INTERNATIONAL CONFERENCE GIS-IDEAS 2023

PROCEEDINGS

Geospatial Integrated Technologies for Natural Hazards and Environmental Problems

HUNRE, Ha Noi, Viet Nam

07-09 November 2023

PUBLISHING HOUSE FOR SCIENCE AND TECHNOLOGY


INTERNATIONAL CONFERENCE

GEOSPATIAL INTEGRATED TECHNOLOGIES FOR NATURAL HAZARDS AND ENVIRONMENTAL PROBLEMS

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HA NOI - 2023

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TABLE OF CONTENT

APPLICATION FOR GIS TECHNOLOGY TO COMPARISON OF ORDINARY LEAST SQUARES AND GEOGRAPHICALLY WEIGHTED REGRESSION MODEL IN THE ASSESSMENT OF THE MARKET RESIDENCE LAND IN THUY VAN WARD, HUE CITY, VIETNAM

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ABSTRACT

The objective of this paper is to compare the application of GIS technology to compare ordinary least squares (OLS) and Geographically Weighted Regression (GWR) regression models in determining market land prices at Thuy Van ward. Research results show that both models identify the same variables affecting land prices in the market, including the following factors: Area of the land, width of road attached to the land plot, distance to hospital, being able to generate cash flow, planning information with different equation coefficients. However, the level of R^2 interpretation of both models is quite similar to the GWR model, which is 76 % lower than 78 % of the OLS model. Besides, the difference between the market land price and the estimated land price from the two models is quite similar when about 75 % of the difference goes under about 3 million VND per m^2. Thus, both models are easy to apply and have high accuracy in valuing residential land in series; also, these models contribute to improve the efficiency of land valuation.

1. INTRODUCTION

The field of Geographic Information Systems (GIS) technology has seen significant as a big and rapid progress in recent years (Li & Li, 2012). GIS technology has been widely applied to the following contents: determining land suitability (Chandio et al., 2011), real estate (Qian, 2013), land information (Longley & Cheshire, 2017), and land price (Xu & Li, 2014). Nowadays, Geographic Information Systems (GIS) and web service technologies facilitate the dissemination, exploration, and examination of land price data. The principal benefit of the GIS-based web approach resides in its incorporation of spatial-temporal analysis models and web GIS technology. Thereby, it enables a greater number of investors and administrators with restricted domain expertise in order to acquire a more comprehensive comprehension of the evolving pattern and spatial arrangement of land prices (Yang et al., 2015). The problem of determining land price is an important, a complicated and complex issue, therefore it is necessary to combine many different research methods to find the most optimal models of land price determination. In GIS technology, there are many different models to determine land prices. In this study, the author uses two models: Ordinary Least Squares (OLS) and Geographically Weighted Regression (GWR). Ordinary least-squares (OLS) regression is a statistical technique used to model a single response variable that has been measured on at least an interval scale. The technique can be applied to both single and multiple explanatory variables, including categorical variables that have been appropriately coded (Dismuke & Lindrooth, 2006). GWR is one of the collections of spatial regression methodologies that are employed in the field

of geography and other related disciplines. GWR assesses a localized model of the particular variable or procedure that one aims to comprehend or anticipate through the process of fitting a regression equation to each and every characteristic within the dataset given. Subsequently, GWR formulates these distinct equations by assimilating the dependent and explanatory variables of the characteristics that are situated within the vicinity of every designated characteristic (Wheeler & Páez, 2009). There have been numerous scholarly endeavors employing these two models for investigation. In Thailand, the team of researchers has constructed a model encompassing the evaluation and market prices of land within the metropolitan region of Bangkok (Malaitham et al., 2020). An analysis of the determinants of commercial land prices in the city of Hangzhou, China, using Geographically Weighted Regression (GWR) and Ordinary Least Squares (OLS) techniques (Garang et al., 2021) and analyzing the changes in real estate prices in Taitung City, Taiwan (Wang et al., 2019). In Vietnam; particular in Hanoi, researchers have built a market house price model (Phe et al., 2016). Research results in the world as well as in Vietnam, show that the use of OLS and GWR methods in determining land prices is appropriate. However, my explicit knowledge, there has been not any single research to compare the land price model in Thuy Van ward, Hue city, Vietnam. Therefore, this is the first study as well as valuable potential one with the aim of assessing the market residence land in Thuy Van ward, Hue city, Vietnam by using OLS and GWR models to build on QGIS software. The research results have contributed to straightforward mass land valuation for this area and found the advantages of two models in determining land prices.

