The Extent of Land Use Externalities in the Fringe of Jakarta Metropolitan: An Application of Spatial Panel Dynamic Land Value Model

Rahma Fitriani, Eni Sumarminingsih, Suci Astutik

Abstract**—**In a fast growing region, conversion of agricultural lands which are surrounded by some new development sites will occur sooner than expected. This phenomenon has been experienced by many regions in Indonesia, especially the fringe of Jakarta (BoDeTaBek). Being Indonesia's capital city, rapid conversion of land in this area is an unavoidable process. The land conversion expands spatially into the fringe regions, which were initially dominated by agricultural land or conservation sites. Without proper control or growth management, this activity will invite greater costs than benefits. The current land use is the use which maximizes its value. In order to maintain land for agricultural activity or conservation, some efforts are needed to keep the land value of this activity as high as possible. In this case, the knowledge regarding the functional relationship between land value and its driving forces is necessary. In a fast growing region, development externalities are the assumed dominant driving force. Land value is the product of the past decision of its use leading to its value. It is also affected by the local characteristics and the observed surrounded land use (externalities) from the previous period. The effect of each factor on land value has dynamic and spatial virtues; an empirical spatial dynamic land value model will be more useful to capture them. The model will be useful to test and to estimate the extent of land use externalities on land value in the short run as well as in the long run. It serves as a basis to formulate an effective urban growth management's policy. This study will apply the model to the case of land value in the fringe of Jakarta Metropolitan. The model will be used further to predict the effect of externalities on land value, in the form of prediction map. For the case of Jakarta's fringe, there is some evidence about the significance of neighborhood urban activity – negative externalities, the previous land value and local accessibility on land value. The effects are accumulated dynamically over years, but they will fully affect the land value after six years.

Keywords**—**Growth management, land use externalities, land value, spatial panel dynamic.

I. Introduction

URBAN growth is a consequence of the economic growth. The growth has been associated with conversion of agricultural land or open space for urban use. The spatial interaction among land uses or land use externalities has been indicated as one among some other factors which drives the land use change [1]-[3]. As a result, in a region with strong economic growth, agricultural sites which are surrounded by developments will be converted soon, even though they are still in their productive state; the regions in the fringe of Jakarta (Bogor, Depok, Tangerang, and Bekasi – BoDeTaBek), as well as some other major cities in Indonesia, have faced this phenomenon.

BoDeTaBek has its special function to support Jakarta as Indonesia's capital city. Lands in those regions are mainly dedicated for residential use. Other than for residential use, according to 2012 data, 15% of Bogor Regency's area, 44.5% of Tangerang Regency's area and 49% of Bekasi Regency's area, are productive agricultural and conservation land. Due to the domination of externalities [4] on land value, the development in proximity of those sites puts much pressure on their value in their current state, and increases their value for urban use. Furthermore, there is no enforcement of effective land use policy, leading to immature conversion of productive agricultural sites and conservation areas. As a result, Jakarta and its fringe regions have suffered serious environmental problems, such as yearly flooding and water quality degradation [5]. It implies that the current land conversion activity invites greater costs than benefits.

Some studies indicate that the negative consequences of land conversion can be reduced by applying proper land use policy (e.g. urban growth boundaries, incentive based policies, or zoning) based on the extent and dominant type of the externalities [6]-[8]. The implemented policy is expected to reduce the development pressure on productive agricultural sites and conservation areas.

Knowledge regarding the driving forces of land value is an important reference to formulate effective land control or regulation. Such knowledge will be reflected on a land value model, which is defined as a functional relationship between land value and its determinants.

Alonso's traditional monocentric city model [9] is the origin of the land value model. The model is static and includes only the distance from the CBD as the determinant of land value. More realistic recent models have accommodated additional factors such as externalities [1], [2], [10], urban pressure [11], [12] and time dimension [1], [2], [12], [13]. They indicate that land value is a result of dynamic interaction among spatially distributing agents.

The development of spatial econometrics models, specifically a spatial panel dynamic model, provides a framework to include the dynamic nature and the spatial interaction in the empirical model of land value. Within this framework, in addition to the analysis of the ordinary marginal effect of the driving force on the land value, the analysis

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regarding the spatial effect of the driving force on the land value and its dynamic can be carried out explicitly. Here, the spatial effect refers to the externalities of land use.

Since the externalities and their dynamic are considered as the dominant driving forces on the land value of Jakarta's fringe, the objective of this study is to empirically model the agricultural land value in this area based on the spatial panel dynamic framework. The estimated model's parameters will be used further to test the significance of the externalities and predict the future agricultural land value. The analysis will include the prediction of the effect of the dominant driving forces on agricultural land value.

