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A GIS-BASED LAND READJUSTMENT SYSTEM FOR URBAN DEVELOPMENT

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ABSTRACT

Rapid urbanisation in the developing world is causing a lack of municipal resources with public services falling further and further behind demand. New and redesigned settlements are needed but appropriate plots of land are not usually available. A more efficient distribution of land is required. Land readjustment is one of the approach to deal with these urbanisation problems. This paper briefly explains the land readjustment process and its potential use in urban development, then, illustrates the development of a GIS-based land readjustment model for a better land management in rural-to-urban land-use change procedures.

INTRODUCTION

Since land is a limited natural resource for human activities, it require effective management systems. Especially, rapid urbanisation requires serviceable land for public and private needs. Traditionally, not only in Europe but also in the other parts of the world, continued subdivision of land over the years has resulted in the fragmenting of land parcels into incredibly small units. Since land is basic and tenaciously held, remedies to the fragmenting of land parcels must be deliberate, carefully planned, and executed both by government and private bodies. However, land readjustment is one of the urban planning process that can provide with these requirements.

Land readjustment (LR) may be defined as a land management tool which assists to orderly urban development by the contribution of landowners. The main objective of LR is to convert irregulary developed land parcels into the suitable forms according to town planning requirements. It has great advantages in solving the land-use problems in urban areas but the current implementations are still faced with some limitations. These included technical limitations in handling the wealth of data, economical limitations in compensation for acquiring land, and social limitations in minimising the inconvenience and conceived injustices. Therefore, the re-examination of these issues are essential.

Geographical information systems (GIS) have been widely used in many urban planning applications (Maguire, 1991). To maximise the benefits from LR a new approach has been developed using GIS. In this approach, many substantial criteria which may affect a land parcel value are evaluated and their contribution spatially analysed for the LR process. This paper, first, gives a brief introduction about LR, then explains the development of a GIS-based land readjustment model for urban development.

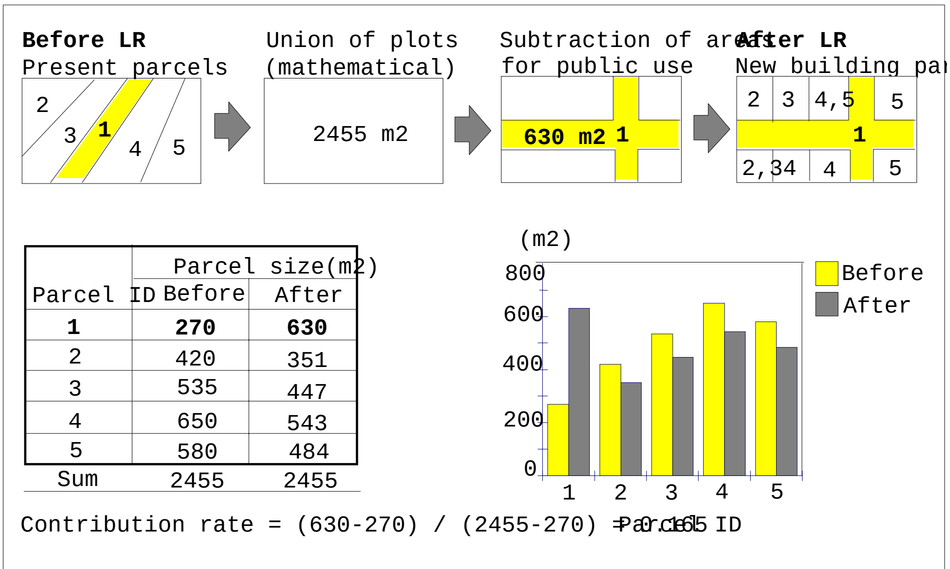
THE CONCEPT OF LAND READJUSTMENT

LR is a technique for managing the urban development of urban-fringe lands, whereby a group of separate land parcels are assembled for their unified planning, servicing and subdivision as a single estate, and redistribution of new building lots back to the original landowners (Archer, 1992). The process primarily takes the rural or unplanned urban land and reallocate it in a more effective use with respect to town planning requirements (Yomralioglu and Parker, 1992). However, as an urban land management tool, LR easily provides the land in a reorganised way for public and private needs. Particularly, the main objectives with LR are:

- the provision of land required for public use, such as streets, parks, hospital, school from all participated landowners in a project area;
- to create such plots suitable for building use according to the rules of zoning plan;
- to transfer the existing land rights on the previous sites to the new replotted sites while carring out the urban development.

