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MAPPING OF GENDER INEQUALITY IN INDONESIA BASED ON INFLUENCING FACTORS USING GEOGRAPHICALLY WEIGHTED ORDINAL LOGISTIC REGRESSION

Hani Khaulasari[1*], Fadjar Suhaeri[2]

[1,2]Mathematics, Faculty of Science and Technology, UIN Sunan Ampel Surabaya
St. Dr. Ir. H. Soekarno No.682, Surabaya, 60294, Indonesia

[2]BPS Surabaya
St. Ahmad Yani No.152E, Surabaya, 60235, Indonesia

*Corresponding author's e-mail: * **hani.khaulasari@uinsa.ac.id***

ABSTRACT

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Gender inequality is a condition of discrimination between men and women that results from unequal social systems and structures. Gender inequality is measured based on the gender inequality index (IKG). This research aims to map gender inequality in Indonesia based on influencing factors and compare classification accuracy results between the GWOLR and ordinal logistic regression model. Data was obtained from the Indonesian Central Statistics Agency (BPS RI) and KemenPPPA in the year of 2022. The Gender Inequality Index data as the response variable is categorized using an ordinal data scale, namely IKG (1) Low, IKG (2) Middle, and IKG (3) High, with ten predictor variables from the dimensions of health, education, human empowerment, socio-culture, and employment, with the amount of data is 34 observation data. The research method uses geographically weighted ordinal logistic regression (GWOLR) based on exponential kernel weighting. In the data analysis stage, ordinal logistic regression is performed before applying GWOLR, and after the model is formed, the classification accuracy will be calculated. The results of this study indicate that mapping gender inequality in Indonesia based on influencing factors using the GWOLR model forms three groups. The first mapping location labeled as low inequality is influenced by women whose birth was attended by a health worker (X_1), women who have a pre-employment card (X_7), women who are employed (X_8), and the percentage of women who married before the age of 17 (X_{10}). The second mapping location labeled with middle inequality is influenced by women whose delivery is attended by a health worker (X_1), women's net enrolment in higher education (X_2), and women married before the age of 17 (X_{10}). The three locations categorized as high inequality are influenced by female birth attendance by health personnel (X_1), Women's Human Development Index (X_3), female rape offenses (X_4), female domestic violence offenses (X_6), and female marriage under the age of 17 (X_{10}). Modeling the Gender Inequality Index using the GWOLR model resulted in higher classification accuracy than the ordinal logistic regression model, which was 94.11%.

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1. INTRODUCTION

Gender refers to the inherent traits, behaviors, and the division of responsibilities and tasks between males and females, shaped by societal norms, beliefs, customs, and local culture [1]. Within the Islamic perspective, gender equality emphasizes a balanced relationship where neither gender holds dominance. Both men and women possess equal potential for achievements in spiritual and professional realms, such as governance, commerce, and the economy, challenging the notion of exclusive gender-based roles. Misinterpretations of gender arise from societal, historical, cultural, and traditional influences, leading to gender disparities [2].

Gender inequality emerges from discriminatory practices within the social system, resulting in an uneven development process between men and women. For instance, women may be excluded from developmental activities like planning, decision-making, policy formulation, and evaluation, limiting them to domestic roles [3]. Achieving gender justice and equality entails granting equal opportunities for contribution and participation, and eliminating role standardizations, dual burdens, and marginalization. Gender inequality adversely affects various spheres of development, including social, economic, educational, defense, and security aspects, exacerbating poverty and limiting access to education, health services, and financial resources [4], [5].

Indicators of gender inequality encompass health risks (maternal mortality, adolescent fertility), empowerment (education, political representation), and labor market disparities [6]. Notably, research from the 2020 BPS reveals a negative correlation between the Gender Empowerment Index (IDG), the Human Development Index (IPM), and the Gender Development Index (IPG), signifying gender inequality in Indonesia. Gender inequality indexes vary widely across Indonesian provinces, with some regions displaying high levels of disparity[7].

The Indonesian government introduced INPRES Number 9 of 2000, focusing on Gender Mainstreaming (PUG) in National Development [8]. Similarly, [9] the Rector of UIN Sunan Ampel issued Regulation number: Un.07/1/PP.00.9/SK/809/P/2016, emphasizing gender equality and mainstreaming to attain Millennium Development Goals (MDGs) linked to gender equity [10], [11]. Research on the influence of gender inequality has been carried out by [12], considering factors such as education, early marriage rates, births in health facilities, HDI, and IDG. However, the results of this study only achieved a model suitability level of 74.48%. Therefore, it is suspected that there are spatial effects that need to be taken into account, so it needs to be expanded by using methods that consider spatial effects, such as Geographically Weighted Ordinal Logistic Regression (GWOLR).