II. Empirical Land value Model with Spatial and Temporal Effects

The latest works regarding the empirical land value model are mainly based on the theoretical model which assumes that land value is the product of dynamic interaction among spatially distributing agents. Hence, the dynamic nature and the spatial interaction must be included in the empirical model. Some studies only implicitly treat the spatial factor by including the spatially correlated error terms in the model [14], or by using the econometrics model with random spatial effects [15], [16]. Whereas, Fitriani and Sumarminingsih [17] accommodate the spatial autocorrelation explicitly in a spatial econometrics model. The spatial autocorrelation represents the land use externalities. The use of panel data in Hardi, Narayan et el. [14] is an attempt to take into account the temporal factor. This same approach is used by Fitriani and Sumarmingsih [18]; they conduct semivariogram analysis on several years of spatial data of land use for the case of Jakarta's fringe. The study shows the dynamic nature of the extent of externalities over time. Those empirical works indicate that the spatial effect and the dependence over time create a substantial effect on land value. However, most of those studies still treat each dimension separately. Therefore, to support the applicability of the latest theoretical land value model, it would be better to accommodate both dimensions in the empirical model. The current development of the spatial econometrics model allows for the inclusion of both dimensions, in a spatial panel dynamic model.

A spatial land value model is a tool to analyze how the change of one driving force of a location affects the land value of the same location (the direct effect) as well as the land value of the neighboring locations (the indirect effect). The second effect refers to the land use externalities; whereas, a time series model will be useful to analyze the short run and the long run – dynamic effects. The first effect on land value is observed instantly due to the change of the explanatory variable, and the second one will be observed some periods of time after the change. When both dimensions are accommodated within the spatial panel dynamic setting, additional analysis can be carried out, namely the dynamic indirect effect. It measures how much the change of the local driving force affect the neighboring locations' land value after some periods of time. In the case of land value, this effect is the dynamic of externalities.

The analysis of the spatial dynamic model includes the model's parameters estimation and hypothesis testing on their significance. The process needs a set of spatial panel data, i.e., a set of spatial data observed at several periods of time. Estimation method for the model's parameters (Quasi Maximum Likelihood Estimation – QMLE) and hypothesis testing of their significance have been discussed in Yu and Lee [19] or Elhorst [20], [21]. The estimated model's parameters can be used further to estimate the indirect effects and how the effects dynamically evolve over time. The derivation of the direct and indirect effects of the model in general follow the formulation in Lee and Yu [22]. Specifically for the case of land value, Fitriani et al. [23] have conducted the derivation of such effects. Furthermore, this study uses the model for prediction, following the procedure in Fingleton [24].

III. The Application of Spatial Panel Dynamic Model of Land Value for Jakarta's Fringe

A. The Spatial Panel Dynamic Model of Agricultural Land Value

The empirical model of land value for agriculture developed in this study is based on the theoretical land value model in Fitriani [10], namely a model of location's choice with externalities. It follows the crowding – positive externalities model in Fujita [25], with additional type of externalities, the negative ones. The inclusion of two opposite types of externalities is similar to the work of Caruso et al. [1]. The model assumes that the utility of choosing a location is a function of both types of externalities which are observed at the previous time period. The positive externalities are produced by the same or similar land use, whereas the negative ones come from completely different land use. Here, the dynamic nature of the decision making process is taken into account. The utility maximization process subject to a budget constraint, leads to the final land value, which is a function of location characteristics: distance to the CBD, geographical conditions, and land use externalities.

The empirical agricultural land value model, using the spatial panel dynamic setting, is defined such that agricultural land value of location i at time t (Y_{it}) is a function of the following explanatory variables:

1. The neighborhood present agricultural land value ($Y_{jt}, j \in$ neighborhood of i)
2. The local previous period agricultural land value ($Y_{i,t-1}$)
3. The neighborhood previous period agricultural land value ($Y_{j,t-1}, j \in$ neighborhood of i)
4. The neighborhood previous period land value for different use, i.e. urban use ($De_{j,t-1}, j \in$ neighborhood of i)
5. The local present land characteristic, i.e. distance to the central Jakarta, in terms of accessibility ($\boldsymbol{X}_{it}$).

The observed externalities at the previous period which affect the utility are presented by (3) and (4), respectively for the positive and negative type. Together with variable (2), they capture the dynamic of agricultural land value. Variable (1) and variable (5) capture the local condition which affects land value.

