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The Best Spatial Weight Matrix Order of Radius for GSTARIMA

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ABSTRACT

Some methods of statistical methods for modelling and forecasting, such as generalized space time autoregressive integrated moving average (GSTARIMA). The GSTARIMA model expresses each observation at time and space as a weighted linear combination of space and time. One of the most important in GSTARIMA model is the spatial weight matrix. The aim of this study is to choose the best spatial weight matrix order of radius. The best model GSTARIMA to the relative the Nilaparvata lugens Stäl attacks in Aceh province, North Sumatera province, West Sumatera province, Riau province, Jambi province, Bengkulu province, South Sumatera province, and Lampung province is GSTARIMA (1,0,0)3.

***Keywords*—** GSTARIMA, Nilaparvata lugens Stäl, spatial weight matrix order of radius

I. INTRODUCTION

Rice is the main food source of the Indonesians (Jamilah et al., 2012). Irwandi (2015) has been explaining that the lack of rice production is caused by the bad quality of rice and pests attacks. Nilaparvata lugens Stäl. is one of the most serious rice pests in the tropical regions like Indonesia (Alfitra, 2011). Damage is caused the Nilaparvata lugens Stäl. cells capable of sucking liquid rice so that the plants become dry until die and can transfer rice ragged stunt virus. Various attempts have been made to control the pests, among others approaches are cultivation techniques, chemical engineering and biological control techniques, but the threat never stopped.

Gunawan et al. (2015) have been explaining that the rice ragged stunt virus reduces yield by causing partially exerted panicles and unfilled grains. Leaves of infected plants have a ragged appearance. The rice ragged stunt virus infection is particularly high in tropical conditions. Several factors are considered as the cause, among others, is the presence of the Nilaparvata lugens Stäl or the rice ragged stunt virus as organism migrant into a crop, the presence of food, weather, climate, and applications agronomic. The events of the Nilaparvata lugens Stäl attacks is systematic events so it can be monitored. If the Nilaparvata lugens Stäl attacks can be predicted before then the priority areas to be controlled can be determined precisely.

Some methods of statistical methods for modelling and forecasting, such as generalized space time autoregressive integrated moving average (GSTARIMA). The GSTARIMA model expresses each observation at time and space as a weighted linear combination of space and time. One of the most important in GSTARIMA model is the spatial weight matrix (Wijaya, 2015). In general, the first order spatial weight matrix is used in GSTARIMA model. Kamarianakis and Prastacos (2005) have been explain that the spatial weighting matrix of order-2 in generalized space time autoregressive (GSTAR). It is a challenging problem in spatial, such as spatial time series analysis to take into account both the geographic information (e.g., locations and nearest neighbors) and multiple aspatial variables in the detection of patterns. First order neighbors are understood to be closer than second order neighbors, third order neighbors and so on (high order neighbors). Approach to the radius (circle) which is formulated by inverse distance will be created in n-order spatial weight matrix. Finally, we discuss the results and their implications for the applicability of the best order spatial weight matrix in GSTARIMA model.

II. METHODOLOGY

The relative the Nilaparvata lugens Stäl attacks from January 2010 to December 2016 are used in this study. Several provinces are used in this study, such as Aceh province, North Sumatera province, West Sumatera province, Riau province, Jambi province, Bengkulu province, South Sumatera province, and Lampung province.

These 6 steps are in this study:

1. Splitting the relative the Nilaparvata lugens Stäl attacks into training (January 2010 to December 2015) and testing (Januari 2016 to December 2016).
2. Stationarty testing. The stationarity or otherwise of a series can strongly influence its behaviour and properties e.g. persistence of shocks will be infinite for nonstationary series.
3. Identifying the orders of autoregressive (AR) and moving average (MA) terms of each province. In this section we will begin our study of models for stationary processes which are useful in representing the dependency of the values of a time series on its past.
4. Constructing the spatial weight matrix of radius. The weighted criteria matrix is a valuable decision making tool that is used to evaluate program alternatives based on specific evaluation criteria weighted by importance.
5. Constructing GSTARIMA models. The model form of the GSTARIMA class is tentatively chosen after an examination of higest order AR, MA terms, and the spatial weight matrix of radius.