Provinces in Indonesia have diverse socio-cultural characteristics that influence gender views. Gender inequality is classified by the Central Statistics Agency as low to high. Geographically Weighted Ordinal Logistic Regression (GWOLR) using an exponential kernel function offers superior classification accuracy (86.84%) compared to ordinal logistic regression, with excellent mapping capabilities (94.7%) [13]. Research using the GWR method is better than the Ordinal Logistic Regression method. The GWOLR method provides higher classification accuracy than Ordinal Logistic Regression [14], [15]. This research aims to map the gender gap in Indonesia based on the factors that influence it and compare the classification accuracy results between the GWOLR model and the ordinal logistic regression model. This initiative aims to support the government's efforts towards achieving a Golden Indonesia by 2045.

2. RESEARCH METHODS

2.1 Geographically Weighted Logistic Ordinal Regression

The GWOLR model is a fusion of the Geographically Weighted Regression (GWR) model and the ordinal logistic regression model[16]. The purpose of the GWOLR model is to depict the relationship between an ordinal-scaled response variable and predictor variables, where each regression coefficient depends on the location of the observed data [17]. If the response variable consists of L categories, then the GWOLR model will be used for site l. This can be expressed as in **Equation (1)**.

$$logit[[P(Y \leq l|\boldsymbol{x}_i)]] = ln\left[\frac{P(Y\leq l|x_i)}{1-P(Y\leq l|x_i)}\right] = \beta_{0_l}(u_i, v_i) + \boldsymbol{x}_i^T\boldsymbol{\beta} \quad (1)$$

Where *l=1,2,...,L-1, i=1,2,...,n*, then $P(Y \leq l|x_i)$ is the cumulative probability of *l-th* category respond against x_i, and $\beta_{0l}(u_i,v_i)$ is intercept parameter regression, (u_i,v_i) is coordinate point (latitude and longitude) for location *i-th*, $\boldsymbol{\beta}(u_i,v_i) = [\beta_1(u_i,v_i) \quad \beta_2(u_i,v_i) \quad \cdots \quad \beta_p(u_i,v_i)]^T$ is vector of regression coefficients for the *i-th* location, and $\mathbf{x}_i = [x_{i1} \quad x_{i2} \quad \cdots \quad x_{ip}]^T$ is vector variable predictor for location *i-th*.

The cumulative probability of the *l*-th response category can be expressed as **Equation (2).**

$$[P(Y_i \leq l|\boldsymbol{x_i})] = \frac{exp\left(\beta_{0l}(u_i,v_i)+\boldsymbol{x_i^T\beta}(u_i,v_i)\right)}{1+exp\left(\beta_{0l}(u_i,v_i)+\boldsymbol{x_i^T\beta}(u_i,v_i)\right)} \quad ,l = 1,2,\dots,L-1 \tag{2}$$

The probability of the response variable at the location-*i* belonging to category *l* can be expressed as **Equation (3)**:

$$\pi_l(\boldsymbol{x_i}) = \frac{exp\left(\beta_{0l}(u_i,v_i)+\boldsymbol{x_i^T\beta}(u_i,v_i)\right)}{1+exp\left(\beta_{0l}(u_i,v_i)+\boldsymbol{x_i^T\beta}(u_i,v_i)\right)} \quad ,l = 1,2,\dots,L-1 \tag{3}$$

The GWOLR model estimates parameters using the Maximum Likelihood Estimation (MLE) method. The likelihood function is then converted into the ln-likelihood process by applying a logarithmic transformation. The GWOLR model incorporates a weighting factor based on geographical location. The value of this factor varies for each site, indicating the localized nature of the GWOLR model **[16]**. Consequently, the ln-likelihood function of the GWOLR model is weighted accordingly. Parameter estimation is done by performing the first partial derivative of the ln-likelihood function equation weighted against the parameter to be estimated and then equated to zero. The first partial derivative result obtained is nonlinear, so the Newton Raphson iteration method is used **[17]**.

Hypothesis testing in the GWOLR model includes testing the equality between the GWOLR model and the ordinal logistic regression model, testing parameters as a whole, and testing parameters individually. Equality Test between GWOLR Model and Ordinal Logistic Regression Model. This test aims to examine the significance of the geographical factor **[18]**.

The hypothesis used is:

H_0: $\beta_k(u_i,v_i) = \beta_k$; $i = 1,2,\dots,n$; $k = 1,2,\dots,p$ or [There is no notable distinction between the GWOLR model and the ordinal logistic regression model in terms of significance]

H_1: At least one $\beta_k(u_i,v_i) \neq \beta_k$ or [significant difference between the GWOLR model and the ordinal logistic regression model]

Where *k* is the number of predictor variables and *n* is the number of observation location province,

F-Test statistics is calculated by **Equation (4).**

$$F = \frac{D(\hat{\theta})/df_1}{D(\hat{\theta}^*)/df_2} \tag{4}$$

Where $D = (\hat{\theta})$ is the devians value of the ordinal logistic regression model calculated based on the maximum likelihood value below H_0 $\left(L(\hat{\omega})\right)$ with free degrees df_1 and $D = (\hat{\theta}^*)$ is the devians value of the GWOLR model calculated based on the maximum likelihood value below the population $\left(L(\hat{\Omega})\right)$ with free degrees df_2.