Procedures in Land Readjustment

LR projects usually undertaken by local government following the related legislation procedures. A typical LR process begins with the preparation of a zoning plan by the municipality. On the zoning plan, within the site blocks which formed by the streets, lots are allocated for private development. The area for public use are then determined by measuring the square meters in the planned streets, parks, and so forth and comparing it to the total area of project (Doebele, 1982). In other words, all land parcels within a project area are grouped together and a percentage of each land parcel calculated to determine a contribution to public areas. This percentage depends on the size of the project area and the total size of required public-use areas. The remaining land is then reallocated within the blocks defined by the plan (see Figure.1). To do this, first, each site block is subdivided into suitable new lots, then land re-distribution is carried out. The basic principle in the distribution is to keep land in nearby its original location, at least in the same block.



Parcel ID	Parcel size(m2) Before	After
1	**270**	**630**
2	420	351
3	535	447
4	650	543
5	580	484
Sum	2455	2455

Contribution rate = (630-270) / (2455-270) = 0.165

Figure.1 A land readjustment process

The Role of LR in Urban Development

The concept of LR is primarily based on the increasing of public-use land while the size of private land is decreasing. As a result of this, the size of private lands are reduced and become more smaller but their economic values increase due to the extra developments which zoning plan brings. Meanwhile, new built-up lots are created and municipalities acquire the public land to install new services as rapidly as they required. The LR process also provides a great opportunity for government to simply and inexpensively resurvey the land and demarcate new parcel boundaries. Therefore, the practice of LR can be considered as a way of strengthening the reorganisation of cadastre (Chou and Shen, 1982). LR is a method by which the city government, other designated public bodies, or even private associations can participate directly in the process of urbanisation and thereby share in its profits (Rainer, 1992). Besides the improving land utilisation for government, it is also a significant method for landowners to economically improves the use of their land. However, some benefits of LR for both government and landowners may be given as follows:

LR Benefits for the government

- Compensation expenses for public-use land are greatly reduced so that the provision of public areas is captured in a more economical way,
- A zoning plan is realised in a short time, and urban land development projects are achieved rapidly,
- Tax revenue increases within project area. This provides an extra source to government,
- The land development programmes in urban fringe areas are systematicaly carried out,
- The existing cadastral records are updated, reorganised and cadastral administration is improved.

LR Benefits for landowners

- After the project, land values increase very rapidly and land become more valuable for landowners,
- A cadastral parcel is re-shaped and transformed into a sufficient site lot that can be used more economically,
- Fragmented small parcels are consolidated into a new building parcel so that land use are maximised,
- Because of the effects of LR project are same for every landowners, disputes about land planning injustices are reduced,
- At the end of the project, basic public services are supplied to new lots, therefore the new social services are brought into to the project area,
- There is no extra charge to landowners for the project expenses, except that they forfeit part of their land. In many case, all project expenses are met by the municipalities.

