Application of Finite Difference Method to Develop Land Value Map

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Key words: finite difference, isovalue, land value zone

SUMMARY

In the property taxation, land value map is used to identify the value of tax objects (parcels) when mass appraisal is applied. The problem in generating land value map rises because of their abstract boundary. The land value map is developed in the basis of land value data in the certain area. Generally the sample data of land transactions are very limited, this need to be developed a model to generate land value map.

The research was intended to develop a land value map using a mathematical method called a finite difference. Sample data used in the research was a small part area in the north of Yogyakarta, Indonesia. The study area was divided into two dimensional grids map. After the finite difference method was applied every cross-point would have its characteristic which represent the land value. Land values surrounding the main road were established as the outer boundary conditions, whereas the impact of main road in the land value and the data samples were established as the inner boundary conditions.

The finite difference calculation yielded an isovalue lines that representing the land values. Land value map was generated by overlaying the isovalue lines with the land parcel map. The result shows that the land value map indicates about 80% of land value resulted by the model are close to the actual values. The model also provides a smooth change in the boundary classes. This means that every land value zone class bounded one class lower or higher value.

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1. INTRODUCTION

In Indonesia, property valuation for taxation purposes is under authority of the Land and Building Tax Agency (PBB Office). The property valuation is based on the Land and Building Tax Law 1985 which clearly mention that the property value should be derived from the market value. If there are no market data in a certain area, then comparative, income, or cost approach should be applied.

Rural and urban properties are valued through a mass appraisal system. The average land value of each block is taken as the value in that area and listed in the land value book. Data related to the valuation processes are collected from the taxpayers and field survey by the PBB Office. The distribution of land value in a certain area is depicted on the land value map in which called *land value zone (*LVZ) map.

Land value zone is a geographical zone that shows several groups of tax object (demarcated land parcel boundaries) in a certain area in which every groups of zone has a class of land value in accordance with standard of classification in PBB Office. The value every class is derived from the mean land prices of sample data. When there is no data in the area, we have to develop a technique in generating land value in the area. The method will be discussed in this paper is using a mathematical model, called finite difference method.

2. CONCEPTUAL THEORY

Finite difference is a method to estimate values that is as a characteristic domain in the research area. The finite difference method use a grid map for calculation processes. The intersection of grids are called grid points or nodes.

Figure 1 shows an R (two dimensional) area that identified by grid points in which P1, P2, and P3 are the independent values. Based on the fixed independent values of P1, P2, and P3 then values of all grid points will be estimated by using finite difference method. Hoffmann (1999; 14) said that numerical method to solve a differential equation could be done using finite difference approach that derived in accordance with Taylor series formula.

Elliptic differential equation has closed area that influenced by its boundary condition. The estimation of land values in surrounding research area are taken as outer boundary condition, while land value data that yielded from field survey involved as inner boundary condition.

Kouitas (1983; 22) said that if there is $\mathbf{x_i}$ in the function of $f(x)$, and there a value of derivation of f to x, and $x_{i+1} = x_i + \Delta x$, therefore in accordance with Taylor series can be said :

$$f(x_{i+1}) = f(x_i) + f'(x_i)\frac{\Delta x}{1!} + f''(x_i)\frac{\Delta x^2}{2!} + ... + f^n(x_i)\frac{\Delta x^n}{n!} + Rn \quad \text{.....(1)}$$

where, Rn is the intersection error.

The solution of the equation $\frac{d^2 f}{dx^2}$ is given by :

$$\frac{d^2 f}{dx^2} = \frac{f(x_{i+1}) - 2f(x_i) + f(x_{i-1})}{\Delta x} - Rn \quad \text{.....(2)}$$

In this case, Laplace equation of the elliptical form is :

$$\frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2} = 0 \quad \text{.....(3)}$$

In the context of land values determination on land value zone, f(i,j) is defined as a grid point (i,j), while Δx and Δy are the distance between grids respectively.