$$\nabla \boldsymbol{Y}_i(t) = \sum_{k=1}^{p}\sum_{l=0}^{\lambda_k} \Phi_{kl}^{(i)} \boldsymbol{W}^{(l)} \nabla \boldsymbol{Y}_i(t-k) + \boldsymbol{\varepsilon}_i(t) - \sum_{k=1}^{q}\sum_{l=0}^{m_k} \boldsymbol{\Theta}_{kl}^{(i)} \boldsymbol{W}^{(l)} \boldsymbol{\varepsilon}_i(t-k) \quad (1)$$

where $\nabla \mathbf{Y}_i(t)=(1-B)^d \mathbf{Y}_t$ is vector with N dimension, p is *autoregressive* order, q is *moving average*, d *differencing* order, λ_k is spatial order in *autoregressive*, m_k is spatial order in *moving average*, $\mathbf{\Phi}_{kl}$ is diagonal matrix $(\phi_{kl}^{(1)}, \phi_{kl}^{(2)}, \ldots, \phi_{kl}^{(N)})$, $\mathbf{W}^{(1)}$ is the spatial weight matrix of radius, $\mathbf{W}^{(0)}$ is identity matrix, $\mathbf{\Theta}_{kl}$ diagonal matrix $(\theta_{kl}^{(1)}, \theta_{kl}^{(2)}, \ldots, \theta_{kl}^{(N)})$ and $\boldsymbol{\varepsilon}_t$ is error.

6. Choosing the best model with RMSE. The use of RMSE is very common and it makes an excellent general purpose error metric for numerical predictions.

$$\text{RMSE}=\sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(Y_t-\hat{Y}_t\right)^2} \quad (2)$$

III. RESULT

Based on Table 1 – Table 8, choosing the best ARIMA model using the minimum bayesian information criterion (BIC). Based on Table 9, The Bengkulu province has a good model (only the Bengkulu province). The Bengkulu province also has a AIC 249.8547 and BIC -0.79476 relatively small when compared to other provinces. It also makes GSTARIMA (1,0,0)k as well the maximum order of the autoregressive, differencing, and moving average.

TABLE I
ACEH

Lags	MA 0	MA 1	MA 2	MA 3	MA 4	MA 5
AR 0	0,4207	0,4415	0,4030	0,4342	0,4878	0,5169
AR 1	0,4493	0,5009	0,4580	0,4915	0,5440	0,5672
AR 2	0,4061	0,4641	0,5135	0,5508	0,5992	0,6181
AR 3	0,4596	0,5115	0,5543	0,6094	0,6586	0,6596
AR 4	0,4301	0,4678	0,5243	0,5560	0,5229	0,5538
AR 5	0,4667	0,4224	0,4665	0,5244	0,5279	0,5420

TABLE II
NORTH SUMATERA

Lags	MA 0	MA 1	MA 2	MA 3	MA 4	MA 5
AR 0	0,2116	0,2643	0,3131	0,3633	0,4159	0,2116
AR 1	0,2608	0,3087	0,3624	0,4174	0,4692	0,2608
AR 2	0,3111	0,3637	0,4133	0,4686	0,5222	0,3111
AR 3	0,3627	0,4189	0,4682	0,5253	0,5788	0,3627
AR 4	0,4155	0,4711	0,5217	0,5788	0,6354	0,4155
AR 5	0,4653	0,5192	0,5525	0,6106	0,6700	0,4653

TABLE III
WEST SUMATERA

Lags	MA 0	MA 1	MA 2	MA 3	MA 4	MA 5
AR 0	0,5273	0,3914	0,4473	0,4948	0,5073	0,4348
AR 1	0,4738	0,4467	0,4840	0,5260	0,5456	0,4939
AR 2	0,5331	0,4749	0,5336	0,5822	0,5901	0,5346
AR 3	0,5806	0,5236	0,5825	0,6413	0,6119	0,5838
AR 4	0,6211	0,5600	0,6189	0,6770	0,6524	0,6226
AR 5	0,5756	0,5346	0,5936	0,6481	0,6859	0,6761