2. STUDY AREA AND MATERIALS

2.1 Study area

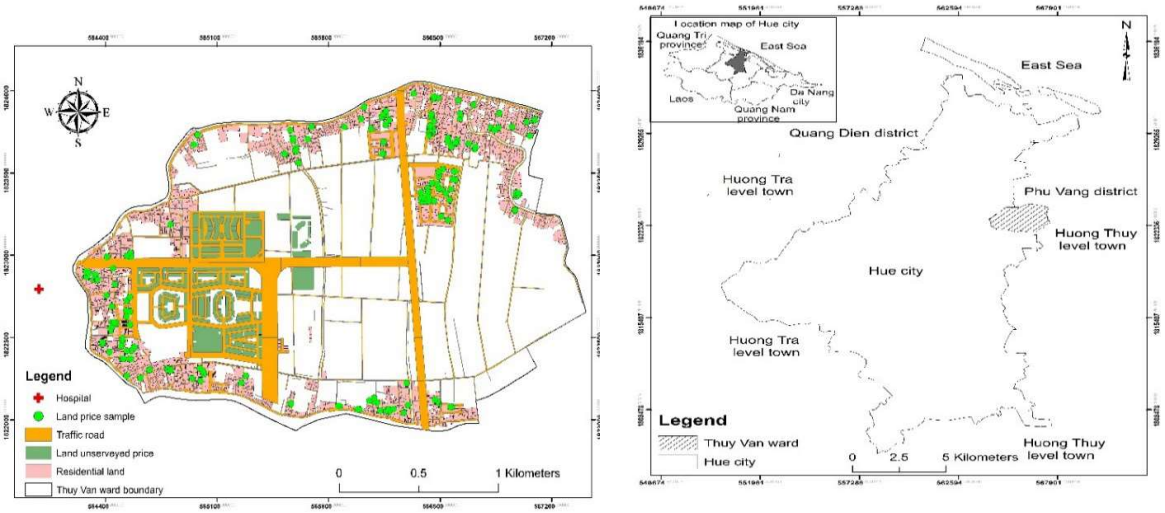


Figure 1. Cadastral map of Thuy Van ward and land price sampling point.

Thuy Van ward has a natural area of 4.92 km^2 and a population of 7,932 inhabitants. According to the 2022 socio-economic report of Hue City, in-addition, Thuy Van ward has a plain terrain located in the planning area of An Van Duong new urban area. At the same time, there is an arterial traffic route of the 49th National Highway through the connections with nationwide others, convenience for exchanges with many regions in among towns and provinces, and is a destination attracting domestic and foreign investment, and it is really creating favorable conditions for

infrastructure development and boosting up the local economy. Thuy Van ward is located as a suburban area towards the south of Hue City with much potential for urban development and a high urbanization rate when it borders Huong Thuy town to the east and Vy Da ward to the west. It is bordered by a line of distinction between An Dong ward and Xuan Phu ward to the South and the North by Phu Thuong ward and Phu Vang district.

2.2 Materials

The study uses the following data collected, such as cadastral maps from the Information Technology Center, Department of Natural Resources and Environment of Thua Thien-Hue province. In addition, we collected 200 transferred land plots, and the factors affecting the land price were determined to be suitable for the area. It aims to collect information about transferred land plots, including land prices and other information in Thuy Van ward, Hue City to run 2 models in QGIS.

3. METHODOLOGY

The research process consists of 5 stages as follows:

Figure 2. Data processing process.

Stage 1: Collecting land price data, factors which are affecting land price, cadastral map

The study was conducted to collect 200 transferred land plots, and the factors affecting the land price were determined suitable for the area, including the area of the land, width of road attached to the land plot, distance to the hospital, Ability to generate cash flow; Planning information and information about residential land price as shown in Table 1 and the cadastral map in 2022.

Stage 2: Building a current map

The study was conducted using the FME tool to convert all data to the current status map with the VN2000 coordinate system with a 3-degree projection zone of Thua Thien-Hue province.