An isovalue line is a line shows connected points that has a similar land value. The line is derived by interpolation processes using finite difference method. Then determination of land value zone is done by overlaying between parcel map and isovalue line map. The classification of land value zone is needed to show all land value classes on the land value zone map.

3. METHODOLOGY

The data for all parcels that digitized on parcel map of Desa Condongcatur, Kecamatan Depok, Yogyakarta were used to illustrated the methods discussed in this paper. The transaction of land sales data were collected in period May 2003 till January 2004. All of the land sales data are adjusted and transformed to date of 01 January 2004 using standard correction that determined by PBB Office. The research was executed through many stages illustrated in figure 2.

The model development involved determination of grids, boundary condition, and value of the grid points. The general algorithm of the model is derived from Laplace equation, that is based on the equation (2) and (3), then

$$f_{(i,j)} = \frac{(\Delta x)^2[f_{(i+1,j)} + f_{(i-1,j)}] + (\Delta y)^2[f_{(i,j+1)} + f_{(i,j-1)}]}{2[(\Delta x)^2 + (\Delta y)^2]} \quad \text{.....(4)}$$

The equation (4) was applied to calculate of all grid point values based on the outer and inner boundary condition of land values. The calculation processes was done on Microsoft Excel software package. Therefore, every grid point has value represent land value in that area.

The isovalue map (Figure 3), then generated based on grid point values. This was done using Surfer software package. Value of the isovalue line showed classes of land value according to Decree of Ministry of Finance the Republic of Indonesia No. 523/KMK.04/1998. Finally, the land value zone map (Figure 5) was developed by overlaying between parcel map and isovalue map using MapInfo software package.

4. RESULT AND DISCUSSION

The final result of the research is land value zone (LVZ) map that shows distribution of land value zone of the study area (Figure 5). The LVZ map was generated by overlaying between parcel map and isovalue line map. In fact, the isovalue lines were not exactly mach to the parcel boundaries. When one parcel is crossed by an isovalue line then the value of the parcel is the value class in the its bigger area.

When we make a comparison between LVZ map developed by PBB Office that done manually (called old LVZ map) and LVZ map yielded the research (called new LVZ map) that illustrated in figure 4, therefore can be prompted that the distribution of the land value zones shows that a value zone class exactly next to the one land value class upper or lower at the new LVZ map. In contrast old LVZ map indicated that there are many gaps between land value classes in neighboring zone. It can be said that the land value zone class changes smoothly in the new LVZ map because the value mainly determined by function of distance and value of grid points. Table 1 illustrated increasing land values within the study area in period of year 2003-2004. It is relatively high change of land prices (approximately increase 425.000 rupiahs/m2) because of rapid growth development in the area.

The evaluation of the quality of the finite difference model was carried out by examining how the model satisfied of the criteria outlined in the standard valuation processes. Standard Ratio Studies 1990 mentioned that deviation on mean value should be in the range of 0.9 to 1.10 (10% of deviation). Table 2 shows the evaluation of the applied model. The model was tested using 40 data samples. There were 8 samples of parcel data exceeded the range of the valuation standard. This mean that 32 samples (80%) are met to the criteria of quality model.

The value of land depends upon its characteristics that involve many factors, such as its proximity to other land resources (accessibility), availability of transport, adequacy of public services, topographical of land, shape, size, frontage, etc., and also economic climate and government policies. The method discussed in this paper involves only proximity factors that is as boundary conditions. Therefore, it is an opportunity to extent the model which is included more complex factors of land values.

5. CONCLUSIONS

The finite difference method demonstrated an opportunity to use in generating land value map. The application of the method using data samples of Desa Condongcatur, Kecamatan Depok, Yogyakarta, showed significantly met to the field data that was 80% within range of standard of valuation criteria. The methodology used in this paper involved only proximity factors as boundary conditions, however, the value of land depends upon so many factors. Therefore, the model should be developed to include other factors influenced land valued.

