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Analyzing Gender Equality Indicactors Using Principal Component Analysis in Central Papua and Papua Highland

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ABSTRACT

The Gender equality is one of the key targets in Sustainable Development Goal (SDG) 5 and remains a major challenge in Central Papua and Papua Highland, where gender development indicators are among the lowest in Indonesia. This study aims to identify the dominant factors influencing gender equality in these two provinces using Principal Component Analysis (PCA) on seven indicators representing education, health, economic conditions, and political representation of women. The analysis results show that two main factors are formed with a total variance explained of 77.248%. The first factor reflects women's economic participation and basic living conditions, while the second factor represents resource capacity and socio-political representation. These findings suggest that limited access to education, health services, and participation in the labor market and political institutions are the primary contributors to gender inequality in this region. Therefore, empowerment-oriented policies and improved service accessibility are required to achieve more equitable gender development in Papua.

Keywords: *Gender Equality, Principal Component Analysis, Papua*

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INTRODUCTION

Gender equality is a social issue that has long been a concern and an important foundation for sustainable development. This equality requires equal access, opportunities, and roles for women and men in various aspects of life (Saputri et al., 2024). In Indonesia, gender equality can be seen in three main indicators, namely the Gender Development Index (GDI), the Gender Empowerment Measure (GEM), and the Gender Equality Index (GEI), which are used as tools to measure progress in gender equality in development. Studies show that the achievement of gender equality correlates with economic and social development, making it a top priority in Indonesia's national development (Ravika & Rhani, 2024).

The provinces of Central Papua and Papua Highland rank lowest in Indonesia's gender equality indicators. Central Papua has the lowest Gender Development Index (GDI)

score nationally at 81.41, indicating limited access for women to education, health, and economic opportunities compared to other provinces. Meanwhile, Papua Highland also ranks last in the Gender Empowerment Index (IDG) with a score of 55.2 and a Gender Equality Index (IKG) of 0.579, reflecting low female participation in politics and the economy and high gender inequality in the region (BPS, 2024). This situation reflects the significant challenges faced in achieving inclusive and equitable development for all segments of society in Papua.

Previous studies have identified factors that influence gender equality in Papua, such as access to education, per capita expenditure, and the quality of human resources, which significantly contribute to the low gender development index (GDI) (Wardani, 2024). Studies show that the patriarchal system, which is deeply rooted in Papuan society, is a major obstacle for women in gaining equal access and opportunities, thereby exacerbating gender inequality in the region (Permadi et al., 2025). In addition, research also reveals that the role of education is very important in overcoming this inequality, because education can open up equal access and opportunities for both men and women, especially in areas facing geographical, cultural, and economic challenges. This is supported by research from Yustie. that education is a key factor in reducing gender inequality in Papua, particularly through Expected Years of Schooling and Per Capita Expenditure for Women, which have a significant impact on the Gender Development Index. Investment in education and improving women's welfare are essential to promote more inclusive gender development in the region (Yustie et al., 2023).

Previous studies analyzed factors that partially influence gender equality; therefore, this study uses Principal Component Analysis (PCA), which provides an alternative approach to grouping and reducing complex variable dimensions. PCA is capable of efficiently identifying patterns and relationships between variables, and allows for simpler analysis of complex data by reducing dimensions, especially when dealing with multidimensional data and the complexity of gender equality indicators (Lesnussa et al., 2025). PCA focuses on reducing data complexity by forming principal components that explain the total variance of the original variables. The principal components formed are a linear combination of the original variables and are selected in such a way as to capture most of the variation or information contained in the initial data (Rencher, 2002).

This study contributes to achieving Sustainable Development Goal 5 (SDG 5) on Gender Equality, which focuses on empowering all women and girls and ensuring equal opportunities, remains a critical challenge in disadvantaged regions. This study is expected to provide deeper insights into the structure and dynamics of gender equality in Central Papua and Papua Highland through the results of factor grouping from PCA analysis. By identifying the dominant factors that influence gender equality, This study aims to identify the dominant factors influencing gender equality in Central Papua and Papua Highland using Principal Component Analysis to support evidence-based policy design as well as prioritizing the most crucial aspects for improving gender equality in these areas.