Reject H_0 if $F_{count} \geq F_{\propto,df_1,df_2}$ so there is a significant difference between the GWOLR model and the ordinal logistic regression model.

In the study by **[19]**, weighting functions generate different parameter estimations for each observation. The Kernel Exponential function can be a weighting function can be written as follows **Equation (5).**

$$w_j(u_i,v_i) = exp\left(-\left(\frac{{d_{ij}}^2}{b^2}\right)\right) \tag{5}$$

With d_{ij} is the Euclidean distance between locations (u_i,v_i) and (u_j,v_j), Formulate from $d_{ij} = \sqrt{(u_i - u_j)^2 + (v_i - v_j)^2}$, and b as a known non-negative parameter commonly called the smoothing parameter (bandwidth). Selecting an optimal bandwidth is crucial in ensuring the model's accuracy towards the data. Bandwidth can be achieved by utilizing Cross Validation (CV) is calculated by **Equation (6)**.

$$CV(b) = \sum_{i=1}^{n} \left(y_{\neq i,j} - \hat{\pi}_{\neq i,j}(b) \right)^2 \tag{6}$$

With $y_{\neq i,j}$ is an indicator variable where the observation is on site (u_i, v_i) omitted from the assessment process, so that $y_{\neq i,l} = 1$ If on-site observation (u_i, v_i) have categories *l* dan 0 for others, $\hat{\pi}_{\neq i,l}$ is the estimated value of the observation opportunity at the site (u_i, v_i) has categories *l*. To get the grade *b* the optimal then obtained from *b* that produces value CV minimum.

A simultaneous test is utilized to assess the collective significance of the variable parameters in the GWOLR model, which does not appear to be modifying the subject [20]. The hypothesis is as follows:

H_0 : $\beta_1(u_1, v_1) = \beta_2(u_2, v_2) = \cdots = \beta_k(u_i, v_i) = 0$ or (no variables that affect the model)

H_1 : at least one of $\beta_k(u_i, v_i) \neq 0$ 0r (at least there is one predictor variable that affects the model)

Test Statistics in **Equation (7)**

$$G^2 = -2\left(\sum_{i=1}^{n} \sum_{l=1}^{L} y_{il} ln \left[\frac{\sum_{j=1}^{n} y_{jl} w_j(u_i, v_i)}{\sum_{j=1}^{n} w_j(u_i, v_i)} \right] - \sum_{i=1}^{n} \sum_{l=1}^{L} y_{il} ln[\hat{\pi}_l(x_i)] \right) \tag{7}$$

With $w_j(u_i, v_i)$ is weight at *j-th* location, y_{il} is the value of the response variable at the *l-th* category response of the *i-th* location, and $\hat{\pi}_l(x_i)$ adalah probability of the response variable at the location-*i* belonging to category *l*.

Reject H_0 if $\boldsymbol{G^2} > \boldsymbol{\chi^2_{(\alpha,df)}}$ *where* $\mathbf{df} = \mathbf{trace}(\boldsymbol{S})$, So there is at least one predictor variable that affects the model.

Afterward, the significance of the parameters is tested individually or partially with the following hypotheses[20], [21] :

H_0 : $\beta_k(u_i, v_i) = 0$,*i=1,2,…,n ; k = 1,2,…,p* (no variables that affect the response)
H_1 : $\beta_k(u_i, v_i) \neq 0$ (the *k*-th predictor variable affects the response variable)

Z_{count} Test Statistics and Standard error are calculated in **Equation (8)**

$$\mathbf{Z_{count}} = \frac{\hat{\beta}_k(u_i,v_i)}{\boldsymbol{SE}\left(\hat{\beta}_k(u_i,v_i)\right)} = \frac{\hat{\beta}_k(u_i,v_i)}{\sqrt{\boldsymbol{Var}\left(\hat{\beta}_k(u_i,v_i)\right)}} \tag{8}$$

With $\sqrt{\boldsymbol{Var}\left(\hat{\beta}_k(u_i, v_i)\right)}$, obtained from the main diagonal to j+1 on $\mathbf{H^{-1}}(\hat{\boldsymbol{\beta}})$**,** i.e. the second derived Hessian matrix that has been inverted from the likelihood function.

H_0 rejected if $|Z_{count}| > Z_{\propto/2}$, so the *k*-th predictor variable affects the response variable

According to [14], the best regression model is determined by comparing the ordinal logistic regression model and GWOLR. One of the criteria used to select the best model is the model that achieves the highest classification accuracy. In this study, the classification accuracy is measured using APER (Apparent Error Rate). [15], [22] The corresponding error rate can be obtained by calculating the APER value. Hence, to determine the classification accuracy, one can use 1-APER.