The concept of "neighborhood" can be defined based on the relative distance between locations or the spatial arrangement of every location. When it is used in the model, this concept will differentiate the proposed spatial model from a non – spatial model. The spatial arrangement will be presented in the form of an $n \times n$ spatial weight matrix $\boldsymbol{W}$. The element w_{ij} of the matrix for $i = 1, \cdots, n$ and $j = 1, \cdots, n$, is positive if locations i and j are considered as neighbors, and zero otherwise. By definition, $\boldsymbol{W}$ has zeros diagonal elements. When two locations are considered as neighbors, they affect each other significantly. Formal definition for each element of $\boldsymbol{W}$, according to a contiguity concept is:

$$w_{ij} = \frac{c_{ij}}{c_{i.}}, c_{ij} = \begin{cases} 1, \text{if location i and j share borders} \\ 0, \text{otherwise} \end{cases}, \quad c_{i.} = \sum_{j=1}^{N} c_{ij} \tag{1}$$

Multiplication between $\boldsymbol{W}$ and a vector variable (says $\boldsymbol{Y}$) defines as a spatial lagged of $\boldsymbol{Y}$. By definition, the *i*-th element of $\boldsymbol{WY}$ is the average of $Y_j, j \in$ neighborhood of i. Therefore, when $\boldsymbol{Y}$ is a vector of agricultural land value, $\boldsymbol{WY}$ defines the neighborhood agricultural land value.

The spatial dynamic panel model of agricultural land value can be defined as:

$$\mathrm{Y_t = \lambda WY_t + \gamma Y_{t-1} + \rho WY_{t-1} + \eta WDe_{t-1} + X_t\beta + \mu + \varepsilon_t}, \tag{2}$$

in which $\boldsymbol{Y}_t$ is an $n \times 1$ agricultural land value vector of each spatial unit – location ($i = 1, \cdots, n$) at time t, and $\boldsymbol{De}_t$ an $n \times 1$ vector of variable representing land value for urban use of every location ($i = 1, \cdots, n$) at time t. Vectors $\boldsymbol{WY}_t$, $\boldsymbol{Y}_{t-1}$ and $\boldsymbol{WY}_{t-1}$ represent the agricultural land value lagged in space, the agricultural land value lagged in time (the previous period local agricultural land value) and the agricultural land value lagged in both space and time, respectively. $\boldsymbol{WDe}_{t-1}$ represents the land value of urban use lagged in both space and time. $\boldsymbol{X}_t$ is an $n \times K$ matrix of K explanatory variables for every location ($i = 1, \cdots, n$) at time t, ($t = 1, \cdots, T$). This matrix is used based on the assumption that the local land value is determined by some local characteristics. In this case, only one explanatory is used, namely the accessibility, such that $K = 1$. λ, γ and ρ are the parameters of $\boldsymbol{WY}_t$, $\boldsymbol{Y}_{t-1}$ and $\boldsymbol{WY}_{t-1}$ respectively. $\boldsymbol{\beta}$ is a $K \times 1$ vector of parameters of the explanatory variables and $\boldsymbol{c_0}$ is an $n \times 1$ vector containing spatial specific effects for each location. They are meant to control for all spatial specific time invariant variables. It is assumed that each component of $\boldsymbol{\mu}$, $\mu_i \sim iid\ N(0, \sigma_\mu^2)$. Lastly, $\boldsymbol{\varepsilon}_t$ is an $n \times 1$ vector of i.i.d disturbance terms, with zero mean and infinite variance σ_ε^2.

The model in (2) is then elaborated to derive the instant – short run – as well as the dynamic – long run – of the indirect effects on land value due to the change of the explanatory variables (externalities). The instant – short run effect is the observed effect instantly after the change. It is assumed that the change and the effect occur at the same time period. The dynamic – long run effect is the observed effect some periods after the change. It is assumed that the change occurs at time $t - r$ and the effect is observed at time t. For both instant and dynamic effects, the indirect effect is calculated by taking the difference between the total and the direct effects. The total effect is the average effect on the expected agricultural land value due to the simultaneous change of the explanatory variable across a location. On the other hand, the direct effect is the average effect on the expected agricultural land value due to the change of the local explanatory variable. The complete derivation has been discussed in Fitriani et al. [23].

Fitriani et al. [23] define the indirect – instant as well as the indirect – dynamic effects, due to the change of the explanatory variable, by taking the first derivative of the model's expected value with respect to the accessibility and land value of urban use. The change of local accessibility affects the local agricultural land value (Y_i), which in turn also affects the neighboring agricultural land value ($Y_j, j \in$ neighborhood of i). Since any location j is also the neighbour of location i, the change Y_j eventually affects Y_i, creating the positive externalities on agricultural land value. On the other hand, since one term in the right hand side of (2) is $\boldsymbol{WDe}_{t-1}$ – the land value of other use lagged in space and time, the change of $\boldsymbol{De}$ affects the neighboring land value (indirectly), at least one period after the change. Because $\boldsymbol{De}$ represents the land value of other use, the change of $\boldsymbol{De}$ leads to the negative externalities.