TABLE IV
RIAU

Lags	MA 0	MA 1	MA 2	MA 3	MA 4	MA 5
AR 0	1,0077	1,0651	1,0900	1,1298	1,1494	1,2082
AR 1	1,0536	1,0758	1,0723	1,1271	1,1702	1,2205
AR 2	1,0981	1,0897	1,1243	1,1689	1,2167	1,2662
AR 3	1,1518	1,1467	1,1650	1,2242	1,2753	1,3256
AR 4	1,1829	1,1918	1,2165	1,2759	1,3340	1,3840
AR 5	1,2415	1,2447	1,2717	1,3307	1,3900	1,4378

TABLE V
JAMBI

Lags	MA 0	MA 1	MA 2	MA 3	MA 4	MA 5
AR 0	0,6570	0,6970	0,7350	0,7770	0,7393	0,7597
AR 1	0,6991	0,7564	0,7937	0,8294	0,7985	0,7871
AR 2	0,7373	0,7921	0,8511	0,8888	0,8430	0,8391
AR 3	0,7915	0,8416	0,8984	0,9463	0,8982	0,8862
AR 4	0,7403	0,7942	0,8507	0,9099	0,9569	0,9258
AR 5	0,7561	0,8064	0,8594	0,9147	0,9689	0,9852

TABLE VI

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BENGKULU

Lags	MA 0	MA 1	MA 2	MA 3	MA 4	MA 5
AR 0	-0,778	-0,790	-0,736	-0,682	-0,674	-0,778
AR 1	-0,794	-0,736	-0,688	-0,631	-0,622	-0,794
AR 2	-0,762	-0,705	-0,679	-0,638	-0,623	-0,762
AR 3	-0,708	-0,649	-0,636	-0,579	-0,582	-0,708
AR 4	-0,684	-0,625	-0,598	-0,565	-0,525	-0,684
AR 5	-0,642	-0,583	-0,591	-0,548	-0,491	-0,642

TABLE VII
SOUTH SUMATERA

Lags	MA 0	MA 1	MA 2	MA 3	MA 4	MA 5
AR 0	1,0073	0,9841	0,9774	1,0307	1,0714	1,1230
AR 1	0,8341	0,8803	0,9274	0,9786	0,9986	1,0446
AR 2	0,8701	0,8859	0,7705	0,8268	0,8805	0,8535
AR 3	0,8978	0,9123	0,8162	0,8549	0,9091	0,9005
AR 4	0,9367	0,9270	0,8518	0,9044	0,9575	0,9532
AR 5	0,8518	0,8544	0,7951	0,8534	0,9092	0,8358

TABLE VIII
LAMPUNG

Lags	MA 0	MA 1	MA 2	MA 3	MA 4	MA 5
AR 0	1,0073	0,9841	0,9774	1,0307	1,0714	1,1230
AR 1	0,8341	0,8803	0,9274	0,9786	0,9986	1,0446
AR 2	0,8701	0,8859	0,7705	0,8268	0,8805	0,8535
AR 3	0,8978	0,9123	0,8162	0,8549	0,9091	0,9005
AR 4	0,9367	0,9270	0,8518	0,9044	0,9575	0,9532
AR 5	0,8518	0,8544	0,7951	0,8534	0,9092	0,8358

TABLE IX
CANDIDATES ARIMA

Province	Model	BIC	Check
Province	Model	BIC	Check
Aceh	ARIMA (0,0,2)	0,403054	Not good
North Sumatera	ARIMA (0,0,0)	0,211673	*
West Sumatera	ARIMA (0,0,1)	0,391495	Not good
Riau	ARIMA (0,0,0)	1,007702	*
Jambi	ARIMA (0,0,0)	0,657043	*
Bengkulu	ARIMA (1,0,0)	-0,79476	Good
South Sumatera	ARIMA (2,0,2)	0,770501	Not good
Lampung	ARIMA (4,0,3)	0,759742	Not good

