



Global Patterns of Gender Equality: A Multivariate Analysis of SDG Indicators

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Edith Johana Medina-Hernández 
Universidad del Tolima, Ibagué, Colombia

Abstract

Focusing on the global patterns of gender equality, this study conducts a multivariate analysis of six selected indicators included in the Sustainable Development Goals (SDGs), utilizing data from 160 countries reported in the Sustainable Development Report 2023. Employing the DUAL-STATIS multivariate analysis technique, the study examines the associations between these indicators and countries, identifying the differences or similarities observed. The findings reveal a structural division: while high-income nations advance in political and labor parity, lower-income regions face persistent deficits in maternal health and adolescent fertility. Conclusively, this structural behavior demonstrates that progress in gender targets is highly interdependent and uneven across regions, making it impossible to capture through isolated metrics. Methodologically, it is recommended to apply multivariate techniques to evaluate and understand global indicators. Practically, public gender policies and monitoring frameworks must transition from aggregate targets to integrated, regionalized strategies that simultaneously address reproductive health limitations and institutional representation barriers to guarantee gender equality and women's empowerment.

Keywords

Gender equality; sustainable development; women's studies; multivariate analysis.

Registration

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Patrones globales de la igualdad de género: Un análisis multivariante de indicadores ODS

Resumen

Este artículo examina las relaciones generativas desarrolladas al interior de las familias ensambladas en la Región Cafetera de Colombia, contribuyendo a una comprensión más amplia de estas configuraciones familiares más allá de las perspectivas orientadas al déficit. El estudio tuvo como objetivo explorar los discursos familiares y las relaciones generativas que los miembros de la familia construyen en torno a su organización familiar; este artículo se centra específicamente en los hallazgos relacionados con la generatividad. Se realizó un estudio cualitativo con 25 familias ensambladas (50 participantes, incluyendo padres biológicos y padrastros/madrastras, así como hijos biológicos e hijastros). Los datos se recolectaron a través de entrevistas en profundidad y se analizaron mediante un enfoque temático-interpretivo. Los hallazgos revelan que estas familias construyen relaciones generativas a través de recursos familiares, innovaciones relacionales y procesos de aprendizaje colectivo que fortalecen sus patrones de convivencia y sus relaciones interpersonales. El estudio concluye que, incluso en contextos marcados por la tensión y la complejidad, las familias ensambladas desarrollan formas creativas de organización y cuidado que amplían las comprensiones tradicionales de la paternidad/maternidad, el parentesco y la vida familiar contemporánea.

Palabras clave

Igualdad de género; desarrollo sostenible; estudios de la mujer; análisis multivariante.

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1. Introduction

In 2015, 193 countries from all over the world signed the 2030 Agenda for Sustainable Development, which calls for action and establishes the political commitment to achieve 17 Goals designed to eradicate poverty, protect the planet, and ensure prosperity for all. As explained by [Altuzarra, Gálvez-Gálvez and González-Flores \(2021\)](#), the United Nations Sustainable Development Goals (SDGs) set global standards for achieving gender equality and encourage governments and civil society to implement policies aimed at reaching these standards. To this end, the SDGs rely on a system of specific targets and indicators to assess progress toward sustainable development from a multidimensional perspective that integrates economic, environmental, and social dimensions.

Gender issues, and gender equality in particular, can be regarded as cross-cutting elements in the implementation of the Sustainable Development Goals (SDGs). Gender considerations interact with the other SDGs and, consequently, progress in gender equality contributes directly to the achievement of the SDGs as a whole ([Leal-Filho et al., 2023](#)). In this context, SDG 5 explicitly aims to achieve gender equality and empower all women and girls and is widely recognized as a prerequisite for advancing the remaining sixteen goals. This is because gender inequality persists across multiple domains, including education, employment opportunities, access to healthcare, life expectancy, family life, and political participation, thereby limiting the capacity of societies to contribute effectively to solutions for global challenges ([Shang, Sivertsen, Cao and Zhang, 2021](#)).

SDG 4 addresses gender parity in educational achievement by examining women's access to formal education at various levels: primary, secondary, and tertiary, as well as in specific areas such as STEM disciplines (Science, Technology, Engineering, and Mathematics), where considerable distinctions have historically existed between men and women. As specified by [Psaki, McCarthy and Mensch \(2018\)](#), in the educational field, there may be disadvantages for women, given that girls, compared to boys, face more barriers to staying in school, including early marriage and pregnancy, and that girls face more significant challenges in entering the labor force. Regarding SDGs 8 and 10, attention is given to the conditions that would limit female empowerment in the labor market and female leadership in political decision-making and at the senior management level in private sector companies. These aspects reflect historical patriarchal structures that limit the leadership and empowerment of women and individuals with diverse gender identities ([Alex and Mathew, 2024](#)).

This set of aspects measured by the SDGs represents an opportunity to assess, view, and compare similarities and differences between women and men in different societies around the world. While it makes it easier for academics, the general public, and governmental and non-governmental organizations to understand the trends and form informed opinions on issues relating to gender inequality and SDG 5 ([Saini, Adebayo, Singh and Sharma, 2023](#)). Furthermore, it is essential to highlight that the promotion of gender equality could also have widespread positive or synergistic impacts on the SDG system ([Warchold, Pradhan and Kropp, 2021](#); [Anderson, Denich, Warchold, Kropp and Pradhan, 2021](#)).

The aim of the Gender SDG indicators is to reduce existing gaps between men and women, not only in the economic sphere, but also in different areas where women have traditionally not had significant participation. Recent evidence shows that while gender gaps in health and education have narrowed, inequalities in economic participation and political representation remain persistent. These disparities are driven by structural and institutional barriers that limit women's access to labor markets, resources, and decision-making roles, particularly in less developed contexts and societies with entrenched social norms. As a result, progress toward closing the overall gender gap remains uneven, with economic and political dimensions proving especially resistant to change ([Santos-Silva and Klasen, 2021](#)).