METHOD

This research method uses a quantitative approach with a descriptive design, which is an approach that aims to describe the conditions of the research object as they are in the field without manipulating variables. The research was conducted in 16 districts/cities in Central Papua and Papua Highland provinces based on 2024 BPS data, focusing on seven variables as described in the following table.

Table 1 : Data Variables

Variable	Unit	Scale
Adjusted Expenditure For Women	Rupiah	Ratio
Percentage Of Women > 25 Years Of Age With At Least A High School Education	Percentage	Ratio
Average Length Of Schooling For Women	Years	Ratio
Percentage Of Women In District Councils	Percentage	Ratio
Percentage Of Active Female Workers	Percentage	Ratio
Life Expectancy For Women	Years	Ratio
Level of Female Labor Force Participation	Percentage	Ratio

Source : Badan Pusat Statistik Indonesia (2024)

Data analysis uses factor analysis methods with Principal Component Analysis (PCA) extraction techniques to reduce variable dimensions and identify the main factors that represent gender equality indicators in the region.

The assumptions that need to be met in factor analysis are KMO, MSA, and Bartlett. The Kaiser Meyer Olkin (KMO) test is an index used to assess sample adequacy in factor analysis (Verdian, 2019), The KMO formula is as follows:

$$KMO = \frac{\sum_{i=1}^{p}\sum_{j=1}^{p} r_{ij}^2}{\sum_{i=1}^{p}\sum_{j=1}^{p} r_{ij}^2 + \sum_{i=1}^{p}\sum_{j=1}^{p} a_{ij}^2} \quad (1)$$

Where:

r_{ij} = correlation coefficient between variables i and j

a_{ij} = partial correlation coefficient between variables i and j

The Measure of Sampling Adequacy (MSA) test is a measure of sample adequacy for each variable in factor analysis that indicates whether the variable is suitable for further analysis (Khusna et al., 2021). The MSA formula is as follows:

$$MSA = \frac{\sum_{i \neq j}^{p} r_{ij}^2}{\sum_{i \neq j}^{p} r_{ij}^2 + \sum_{i \neq j}^{p} a_{ij}^2} \quad (2)$$

Where:

r_{ij} = correlation coefficient between variables i and j

a_{ij} = partial correlation coefficient between variables i and j

KMO and MSA must be greater than 0,5 for the data to be used in factor analysis.

Bartlett's test is a statistical test used to test the homogeneity of variances of two or more groups (Sianturi, 2022). The hypothesis for the Bartlett test is

$H_0 : |\mathrm{R}| = I$

$H_1 : |\mathrm{R}| \neq I$

The Bartlett test calculation uses the formula as follows

$$\chi^2 = -\left(n - 1 - \frac{2p + 5}{6}\right) \ln|\mathbf{R}| \tag{3}$$

Where n is the sample size, p is the number of variables, R is the correlation matrix between variables, and $|\mathbf{R}|$ is the determinant of the correlation matrix. If the value of $\chi^2 > \chi^2_{\left(\alpha, \frac{p(p-1)}{2}\right)}$ then H_0 is rejected with the conclusion that the data is suitable for factor analysis.

Factor analysis is a statistical method used to reduce data by identifying a number of latent factors underlying the observed variables (Rencher, 2002). The factor analysis model is written as:

$$\boldsymbol{y} - \boldsymbol{\mu} = \boldsymbol{\Delta f} + \boldsymbol{\epsilon} \tag{4}$$

Principal Component (PC) estimation in factor analysis begins with calculating the covariance (S) matrix using the covariance and correlation formulas written as follows (Tahir et al., 2021).