The Issues

LR have notable advantages in solving land-use problems for urbanisation but there are some issues which affect the adequate use of the process (Satoh, 1986). Land valuation for example has not been dynamically involved in the entire process. Many substantial criteria which may affect a land parcel's value are ignored during the process. As a result of this, inequitable land distribution occurs to the original landholders so that their benefits differ from the project. Due to there not being a standardised land distribution process, the planners have difficulty in making a decision about the new land parcel locations. Land redistribution itself is a very complex task which requires a massive spatial data analysis. In regard to the priorities of zoning plan and cadastral layouts, there are many questions that should be answered by planners. Such questions are, how will land be evaluated; what land characteristics should be considered; who will receive the lots; how will landowners be redistributed or be consolidated so that landowners be satisfied, and so on. Managing the data flow is also insufficient in the current applications. Because of poor information management processes the entire procedure is time consuming and error prone. This causes some undesirable duplications during the project adding to the expensive of the project.

AN APPROACH TO LAND READJUSTMENT USING GIS

To improve the potential use of LR, a new approach has been developed using GIS. The main aim of this approach was to provide parallel value profiles before and after a project, so that all landowners involved are affected in same way from the plan. In other words, to determine a parcel value before and after project, then give back a new parcel to a landowner with the same value as that owned before. Usually the objective of land valuation is to determine ***market value*** (Frizzell, 1979); in this approach, ***value*** is used as a single unit figure which represents a land parcels worth when compared to others. Therefore, the value is simple used a numerical parameter for each land parcel rather than a real market value. These numerical parameters are derived from the combination of some selected land valuation factors (see Table.1).

Table.1 Land valuation factors which may affect a land parcel value

Code	Valuation Factors	Weights
1.	SUPPLIED BASIC SERVICES	87.1
2.	PERMITTED NUMBER OF FLOORS	85.2
3.	LANDSCAPE, VIEW	81.2
4.	ACCESS TO STREET	80.6
5.	PARCEL LOCATION WITHIN BLOCK	80.5
6.	PERMITTED CONSTRUCTION AREA	79.9
7.	ENVIRONMENT	76.0
8.	STREET FRONTAGE	73.6
9.	LAND PARCEL SHAPE	73.4
10.	DISTANCE TO CITY CENTRE	70.1
11.	CURRENTLY USABLE AREA	68.8
12.	DISTANCE FROM NUISANCE	66.0
13.	DISTANCE TO EDUCATIONAL CENTERS	65.1
14.	ACCESS TO HIGHWAY	64.2
15.	SOIL CONDITION	64.0
16.	DISTANCE TO SHOPPING CENTERS	63.9
17.	DISTANCE FROM NOISE	61.2
18.	DISTANCE TO HEALTH SERVICES	59.5
19.	DISTANCE TO RECREATIONAL AREAS	57.8
20.	TOPOGRAPHY	56.8
21.	DISTANCE TO RELIGIOUS PLACES	55.4
22.	AVAILABLE UTILITIES	55.0
23.	DISTANCE TO PLAY GARDEN	53.4
24.	DISTANCE TO CAR PARKING AREA	52.7
25.	ACCESS TO WATERWAY	46.5
26.	ACCESS TO RAILWAY	44.9
27.	DISTANCE TO FIRE STATION	40.0
28.	DISTANCE TO POLICE STATION	35.5

Determination of a Land Parcel Value

In a successful LR process, total land value of all the land parcels should be same before and after the project. In practice, the determination of an exact value for a land parcel is almost impossible but an estimation of value can be conceivable in many ways (Dale and McLaughlin, 1988). However, using equation [1], the land parcel values are estimated in both stages, before and after . In this equation, variable ***V*** represents the total value for a land parcel while variable ***f*** represents the individual selected factor's value, variable ***w*** represents the factor's weight. In the determination of variable ***f***, it assumes that each factor can be evaluated out of 100. Land parcel values are then determined by the combination of mathematical and subjective judgement with the aid of spatial analysis functionality of GIS.

$$V_i = AREA_i * \sum_{j=1}^{k} (f_{ji} * w_j) \qquad [1]$$

V	: Total value of a parcel	*k: Total number of factors*
Area	: Land parcel size	*n: Total number of old parcels*
f	: Factor value	*m: Total number of new produced parcels*
w	: Factor weight	

GIS-based LR

In order to determine the land parcel values, each basic geographic unit can be characterised by a set of economic, environmental, and spatial attributes. To achieve this, some basic spatial analysis tasks such as overlaying, buffering and data extraction are highly required. Today, GIS has ability to do these requirements. However, using ARC/INFO GIS, a new model called LARES (**LA**nd **RE**adjustment **S**ystem) has been developed to increase the performance of current LR applications. Nevertheless, the LARES has five basic functions to accomplish the required tasks in a LR process (Table.2).