Most studies on the 2030 Agenda analyze each Sustainable Development Goal or indicator separately. However, evaluating these metrics through isolated approaches or simple indices can obscure the structural relationships between variables and ignore the regional contexts of the countries. Therefore, a research

gap exists regarding macro-structural analyses that evaluate how different gender dimensions interact simultaneously across regions. To address this limitation, this study uses a multi-way multivariate approach. Specifically, the DUAL-STATIS technique is applied to examine six selected indicators across 160 nations grouped into four major regions. This three-way methodology is chosen because it allows the simultaneous evaluation of regional covariance structures over time, capturing structural differences and cross-regional patterns without loss of variance or information.

Consequently, this study examines the current global landscape of gender indicators using data from the most current edition of the quantitative report on the progress of UN Member States towards Sustainable Development Goals (SDGs) ([Sachs, Lafortune, Fuller and Drumm, 2023](#)), from a multidimensional perspective. The intention is to answer the questions: Are there any statistically significant relationships between the various Gender SDG indicators? How can the observed associations be described in a multidimensional way? Which Gender SDG indicators display the greatest differences between the world's regions and countries? Which countries currently present the most significant development challenges and structural gaps in achieving gender equality and the empowerment of women?

The scope of this study is exploratory and correlational because the aim is not to statistically prove predefined relationships between the variables, but rather to understand the existing relationships between the gender indicators and the countries, to describe any existing differences or similarities between them, both within regions and from a comparative perspective. To this end, the DUAL-STATIS multivariate analysis technique is used, which enables performing three-way analysis of information organized in multitable data.

2. Methodology

2.1. Data in Analysis

This study presents a quantitative analysis of the six indicators that belong to the set of gender targets of the Sustainable Development Goals (SDG) that were included in the 2023 Sustainable Development Report and its associated dashboards ([Sachs et al., 2023](#)), in which most of the indicators are reported with a cutoff for the years 2020 to 2022 (see [Table 1](#)). These indicators contribute to achieving gender equality to the extent that they seek the empowerment of women in society and the improvement of their quality of life in a sustainable manner. Consequently, it must be explicitly noted that this selection analyzes a specific macro-structural dimension rather than the complete multidimensional framework of gender equality, serving as an initial proxy to evaluate cross-regional patterns.

Although other critical aspects of gender inequality -such as the wage gap, the bodily autonomy of women and people with diverse gender identities, child marriage, and gender-based physical or psychological violence- are integral to SDG 5 targets, they are not examined in this study. While international databases report information on these issues with different levels of coverage, these specific indicators were not available or complete for all countries within the 2023 Sustainable Development Report. Therefore, these metrics are excluded from [Table 1](#) because this multivariate technique requires a complete dataset without missing values for all the analyzed nations.

Table 1.

Summary of findings by category

SDG	Code	Gender Indicator	Observation
3	MaternalMort	Maternal mortality rate	Number of maternal deaths per 100,000 live births among women aged 15–49
3	AdolesFertility	Adolescent fertility rate	Number of births per 1,000 women aged 15–19
5	DemFamPIMM	Demand for family planning satisfied by modern methods (%)	Proportion of women of reproductive age whose family planning needs are met through modern contraceptive methods

Continued on the next page

SDG	Code	Gender Indicator	Observation
5	FemMaleEduc	Ratio of female-to-male mean years of education received (%)	Ratio between the average years of schooling of women aged 25 and over and that of men in the same age group
5	FemMaleLabor	Ratio of female-to-male labor force participation rate (%)	Ratio of economically active women aged 15 and over to economically active men in the same age group
5	SeatsWomParl	Seats held by women in national parliament (%)	Percentage of parliamentary seats occupied by women in national legislatures.

Note: Author's own elaboration based on [Sachs et al. \(2023\)](#).

The analysis of the behavior of the Gender SDG indicators and their existing interrelationships is based on the study of 160 countries grouped into four regions: Africa (47 countries), the Americas (29 countries), Asia and Oceania (48 countries) and Europe (36 nations). For analytical and graphical purposes, the 3-letter abbreviation of the countries' names is used according to ISO 3166 ALPHA-3 codification.

Regarding data preparation and processing, the inclusion and exclusion criteria for both countries and variables were governed strictly by data completeness to preserve the official nature of the source. Missing data treatment via statistical imputation was deliberately avoided because imputing macro-level institutional indicators can introduce significant artifactual bias into official international assessments. Consequently, the selection of the six analyzed gender indicators was justified precisely because they presented full data completeness across all observations within the 2023 Sustainable Development Report. Following this filter, countries with missing values in any of these specific metrics were excluded, establishing the final balanced panel of 160 nations.

From a theoretical standpoint, a clear conceptual distinction must be noted between sex as a biological attribute and gender as a socially constructed institutional dynamic. While current gender-responsive frameworks and intersectional perspectives emphasize the diverse spectrum of gender identities, including transgender, non-binary, and LGBTIQ+ individuals, the macro-level indicators standardized by international monitoring bodies remain predominantly limited to binary male and female categories. As demonstrated by [Heidari, Palmer-Ross and Goodman \(2021\)](#), this binary structure represents a significant methodological constraint in global cross-country analyses, since aggregate national statistics often flatten internal socio-economic disparities and fail to capture the specific vulnerabilities faced by gender-diverse populations.

Consequently, the scope of this multivariate analysis is explicitly confined to the institutionalized, binary metrics available in the Sustainable Development Report 2023. This approach is adopted not to oversimplify the complexity of gender dimensions, but to evaluate global structural covariances within the current limits of harmonized cross-country data.

Finally, it is necessary to point out that, to eliminate scaling biases and ensure that differences in measurement units did not distort the multivariate analysis, all indicators were standardized to zero mean and unit variance prior to executing the DUAL-STATIS technique.

2.2. The STATIS Analysis

STATIS (Structuration de Tableaux A Trois Indices de la Statistique) was first introduced in a study by [L'Hermier des Plantes \(1976\)](#) and was proposed as a statistical method by [Lavit \(1988\)](#). Since then, several authors have developed computerized applications, including ([Chessel, Dufour and Thioulouse, 2004](#)), ([Dray and Dufour, 2007](#)) and ([Bougeard and Dray, 2018](#)). The statistical software R includes the ade4 ([Thioulouse, Simier and Chessel, 2018](#)) and adegraphics ([Julien-Laferrière, Siberchicot and Dray, 2021](#)) packages for implementing this methodology and was used in this study to obtain the results.