FIGURES AND TABLES

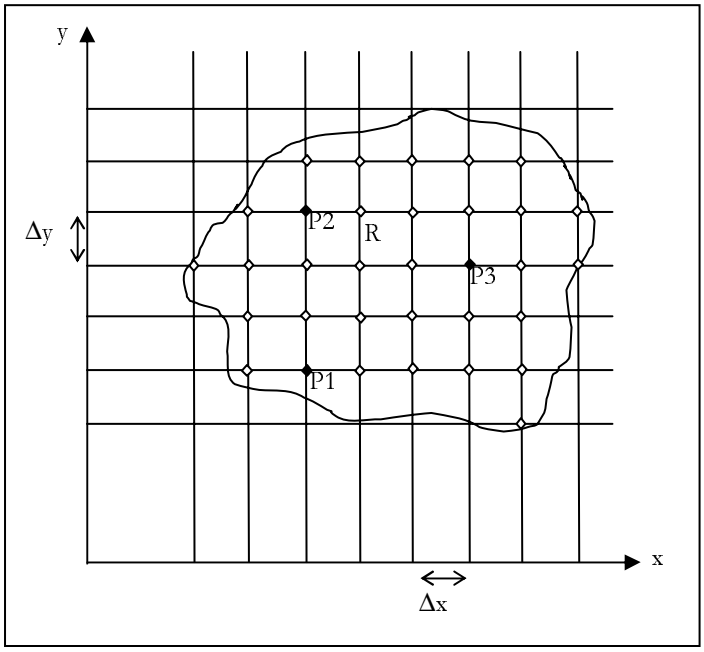

Figure 1. *Domain* R and Grid Points (Suorces : Jain, et al, 1985)

Table 1. The change of land values

The change of land value class	decrease	constant	increase
Percentage of land values (rupiahs)	0,00%	0,01%	99.99%
Total area of parcel (square metre)		722	5.819.821
Mean increasing land values/m^2 (rupiahs)			425.742,08

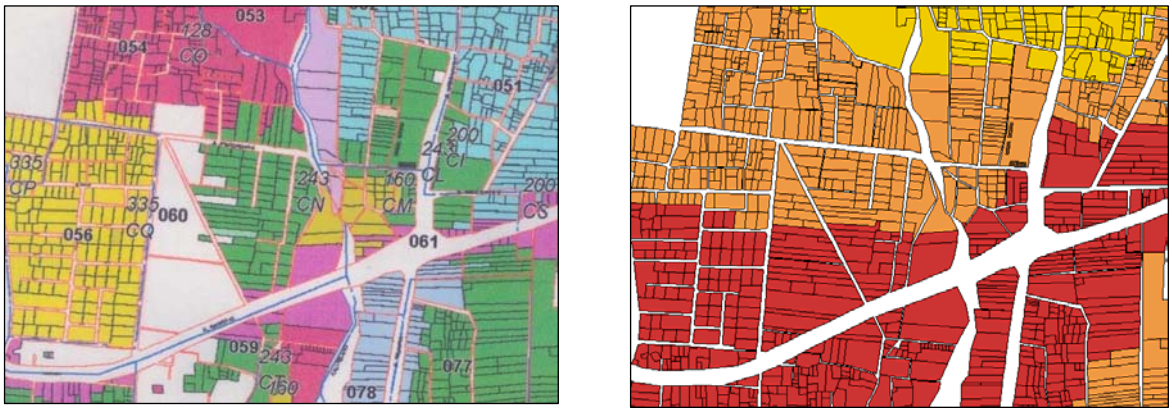

Figure 4. The old LVZ map (left) and new LVZ map (right)