$$\mathbf{S} = \ \mathrm{cov}(\mathrm{X}, \mathrm{Y}) = \frac{1}{n-1} \sum_{i=1}^{n} (X_i - \bar{X})(Y_i - \bar{Y}) \tag{5}$$

$$\mathbf{R} = \ \mathrm{corr}(\mathrm{X}, \mathrm{Y}) = \frac{\sum_{i=1}^{n} (X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum_{i=1}^{n} (X_i - \bar{X})^2} \ \sqrt{\sum_{i=1}^{n} (Y_i - \bar{Y})^2}} \tag{6}$$

In the principal component approach, spectral decomposition is performed on the S matrix as follows

$$\boldsymbol{S} = \boldsymbol{CDC}' \tag{7}$$

Where:

C = Eigenvector matrix

D = Diagonal eigenvalue (θ) matrix.

The loading factor matrix is estimated as follows

$$\widehat{\boldsymbol{\Delta}} = \boldsymbol{C_1 D_1^{\frac{1}{2}}} = \left(\sqrt{\theta_1}\boldsymbol{c_1}, \sqrt{\theta_2}\boldsymbol{c_2}, \ldots, \sqrt{\theta_m}\boldsymbol{c_m}\right) \tag{8}$$

Varimax rotation function aims to improve the interpretability of results by adjusting the direction of factors so that the pattern of factor loadings becomes simpler and easier to understand (Rencher, 2002).Varimax is performed iteratively with the following convergent function as follows

$$V = \sum_{j=1}^{m}\left[\frac{1}{p}\sum_{i=1}^{p}\left(\hat{\lambda}_{ij}^{*}\right)^{4} - \left(\frac{1}{p}\sum_{i=1}^{p}\left(\hat{\lambda}_{ij}^{*}\right)^{2}\right)^{2}\right] \quad (9)$$

FINDING AND DISCUSSION

RESEARCH RESULT

Descriptive Statistics

To describe the initial conditions of gender equality in Central Papua and Papua Highland, descriptive statistics are presented to show the characteristics of each variable used. Details of the descriptive values for each variable are shown in the following table.

Table 2: . Descriptive Statistics

Variable	Min	Max	Mean	Std. Dev
Adjusted Expenditure For Women	2223	9164	4570	1696,5
Percentage Of Women > 25 Years Of Age With At Least A High School Education	1,44	63,76	18,32	17,60
Average Length Of Schooling For Women	1,65	10,44	3,391	2,65
Percentage Of Women In District Councils	0	0,15	0,446	0,015
Percentage Of Active Female Workers	0,29	0,49	0,42	0,06
Life Expectancy For Women	57,59	75,15	67,73	3,69
Level Of Female Labor Force Participation	41,31	95,08	74,16	18,53

Source : Results of Data Processing IBS SPSS Statistics 27 (2025)

Based on Table 1, it can be seen that the overall condition of women in Central Papua tends to be at the lowest level compared to other regions. Per capita expenditure for women varies between 2,223 and 9,164, with an average of 4,570, while the percentage of women over the age of 25 who have at least a high school education only reaches an average of 18.32%, and the average length of schooling for women is 3.39 years. Women's participation in the workforce and as active workers ranges from 41.31 to 95.08, with some districts showing very low values, for example Mimika at only 0.29 and Deiyai at 41.31. Women's health also shows disparities, as seen in the life expectancy of a minimum of 57.59 years in Nduga compared to an average of 67.73 years. Most striking is the representation of women in district/city DPRD, where many regions, including in Central Papua, have 0 percent representation. In addition, Puncak District stands out because it has the lowest values on three indicators at once (Percentage of High School Education, Average Length of Schooling, and Per Capita Expenditure for Women), indicating a serious lag in women's education and economic aspects.

KMO MSA and Bartlet Asumption

Before conducting factor analysis, KMO and Bartlett's assumption tests were performed. The results of the analysis for the seven variables can be seen in the following table.