The model's parameters are estimated using QMLE method. Yu and Lee [19] or Elhorst [20], [21] have discussed the estimation method and the hypothesis testing of the parameter's significance thoroughly. The estimated parameters are then used to estimate the instant and the dynamic indirect effects. Furthermore, the estimated model's parameters are also useful to predict the future agricultural land value.

To accommodate the dynamic nature of the model, the prediction will be done recursively based on the time series data. The defined model in (2) indicates that the recursive process needs the availability of the initial value of the response ($\boldsymbol{Y}_0$) and one of the predictor ($\boldsymbol{De}_0$). Fingleton [24] discussed five prediction methods for this dynamic model. Each of the methods treats the initial value problem differently or accommodates the interdependence of disturbance. This study uses the best proposed method in Fingleton [24].

By modification, model (2) becomes:

$$\boldsymbol{Y}_t = \boldsymbol{G}^{-1}(\gamma \boldsymbol{Y}_{t-1} + \rho \boldsymbol{WY}_{t-1} + \eta \boldsymbol{WDe}_{t-1} + \boldsymbol{X}_t \boldsymbol{\beta} + \boldsymbol{\mu} + \boldsymbol{\varepsilon}_t)$$
$$\boldsymbol{G} = (\boldsymbol{I} - \lambda \boldsymbol{W}), \tag{3}$$

such that

$$\boldsymbol{u}_t = \boldsymbol{\mu} + \boldsymbol{\varepsilon}_t = \boldsymbol{Y}_t - \gamma \boldsymbol{Y}_{t-1} - \rho \boldsymbol{WY}_{t-1} - \eta \boldsymbol{WDe}_{t-1} - \boldsymbol{X}_t \boldsymbol{\beta} \tag{4}$$

and

$$\boldsymbol{\mu} = (\boldsymbol{Y}_t - \gamma \boldsymbol{Y}_{t-1} - \rho \boldsymbol{WY}_{t-1} - \eta \boldsymbol{WDe}_{t-1} - \boldsymbol{X}_t \boldsymbol{\beta}) - \boldsymbol{\varepsilon}_t$$
$$\boldsymbol{\varepsilon}_t \sim N_n(0, \sigma_\varepsilon^2 \boldsymbol{I}_n). \tag{5}$$

The estimated model's parameters and the observed data are used to calculate $\widehat{\boldsymbol{\mu}}$ according to the relation in (5), using a random vector of $\boldsymbol{\varepsilon}_t$, which is drawn from the assumed distribution. For each $t, t = 1, \dots, T$, when $\boldsymbol{Y}_0$ and $\boldsymbol{De}_0$ are available, there will be T different estimates of $\boldsymbol{\mu}$. By averaging the estimates across time, there will be a single estimate of time invariant vector of $\boldsymbol{\mu}$, denoted by $\overline{\boldsymbol{\mu}}$. Together with the estimated model's parameter, the following equation is used recursively to predict the response:

$$\widehat{\boldsymbol{Y}}_t = \widehat{\boldsymbol{G}}^{-1}\left(\hat{\gamma}\widehat{\boldsymbol{Y}}_{t-1} + \hat{\rho}\boldsymbol{W}\widehat{\boldsymbol{Y}}_{t-1} + \hat{\eta}\boldsymbol{W}\boldsymbol{De}_{t-1} + \boldsymbol{X}_t\widehat{\boldsymbol{\beta}} + \overline{\boldsymbol{\mu}}\right), \quad (6)$$

using the available initial values, $\boldsymbol{Y}_0$ and $\boldsymbol{De}_0$, for $t = 1, \dots, T, T+1, \dots, T+\tau$. τ is the time horizon for the prediction.

B. The Study Area and the Description of Variables

The area of study covers the fringe of Jakarta: Bogor Regency, Bogor Municipality, Depok, Bekasi Regency, Bekasi Municipality, Tangerang Regency and Tangerang Municipality. Every region/municipality has several districts at the lower administration level, 84 districts overall. Since the district is the lower administration level in which the spatial data is formally available, it will be the spatial unit of this study. The spatial information of each district is extracted from the map of the region provided by BIG (Geospatial Information Agency) Indonesia. The land use related variables are available from "Regions in Numbers" by *BPS* (Central Statistics Biro) Indonesia. Data from 2010 – 2014 are used.

