence the value much as Singapore is small and has a very good roadway system. Therefore the weight here is smaller. A similar argument can be constructed for proximity to recreation area because of Singapore's size. The results obtained are similar to those earlier except for a few parcels that ought to be rated lower.

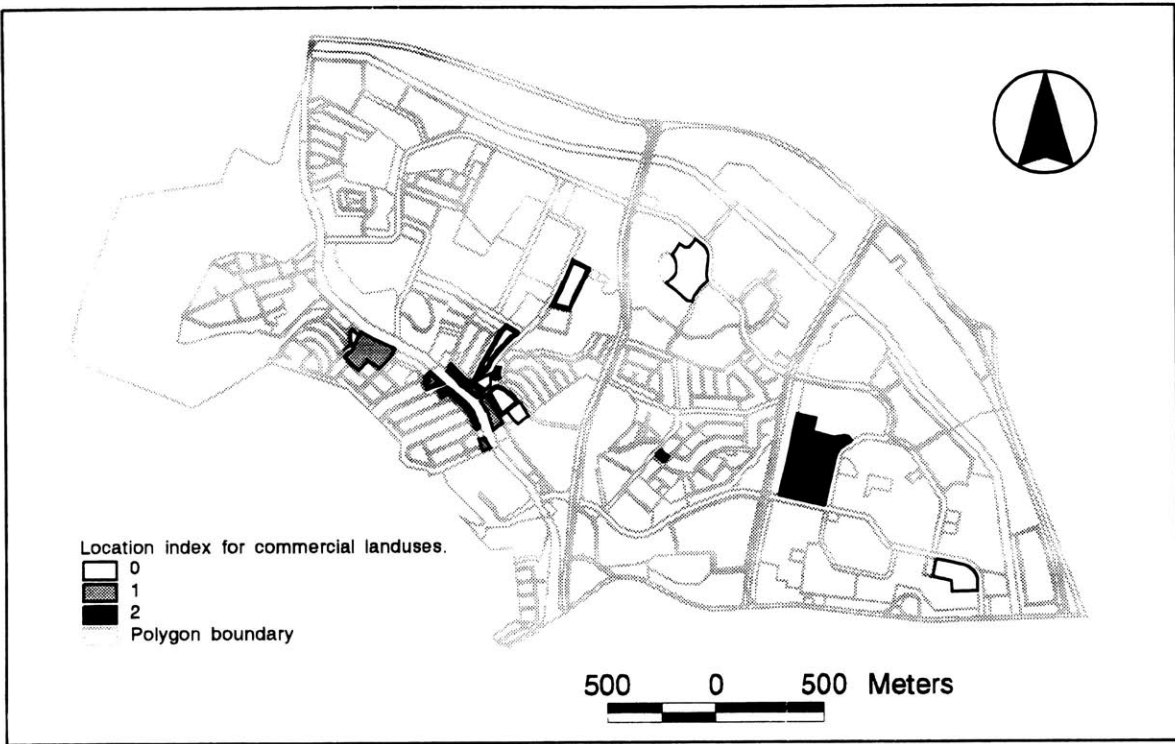


Figure 15: Map of location index for commercial land use (using equal weights).