A number of technical steps are however needed to carried out the process. Firstly, the required data are derived from the property, land-use, thematic, topographical maps, and from the other related textual records. Then, site blocks on the land-use plan are subdivided into new land parcels with respect to detailed zoning codes. Following the subdivision process, cadastral and created new parcels are individually analysed by the selected land valuation factors. Using equation [1], each land parcel's value is determined for the parcels, before and after. Land re-distribution is then performed. Based on the calculated valuation figures, each old land parcel is finally re-allocated within the new lots.

An example

As an example, a LR project area of 9.8 hectares with by 105 land parcels is illustrated in Figure 3. To test the performance of LARES the property map, the land-use plan and topographical maps were digitised. Land ownership records were also included in the database. Then, 19 site blocks were subdivided into 156 land parcels according to the plan's rules. Because of the nature of the LR concept, the total area of all land parcels was reduced to 6.2 hectares with the process. In another words, 3.6 hectares of public-use areas were gained by the contribution of the landowners. Including the previous public-user area of 0.8 hectares a total of 4.4 hectares of land was reserved for public-use after the project. The rest of the land was then redistributed among the involved landowners. The total value for the project area was estimated as 5 687 024 units by 28 land valuation factors. These units were distributed to the landowners with respect to the their calculated old unit value. For example, the land parcel no.2 within the block no.500, had a total of 77 337 units value before the distribution as a single parcel. With the process this total value was reallocated within three new site lots. These lots are no.3 and no.21 within block no.101, and lot no.38 within block no.107. It must to be noted that after land distribution some new lots such as no.38 can be shared by more than one landowner. This occurs because the limits of a new parcel size are given by the land-use plan that must be followed.

Table 2: The components of LARES

ARC-MODULES; provides all functionality of Arc/Info including Arcedit, Arcplot, Tin and Network utilities. Basically, data input, edit and topology building are performed here,

SUBDIVISION; performs the land subdivision process. The site blocks are automatically subdivided into the new patterns according to land-use planning details. Required modifications in subdivision layout can also be made interactively through the LARES menu,

VALUATION; analyses the land parcels with selected land valuation factors in property map and subdivision layout. Each selected factor is evaluated individually in both stages, before and after. All required information is stored in suitable formats for other uses, especially for land distribution,

DISTRIBUTION; performs land redistribution using the results of land valuation analysis. All old land parcels are reallocated within the site blocks with respect to their original locations. An optimal solution is provided to consolidate, divide, and redistribute the land parcels to minimise the number of shares within a single land parcel,

QUERY; utilises the display of results for user's requirements. All process results both graphical and textual, including land valuation maps with 3D visualisations, street networks, ownership records, and land-distribution tables are stored for further use. Any information about a land parcel can be easily queried (see Figure.2).