Table 1. Confusion Matrix Table of The Classification

Observation		**Actual Class**			**Total**
		Class=1	**Class=2**	**Class=3**	
Class Prediction	Class =1	F_{11}	F_{12}	F_{13}	TP_1
	Class=2	F_{21}	F_{22}	F_{23}	TP_2
	Class=3	F_{31}	F_{32}	F_{33}	TP_3
Total		TA_1	TA_2	TA_3	A_{total}

Referring to **Table 1**, mistakes made in categorizing objects can be computed through APPER **[30]**, which is described as **Equation (9)**

$$APER = \frac{F_{12}+F_{13}+F_{21}+F_{23}+F_{31}+F_{32}}{A_{total}} \times 100\% \quad (9)$$

Where: $A_{total} = F_{11} + F_{12} + F_{13} + F_{21} + F_{22} + F_{23} + F_{31} + F_{32} + F_{33}$

Meanwhile, to assess the accuracy of the classification, the following **Equation (10)** can be used:

$$\text{Total Accuracy Rate } \% = 1 - \text{APER} \quad (10)$$

2.2 Data and Variables

This study utilizes a combined secondary dataset sourced from the Central Statistics Agency (BPS) through the website www.bps.go.id and the gender report book from BPS and the Ministry of PPPA from the year 2022. The experimental units located in 34 provinces in Indonesia, as depicted in **Figure 1.** These 34 locations are a lot of data that will be used for GWOLR analysis because the GWOLR data structure is cross-sectional. The dataset in this study consists of a response variable, namely the gender inequality index (IKG), and predictor variables from the dimensions of health, education, women's empowerment factors, social, and labor market where the focus is on the female gender, can be seen in **Table 2.** The analysis steps in this study, as illustrated in the flowchart **Figure 2**, consist of:

1. Data Description
2. Multicollinearity Detection
3. Ordinal Logistic Regression Modelling
4. Breush Pagan Spatial Effects Test
5. GWOLR Modelling and Mapping
6. Model Accuracy Calculation
7. Conclusion

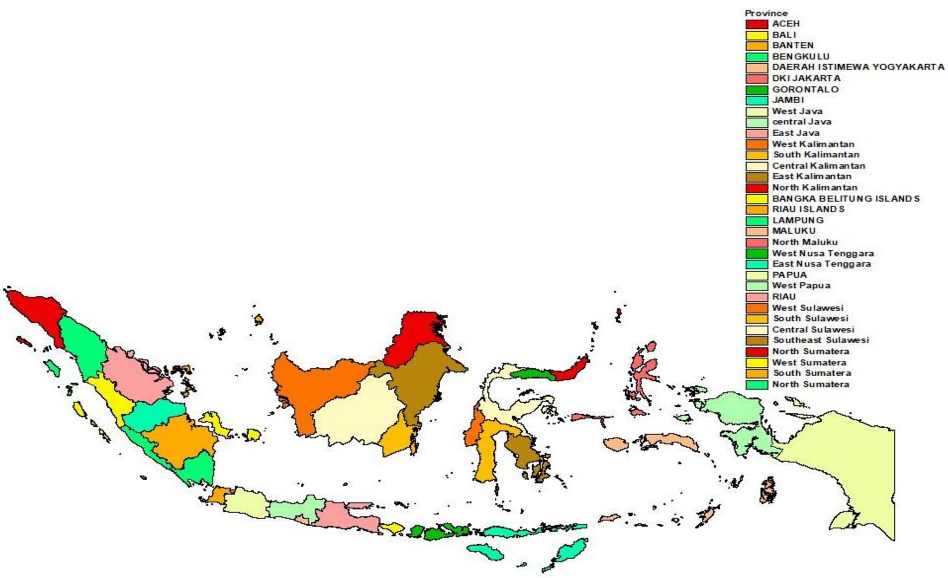

Figure 1. Research Data Collection Locations in 34 Provinces in Indonesia

Table 2. Variables Research

Symbol	Variables
Y	the gender inequality index (1) low (IKG <0.3999) (2) middle (IKG 0.400-0.449 and (3) high (IKG> 0.450)
X_1	Percentage of ever married women aged 15-49 years who have had a birth assisted by trained health personnel
X_2	Percentage of net enrolment of women in higher education
X_3	Percentage of women's human development index
X_4	Percentage of follow crime rape of women
X_5	Percentage of involvement women in parliament
X_6	Percentage of female victims who experienced domestic violence
X_7	Percentage of recipient card women's pre-employment
X_8	Percentage of vacancies informal work for woman
X_9	Percentage of women with status head families with high school diplomas
X_{10}	Percentage of women married before 17 years old
(u_i)	point *longitude*
(v_i)	point *latitude*