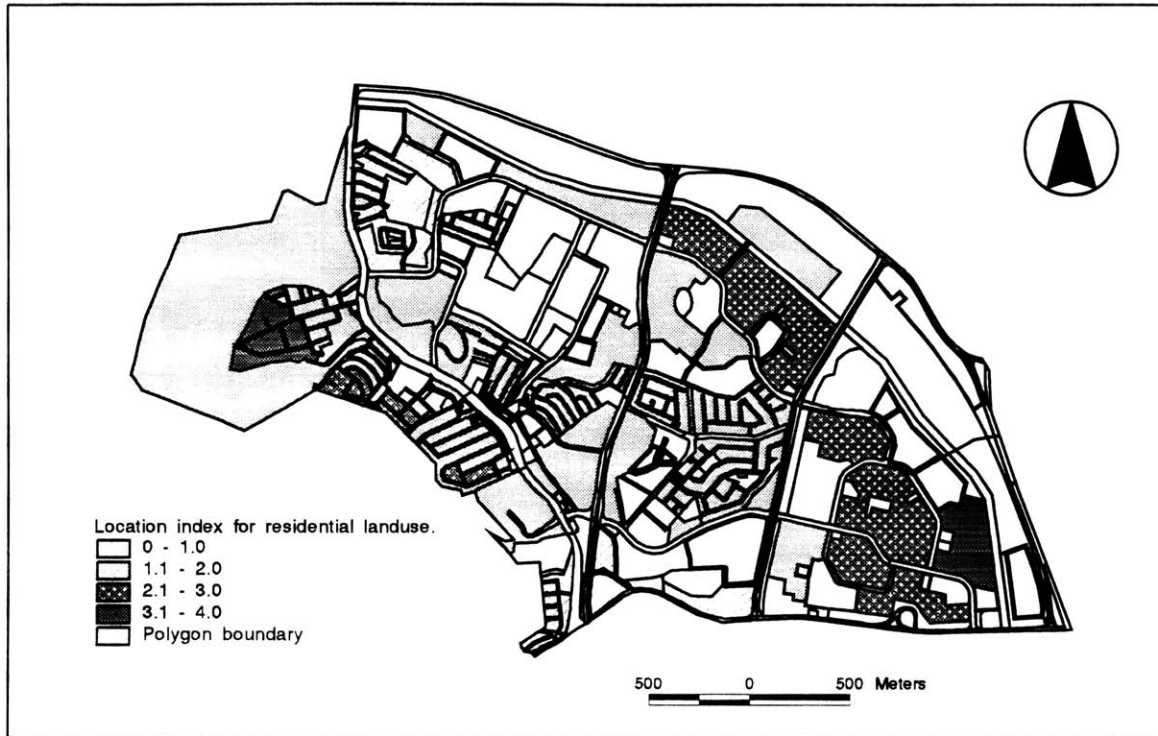


Figure 16: Map of location index for residential land use calculated using different weights.

Proximity to:	Coefficients
commercial establishment	1
industry	0
major thruways	0.5
river or waterbody	1
good class bungalow area	2
recreation area (park, open spaces, etc.)	0.5

Table 9: Location factors for residential land use and their new coefficients.

In its present form, the index can only be used to give an indication of the presence of important micro-location factors. A more useful form of the index would be one where the price impact of each location variable is known. A hedonic price model can be specified as we did and calibrated using sales data. However, the current model specification (additive structure) cannot account for any interactions between the location factors which might be significant.

Issues

Data Conversion

The data used to support the prototype was collected from a variety of sources, ranging from the Internet to a GIS Land Data Bank in Singapore. A lot of time was spent on converting the data because it was not available in Arcinfo's indigenous format. This problem stems from the fact that there is no agreed standard for exchange of geographic information. The GIS vendors have largely circumvented this problem by supporting a variety of import and export formats. However, one still cannot directly export and import the most important element of a GIS dataset that is the spatial (topology) and attribute relationships. This problem impedes planning organizations like the URA from using different GIS for different purposes because of the difficulty in data sharing.

Implementation

A major learning point here was the use of a prototyping approach to demonstrate the use of GIS. Prototyping allowed a working model to be developed in a relatively short time. The reduction in time makes it very flexible to accommodate last-minute changes to the requirements. A relatively simple and straight forward application as above would have taken weeks to develop and implement using the traditional system development methodology (see Figure 17).

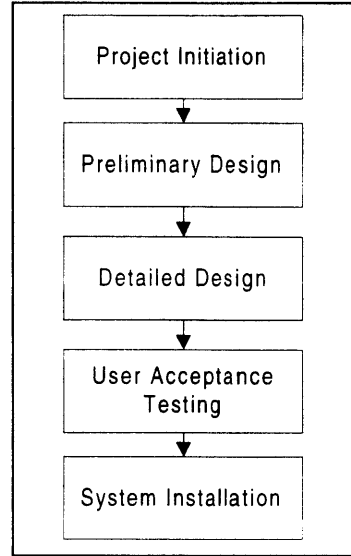


Figure 17: Traditional System Development Methodology.

The availability of a product that can accommodate rapid prototyping is also important. After completing the modules that compute the land value, I integrated them with the ArcTools module that is packaged with ArcInfo. The result is a working prototype with editing, mapping and analysis features. This plug-and-play feature of ArcTools significantly reduced the amount of time required to develop and customize GIS products for a department.