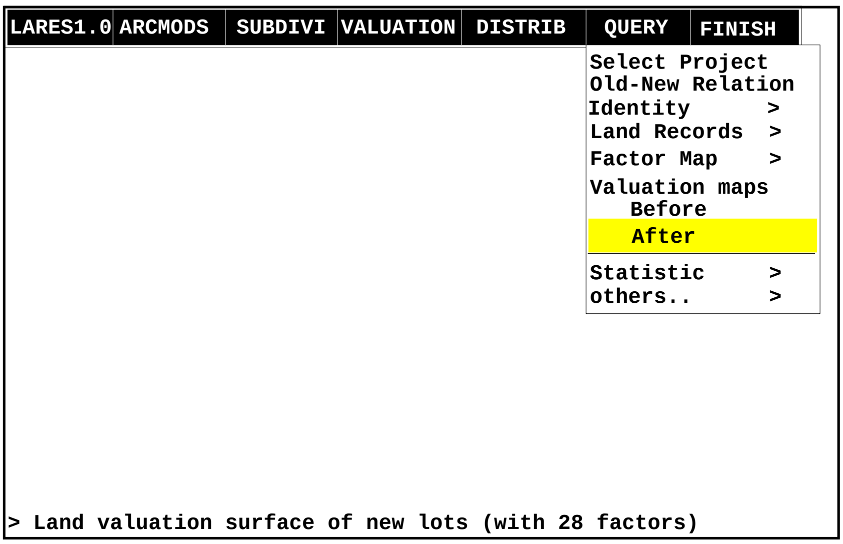


Figure 2 A view of LARES menu

CONCLUSIONS

LR is used in urban development process when suitable reformation of public and private land is needed. Practically, LR controls the rural-to-urban land use changes according to town planning requirements After a LR project, local authorities can able to reconstruct urbanisation by the contribution of landowners. In addition to the provison of public-use area, the private land parcels are also rearranged in a more economic way and landowners receives new land parcels nearby their original land.

LR is a simple concept but it has great benefits for urbanisation. However, currently used methods are having some issues which affect the performance of LR. A non-dynamic land valuation analysis and the use of poor information management system, for example, cause to obtain more benefits from the LR projects. To maximise the benefits from LR, a value-based LR model LARES has been developed using the capabilities of GIS. In this model, some land valuation criteria which may affect the total perceived value of a parcel are formulated and individually analysed. All land parcels are then reallocated within new site blocks in accordance with their calculated numerical values.

Consequently, LR is a significant land planning tool which creatively mobilises land as a physical and financial resource and resolves certain impediments of land in local area development. Nevertheless, to accomplish the technical requirements of the LR process, the use of GIS is very essential. A GIS-based approach certainly increased the performance of LR. While providing an effective information management process, many complex tasks, such as land valuation analysis and land redistribution have been accomplished in a short time. As a bonus, the data for a full land information system resulted.

REFERENCES

Archer, R.W. (1992), Introducing the Urban Pooling/Readjustment Technique into Thailand to Improve Urban Development and Land Supply, Public Administration and Development, Vol.12, pp. 155-174, John Wiley & Sons, Ltd.

Chou, T.C. and Shen, S.K. (1982), Urban Land Readjustment in Kaohsiung, In Doebele,W.A (ed.), Land Readjustment: A Different Approach to Financing Urbanization, Massachusetts: D.C. Health and Company, Lexington Books.

Dale, P.F and McLaughlin, J.D. (1988), Land Information Management, Oxford University Press, New York.

Doebele, W.A. (1982), Land Readjustment: A Different Approach to Financing Urbanization, Massachusetts: D.C. Health and Company, Lexington Books.

Frizzell, R. (1979), The Valuation of Rural Property, Lincoln College, New Zeland.

Maguire, D.J. (1991), An Overview and Definition of GIS, In: Maguire D J, Goodchild M, Rhind D (eds.), Geographical Information Systems: Principles and Applications, pp.9-22, Vol.1, Longman, London.

Rainer, M.J. (1992), Detailed District Plan and Land Readjustment Project, International Conference on Urban Development Policies and Projects, Nagoya.

Satoh, T. (1986), Land Readjustment Problems in Implementation and Representation, In Minerbi, L. et.al.(ed.), Land Readjustment: The Japanese System, University of Hawaii, OGunn&Hain/A Lincoln Institue of Land Policy, Boston.

Yomralioglu, T. and Parker, D. (1992), A New Approach to Land Reallocation Using GIS, EGIS'92 Coneference Proceedings, Vol.II., p.1519-1520., The Netherlands.