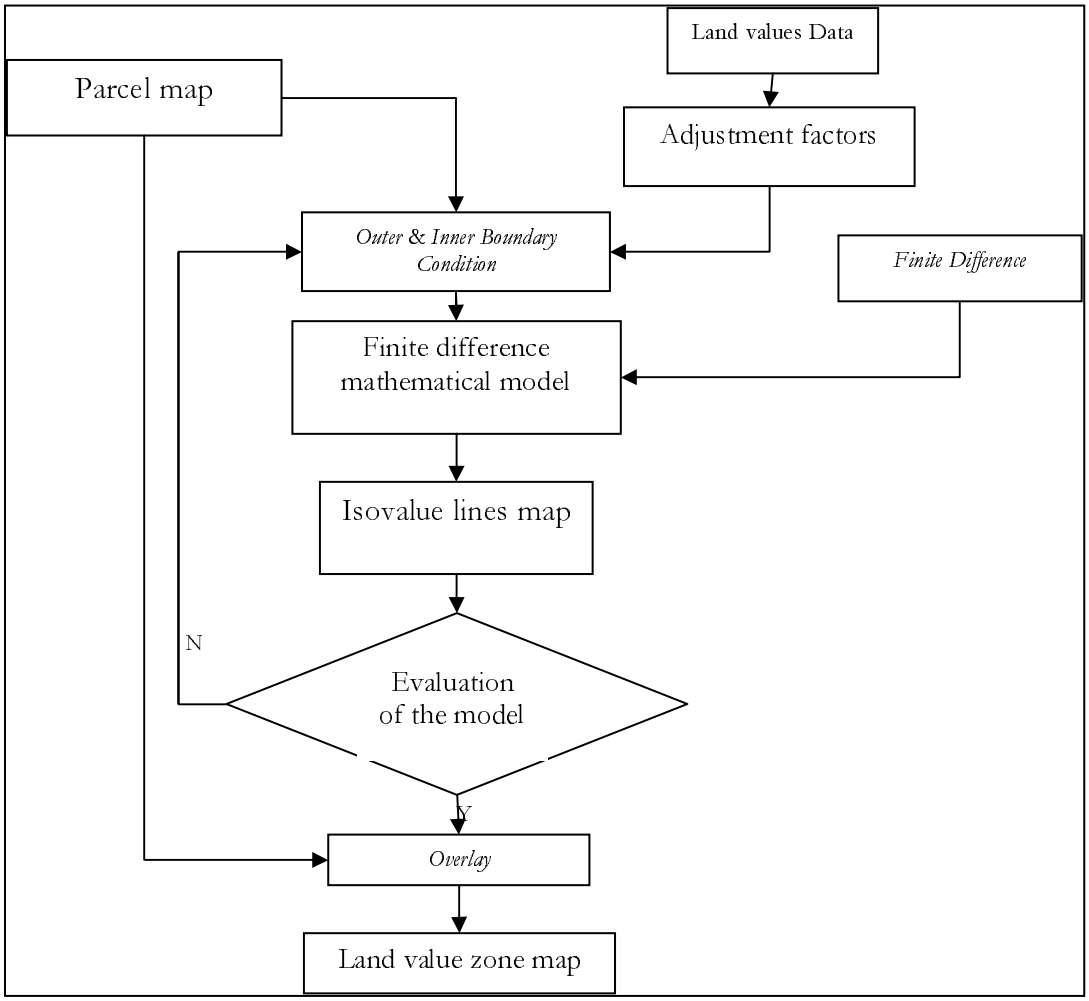

Figure 2. Flow chart of research stages

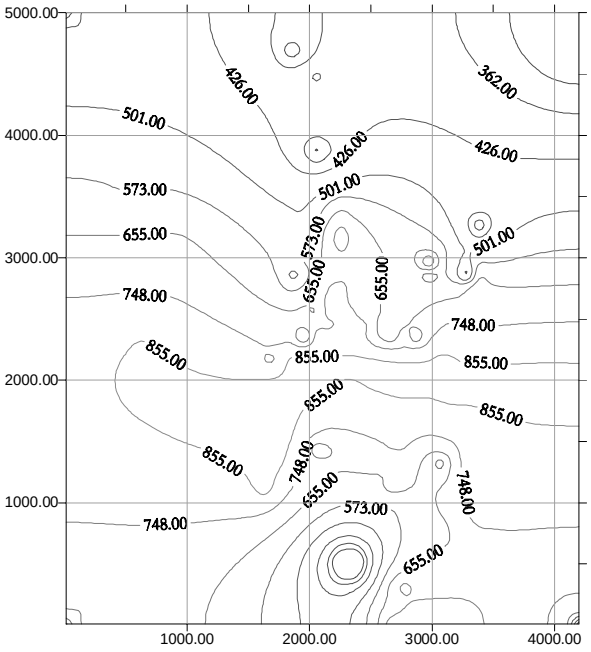

Figure 3. *Isovalue line map*

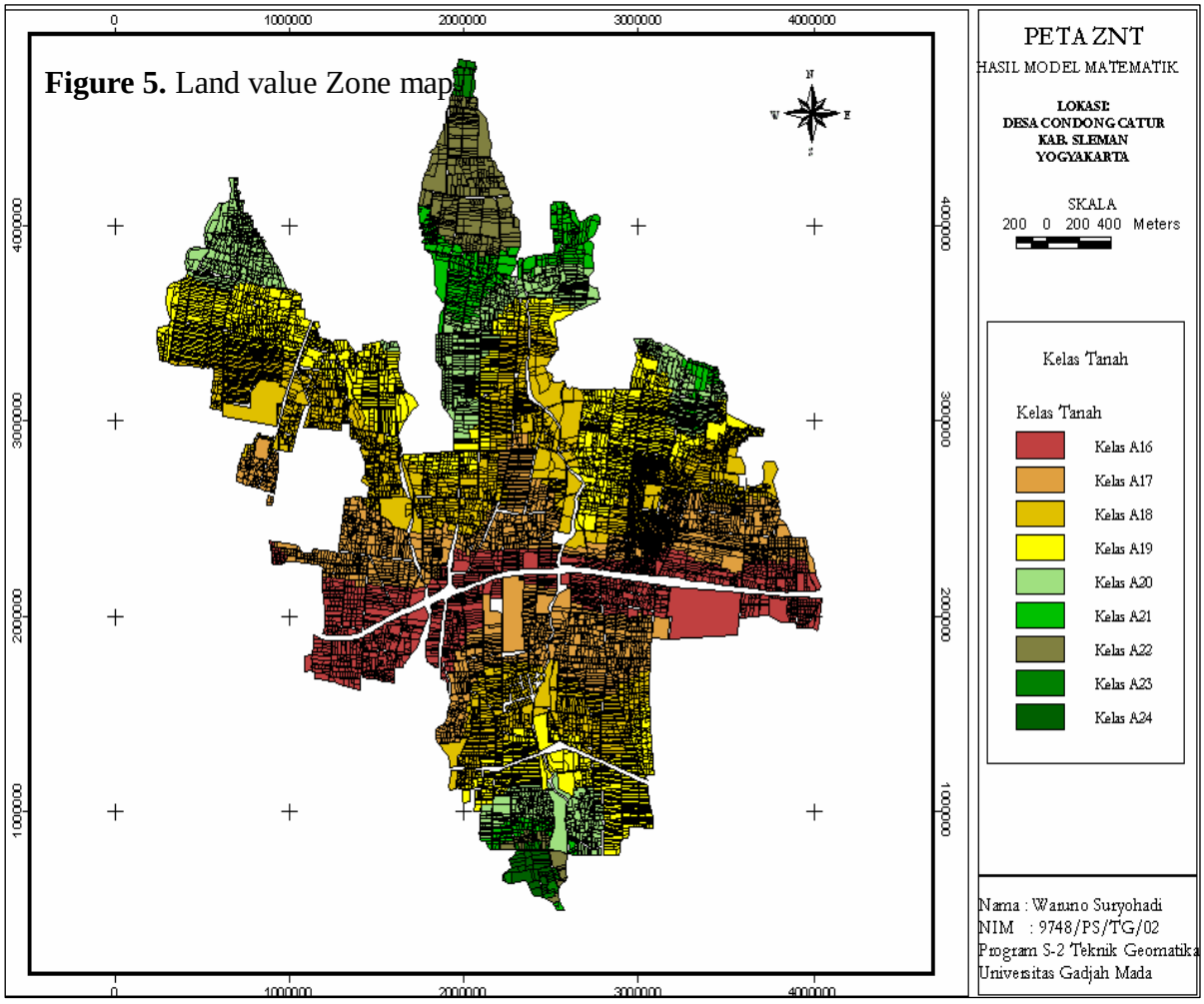

Table 2 : Evaluation of the model

NOP	Sales data	Class of zone	Land value boundary		Deviation of Land value		Deviation Least than 10% ?
			Max	Min			
	x Rp 1.000		x Rp 1.000	x Rp 1.000	Max	Min	
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
014-0040.0	754.6	A18	748.0	655.0	1%	13%	Y
020-0101.0	651.2	A18	748.0	655.0	15%	1%	Y
021-0012.0	547.4	A20	573.0	501.0	5%	8%	Y
021-0039.0	530.4	A19	655.0	573.0	23%	8%	Y
022-0103.0	489.6	A20	573.0	501.0	17%	2%	Y
023-0111.0	811.1	A18	748.0	655.0	8%	19%	Y
027-0021.0	306.1	A22	426.0	362.0	39%	18%	N