Stage 3: Giving land price data and land parcel information, factors which are affecting land price

Use the important tool to bring all information from Excel linked to the land plot information so that the land plot has all the data to ensure the process of running the model.

Stage 4: Running OLS, GWR models

This study applies the OLS model and GWR model with tools on QGIS and edited/renewed the results from the two models mentioned above.

Stage 5: Comparing the results of two models

The results of the two models are compared from parameters such as R2, AICC, multi-

collinearity, significance level of variables, residuals, and normal distribution.

Table 1. Variable format for land price model.

No.	Variable symbol	Description	Unit	Type
1	LP	Land price (Dependent variable)	million vnd/m^2	Quantitative
2	A	Area of the land	m^2	Quantitative
3	WD	Width of road attached to the land plot	m	Quantitative
4	DH	Distance to hospital	m	Quantitative
5	CF	Ability to generate cash flow	1= yes; 0 = no	Dummy variable
6	PI	Planning information	1= yes; 0 = no	Dummy variable

4. RESULT AND DISCUSSION

In the process of evaluating and building a land valuation model, several models can be selected, but this study focuses on comparing the two models, OLS and GWR, as a case to illustrate for this paper.

4.1 OLS model

Using the OLS tool in Spatial Statistics in QGIS to run the model results, the results are shown in Table 2 below.

Table 2. Summary of OLS results - model variables.

Variable	Symbol	Coefficient [a]	Std. Error	t- Statistic	Probability [b]	VIF (c)
Intercept		19.148	1.439	13.308	0.0000	
Area of the land	AL	-0.023	0.003	-7.818	0.0000	1.063
Width of road attached to the land plot	WD	0.416	0.028	14.982	0.0000	1.556
Distance to hospital	DH	-0.002	0	-6.999	0.0000	1.408
Ability to generate cash flow	CF	2.091	0.639	3.271	0.0010	1.386
Planning information	PI	4.826	0.954	5.057	0.0000	1.257

Adjusted R-Squared [d]: 0.78000l; Prob(>F), (5.165) degrees of freedom: 0.000000*

Akaike's Information Criterion (AICc) [d] = 880

The data results from Table 2 show that the OLS land pricing model is significant with sig = 0.00 < 0.05, and the model explains 78 % of the land price variation with the following influencing factors: Area of the land; Width of road attached to the land plot; Distance to hospital; Ability to generate cash flow; Planning information. The AICc value is achieved at 880, and the VIF results are all < 2, so there is no multi-collinearity phenomenon. The variables are entirely independent of the impact on land prices. Thus, the OLS model builds the land price determination equation as follows:

$$LP = 19.148 - 0.23 \times AL + 0.416 \times WD - 0.002 \times DH + 2.091 \times CF + 4.826 \times PI$$

Table 3. The importance of the factors affecting the land price of the OLS model.

No.	Variable symbol	Description	The absolute value of the coefficient	Percentage (%)	Rank
1	AL	Area of the land	0.023	0.31	4
2	WD	Width of road attached to the land plot	0.416	5.6	
3	DH	Distance to hospital	0.002	0.03	5
4	CF	Ability to generate cash flow	2.091	28.42	2
5	PI	Planning information	4.826	65.59	1
		Total	**7.358**	**100.00**	

At the same time, the results of Table 3 also show that the influence of the factors on the price is evaluated in order, with the most important factor being planning information at 65.59 % and the least influential factor being distance to hospital with 0.03 %. This is consistent with the fact that when the price of land in this area increases, it is concentrated in areas with planning information related to road widening and construction of housing projects such as Ecogarden, Royal Park, and Parks. FPT technology, eco-tourism area, etc. The rest of the remaining areas do not have projects, and land prices are often less volatile and low because the degree of urbanization here is relatively low, reflecting the current situation of rural landscape in residential areas.