TABLE X
DISTANCE OF NEAREST NEIGHBORS PROVINCES

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1)	*	431,9	914,9	882,3	1216,4	1300,1	1415,1	1649,6
(2)	431,9	*	536,9	460,1	794,9	916,8	995,4	1243,4
(3)	914,9	536,9	*	202,0	366,3	385,8	538,8	740,6
(4)	882,3	460,1	202,0	*	335,1	491,8	535,3	787,3
(5)	1216,4	794,9	366,3	335,1	*	286,1	200,6	466,1
(6)	1300,1	916,8	385,8	491,8	286,1	*	290,2	377,0
(7)	1415,1	995,4	538,8	535,3	200,6	290,2	*	280,0
(8)	1649,6	1243,4	740,6	787,3	466,1	377,0	280,0	*

Provinsi: (1) Aceh, (2) Sumatera Utara, (3) Sumatera Barat, (4) Riau, (5) Jambi, (6) Bengkulu, (7) Sumatera Selatan, (8) Lampung.

$$\mathbf{Y}_i(t)=\mathbf{\Phi}_{11}^{(i)}\mathbf{Y}_i(t-1)+\mathbf{\Phi}_{11}^{(i)}\mathbf{W}^{(1)}\mathbf{Y}_i(t-1)+\boldsymbol{\varepsilon}_i(t)$$

1-st order the spatial weight matrix of radius.

$$\begin{array}{c|cccccccc}
 & (1) & (2) & (3) & (4) & (5) & (6) & (7) & (8) \\ \hline
(1) & 0 & \frac{1}{431,95} & 0 & 0 & 0 & 0 & 0 & 0 \\
(2) & \frac{1}{431,95} & 0 & \frac{1}{536,98} & \frac{1}{460,13} & 0 & 0 & 0 & 0 \\
(3) & \frac{1}{914,95} & \frac{1}{536,98} & 0 & \frac{1}{202,05} & \frac{1}{366,37} & \frac{1}{385,84} & \frac{1}{538,8} & 0 \\
(4) & \frac{1}{882,30} & \frac{1}{460,13} & \frac{1}{202,05} & 0 & \frac{1}{335,11} & \frac{1}{491,80} & \frac{1}{535,35} & 0 \\
(5) & 0 & \frac{1}{794,97} & \frac{1}{366,37} & \frac{1}{335,11} & 0 & \frac{1}{286,17} & \frac{1}{200,69} & \frac{1}{466,12} \\
(6) & 0 & 0 & \frac{1}{385,84} & \frac{1}{491,80} & \frac{1}{286,17} & 0 & \frac{1}{290,20} & \frac{1}{377,02} \\
(7) & 0 & 0 & \frac{1}{538,88} & \frac{1}{535,35} & \frac{1}{200,69} & \frac{1}{290,20} & 0 & \frac{1}{280,00} \\
(8) & 0 & 0 & 0 & 0 & \frac{1}{466,12} & \frac{1}{377,02} & \frac{1}{280,00} & 0
\end{array}$$

2-nd order the spatial weight matrix of radius.

$$\begin{array}{c|cccccccc}
 & (1) & (2) & (3) & (4) & (5) & (6) & (7) & (8) \\ \hline
(1) & 0 & \frac{1}{431,95^2} & \frac{1}{914,95^2} & \frac{1}{882,30^2} & \frac{1}{1216,44^2} & 0 & 0 & 0 \\
(2) & \frac{1}{431,95^2} & 0 & \frac{1}{536,98^2} & \frac{1}{460,13^2} & \frac{1}{794,97^2} & \frac{1}{916,85^2} & \frac{1}{995,42^2} & 0 \\
(3) & \frac{1}{914,95^2} & \frac{1}{536,98^2} & 0 & \frac{1}{202,05^2} & \frac{1}{366,37^2} & \frac{1}{385,84^2} & \frac{1}{538,88^2} & \frac{1}{740,66^2} \\
(4) & \frac{1}{882,30^2} & \frac{1}{460,13^2} & \frac{1}{202,05^2} & 0 & \frac{1}{335,11^2} & \frac{1}{491,80^2} & \frac{1}{535,35^2} & \frac{1}{787,35^2} \\
(5) & \frac{1}{1216,44^2} & \frac{1}{794,97^2} & \frac{1}{366,37^2} & \frac{1}{335,11^2} & 0 & \frac{1}{286,17^2} & \frac{1}{200,69^2} & \frac{1}{466,12^2} \\
(6) & \frac{1}{1300,16^2} & \frac{1}{916,85^2} & \frac{1}{385,84^2} & \frac{1}{491,80^2} & \frac{1}{286,17^2} & 0 & \frac{1}{290,20^2} & \frac{1}{377,02^2} \\
(7) & \frac{1}{1415,18^2} & \frac{1}{995,42^2} & \frac{1}{538,88^2} & \frac{1}{535,35^2} & \frac{1}{200,69^2} & \frac{1}{290,20^2} & 0 & \frac{1}{280,00^2} \\
(8) & 0 & \frac{1}{1243,46^2} & \frac{1}{740,66^2} & \frac{1}{787,35^2} & \frac{1}{466,12^2} & \frac{1}{377,02^2} & \frac{1}{280,00^2} & 0
\end{array}$$