This exploratory and descriptive multivariate technique facilitates the simultaneous analysis of different tables or matrices of quantitative data that represent the same observations (information in rows, or first-way) considering different variables (in columns – second way), for different conditions or occasions (third way). It also enables examining the same variables measured on separate occasions, for different individuals, in which case it is called DUAL-STATIS. This is the technique used, since this study analyses the Gender SDG indicators in different countries that belong to different regions or continents. When the same observations and the same variables are analyzed for separate occasions or conditions, the technique is called the X-STATIS method or Partial Triadic Analysis (PTA), which was first proposed by [Jaffrenou \(1978\)](#) and was later developed by [Kroonenberg \(1989\)](#) and [Abdi, Williams, Valentin and Bennani-Dosse \(2012\)](#).

The objective of DUAL-STATIS is to find a common or representative structure of all the tables (in this case, 4 continents), and to find the distances between the observations ($n=160$ countries), to examine the stability of the covariance structure between the variables ($p=6$ Gender SDG indicators) across the regions, with the specific objective of studying the relationships between the variables. In the family of STATIS methods, three stages or phases are considered, called: Interstructure, Compromise and Intrastructure, as summarized in [Figure 1](#).

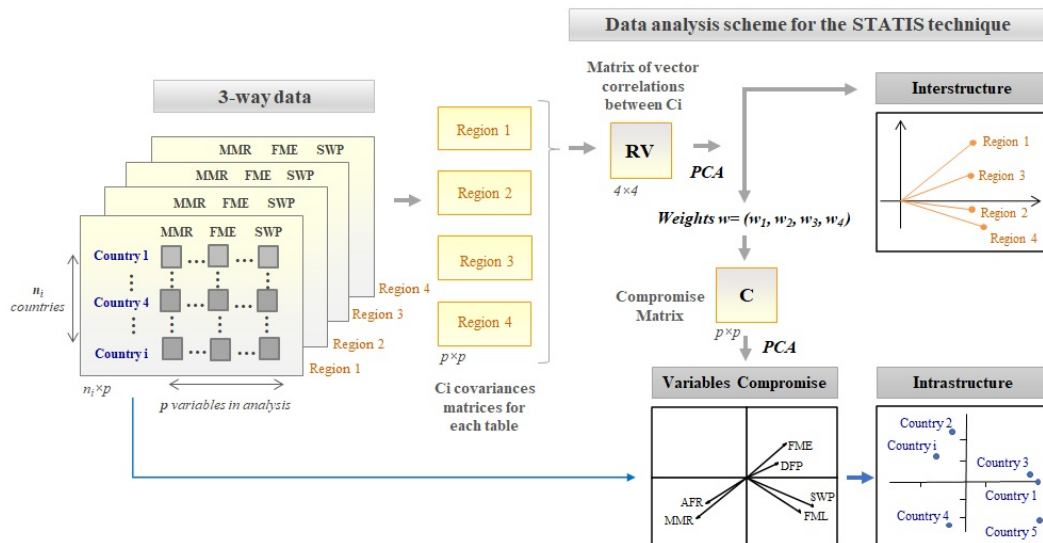


Figure 1. DUAL-STATIS Method Analysis Process.

Note: Prepared by the author based on ([Thioulouse et al., 2004](#) and [Rolland et al., 2009](#)).

The first step in DUAL-STATIS analysis is to capture the factorial structure of each data table to study its overall difference based on the variance-covariance matrix, or the matrix of correlations between the variables. Based on these statistical operators, the vector correlation matrix is calculated and analyzed through a Principal Component Analysis (PCA) ([Pearson, 1901](#) and [Hotelling 1933, 1936](#)), to obtain the Interstructure.

The Interstructure provides a graphic representation in which each matrix is represented by a vector, and whose links to the origin provide a graphic reflection of the vector correlation (RV) between pairs of matrices ([Robert and Escoufier, 1976](#)). Thus, in this first stage of the analysis the aim is to assess the overall difference between tables, which in this case means identifying the differences or similarities between the four regions.

The Interstructure analysis also provides the weighting for each table (w_1 , w_2 , w_3 , w_4), obtained from the first eigenvector to develop an average table, called the Compromise (C). The PCA of this compromise allows for displaying a graphic representation of the structure of the mean covariance between the six studied variables to summarize the information of the initial matrices in a single graph. It provides an image of the structures that are common to all tables, thereby summarizing the existing relationships between the studied Gender SDG indicators in the 160 countries and the four regions.

The last stage of the analysis consists in studying the Intrastructure, where the rows (countries) of the original tables are projected onto that compromise. It enables the examination of the trajectories of the observations of each data table through the third way of interest, and their relative position in the compromise space. This analysis allows representing the positions of the countries that comprise the various tables of the regions, and interpreting their relative positions compared to the compromise.

STATIS has been used in numerous applications in the context of biology and ecology, such as the papers by [Vivien and Sabatier, \(2004\)](#), [Feki-Sahnoun et al., \(2018\)](#) or [Prieto, Amor, Turias, Almorza and Piniella, \(2021\)](#). Applications of STATIS to social, political, or economic data remain limited. Recent examples include the studies by [Bocci, D'Urso, Vicari and Vitale, \(2021\)](#), [Gallego-Álvarez, Rodríguez-Rosa and Vicente-Galindo, \(2021\)](#) and [Rodríguez-Martínez, Cubilla-Montilla, Vicente-Galindo and Galindo-Villardón, \(2023\)](#) which indicate that this methodology can also be applied to the social sciences and population research.