In every district i, the yearly proportion of agricultural land and yearly density (10000 people/km^2), are used respectively, as proxies for agricultural land value (Y_{it}) and land value for competitor use (De_{it}), namely urban use ($i = 1, \dots, 84$ and $t = 2010, \dots, 2014$). Those variables are chosen since the land market in the area has been dominated by the informal sector such that information of land value in terms of price is limited. Data from 2010 are used as initial values (Y_{i0} and De_{i0}), which makes $T = 4$ as the effective size of the time period. The local land characteristic is represented by each district's distance (km) to the CBD, in terms of accessibility ($\boldsymbol{r}_t$). The predictors from 2015 data are used to illustrate the procedure for prediction based on the estimated model.

C. The Estimated Model, the Extent of Externalities and the Predicted Land Value

The dynamic of the proportion of agriculture and density of the area are shown in Figs. 1 and 2, respectively. Those figures show that the average agriculture proportion decreases over the observed years, while the opposite holds for the average density. The QMLE of spatial panel dynamic model's parameters and their significance are presented in Table I. The estimated coefficients in Table I indicates the positive effect of the previous and the current neighborhood's agricultural activity ($\boldsymbol{WY}_t$ and $\boldsymbol{WY}_{t-1}$ respectively), as well as the previous local proportion of agricultural area ($\boldsymbol{Y}_{t-1}$) on the current land value of agriculture, in terms of a district's proportion of agricultural area in the region. Even though only the coefficient of the $\boldsymbol{Y}_{t-1}$ is significant, the results are in line with the theoretical model regarding the positive externalities. The same activities support the land value of that particular use. On the other hand, the result in Table I shows that the accessibility (r) and the neighborhood land use competitor ($\boldsymbol{WDe}_{t-1}$) significantly creates a negative impact on land value for agriculture. Therefore, accessibility still determines the land value for agricultural activity. Good accessibility implies good market of its product, leading to high productivity and eventually high land value for the activity. Whereas, the more intensive urban activity there is in the surrounding locations, the more pressure for development of a location will be. There is no indication of spatial autocorrelation among the model's residuals (p value = 0.29 of the LM test in Table I), implying that the spatial effect has been well accommodated in the model.

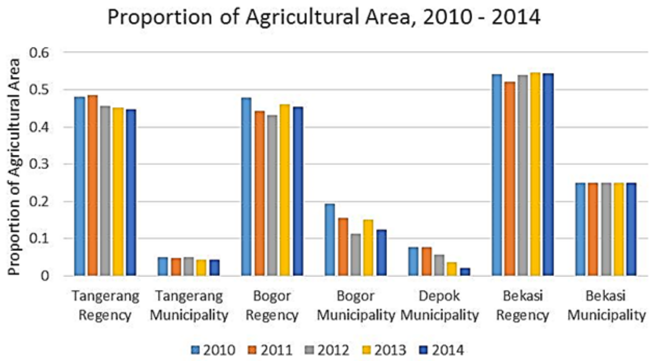

Fig. 1 The Proportion of Agricultural Area, 2010 - 2014

TABLE I
THE ESTIMATED MODEL'S COEFFICIENTS AND THEIR SIGNIFICANCE, THE SHORT RUN EFFECT

Variable	Coefficient	p value of the t test
$\boldsymbol{Y}_{t-1}$	0.1236	0.0186 (*)
$\boldsymbol{WY}_t$	0.0918	0.3617
$\boldsymbol{WDe}_{t-1}$	-0.1918	0.0080 (**)
$\boldsymbol{r}_t$	-0.0049	0.0057 (**)
$\boldsymbol{WY}_{t-1}$	0.0798	0.3128

(*): significant at 5% α, (**): significance at any level of α
Likelihood =760.112422, σ^2= 0.0015
LM for spatially correlated errors : 1.130784
chi sq. (1)= 6.64, p value = 0.2876,

The magnitude of each estimated coefficient in Table I is the short run effect of each variable on the proportion of agricultural area. For example, if the current average neighborhood density increases by 1000 people/km^2, the next year, the local proportion of agricultural area will decrease by 19%.

The estimated model's coefficients can be elaborated further to analyze the extent of the externalities and their dynamic on land value of agriculture in the fringe of the Jakarta Metropolitan. Two sources of externalities are considered, namely the local land characteristic in terms of accessibility (r) and the density ($\boldsymbol{De}$), respectively, for the positive and the negative externalities. The estimation process needs the calculation of the total, direct and indirect (externalities) effects for each source, which follows the formulation in Fitriani et al. [23]. It is assumed that those effects occur instantly as well as dynamically.