The analysis steps in this study, as illustrated in **Figure 2.**

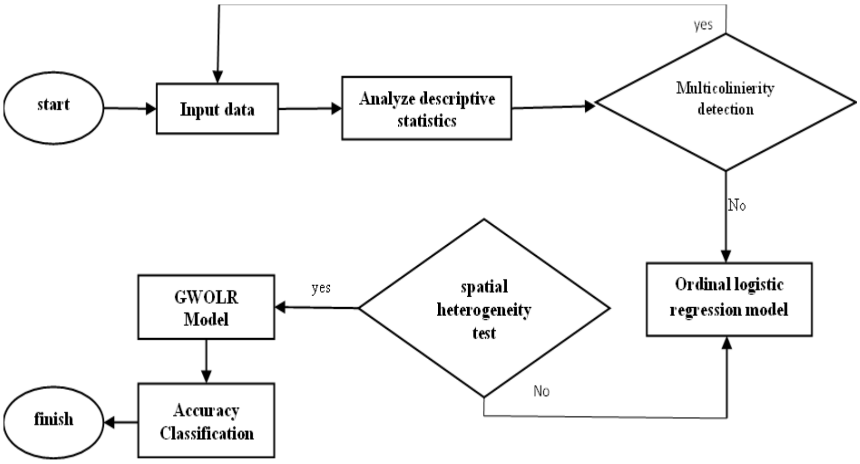

Figure 2. Flow Chart of Research Analysis Steps

3. RESULTS AND DISCUSSION

Based on the examination of multicollinearity, it was found that the values of the Variance Inflation Factor (VIF) for each predictor variable are below 10. Therefore, it can be concluded that there is no significant correlation between the predictor variables.

Data description of the gender inequality index is categorized into three, namely (1) low (IKG <0.3999); (2) middle (IKG 0.400-0.449; and (3) high (IKG> 0.450), as presented in **Figure 3.**

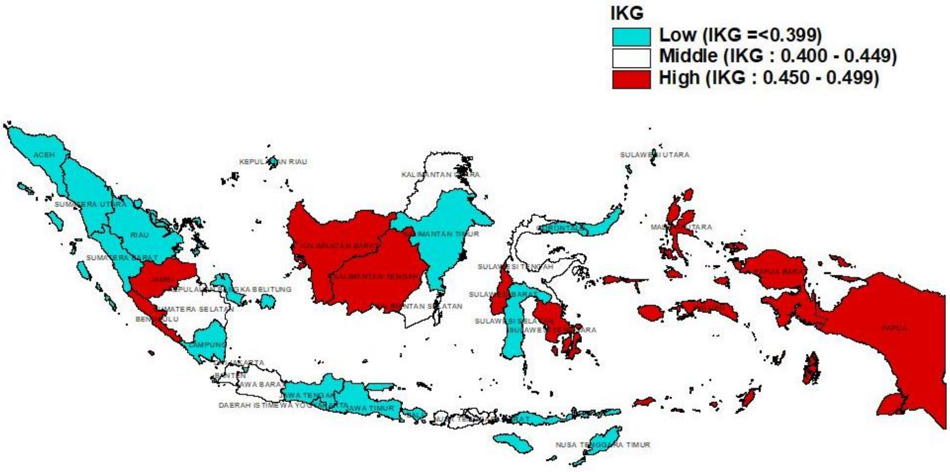

Figure 3. Description of Gender Inequality Index in Indonesia in The Year 2022.

Gender inequality in Indonesia varies greatly in each province and shows that there is a relationship between location factors: locations that are close to each other will influence other provinces; locations with high gender inequality will influence neighboring locations so that these locations will have the opportunity to become areas with high gender inequality as well. This indicates that there are location factors in the research and the appropriate alternative method is a method based on Spatial Statistics. Ten provinces are priority locations for the government's attention because they have high gender inequality, namely the locations in the Eastern Indonesia (WIT) region, including Maluku, North Maluku, West Papua, and Papua, then the locations in the Central Indonesia region (WITA), including Jambi, Bengkulu, West Kalimantan, Central Kalimantan, Southeast Sulawesi, and West Sulawesi. Apart from that, provinces with moderate gender inequality are in the alert category so as not to move into the high category, these provinces include South Sumatra, West Java, Banten, West Nusa Tenggara, South Kalimantan, North Kalimantan, and Southeast Sulawesi. The condition of gender inequality in Indonesia has improved from 2021 to 2022. The gender inequality index in each province in Indonesia has decreased by 2.65% from the 2022 average of 0.382 and the 2021 average of 0.392. The gender inequality index was the highest in 2022. It was 0.492, which has decreased compared to 2021, which was 0.506. However, overall gender inequality in each Indonesian province still needs attention because almost 50% of the total number of provinces still have above average gender inequality, as in **Figure 3.**

The initial step in modeling the gender inequality index in each province of Indonesia is to determine the geographical locations based on Latitude and longitude in each region. Based on the results of the Breusch-Pagan test, it can be concluded that spatial heterogeneity exists in each province in Indonesia. Next, the Euclidean distance is calculated from locations i and j. Subsequently, the optimal bandwidth is determined using the Cross Validation (CV) method. Using an optimal bandwidth of 1.091, the best weight matrix is obtained by incorporating the Euclidean distance and the optimal bandwidth into the exponential kernel weighting function. The weights obtained for each research location are then used to estimate the GWOLR parameters in each province of Indonesia using Newton Raphson iteration. After getting the GWOLR model estimation, tests are conducted to determine the similarity between the GWOLR model and the Ordinal Logistic Regression model regarding overall and individual parameter levels involved.