Table 3: .KMO and Bartlett's

KMO	0,671
Bartlett's P-Value	< 0,001

Source : Results of Data Processing IBS SPSS Statistics 27 (2025)

Table 4: .MSA

Variable	MSA
Adjusted Expenditure For Women	0,805
Percentage Of Women > 25 Years Of Age With At Least A High School Education	0,662
Average Length Of Schooling For Women	0,681
Percentage Of Women In District Councils	0,664
Percentage Of Active Female Workers	0,626
Life Expectancy For Women	0,743
Level Of Female Labor Force Participation	0,622

Source : Results of Data Processing IBS SPSS Statistics 27 (2025)

Based on the output, the overall KMO value and the Measure of Sampling Adequacy (MSA) for each variable are above 0.5, indicating that the data meet the sampling adequacy criteria. Therefore, the factor analysis can be appropriately carried out.

Principal Component Analysis

The total variance explained and eigen value used to determine the m factors used are presented in the following table

Table 5: .Total Variance Explained

Component	Initial Eigenvalue		
	Total	**% of variance**	**Comulative %**
1	3,229	47,125	47,125
2	2,109	30,122	77,248
3	0,781	11,159	88,407
4	0,461	6,580	94,987
5	0,235	3,364	98,35
6	0,074	1,064	99,415
7	0,041	0,585	100

Source : Results of Data Processing IBS SPSS Statistics 27 (2025)

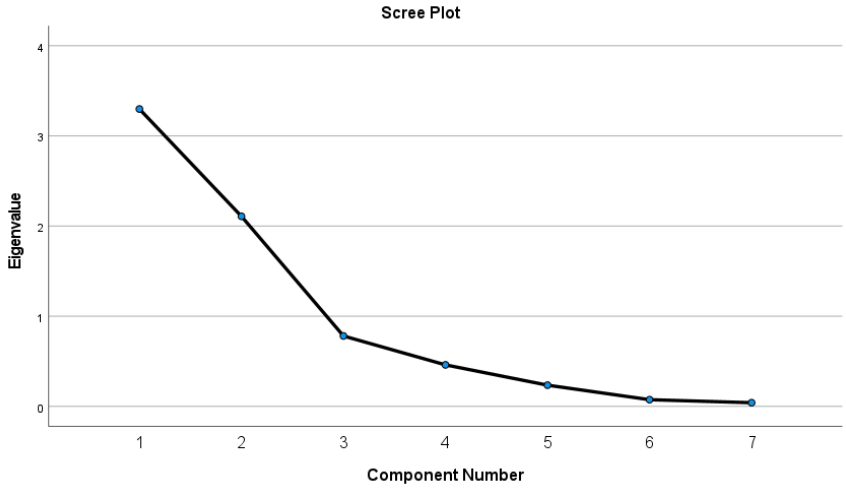

Figure 1 : Eigenvalue Scree Plot

Based on Table 3 and Figure 1, there are two components that have eigenvalues above 1. The first component explains 47.125% of the variance, while the second component explains 30.122% of the variance. Cumulatively, these two components explain a total variance of 77.248%. Thus, the number of factors (m) used in the analysis is two factors.

Table 6: . Rotated Component Matrix

Variable	Component	
	1	**2**
Adjusted Expenditure For Women	0,203	**0,802**
Percentage of Women > 25 Years Of Age With At Least A High School Education	-0,422	**0,864**
Average Length of Schooling For Women	-0,522	**0,809**
Percentage of Women In District Councils	0,116	**0,716**
Percentage of Active Female Workers	**0,939**	0,0006
Life Expectancy For Women	**-0,780**	0,11
Level of Female Labor Force Participation	**0,917**	0,045

Source : Results of Data Processing IBS SPSS Statistics 27 (2025)

Based on the Rotated Component Matrix in Table 4, it can be seen that each variable has a high factor loading value on one of the two factors formed, thus facilitating the interpretation process. Based on these results, the naming and interpretation of factors are summarized in Table 5 below.