3-th order the spatial weight matrix of radius.

$$\begin{array}{c|cccccccc}
 & (1) & (2) & (3) & (4) & (5) & (6) & (7) & (8) \\ \hline
(1) & 0 & \frac{1}{431,95^3} & \frac{1}{914,95^3} & \frac{1}{882,30^3} & \frac{1}{1216,44^3} & \frac{1}{1300,16^3} & \frac{1}{1415,18^3} & \frac{1}{1649,68^3} \\
(2) & \frac{1}{431,95^3} & 0 & \frac{1}{536,98^3} & \frac{1}{460,13^3} & \frac{1}{794,97^3} & \frac{1}{916,85^3} & \frac{1}{995,42^3} & \frac{1}{1243,46^3} \\
(3) & \frac{1}{914,95^3} & \frac{1}{536,98^3} & 0 & \frac{1}{202,05^3} & \frac{1}{366,37^3} & \frac{1}{385,84^3} & \frac{1}{538,88^3} & \frac{1}{740,66^3} \\
(4) & \frac{1}{882,30^3} & \frac{1}{460,13^3} & \frac{1}{202,05^3} & 0 & \frac{1}{335,11^3} & \frac{1}{491,80^3} & \frac{1}{535,35^3} & \frac{1}{787,35^3} \\
(5) & \frac{1}{1216,44^3} & \frac{1}{794,97^3} & \frac{1}{366,37^3} & \frac{1}{335,11^3} & 0 & \frac{1}{286,178^3} & \frac{1}{200,69^3} & \frac{1}{466,12^3} \\
(6) & \frac{1}{1300,16^3} & \frac{1}{916,85^3} & \frac{1}{385,84^3} & \frac{1}{491,80^3} & \frac{1}{286,17^3} & 0 & \frac{1}{290,20^3} & \frac{1}{377,02^3} \\
(7) & \frac{1}{1415,18^3} & \frac{1}{995,42^3} & \frac{1}{538,88^3} & \frac{1}{535,35^3} & \frac{1}{200,69^3} & \frac{1}{290,20^3} & 0 & \frac{1}{280,00^3} \\
(8) & \frac{1}{1649,68^3} & \frac{1}{1243,46^3} & \frac{1}{740,66^3} & \frac{1}{787,35^3} & \frac{1}{466,12^3} & \frac{1}{377,02^3} & \frac{1}{280,00^3} & 0
\end{array}$$