The following are the hypotheses used to test the equivalence between the GWOLR model and the Ordinal Logistic Regression model, as presented in **Table 3.**

Table 3. Test of Equality between the GWOLR Model and Ordinal Logistic Regression model.

Model	Deviants	Df	Deviant/Df	F
RLO	30.276	56	0.541	4.077
GWOLR	27.004	203.65	0.133	

The computed F test value for testing the equivalence between the GWOLR and Ordinal Logistic Regression models is 4.007. The added F test value is greater than the critical F value of F(0.05; 56; 203.65), which is 1.39. Therefore, there is a significant difference between the GWOLR and Ordinal Logistic

Regression models. The modeling of the Gender Inequality Index in the provinces of Indonesia in 2022 yields significantly different results between the GWOLR and Ordinal Logistic Regression models.

The following is the simultaneous testing of the parameters of the GWOLR model in this study. G^2 statistic value is 49.661, compared to the χ^2 (0.05;5.534) value of 11,889. Therefore, the G^2 statistic value is greater than the χ^2 (0.05;5.534) value. Hence, it can be concluded that at least one predictor variable significantly influences the Gender Inequality Index in the provinces of Indonesia.

The partial testing of the parameters of the GWOLR model is conducted using the following hypotheses:

$H_0 : \beta_k(u_i, v_i) = 0$,*i=1,2,...,34 ; k = 1,2,...,10*
$H_1 : \beta_k(u_i, v_i) \neq 0$

Each province in Indonesia has a different model, resulting in other significant variables. For example, testing will be conducted on the parameter βk that influences variable H_1 for each i, k with $i = 1, 2, \cdots, 34$ and $k = 1, 2, \cdots, 10$. Assuming that β_k at the eleventh location (u_{11}, v_{11}) representing East Java province has a significant effect, the Z-test values can be observed in **Table 4.**

Table 4. Test of Significance of Partial Parameters of the GWOLR model in East Java

Parameter	Estimate	SE	Z_{ccount}	P-Value	Odd ratio
$\beta_{0_1}(u_{11}, v_{11})$	53.14	21.456	2.477	**0.018***	
$\beta_{0_2}(u_{11}, v_{11})$	50.32	19.450	2.587	**0.014***	
$\beta_1(u_{11}, v_{11})$	-0.3083	0.125	-2.466	**0.019***	1.36
$\beta_2(u_{11}, v_{11})$	-0.0783	0.073	-1.070	0.225	1.08
$\beta_3(u_{11}, v_{11})$	-0.2007	0.120	-1.668	0.099	1.22
$\beta_4(u_{11}, v_{11})$	0.2494	0.343	0.728	0.306	1.28
$\beta_5(u_{11}, v_{11})$	-0.106	0.115	-0.919	0.261	1.11
$\beta_6(u_{11}, v_{11})$	0.351	0.244	1.439	0.141	1.42
$\beta_7(u_{11}, v_{11})$	0.352	0.156	2.256	**0.031***	1.42
$\beta_8(u_{11}, v_{11})$	-0.3783	0.164	-2.307	**0.028***	1.46
$\beta_9(u_{11}, v_{11})$	0.0683	0.232	0.294	**0.005**	1.07
$\beta_{10}(u_{11}, v_{11})$	0.2727	0.123	2.217	**0.034***	1.31

*) Significant of α=5%

The GWOLR Logit **Equation (12)** model at the 11th location in **East Java (Low Category)** is:

$$g_1(x) = 53.14 - 0.3083X_{1*} - 0.078X_2 - 0.2007X_3 + 0.249X_4 - 0.106X_5 + 0.351X_{6*} + 0.352X_7 - 0.3783X_8 + 0.0683X_9 + 0.273X_{10*}$$
$$g_1(x) = 50.32 - 0.3083X_{1*} - 0.078X_2 - 0.2007X_3 + 0.249X_4 - 0.106X_5 + 0.351X_{6*} + 0.352X_7 - 0.3783X_8 + 0.0683X_9 + 0.273X_{10*} \quad (12)$$

Based on this model of **Equation (12)** from **Table 4**, the predictor variables that affect the Gender Inequality Index in the East Java Province of Indonesia are the percentage of Ever-Married Women aged 15-49 whose last birth was assisted by trained health personnel (X_1), Recipients of pre-employment cards for women (X_7), Percentage of Job Vacancies Informal for women (X_8), and the percentage of women who married before the age of 17 (X_{10}).

With every 1% decrease in ever-married women aged 15-49 years whose births are assisted by trained health personnel (X_1), the East Java region will be at risk 1.36 times to have regional status high gender inequality. For every 1% increase in receiving pre-employment cards for women (X_7), the area of East Java will be at risk 1.42 times of becoming an area with high gender inequality status. For every 1% decrease in the percentage of Informal Job Vacancies for Women (X_8), the East Java region will be at risk of 1.46 times becoming an area of high gender inequality. For every 1% increase in the percentage of women who married before the age of <17 years (X_{10}), the West Java area will be at risk of increasing 1.31 times to become an area with high gender inequality status.