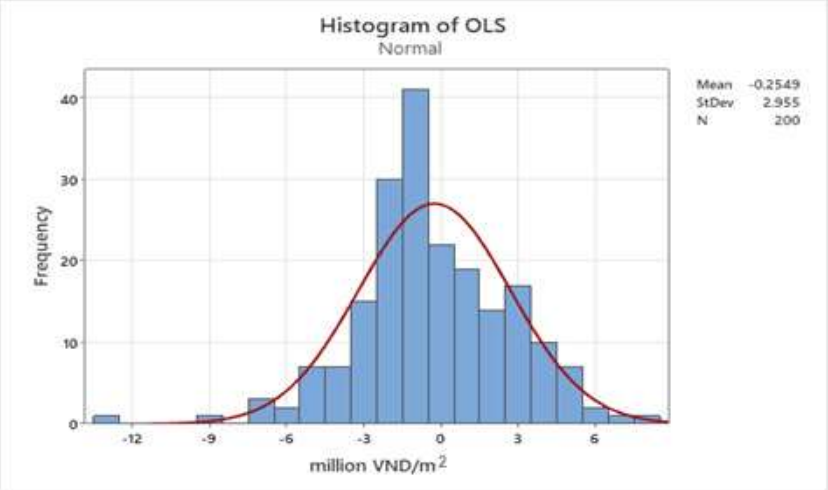


Figure 3. Average distribution histogram OLS model.

In addition to the results of the model's variable parameters, the research results also show that the model's residuals are normally distributed with a relatively low standard deviation of 2.955, and the mean is -0.2549.

4.2 GWR model

Using the GWR tool in Spatial Statistics in QGIS to run the model results, the results are shown in Tables 4 and 5.

Table 4. Results of OLS and GWR models.

	OLS	GWR
Adjusted R^2	0.78	0.76
AICc	880	898

The results from Table 4 show that the GWR model has an Adjusted R2 = 0.76 value with a significant explanation for land price change of 76 %, which is 78 % lower than that of the OLS model in addition. AICc value of 898, which is greater than 880 of the OLS model, also shows that the OLS model has higher performance and better fits to the data set. In addition, the values of conditional Number (CN) range from 10-29, so there is no multi-collinearity. The GWR model builds the land price determination equation as follows:

$$LP = 15.176 - 0.020 \times AL + 0.519 \times WD - 0.004 \times DH + 2.45 \times CF + 4.433 \times PI$$

Table 5. Summary of OLS, GWR results.

Variable	Symbol	Coefficient of OLS	Coefficient of GWR
Intercept		19.148	15.176
Area of the land	AL	-0.023	-0.020
Width of road attached to the land plot	WD	0.416	0.519
Distance to hospital	DH	-0.002	-0.004
Ability to generate cash flow	CF	2.091	2.45
Planning information	PI	4.826	4.433

Table 6. The importance of the factors affecting the land price of the GWR model.

No.	Variable symbol	Description	The absolute value of the coefficient	Percentage (%)	Rank
1	A	rea of the land	-0.020	0.27	4
2	WD	Width of road attached to the land plot	0.519	6.99	3
3	DH	Distance to hospital	-0.004	0.05	5
4	CF	Ability to generate cash flow	2.45	32.99	2
5	PI	Planning information	4.433	59.70	1
		Total	**7.426**	**100.00**	

The data results in Tables 5 and 6 show that both models have the same variables with positive correlation with the width of the road attached to the land plot, ability to generate cash flow; planning information and negatively correlated with distance to the hospital and area of the land. At the same time, the results also show that both models have the same order of factors affecting land price, only the percentage is different. The GWR model with the most critical factor is planning information at 59.70 %, and the least influential factor is to keep a distance from the hospital at 0.27 %.

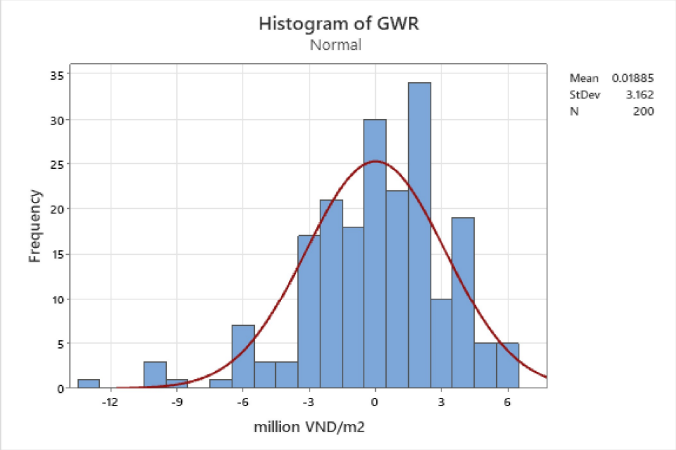


Figure 4. Normal distribution histogram GWR model.