Over the coordinates of the DUAL-STATIS analysis, it is possible to obtain clusters of the observations to explore the relevance of grouping them by criteria other than the one studied in the third way of the analysis. Therefore, in this study clusters are obtained through Ward's method ([Ward, 1963](#)), and the relevance of the conglomerate's formation is verified according to criteria from the R software library NbClust ([Charrad, Ghazzali, Boiteau and Niknafs, 2014](#)).

3. Results

The following are the study's results, beginning with basic descriptive results associated with the studied indicators, followed by an analysis of the Pearson bivariate correlations between pairs of indicators, and then presenting the results of the multivariate analysis in order to explain the interdependencies and covariances observed between the studied gender SDGs, and to emphasize the description of the differences and similarities found between countries.

3.1. Descriptive analysis

To begin the description of results, first the study reviews the map that summarizes the status of the countries in the SDG 5 panel at the global level ([Figure 2](#)), where blue indicates the best scores in terms of achieving gender equality, while red indicates countries with the greatest opportunities for improvement. As shown in [Figure 2](#), countries such as Belgium, Canada, Finland, Namibia, Norway, New Zealand and Sweden display the greatest commitment to the goal of promoting equality between men and women and respecting gender diversity and equal rights for all genders. On the other hand, countries facing the greatest challenges are in Western and Central Africa, Western and South Asia, and the archipelagos of Oceania.

[Figure 2](#) shows intermediate levels of SDG 5 indicators in the European Union and countries such as the Democratic Republic of Korea, Singapore, Kazakhstan, Uzbekistan, Cuba, Costa Rica, Ecuador, Mexico, Nicaragua, South Africa, Zimbabwe, among others. However, most countries around the world continue to face challenges in terms of gender equality, which remains an obstacle to achieving prosperity for all. For this reason, it is relevant to assess the indicators of the 2030 agenda that include a gender perspective, to understand where and in which aspects the most prominent inequalities exist. Overall, [Figure 2](#) demonstrates that global gender equality is highly stratified by geographic regions, indicating that progress is not uniform and that structural barriers are heavily concentrated in specific developing clusters.

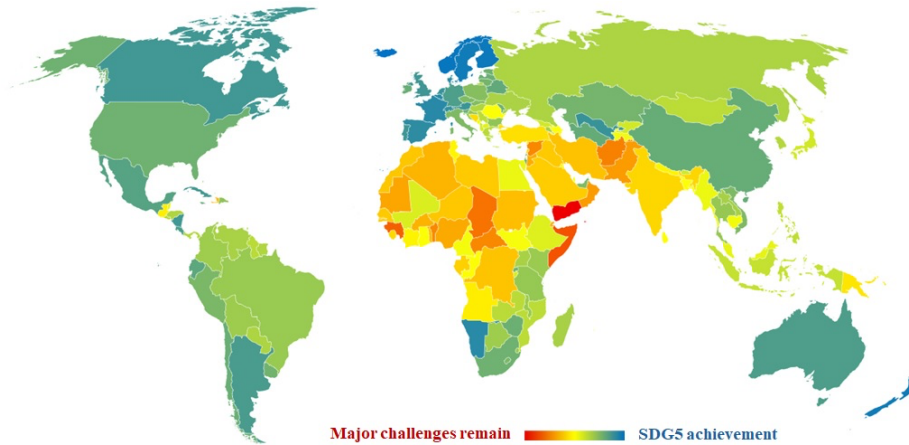


Figure 2. The current perspective on the achievement of SDG 5 in the world.

Note: Author's own elaboration based on [Sachs et al. \(2023\)](#).

[Figure 3](#) depicts descriptive graphs of the gender indicators analyzed across regions, aiming to illustrate that African countries exhibit the lowest performance and the highest standard deviations compared to other regions. In contrast, median values in Europe reflect superior performance and lower variability, suggesting greater consistency among countries in achieving the gender-related targets of the SDGs.

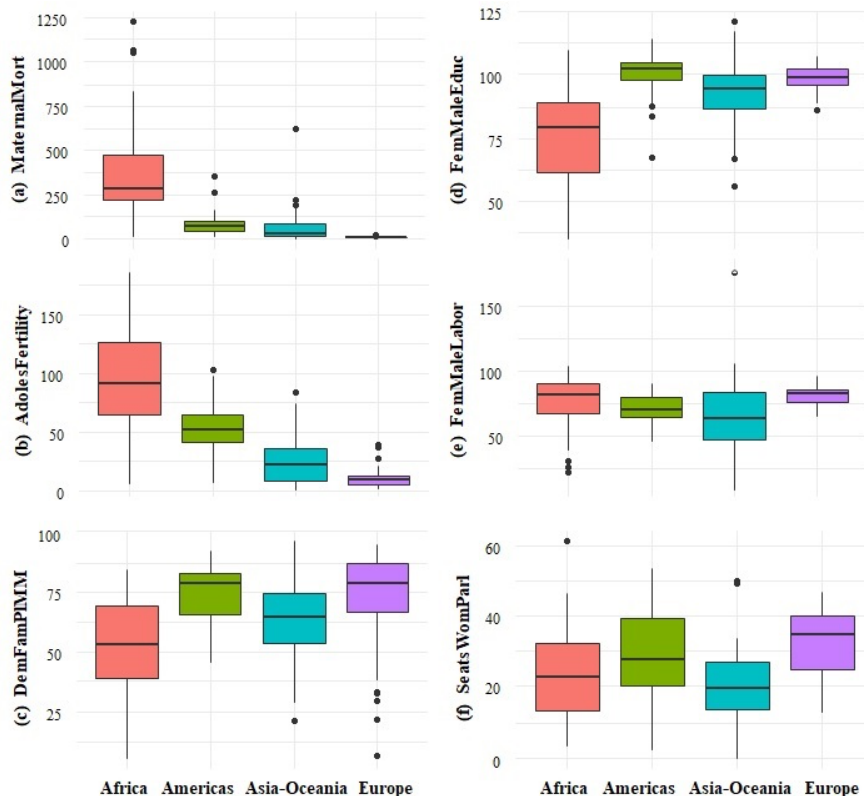


Figure 3. Boxplots of gender SDG indicators by region.