The GWOLR Logit **Equation (13)** Model at the 9th location in **West Java (Middle Category)** is:

$$g_1(x) = 53.78 - 0.321X_{1*} - 0.437X_{2*} - 0.209X_3 + 0.123X_4 - 0.324X_5 + 0.241X_6 + 0.198X_7 - 0.133X_8 + 0.097X_9 + 0.234X_{10}$$
$$g_2(x) = 60.23 - 0.321X_{1*} - 0.437X_{2*} - 0.209X_3 + 0.123X_4 - 0.324X_5 + 0.241X_6 + 0.198X_7 - 0.133X_8 + 0.097X_9 + 0.234X_{10} \quad (13)$$

The GWOLR Logit **Equation (14)** Model at the 24th location in **Papua (High Category)** is:

$$g_1(x) = 55.14 - 0.328X_{1*} - 0.078X_2 - 0.501X_{3*} + 0.949X_{4*} - 0.006X_5 + 0.321X_{6*} + 0.520X_7 - 0.1783X_8 + 0.0683X_9 + 0.291X_{10*}$$
$$g_2(x) = 51.32 - 0.328X_{1*} - 0.078X_2 - 0.501X_{3*} + 0.949X_{4*} - 0.006X_5 + 0.321X_{6*} + 0.520X_7 - 0.1783X_8 + 0.0683X_9 + 0.291X_{10*} \quad (14)$$

The grouping of provinces based on the significant variables in the GWOLR model can be seen in **Figure 4** and **Table 5**.

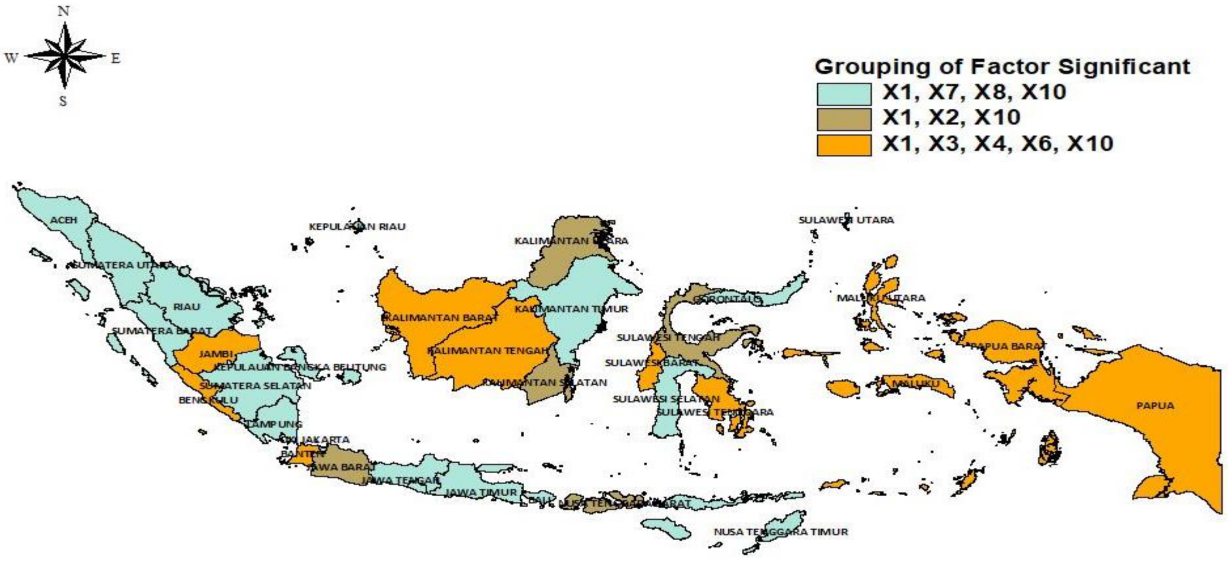

Figure 4. Mapping of Provinces Based on Significant Variables in the GWOLR Model Using The Exponential Kernel Function weighting.