In addition to the results of the model's variable parameters, the research results also show that the model's residual normal distribution has a higher standard deviation (SD) than the OLS model when the value is 3.162 and the mean value is 0.01885.

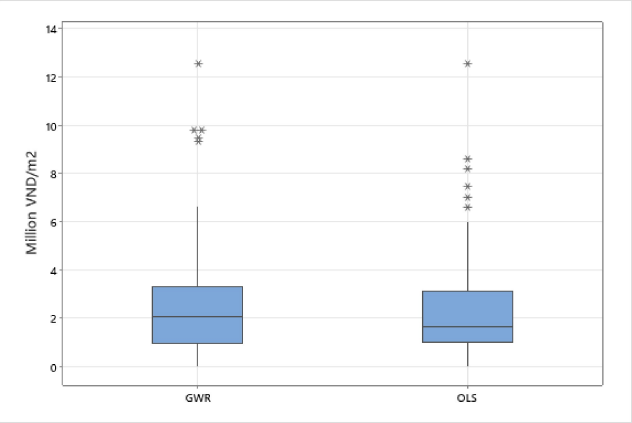
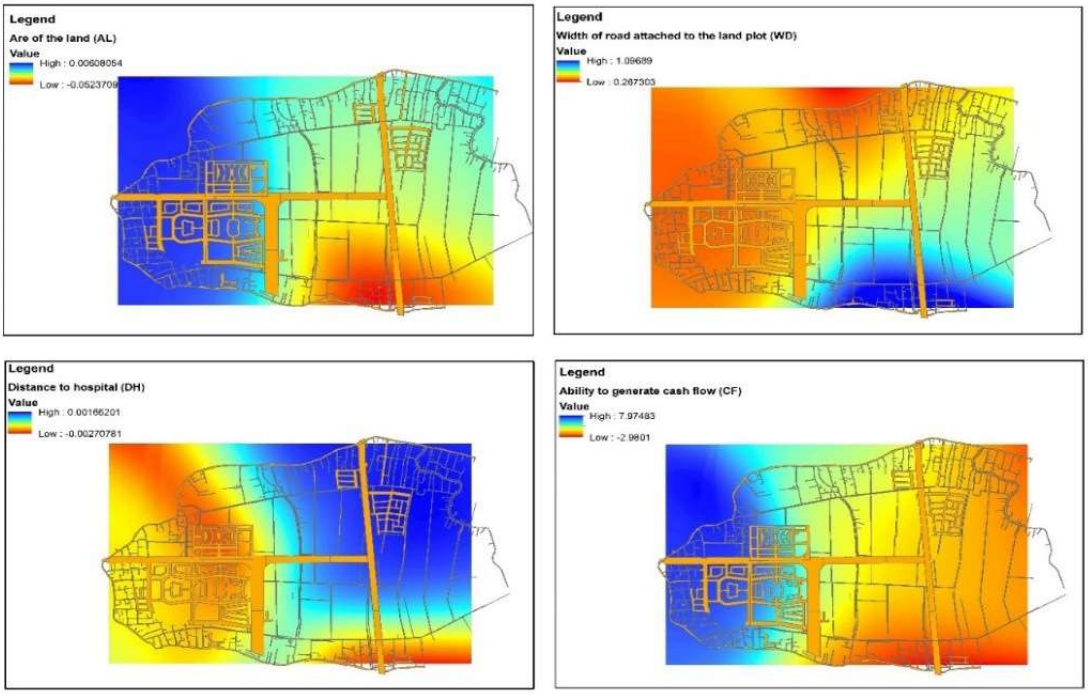


Figure 5. Residual absolute value boxplot of 2 models.

The results show that after taking the absolute value of the residuals of the two models, the errors of the two models are similar when both models have 75 % error at less than 3 million VND/m^2. However, the OLS model shows that at less than 50 %, the GWR model shows a result of 2 million VND/m^2, while the OLS model is only about 1,6 million VND/m^2 lower. Thus, the OLS model with a normal distribution of residuals shows that the level of prediction error is relatively lower than that of the GWR model.