Note: Author's own elaboration using R, based on data from [Sachs et al. \(2023\)](#).

[Figure 3\(a\)](#) shows a low prevalence of maternal mortality in Europe, given that the median in the continent is five women who die due to complications associated with pregnancy for every 100,000 live births. In contrast, in Africa the same indicator is two hundred eighty-two women, and in countries such as Chad, Nigeria and South Sudan, which are seen in the graph as outliers, this number exceeds one thousand women. [Figure 3\(a\)](#) also shows that in Asia, Oceania, and the Americas, the countries with outlying values are Afghanistan, Cambodia, Haiti, and Venezuela.

[Figure 3\(b\)](#) also indicates a sharp contrast between Africa and Europe in terms of achievements toward the target of reducing adolescent fertility. While the median for African countries is ninety-one births per 1,000 females aged 15 to 19, in Europe the value is nine. Bulgaria and Romania display outlying values within the countries of the old continent, with more than thirty-six births. [Figure 3\(b\)](#) also shows that in the Americas, Asia and Oceania the countries that represent outliers are Nicaragua and Laos.

In [Figure 3\(c\)](#), it is essential to note that although the lowest median demand for modern planning methods is recorded in Africa, critical lower outliers are observed in other regions too for countries such as Albania, Armenia, Azerbaijan, Bosnia and Herzegovina, Haiti, Maldives, North Macedonia, Oman and Yemen. Regarding the indicator of women's access to formal education (FemMaleEduc), [Figure 3\(d\)](#) shows greater variability in Africa and Asia-Oceania compared to the countries of the Americas and Europe. Additionally, in these regions, the goals are reported close to 100%, implying fewer differences between the conditions of men and women with respect to access basic education (primary and secondary).

Concerning [Figure 3\(e\)](#), Algeria, Afghanistan, Jordan, Egypt, Iraq, Iran, Syrian Arab Republic and Yemen, are some of the countries in which female participation in the labor market is critical because, for every 100 men who work, there are fewer than 30 women in the labor force.

Concerning the percentages of women in parliament, the differences between continents are smaller compared to the differences in other gender SDGs. Similar variabilities are displayed between regions, with a slightly lower proportion of women in parliament in Asia and Oceania. In [Figure 3\(f\)](#) it is worth noting that in all regions the medians are nowhere near 50%, which would be equivalent to parity in the political representation of women in the parliaments of the different regions of the world. The two outlying values shown in [Figure 3\(f\)](#) are those of Rwanda, with a current proportion of 61% of women in parliament, and the United Arab Emirates, which displays parity. In Latin America, Cuba, Mexico and Nicaragua also currently report 50% of women in parliament. Synthesizing the regional behavior from [Figure 3](#), a clear structural pattern emerges: while basic institutional indicators like education tend toward global convergence, health and political representation metrics remain highly unequal, proving that formal legal access does not automatically translate into bodily autonomy or institutional power for women.

Continuing with the analysis, [Figure 4](#) displays the matrix of correlations between pairs of indicators, in which the regions and continents are color-coded. In the upper triangle of the matrix, the first value displayed is the correlation calculated for all the countries, regardless of region, and the values below are the calculated correlations between countries of the same region. [Figure 4](#) shows that the different Gender SDG indicators are correlated with each other, though it should be kept in mind that correlation does not imply causality. In assessing all the countries together, the highest positive association found is 0.737 between maternal mortality and adolescent fertility. This correlation is statistically significant with a significance level of $\alpha < 0.01$, which implies that when one of these ratios is high in a country, the other ratio is also high, and consequently both conditions represent challenges in the gender dimension of sustainable development.

In terms of negative correlations, a high inverse relationship is observed between maternal mortality and the ratio of female-to-male mean years of education received (correlation of -0.619), which is statistically significant and implies that when a country achieves greater parity between men and women in access to formal education, it has fewer maternal deaths due to complications associated with pregnancy, and also fewer adolescent pregnancies.

Among the calculated correlations, it should be noted that in the countries of Africa and the American continent, there is no significant correlation between the indicators Ratio of female-to-male mean years of education received and Ratio of female-to-male labor force participation rate. The fact that such correlation between these ratios was not found in these regions implies that greater gender equality in access to formal education does not necessarily lead to greater equality in the way men and women contribute to a country's labor force. Another correlation that was found to be small in all regions and not statistically significant at a significance level of $\alpha = 0.05$ is the indicator on women in parliament and the gender SDG that measures equal rights to education between women and men.

This bivariate landscape connects the preceding regional descriptions by confirming that reproductive health outcomes are deeply intertwined with socio-educational access, yet economic and political empowerment metrics operate through separate institutional pathways that require distinct policy interventions.