031-0040.0	206.0	A22	426.0	362.0	107%	76%	N
040-0083.0-0085.0	810.9	A19	655.0	573.0	19%	29%	N
040-0092.0-0094.0	534.9	A19	655.0	573.0	22%	7%	Y
042-0041.0	426.2	A20	573.0	501.0	34%	18%	N
043-0054	350.2	A20	573.0	501.0	64%	43%	N
046-0059.0	771.6	A18	748.0	655.0	3%	15%	Y
047-0175.0	772.3	A18	748.0	655.0	3%	15%	Y
047-0177.0	744.8	A18	748.0	655.0	0%	12%	Y
048-0023.0	537.5	A19	655.0	573.0	22%	7%	Y
049-0034.0	751.7	A17	855.0	748.0	14%	0%	Y
050-0080.0	711.2	A18	748.0	655.0	5%	8%	Y
051-0036.0	494.4	A18	748.0	655.0	51%	32%	N
052-0112.0	696.0	A18	748.0	655.0	7%	6%	Y
052-0139.0	721.7	A17	855.0	748.0	18%	4%	Y
056-0055.0	849.8	A17	855.0	748.0	1%	12%	Y
061-0068.0	728.0	A17	855.0	748.0	17%	3%	Y
062-0052.0	902.4	A16	977.0	855.0	8%	5%	Y