The research results show that the land price determination model built by the OLS model has a higher level of significance and relevance. However, the GWR model has the advantage that there are map layers of each variable representing the distribution in space, supporting the observation of the impact of variables on land prices.



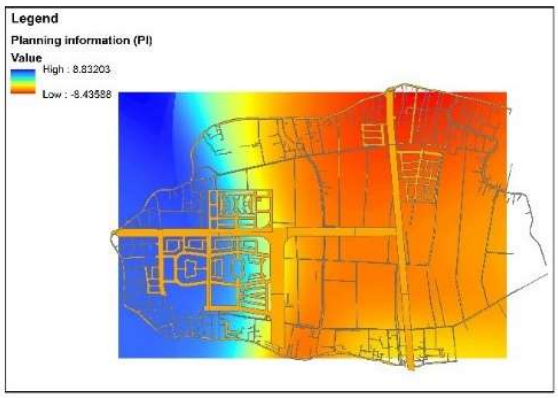


Figure 6. The distribution of the influence of factors on land prices in Thuy Van ward.

In Figure 6, the blue portion indicates a significant level of influence for that particular factor and vice versa for the red color. The results obtained from conducting spatial analysis on each factor concerning residential land prices, using the GWR model, reveal that the western area of Thuy Van ward, bordering the center of Hue city and housing projects, exhibits notable characteristics. When the concentration of blue is observed in the western region, it signifies the area favorable suitability for business activities. Furthermore, factors such as cash flow and planning information contribute to the influence on land prices. On the contrary, the eastern area of Thuy Van ward is affected by the distance factor to the hospital because this area is quite far from the hospital and the greater the distance to the hospital, the lower the land price will tend to be. The support of spatial analysis in the GWR model is clearly an advantage in assessing the factors affecting land prices in terms of surface space, which the OLS model does not provide.

5. CONCLUSION

Research results have built two land valuation models, OLS and GWR, which are being supported by GIS technology. The study analyzed the similarity of both models that have been significant with the factors affecting land price, including area of the land; width of road attached to the land plot; distance to the hospital; ability to generate cash flow; and planning information. In the same vein, the level of explanatory significance of both OLS models and GWR are both high, 78 % and 76 %, respectively. However, the results also show that the GWR model brings about image results in terms of spatial analysis of factors, supporting in terms of factor evaluation according to the spatial surface area.

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PUBLISHING HOUSE FOR SCIENCE AND TECHNOLOGY
A16, 18 Hoang Quoc Viet Road, Cau Giay, Ha Noi
Marketing & Distribution Department: **024.22149040**;
Editorial Department: **024.37917148**
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Hanoi University of Natural Resources and Environment,
Vietnam 07-09 November 2023

Hanoi University of Natural Resources and Environment (HUNRE)
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Responsible for Publishing
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Editors:	**Nguyen Van Vinh, Nguyen Thi Chien Ha Thi Thu Trang, Natraj VADDADI Venkatesh RAGHAVAN**
Computing Technique:	**Nguyen Duc Manh**
Cover design:	**Tran Thu Hien**

Corporate publishing:
Hanoi University of Natural Resources and Environment
Address: 41A Phu Dien Road, Phu Dien Ward, Bac Tu Liem District, Ha Noi

ISBN: 978-604-357-207-0

Printing 400 copies, size 20,5 × 29,5 cm, printed at Consulting Publishing and Media Viet Joint Stock Company. Address: No. 4/20, Lane 156 Hong Mai, Bach Mai Ward, Hai Ba Trung District, Ha Noi City, Vietnam.
Registered number for Publication: 3759-2023/CXBIPH/01-42/KHTNVCN.
Decision number for Publication: 87/QĐ-KHTNCN was issued on 15 December 2023.
Printing and copyright deposit were completed in the 4th quarter, 2023.

Organized by

Hanoi University of Natural Resources and Environment
The Japan - Vietnam Geoinformatics Consortium (JVGC)
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https://gis-ideas.org/2023/

ISBN: 978-604-357-207-0