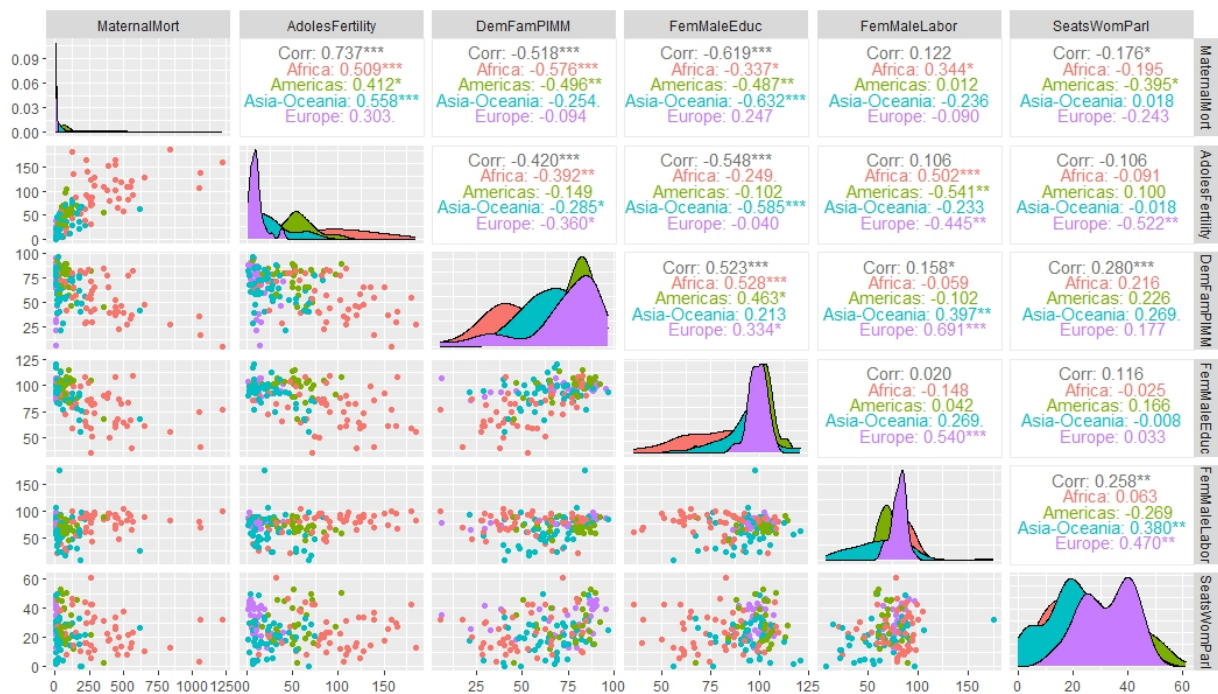


Figure 4. Bivariate correlations between Gender SDG indicators.

Note: Significance levels are denoted as $\alpha = 0.1$ (.), $\alpha = 0.05$ (*), $\alpha = 0.01$ (**), and $\alpha < 0.01$ (***).

Note: Author's own elaboration based on [Sachs et al. \(2023\)](#).

3.2. Multivariate analysis

In terms of the results of the multivariate analysis, [Figure 5](#) displays the Interstructure of the DUAL-STATIS analysis, along with the matrix of vector correlations between regions. To read these multivariate results simply, the proximity between regions on the graph shows how similar they are. When regions appear close to each other, it means that the relationship between their gender indicators follows a very similar pattern. There is a high connection between all the regions, which indicates a common covariation structure between the studied variables (indicators) studied. The regions that are most strongly associated with each other are Africa and the Americas (vector correlation of 0.828), and Africa shows the lowest vector correlation against Europe (0.671).

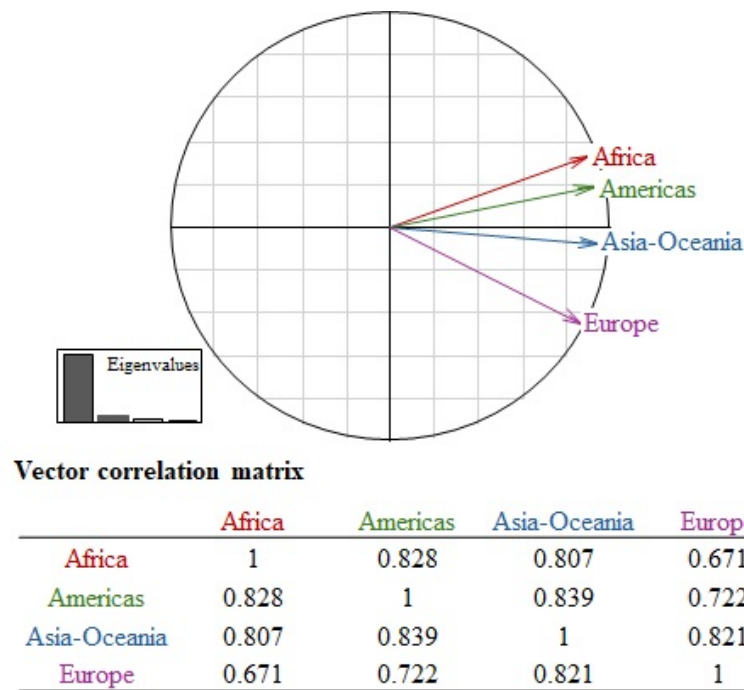


Figure 5. Interstructure plot in the STATIS DUAL results.

Note: Author's own elaboration using the R statistical software.

[Figure 6](#) displays the first plane of the PCA analysis of the Compromise table of the Gender SDG indicators (represented by vectors), along with the relative positions of the countries with respect to the compromise (Intrastructure). In the compromise plot, vector angles reflect the covariance among indicators; acute angles indicate strong positive correlations, whereas angles approaching 180° represent robust inverse relationships. Vector trajectories indicate the direction of values that are higher than the mean of that indicator, whereas values in the opposite direction from the origin indicate values below the mean. In other words, this means that if a country is plotted close to an indicator's arrow, it performs above the global average in that metric, while being on the opposite side indicates performance below the average.

The indicators are highly associated in pairs. In [Figure 6](#), it should be noted that the vectors MaternalMort and FemMaleEduc (representing maternal mortality and parity with women in access to formal education) run in opposite directions, which corroborates the inverse relationship found between these indicators in the bivariate correlations described earlier. Another notable feature in the Figure is that some of the vectors representing indicators can be observed to run in pairs: Maternal mortality and Adolescent fertility have a direct covariation and are located in the left part of axis one. In contrast, the vectors representing women's accessibility to formal education and family planning methods point in the opposite direction, indicating that they covary negatively with the first two indicators. Therefore, countries with high values for the FemMaleEdc and DemFamPMM indicators tend to have low values for AdolesFertility and MaternalMort.

In quadrant IV of the plane, with small angles between each other and characterizing the lower part of axis two, are the vectors representing women's contribution to a country's labor force and their political leadership in decision-making at the parliamentary level, which are also almost independent of the rest of the indicators (angles close to 90°). Mainly, this arrangement reveals that economic and political empowerment metrics do not automatically follow changes in health or education, representing a separate institutional dimension that requires an independent policy focus.