062-0074.0, 0073.0	854.7	A16	977.0	855.0	14%	0%	Y
062-0078.0,0079.0	783.9	A16	977.0	855.0	25%	9%	Y
062-0082.0,0084.0	783.9	A16	977.0	855.0	25%	9%	Y
063-0065.0	762.2	A17	855.0	748.0	12%	2%	Y
064-0113.0	702.7	A18	748.0	655.0	6%	7%	Y
064-0135.0	520.0	A19	655.0	573.0	26%	10%	N
064-0194.0	674.8	A18	748.0	655.0	11%	3%	Yi
066-0096.0	769.0	A18	748.0	655.0	3%	15%	Y
073-0053.0	512.5	A18	748.0	655.0	46%	28%	N
079-0095.0	600.0	A18	748.0	655.0	25%	9%	Y
086-0020.0	653.6	A18	748.0	655.0	14%	0%	Y
086-0059.0	628.9	A18	748.0	655.0	19%	4%	Y
086-0122.0, 0120.0	688.7	A18	748.0	655.0	9%	5%	Y
091-0057.0	525.0	A20	573.0	501.0	9%	5%	Y
101-0052.0	750.9	A18	748.0	655.0	0%	13%	Y
102-0050.0	794.2	A17	855.0	748.0	8%	6%	Y

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