While existence of tools such as ArcTools can help in the development of GIS applications, the entire application development process is still beyond the capability of most planners. At present, there is a lack of planners who are

equipped with IT knowledge and experience and who can successfully prototype and implement GIS systems. Also, equipping and staffing a GIS section can be very cost prohibitive for many small planning agencies (city, county or municipal). As such, there is a reliance on the existing information systems department to supply the technical knowledge and personnel necessary to put such systems in place. This added layer of interface between the planners and the application developers usually lengthens the development time and can result in mis-specification of requirements.

CONCLUSION

The main objective of this thesis is to develop a framework to estimate changes in land value due to new planning proposals. Planning proposals have real economic impact on land values in Singapore. In line with the government's policy of elevating the economic welfare of the people, URA has to be mindful that its proposals do not create unnecessary economic hardship to the people affected by any downgrading of land value. However, an impact study is tedious and time-consuming to perform manually every time a proposal is introduced or changed.

We have shown how GIS can be used to significantly reduce the efforts required. A prototype application was developed to automatically estimate land values based on development charge rates and produce land value maps. While this method of estimation might not produce land values that mirror the land market closely, it still provides a good and reasonable indication of land value based on planning proposals. It will be helpful in instances where time is critical and only an approximation of land value is required. The land value maps are useful in a variety of ways; for example, in giving decision makers a spatial reference to visualize the changes in land value and also in allowing planners to notice spatial trends quickly. Planners in URA now have a tool to quickly evaluate land value changes due to their land use proposals.

We have also established the framework for generating a composite index of location factors that influence land value. The index is simple and quick to construct and can be used to improve on the estimates calculated using the development charge rates. The composite index is not meant to be comprehensive and all-encompassing. It is to indicate how GIS can be used effectively and practically to aid planners in refining their analysis.

We also demonstrated the technique of prototyping in building the application. The technique shows great promise in speeding up the application development process and reducing the chance of mis-specifications in requirements.

Areas for further work

Further work should be done in calibrating the composite index to better account for the strength of the different location factors. Data on land sales should be collected so that a hedonic model can be built.

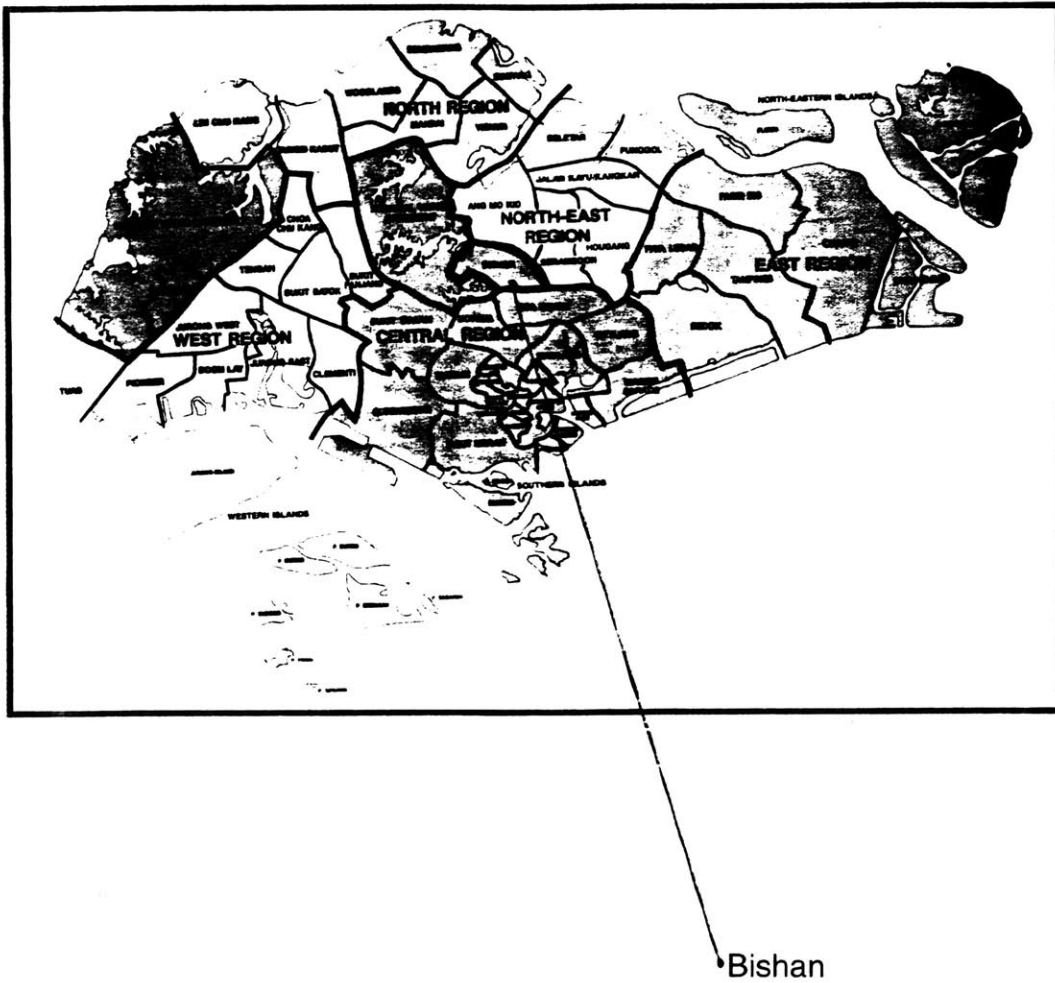
The key assumptions here are:

- a land parcel is not a single heterogeneous unit but rather a bundle of many characteristics like site area, location, etc.
- each one of these characteristics has its own price that can be estimated using multivariate regression analysis.

Another refinement to the composite index for residential use is the inclusion of proximity to MRT stations. Evidence shows that it is a characteristic that commands a premium.

A. APPENDICES

A-1. Location map of Bishan.



A-2. Map of development charge zones.



A-3. Table of development charge rates.

TABLE OF USE GROUPS

For the purpose of Development Charge computation, uses that will be charged at the same development charge rate are grouped together. These use groups are summarised below. The uses may be re-grouped and use groups may be re-defined during the reviews.

Group	Uses	Master Plan Zones for determining Base Amount
A	Shops, offices, association's offices, cinema, places of entertainment, clinics/medical suites, restaurants petrol station, auto-service centre, commercial garage, market	Main Shopping, Commercial, Mixed Use, Local Shopping (40% of Gross Floor Area), Recreation
B	Residential, hotel rooms	Residential, Rural Centre And Settlement, Local Shopping (60% of Gross Floor Area), Hotel
C	Hospital and health centre	Hospital and Health Centre
D	Industrial, warehousing Science Park, airport, dock/port uses, utility installations	Industry, Warehouse, Science Park, Mineral Workings, Major Utility Installation, Car Park/Transport Depot, Airport/Airfield, Dock/Port Area, Special Use
E	Places of worship, community buildings, educational and institutional uses, government buildings	Place Of Worship, Community Building, Educational Institution, Other Institutions, Amusement Park (existing zone), Administrative Area, Government Building
F	Open spaces, nature reserve	Green Belt, Public Open Space, Private Open Space, Nature Reserve, Reserved Site
G	Agriculture	Agriculture, Rural, Unscheduled Area
H	Drains, roads, railways, cemeteries	Drainage, Water Area, Water Catchment, Major Traffic Routes, Other Road Provision, Service Road, Expressway, Mass Rapid Transit Routes/Station/Railway/Railway Land, Cemetery

**"PART II — TABLE OF DEVELOPMENT CHARGE
RATES PER SQUARE METRE**

<i>Geographical Sectors</i>	<i>Use Groups</i>							
	A	B	C	D	E	F	G	H
1	\$3,500	\$890	\$740	\$570	\$430	\$6	—	\$1
2	\$2,800	\$890	\$740	\$570	\$430	\$6	—	\$1
3	\$2,300	\$890	\$740	\$570	\$430	\$6	—	\$1
4	\$2,200	\$890	\$740	\$570	\$430	\$6	—	\$1
5	\$1,560	\$890	\$740	\$615	\$430	\$6	—	\$1
6	\$2,500	\$890	\$740	\$570	\$430	\$6	—	\$1
7	\$2,000	\$890	\$740	\$615	\$430	\$6	—	\$1
8	\$1,360	\$890	\$740	\$615	\$430	\$6	—	\$1
9	\$1,570	\$890	\$740	\$570	\$430	\$6	—	\$1
10	\$1,590	\$890	\$740	\$570	\$430	\$6	—	\$1
11	\$1,170	\$855	\$740	\$645	\$430	\$6	—	\$1
12	\$1,090	\$855	\$740	\$615	\$430	\$6	—	\$1
13	\$1,090	\$1,065	\$750	\$570	\$430	\$6	—	\$1

Note: The rates are applicable from August 1995 to August 1996.