Table 7: . Rotated Component Matrix

Component	Variabel	New Factor Name
Component 1	Percentage of Active Female Workers, Life Expectancy For Women, Level of Female Labor Force Participation.	Access To Education and Representation of Women
Component 2	Adjusted Expenditure For Women, Percentage of Women > 25 Years of Age With At Least A High School Education, Average Length of Schooling For Women, Percantage of Women in District Councils	Women's Economic Independence and Health

Source : Results of Data Processing IBS SPSS Statistics 27 (2025)

Factor 1 is dominated by variables related to women's involvement in economic activities, namely Percentage of Active Female Workers (0.939), Level of Female Labor Force Participation (0.917), and Life Expectancy for Women (-0.780). The high loading values on these variables indicate that Factor 1 represents the dimension of economic participation and essential conditions for women.

Meanwhile, Factor 2 has high loadings on variables related to access to and quality of education and women's representation, namely Adjusted Expenditure for Women (0.802), Percentage of Women > 25 Years of Age With at Least a High School Education (0.864), Average Length of Schooling for Women (0.809), and Percentage of Women in District Councils (0.716). This shows that Factor 2 reflects the dimension of women's resource capacity and socio-political representation.

DISCUSSION

Two main factors identified through principal component analysis, namely Access to Education and Representation of Women and Women's Economic Independence and Health, describe the dimensions of women's economic participation and basic conditions, as well as women's resource capacity and socio-political representation. The low level of women's labor participation in several regions, such as Mimika and Deiyai, as well as the low life expectancy of women in Nduga, indicate that women's access to economic and health services is still limited. In addition, the absence of women's representation in regional representative councils (DPRD) in most regions indicates that structural barriers in the political sphere remain strong. These findings are in line with previous studies which state that educational inequality, patriarchal cultural norms, and weak policy support are the main causes of gender inequality in Papua.

Previous research, such as Empowering Women in Papua Province, Indonesia as Part of the Green Economy, shows that women's economic empowerment through the utilization of local resources and small-scale enterprises can improve women's economic role and welfare in Papua despite the structural barriers they face in the form of limited

access and social norms that favor men (Ginting et al., 2022). In line with this, The Empowerment of Indigenous Papuan Women Through Home-Based Industries: A Case Study in Papua, Indonesia reports that home-based industries and community empowerment approaches are effective strategies for increasing the economic independence of Papuan women, despite remaining hampered by capital constraints and socio-cultural conditions (Merina, 2023). The findings of this study, namely that two main factors influence gender equality in Papua, namely "Access to Education and Representation of Women" and "Women's Economic Independence and Health," reinforce empirical evidence of the importance of women's economic access, resources, and political representation as the foundation for gender equality in the region.

The results of this study also demonstrate a strong alignment with the goals of SDGs 5.1 and 5.5, which emphasize the elimination of all forms of discrimination against women and the enhancement of women's full participation in decision-making processes. The limited access to education, low labor force participation, and minimal representation of women in regional councils found in several districts in Papua reflect persistent structural inequalities that SDGs 5.1 seeks to address. At the same time, the absence of women's voices in political leadership and the restricted opportunities for women to influence public policies highlight the urgency of achieving SDGs 5.5. These findings reinforce the need for integrated interventions that not only expand women's economic and educational opportunities but also remove institutional barriers that hinder women's leadership and representation, ensuring that progress toward gender equality in Papua is aligned with global development targets.

This study still has limitations, such as a limited number of variables and the use of aggregate data that does not describe specific individual conditions, as well as the lack of in-depth consideration of sociocultural aspects. However, the results of this study have important implications for policy formulation, including the need to expand access to education for women, improve local-based economic empowerment programs, strengthen affirmative political policies, and improve basic health services for women. Further research is recommended to include cultural perspectives and more comprehensive data in order to describe gender inequality more comprehensively and in greater depth.

CONCLUSION

The results of the study show that from the seven variables analyzed, two main factors were formed with a total variance explained of 77.248%, namely the factors of Access To Education and Representation of Women and Women's Economic Independence and Health. These two factors reflect that gender equality in Central Papua and Papua Highland is greatly influenced by the level of women's involvement in the economy and their access to education and political space. This condition indicates that women's development in these regions is still low and uneven, requiring improved access to education, health, employment opportunities, and support for women's representation in decision making.

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