TABLE II
THE ESTIMATED (INSTANT) TOTAL, DIRECT, INDIRECT EFFECTS, AND THEIR SIGNIFICANCE

Effect	Estimate	p value (significance)
$ATIE_r$ (Total Effect of r)	-0.0056	0.0026 (**)
$ADIE_r$ (Direct Effect of r)	-0.0051	0.0027 (**)
$AIIE_r$ (Indirect Effect of r) – positive externalities	-0.0005	0.3233
ATE_{De} (Total Effect of $\boldsymbol{De}$)	-0.2019	0.0129 (*)
ADE_{De} (Direct Effect of $\boldsymbol{De}$)	-0.0031	0.3438
AIE_{De} (Indirect Effect of $\boldsymbol{De}$) – negative externalities	-0.1988	0.0128 (*)

(*): significant at 5% α, (**): significance at any level of α

The calculated instant effects as well as their significance (of the t test, following the procedure in Elhorst [21]) are presented in Table II. The results in Table II indicate that the current change of r and $\boldsymbol{De}$, create current total, direct and indirect negative effects on the proportion of land for agriculture. The results are in accordance with the short run effects presented in Table I. Among those effects, the positive type of externalities is the indirect effect due to the change of the local land characteristic, in terms of accessibility (r). The total effect due to the change of r is significant, and the direct effect dominates the indirect one. It implies that, the change of r mainly determines the local land value, but it does not exhibit significant positive externalities. The estimated coefficient of the direct effect in Table II predicts that for every 1 km of the location from the CBD (r), the proportion of agriculture area in that location decreases by 0.5%. On the other hand, the negative type of externalities is the indirect effect due to the change of the land value of competitor use (in terms of density – $\boldsymbol{De}$). The total effect is significant, but it is dominated by the indirect effect. It indicates the significance of negative externalities. The estimated coefficient of the indirect effect in Table II shows that if the average neighborhood density increases by 10000 people/km^2, the local land proportion of agriculture area decreases by 19%.

In addition to the instant effects, the dynamic effects can also be estimated. The analysis is useful to explore the long run – cumulative effects of the change on land value. The change in accessibility (r) creates a significant direct (local) dynamic effect, and the change in density ($\boldsymbol{De}$) has a significant indirect dynamic effect (negative externalities). Figs. 2 and 3 present the magnitude of the effect along the years, respectively, for the local accessibility and the negative externalities. Those figures show that the effect remains at a certain level at six years and beyond after the change, implying that the change will fully affect the land value after six years. The magnitude of the effect at the 6th year represents the long-run effect.

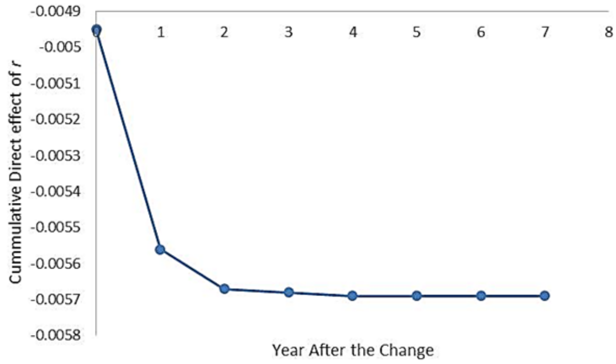

Fig. 2 The magnitude of dynamic local effect of accessibility on land value along the years

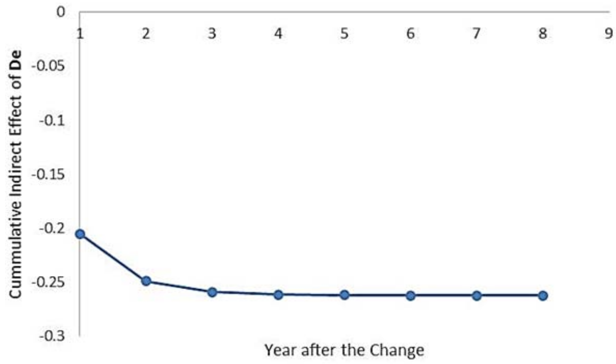

Fig. 3 The magnitude of dynamic negative externalities on land value along the years

D. The Prediction

Using the predictors from 2015 data, the prediction procedure (3)-(6) is applied to obtain the predicted agricultural land value, in terms of the proportion of agricultural land. The 2010 data are used to define the values of $\boldsymbol{Y}_0$ dan $\boldsymbol{De}_0$. The procedure uses the QMLE of the model coefficients, as presented in Table I. The predicted values of all regions are mapped in Fig. 4. The figure indicates that under the 2015 condition, the regions nearby urban centers are predicted to have low agricultural land value. The model also predicts the decrease of the land value for agricultural activity in the southern region of Bogor. However, locations that are relatively far from urban centers are predicted to maintain their land value for agricultural use. By comparing the predicted map in Fig. 4 to the real condition of 2015 in Fig. 5, the prediction is quite relevant to the real condition. The comparison is presented more clearly in Fig. 6. The model predicts accurately for the land value of the areas in proximity of the urban centers and of the areas which are relatively inaccessible from the urban centers (around 56% of all locations). Whereas locations with medium access, which are surrounded by urban activity, are predicted to have higher land value of agriculture than the real condition (over – predicted). Therefore, in reality, in these locations, the negative externalities dominate the market accessibility. Furthermore, in the southern part of Bogor, the effect of nearby urban activity leads to a lower prediction of agricultural land value than the real condition (under – predicted). Both the over – prediction and under – prediction cases indicate that negative externalities dominate the local accessibility.