Table 5. Province Mapping Based on Influencing Factors and Categories of Gender Inequality

Influential Variables	Province
Percentage of Ever Married Women Aged 15-49 Years Who Have Had a Birth Assisted by Trained Health Personnel (X_1), Percentage Recipient Card Women's Pre-Employment (X_7), Percentage of Vacancies informal work for Woman (X_8), Percentage of women married before 17 years old (X_{10})	Aceh, Bali, DI Yogyakarta, DKI Jakarta, Gorontalo, Central Java, East Java, East Kalimantan, Bangka Belitung Islands, Riau Islands, Lampung, NTT, Riau, South Sulawesi, North Sulawesi, West Sumatra, South Sumatra, North Sumatra
Percentage of Ever Married Women Aged 15-49 Years Who Have Had a Birth Assisted by Trained Health Personnel (X_1), Percentage of Net Enrolment of Women in Higher Education (X_2), Percentage of women married before 17 years old (X_{10})	West Java, South Kalimantan, North Kalimantan, NTB, Central Sulawesi
Percentage of Ever Married Women Aged 15-49 Years Who Have Had a Birth Assisted by Trained Health Personnel (X_1), Women's Human Development Index (X_3), Percentage follow crime rape of women (X_4), Percentage of Female Victims who experienced domestic	Banten, Bengkulu, Jambi, West Kalimantan, Central Kalimantan, Maluku, North Maluku, Papua, West Papua, West Sulawesi, Southeast Sulawesi

Influential Variables	Province
violence (X_6), Percentage of women married before 17 years old (X_{10})	

Based on Figure 4 and Table 5, the influential factors in all provinces in Indonesia are the percentage of ever-married women aged 15-49 years who were attended by a health worker (X_1) and the percentage of women who married before the age of 17 years (X_{10}). People in all provinces still believe that childbirth is attended by non-health personnel such as traditional healers. This also illustrates that health facilities and the distribution of health workers in each province are uneven and the lack of public knowledge about the safety of the birth process, so the community prefers to be assisted by non-health workers. The culture of people in Indonesia using traditional healers in the birth process is in line with the study [23], [24]. The five provinces with the lowest percentage of ever-married women aged 15-49 years whose births were assisted by skilled birth attendants or still using traditional birth attendants [25] are Maluku (78%), West Papua (80%), Papua (81%), North Maluku (82%) NTT (84%).

Early marriage among women has also become a culture among communities in every province in Indonesia. Society has a culture that requires girls who have menstruated and men who have worked to get married immediately because they are considered adults. If parents do not immediately marry their children, it will be considered a family disgrace. People still think that women's duties are only to take care of the house, children, and kitchen, so women do not need to go to high school. The community believes that friendship between men and women who are not bound by marriage is a sin and can cause fitnah. In addition, if there are female residents who have reached the age of 15-18 years and have not married, they will become the subject of gossip in the community and be ridiculed as old women who do not sell. The culture of early marriage is in line with research by**[26].** The five provinces with the highest percentage of women married before the age of 17 [25] are West Java (45.40%), South Kalimantan (38.20%), East Java (36.52%), Banten (34.10%), Central Kalimantan (33.59%).

The comparison of the ordinal logistic regression model and the GWOLR is conducted by comparing the accuracy rate and the error value (APER) in classification, which can be seen in **Table 6.**

Table 6. Comparison of Classification Accuracy

Model	APER	Accuracy
Ordinal Logistic Regression	14.71%	85.29%
GWOLR	5.89%	94.11%

Table 6 shows that in modeling the Gender Inequality Index, the use of the GWOLR model yields a higher classification accuracy than the ordinal logistic regression model. The GWOLR model is more suitable than the ordinal logistic regression model for modeling the Gender Inequality Index in Indonesian provinces.

4. CONCLUSIONS

Modeling factors influencing the Gender Inequality Index in 2022 using the GWOLR method with exponential kernel weighting has mapping of gender inequality in Indonesia based on influencing factors using geographical factors that influence the Gender Inequality Index in Indonesian Provinces using the GWOLR in each province is different. The GWOLR model with exponential function weighting forms three region/province groupings based on the influencing factors.

a. The first mapping location labeled the low inequality location is influenced by Percentage of Ever Married Women Aged 15-49 Years Who Have Had a Birth Assisted by Trained Health Personnel (X_1), Percentage of Recipient Card Women's Pre-Employment (X_7), Percentage of Vacancies informal work for Woman (X_8), Percentage of women married before 17 years old (X_{10})

b. The second mapping location labeled the middle inequality location is influenced by Percentage of Ever Married Women Aged 15-49 Years Who Have Had a Birth Assisted by Trained Health Personnel (X_1), Percentage of Net Enrolment of Women in Higher Education (X_2), Percentage of women married before 17 years old (X_{10})

c. The third mapping location labeled the high inequality location is influenced by Percentage of Ever Married Women Aged 15-49 Years Who Have Had a Birth Assisted by Trained Health Personnel (X_1), Women's Human Development Index (X_3), Percentage follow crime rape of women (X_4), Percentage of Female Victims who experienced domestic violence (X_6), Percentage of women married before 17 years old (X_{10})

Modeling factors influencing the Gender Inequality Index in 2022 using the GWOLR method proven superior to using ordinal logistic regression based on its classification accuracy, which is equal to 94.11%. These findings are consistent with previous studies **[13]**, **[14]**, **[15]**, which also concluded that the GWOLR model outperforms the ordinal logistic regression model globally. However, the accuracy level obtained in this study does not surpass that of previous research. The results of this study demonstrate that the GWOLR model outperforms the ordinal logistic regression model globally.

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