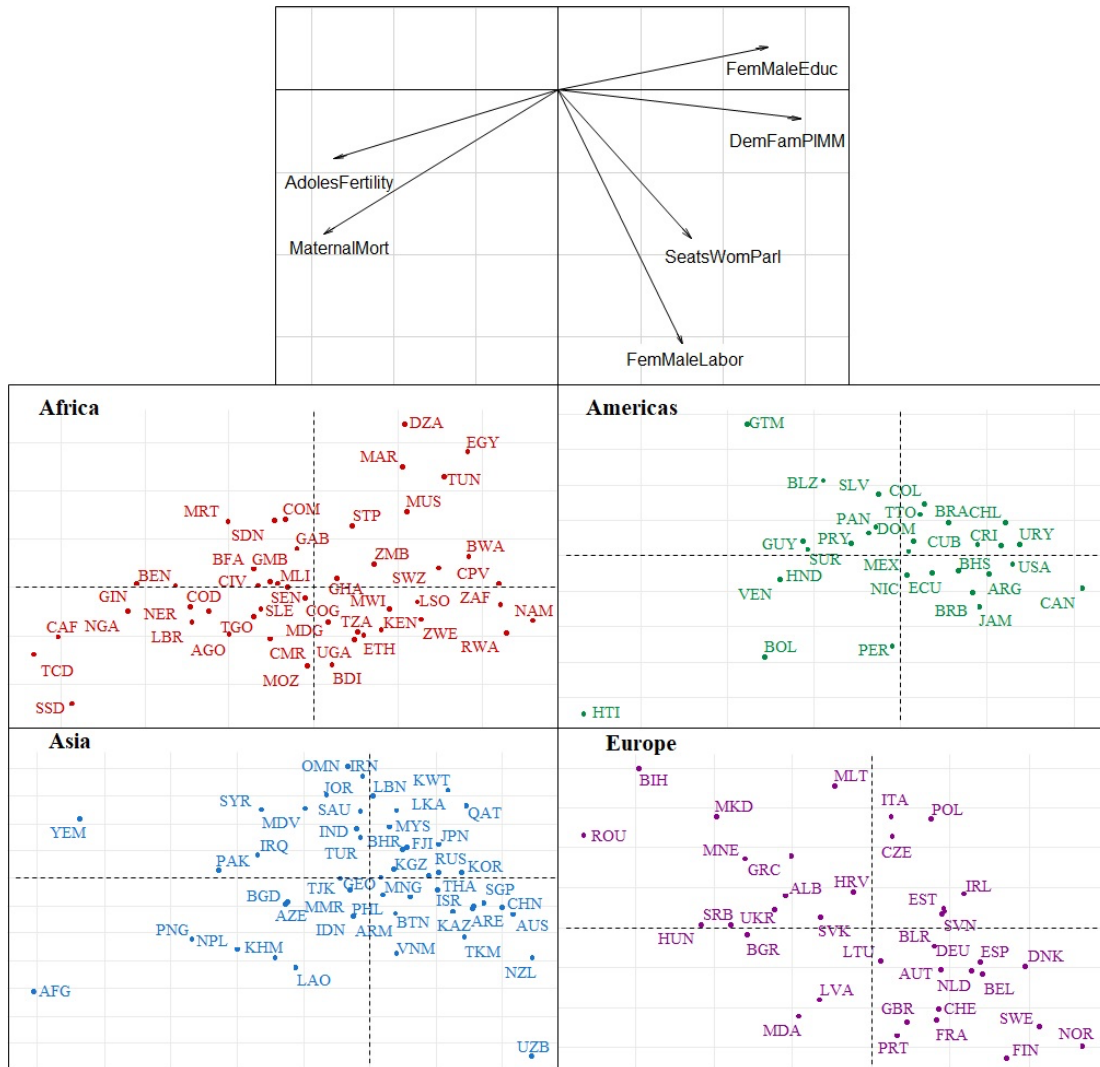


Figure 6. Compromise variables and projection of countries over the compromise.

Note: Author's own elaboration using the R statistical software.

The relative position of the countries compared to these three pairs of indicators can be interpreted based on their location on the plane, since points that are close to each other have similar scores for the studied indicators. For example, the countries that are located in quadrant IV of [Figure 6](#), in all regions, are the ones with the highest percentages of female participation in legislative government bodies, and at the same time they are countries with high percentages of women over the age of fifteen who are economically active. In these aspects, the countries that stand out are Rwanda (RWA), Namibia (NAM), South Africa (ZAF), Canada (CAN), New Zealand (NZL), Australia (AUS), China (CHN), Uzbekistan (UZB), Finland (FIN), Denmark (DNK), Norway (NOR) and Sweden (SWE).

Countries located on the right part of axis one or in quadrant I of the plane in each region exhibit significant levels of access to family planning methods for women and approach gender parity in terms of formal education. The countries that stand out in these aspects include Cabo Verde (CPV), Egypt (EGY) or Botswana (BWA) in the African continent; Cuba (CUB), Uruguay (URY), Costa Rica (CRI) and Chile (CHL) in the Americas; South Korea (KOR), Japan (JPN) and Qatar (QAT) in Asia and Oceania; and Ireland (IRL), Estonia (EST) and Slovenia (SVN) in Europe.

[Figure 6](#) also shows (on the left part of axis 1) the countries that face greater limitations in terms of the search for gender equality and its sustainability over time, especially in controlling aspects related to women's health, such as maternal mortality and adolescent fertility. The countries in the world that face the greatest challenges in this regard are Chad (TCD), Haiti (HTI), Afghanistan (AFG), Yemen, (YEM), South Sudan (SSD), Romania (ROU) and Bosnia and Herzegovina (BIH). Consequently, the position of these countries on the left side of the chart visually summarizes how critical health limitations restrict their overall progress toward gender equality.

To complement the interpretation of the intrastructure analysis, clusters were built on the coordinates of the countries projected on the compromise of the variables. It was found that it was relevant to assess three groups to explain the current global landscape of gender equality, which are represented in the plane of [Figure 7](#).