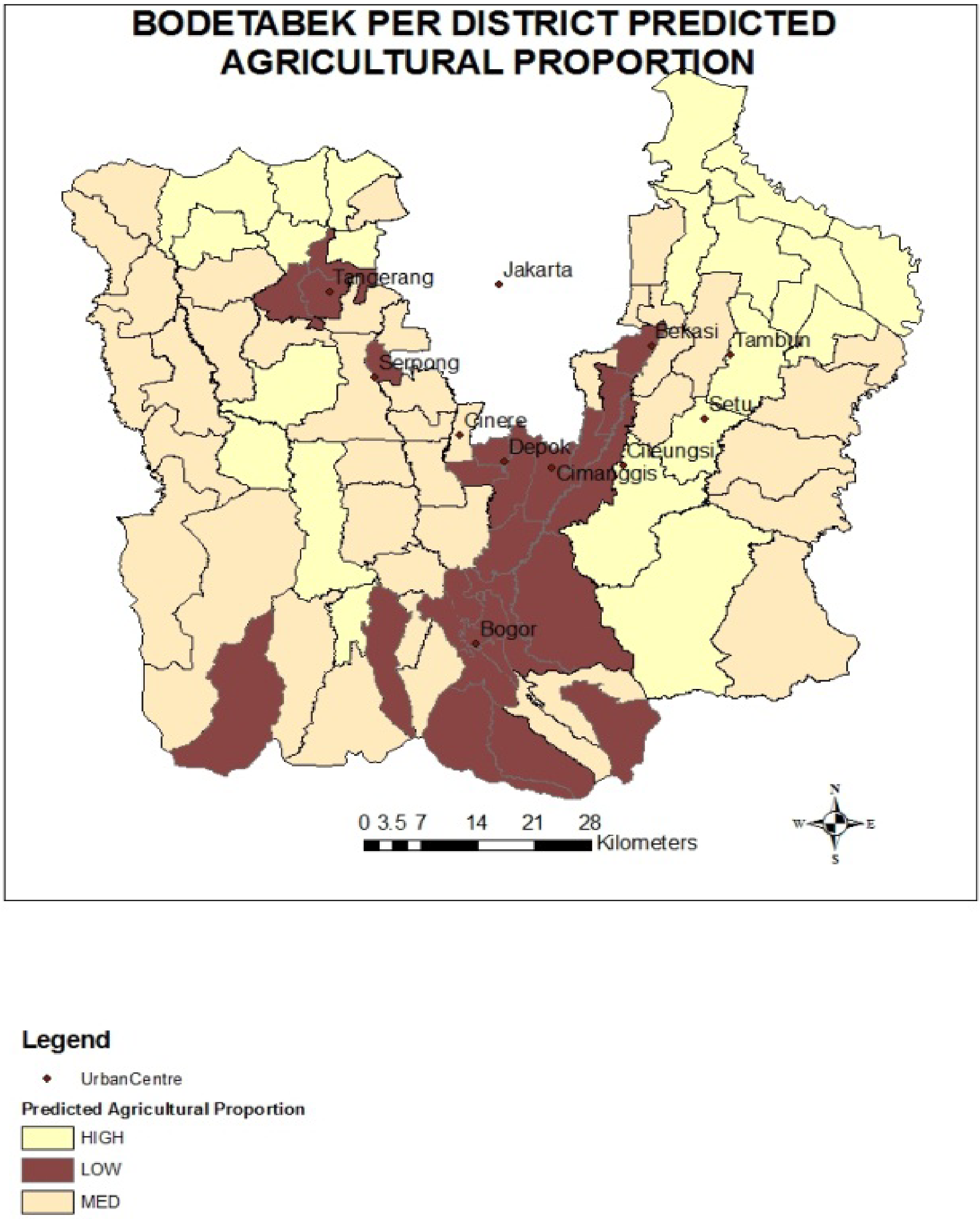

Fig. 4 The Predicted Agricultural Proportion Map in BoDeTaBek, based on the 2015 condition