<i>Geographical Sectors</i>	<i>Use Groups</i>							
	A	B	C	D	E	F	G	H
14	\$2,335	\$1,920	\$750	\$570	\$430	\$6	—	\$1
15	\$1,500	\$1,795	\$750	\$570	\$430	\$6	—	\$1
16	\$1,575	\$1,920	\$740	\$615	\$430	\$6	—	\$1
17	\$2,835	\$2,050	\$925	\$570	\$430	\$6	—	\$1
18	\$2,430	\$2,050	\$925	\$570	\$430	\$6	—	\$1
19	\$2,420	\$2,050	\$925	\$570	\$430	\$6	—	\$1
20	\$2,430	\$2,180	\$925	\$570	\$430	\$6	—	\$1
21	\$1,195	\$1,475	\$925	\$570	\$430	\$6	—	\$1
22	\$1,945	\$2,050	\$925	\$570	\$430	\$6	—	\$1
23	\$1,500	\$1,795	\$925	\$570	\$430	\$6	—	\$1
24	\$1,235	\$1,540	\$740	\$570	\$430	\$6	—	\$1
25	\$1,870	\$1,880	\$925	\$570	\$430	\$6	—	\$1
26	\$1,480	\$1,730	\$750	\$570	\$430	\$6	—	\$1
27	\$1,870	\$1,920	\$750	\$570	\$430	\$6	—	\$1
28	\$1,500	\$1,600	\$750	\$570	\$430	\$6	—	\$1
29	\$1,430	\$1,065	\$650	\$570	\$430	\$6	—	\$1
30	\$1,265	\$1,065	\$680	\$600	\$430	\$6	\$22	\$1
31	\$1,265	\$1,280	\$860	\$550	\$430	\$6	\$22	\$1
32	\$940	\$950	\$680	\$500	\$430	\$6	\$22	\$1
33	\$630	\$660	\$435	\$300	\$240	\$6	\$22	\$1
34	\$800	\$825	\$615	\$400	\$320	\$6	\$22	\$1
35	\$640	\$645	\$435	\$260	\$240	\$6	\$22	\$1
✓ 36	\$935	\$950	\$680	\$450	\$310	\$6	\$22	\$1
37	\$1,225	\$825	\$650	\$700	\$430	\$6	\$22	\$1
✓ 38	\$1,000	\$1,000	\$650	\$650	\$430	\$6	\$22	\$1
39	\$695	\$705	\$500	\$300	\$240	\$6	\$22	\$1
40	\$660	\$705	\$435	\$300	\$240	\$6	\$22	\$1
41	\$1,000	\$1,005	\$680	\$570	\$430	\$6	\$22	\$1

<i>Geographical Sectors</i>	<i>Use Groups</i>							
	A	B	C	D	E	F	G	H
42	\$1,155	\$1,280	\$740	\$570	\$430	\$6	\$22	\$1
43	\$975	\$1,025	\$650	\$400	\$320	\$6	\$22	\$1
44	\$810	\$835	\$490	\$400	\$320	\$6	\$22	\$1
45	\$1,020	\$1,155	\$650	\$400	\$310	\$6	\$22	\$1
✓46	\$1,010	\$1,025	\$680	\$480	\$310	\$6	\$22	\$1
47	\$230	\$220	\$200	\$170	\$140	\$6	\$22	\$1

Made this 24th day of August 1995.