4-th order the spatial weight matrix of radius

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1)	0	$\frac{1}{431,95^4}$	$\frac{1}{914,95^4}$	$\frac{1}{882,30^4}$	$\frac{1}{1216,44^4}$	$\frac{1}{1300,16^4}$	$\frac{1}{1415,18^4}$	$\frac{1}{1649,68^4}$
(2)	$\frac{1}{431,95^4}$	0	$\frac{1}{536,98^4}$	$\frac{1}{460,13^4}$	$\frac{1}{794,97^4}$	$\frac{1}{916,85^4}$	$\frac{1}{995,42^4}$	$\frac{1}{1243,46^4}$
(3)	$\frac{1}{914,95^4}$	$\frac{1}{536,98^4}$	0	$\frac{1}{202,05^4}$	$\frac{1}{366,37^4}$	$\frac{1}{385,84^4}$	$\frac{1}{538,88^4}$	$\frac{1}{740,66^4}$
(4)	$\frac{1}{882,30^4}$	$\frac{1}{460,13^4}$	$\frac{1}{202,05^4}$	0	$\frac{1}{335,11^4}$	$\frac{1}{491,80^4}$	$\frac{1}{535,35^4}$	$\frac{1}{787,35^4}$
(5)	$\frac{1}{1216,44^4}$	$\frac{1}{794,97^4}$	$\frac{1}{366,37^4}$	$\frac{1}{335,11^4}$	0	$\frac{1}{286,17^4}$	$\frac{1}{200,69^4}$	$\frac{1}{466,12^4}$
(6)	$\frac{1}{1300,16^4}$	$\frac{1}{916,85^4}$	$\frac{1}{385,84^4}$	$\frac{1}{491,80^4}$	$\frac{1}{286,17^4}$	0	$\frac{1}{290,20^4}$	$\frac{1}{377,02^4}$
(7)	$\frac{1}{1415,18^4}$	$\frac{1}{995,42^4}$	$\frac{1}{538,88^4}$	$\frac{1}{535,35^4}$	$\frac{1}{200,69^4}$	$\frac{1}{290,20^4}$	0	$\frac{1}{280,00^4}$
(8)	$\frac{1}{1649,68^4}$	$\frac{1}{1243,46^4}$	$\frac{1}{740,66^4}$	$\frac{1}{787,35^4}$	$\frac{1}{466,12^4}$	$\frac{1}{377,02^4}$	$\frac{1}{280,00^4}$	0

The largest distance of nearest neighbors provinces is using to determine the spatial weight matrix of radius order (Tabel 10). The spatial weight matrix of radius order have 4 alternatives (maximum order nearest neighbors). Based on Tabel 11, the smallest RMSE in Table 10 is 3-th spatial order, then selected the best spatial weight matrix of radius.

TABLE XI
RMSE GSTARIMA

Order	Scale	RMSE
1	536,98	1,85889
2	1074,0	1,80539
3	1610,9	1,74903
4	2147,9	1,80762

IV. CONCLUSION

The best model GSTARIMA to the relative the Nilaparvata lugens Stäl attacks in Aceh province, North Sumatera province, West Sumatera province, Riau province, Jambi province, Bengkulu province, South Sumatera province, and Lampung province is GSTARIMA (1,0,0)3 based on the smallest RMSE (1,74903).

$$\mathbf{Y}_i(t)=\mathbf{\Phi}_{13}^{(i)}\mathbf{Y}_i(t-1)+\mathbf{\Phi}_{13}^{(i)}\mathbf{W}^{(3)}\mathbf{Y}_i(t-1)+\boldsymbol{\varepsilon}_i(t)$$

REFERENCES

[1] R. Alfitra, Faktor-Faktor yang Mempengaruhi Keparahan Serangan Wereng Batang Cokelat Nilaparvata lugens Stal. pada Pertanaman Padi di Kabupaten Klaten, Thesis: Bogor Agricultural University, 2011.
[2] C.S.E. Gunawan, G. Mudjiono, L.P. Astuti, Kelimpahan Populasi Wereng Batang Coklat Nilaparvata lugens Stal. dan Laba-Laba pada Budidaya Tanaman Padi dengan Penerapan Pengendalian Hama Terpadu dan Konvensional, Hama dan Penyakit Tumbuhan, 3(1): 117-122, 2015.
[3] D. Irwandi, Strategi Peningkatan Pemanfaatan Lahan Rawa Pasang Surut dalam Mendukung Peningkatan Produksi Beras di Kalimantan Tengah, Agriekonomika, 4(1):96-105, 2015.
[4] Jamilah, Muyassir, Syakur, Pertumbuhan dan Hasil Padi (Oryza sativa L.) akibat Pemberian Arang Aktif dan Urea, Manajemen Sumberdaya Lahan, 1(2): 146-150, 2012.
[5] Y. Kamarianakis, P.P. Prastacos, Space Time Modeling of Traffic Flow, Computers and Geosciences, 31(2):119-133, 2005.
[6] F.B. Wijaya, Pendekatan Space Time Autoregressive (STAR) dan Generalized Space Time Autoregressive (GSTAR) melalui Metode Autoregressive (AR) dan Vector Autoregressive (VAR), Thesis Master: Bogor Agricultural University, 2015.