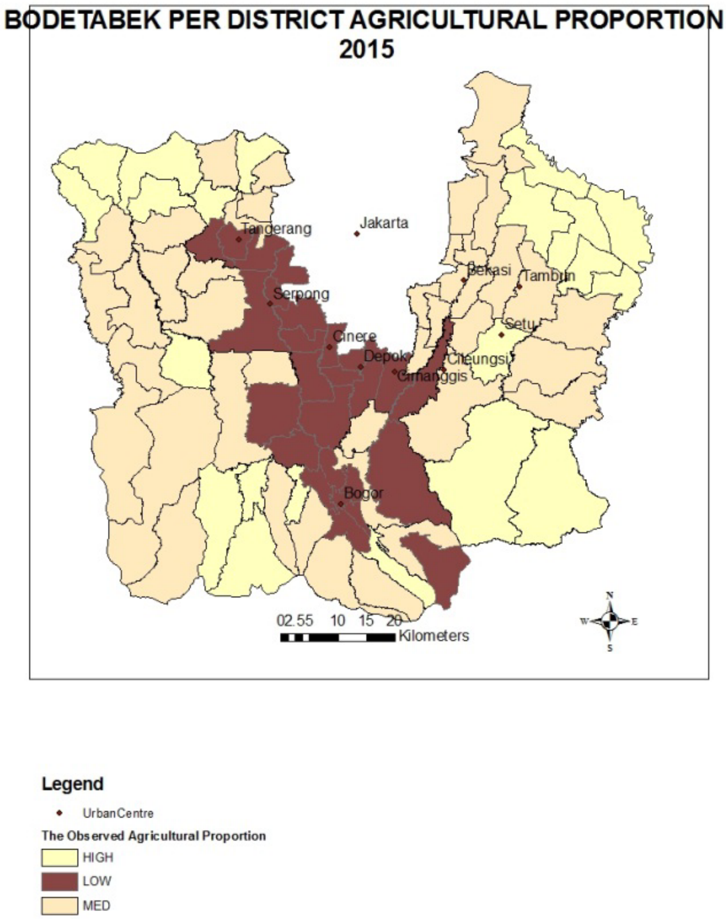

Fig. 5 The Agricultural Proportion Map in BoDeTaBek for 2015

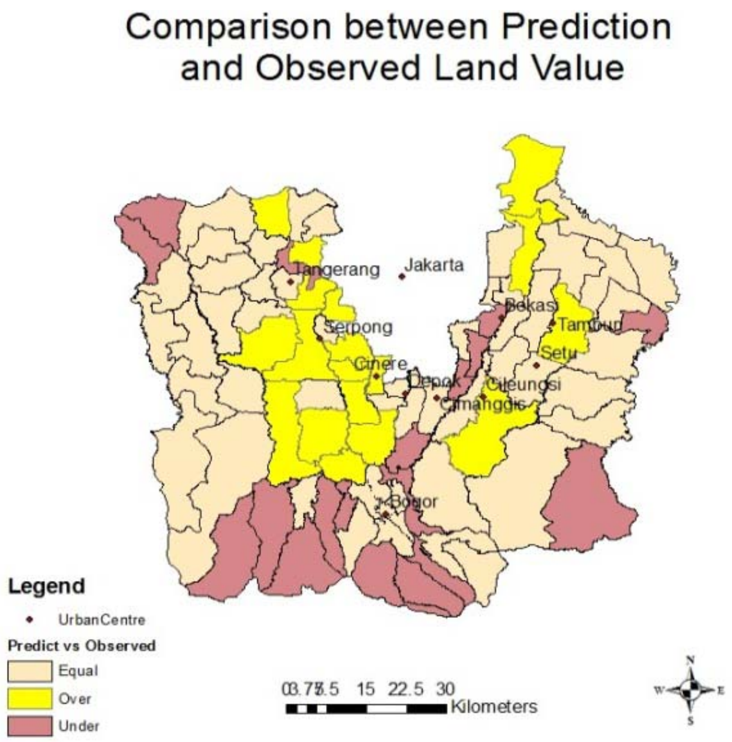

Fig. 6 The Comparison Map between Predicted and the Observed Values

E. Concluding Remarks

The spatial panel dynamic model of agricultural land value succeeds in capturing the externalities of land use and their dynamic in the fringe of Jakarta Metropolitan. The model indicates the domination of negative externalities on the land value. The prediction map has identified the locations where this domination occurs. Therefore, any attempt to manage the urban development must be directed to internalize this type of externalities, using one or combination between growth control, zoning, or incentive based policy [26]-[28]. However, the analysis indicates that any implemented policy will fully affect the land value six years after the first implementation.

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