A-4. Main ArcInfo AMLs for prototype application.

```
/* procedure calc-value.aml

/* Darren Wong Kok-Wai 1996
/*
/* inputs : land use coverage %.incov%
/*          DC zone coverage %.intcov%
/*output:  user specified

/* initialise variables

    &sv dc-factor = 2 /* as DC table gives only 50% of development charge payable

/* find out corresponding DC zones for input coverage
&message &off &info
/* perform the intersection
    intersect %.incov% %.intcov% %.outcov%

/* for each parcel in output coverage, get value

/* check if field RES1 has been created
    &sv ex-item = [iteminfo %.outcov% -poly res1 -exists]
    &if %ex-item% = .FALSE. &then
        additem %.outcov%.pat %.outcov%.pat res1 16 12 N

/* restore the relate as below to link to DC rates
/*
/* RELATION          = DC-RATE
/* TABLE-ID         = dc-rate
/* DATABASE          = info
/* ITEM              = DC-ZONE-ID
/* COLUMN            = zone-id
/* TYPE              = LINEAR

    relate restore myrelate

/* start up arcedit
&ty Working....
arcedit
edit %.outcov%
editfeature poly
select all
&sv n = 1
&sv m = [show number select]
/* for every polygon, find out the land sue group and calculate the land value per sq. meter
&do &while %n% le %m%
    &ty %n% of %m% completed
    select %.outcov%-id = %n%
/* check if parcel in group A (commercial)
    &if [keyword [show label %n% item code] COM1 COM2 COM3 COM4 LSHP MNSP] > 0
&then &do
    &if [show label %n% item PR] <> 0 &then calc res1 = dc-rate//gp_a * pr * %dc-factor%
    &else calc res1 = dc-rate//gp_a * %dc-factor%
```

```

&end
/* check if parcel in group B (residential)
  &else &if [keyword [show label %n% item code] RESI HTL] > 0 &then &do
    &if [show label %n% item PR] <> 0 &then calc res1 = dc-rate//gp_b * pr * %dc-factor%
    &else calc res1 = dc-rate//gp_b * %dc-factor%
  &end
/* check if parcel in group C (health institutions)
  &else &if [keyword [show label %n% item code] HOSP HLTH] > 0 &then &do
    &if [show label %n% item PR] <> 0 &then calc res1 = dc-rate//gp_c * pr
    &else calc res1 = dc-rate//gp_c * %dc-factor%
  &end
/* check if parcel in group D (industrial, utility)
  &else &if [keyword [show label %n% item code] IND1 IND2 UTIL TRPT TELE WHSE TPT
IND] > 0 &then &do
    &if [show label %n% item PR] <> 0 &then calc res1 = dc-rate//gp_d * pr * %dc-factor%
    &else calc res1 = dc-rate//gp_d * %dc-factor%
  &end
/* check if parcel in group E (institutions)
  &else &if [keyword [show label %n% item code] INST EDU WORS COMM GOVT] > 0
&then &do
    &if [show label %n% item PR] <> 0 &then calc res1 = dc-rate//gp_e * pr * %dc-factor%
    &else calc res1 = dc-rate//gp_e * %dc-factor%
  &end
/* check if parcel in group F (park/open spaces)
  &else &if [keyword [show label %n% item code] OPSP PARK REC RESV GRN] > 0
&then &do
    &if [show label %n% item PR] <> 0 &then calc res1 = dc-rate//gp_f * pr * %dc-
factor%
    &else calc res1 = dc-rate//gp_f * %dc-factor%
  &end
/* check if parcel in group G (rural/agricultural)
  &else &if [keyword [show label %n% item code] AGR RURL] > 0 &then &do
    &if [show label %n% item PR] <> 0 &then calc res1 = dc-rate//gp_g * pr * %dc-
factor%
    &else calc res1 = dc-rate//gp_g * %dc-factor%
  &end
/* check if parcel in group H (waterbodies)
  &else &if [keyword [show label %n% item code] WATB RD CEM DRAN WATR] > 0
&then &do
    &if [show label %n% item PR] <> 0 &then calc res1 = dc-rate//gp_h * pr * %dc-
factor%
    &else calc res1 = dc-rate//gp_h * %dc-factor%
  &end
  &else &ty Error, not in any land use group
  &sv n = %n% + 1
&end
&ty Saving.....
save
&message &on
quit
&thread &delete &self
&return

/* ===== end of calc-value.aml =====

/* procedure calc_diff.aml

```

```

/* Darren Wong Kok-Wai 1996
/*
/* inputs : base coverage (%.basecov%)
/*          primary coverage (%.seccov%)
/* output : the difference in land value per sq. meter in field DIFF of resultant
/*          coverage (%.rescov%)

/* initialise variables
  &sv tab = [subst %.seccov% [show workspace]/ ].pat

/* temporarily rename the res1 field for the second coverage
  tables
  sel %tab%
  alter res1 res2,,,,,
  alter code seccode,,,,,
  alter pr secpr,,,,,
  quit
/* &message &off &info
/* perform the union to merge the 2 coverages
  union %.basecov% %.seccov% %.rescov%
  additem %.rescov%.pat %.rescov%.pat diff 16 12 N

/* restore the field name
  tables
  sel %tab%
  alter res2 res1,,,,,

/* calculate the difference for all polygons
  sel %.rescov%.pat
  calc diff = res2 - res1
  quit

  &message &on
  &thread &delete &self
  &return

/*===== end of calc_diff.aml =====

```

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