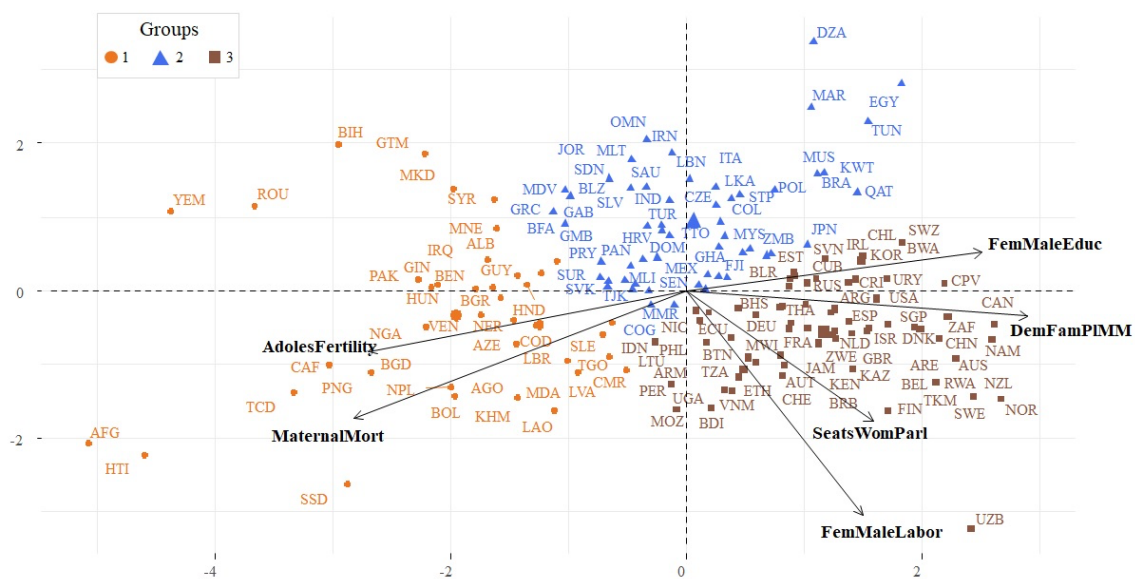


Figure 7. Clusters of countries over the compromise coordinates
Note: Author's own elaboration using the R statistical software

The first group (highlighted in orange) is composed of the 41 countries that have shown the slowest progress towards achieving the goals of the 2030 Agenda. These countries still require significant efforts to address women's sexual and reproductive health, including actions aimed at reducing maternal mortality and teenage fertility. The second group (depicted in blue on the plane) consists of the 54 countries that, despite their efforts to promote gender equality, currently exhibit limited or moderate advancements in achieving SDG 5. The third group (depicted in brown) is comprised of the 65 nations that currently show the best performance in terms of Gender SDG indicators. This cluster includes the most developed countries with the strongest economies. However, there are developing countries within this group that exhibit high indicators of women's participation in education, the labor market, or significant levels of political leadership. For instance, Rwanda currently boasts the highest percentage of female parliamentarians globally (61% of all parliamentary seats). This clustering shows that the global landscape of gender equality cannot be divided by simple regional labels, as high-performing and low-performing nations co-exist across different continents.

To conclude the presentation of the results, [Table 2](#) summarizes the basic statistical measurements of the indicators for the groups of countries. It also includes the totals of countries grouped by income levels ([World Bank, 2024](#)), which are based on gross national income per capita (in US dollars) from the previous year.

Table 2.

Basic statistics of the clusters of countries

Variable	Detail	Cluster1 Significant Challenges	Cluster2 Challenges Remain	Cluster3 Progressive Achievements
Number of countries		41	54	65
Countries in the cluster	Africa	13	18	16
	Americas	6	10	13
	Asia-Oceania	11	19	18
	Europe	11	7	18
World Bank countries classification by income	Low	12	5	7
	Lower middle	15	19	13
	Upper middle	11	15	16
	High	3	15	29
MaternalMort	Mean	280.2	104.5	93.2
	SD	321.6	129.9	139.9
AdolesFertility	Mean	72.6	43.1	37.1
	SD	47.3	38.6	40.7
DemFamPIMM	Mean	46.8	61.0	78.1
	SD	19.9	16.0	11.9
FemMaleEduc	Mean	79.0	93.1	96.1
	SD	18.5	14.4	11.6
FemMaleLabor	Median	70.6	60.6	85.0
	SD	22.9	18.3	14.7
SeatsWomParl	Mean	22.4	18.7	33.1
	SD	11.4	9.9	11.3

Note: SD means standard deviation

[Table 2](#) shows that all groups encompass countries from each region or continent and across all socioeconomic levels. Therefore, in every region, there are nations with specific opportunities that must continue to be addressed in the pursuit of gender equality as a matter of human rights. Moreover, based on the mean values of the gender indicators of the SDGs included in [Table 2](#), it is observable that in Group 2 (with intermediate progress towards achieving SDG 5 goals), despite women having nearly equal access to formal education as men, and showing an average very similar to that of Group 3 (nations with greater progress), the need to promote women's empowerment in the labor market and their participation or leadership in government decision-making bodies becomes apparent. This is evident as group 2 displays the lowest average values in the FemMaleLabor and SeatsWomParl indicators. Conclusively, this contrast reveals an institutional disconnection, demonstrating that achieving gender parity in educational access does not automatically guarantee women's economic integration or political leadership, as these dimensions face independent structural barriers.

4. Discussion

The discussion of the results in this study focuses on the practical implications regarding public policy actions with a gender perspective, with the aim of answering the proposed research questions. Therefore, the analysis starts by reviewing the covariances observed between the Gender SDG indicators and examining the differences found between the regions and countries.

4.1. *Interlinkages of Reproductive Health and Socio-Educational Metrics*

In this study it was found that the different Gender SDG indicators covary with each other, which reflects associations that may favor gender equality in the world or represent limitations to attaining it. This is consistent with the findings of [Song and Jang \(2023\)](#), [Dawes \(2022\)](#), [Ament, Freeman, Carbone, Vassall and Watts \(2020\)](#), [Pradhan, Costa, Rybski, Lucht and Kropp \(2017\)](#), and [Loring, Hinzman and Neufeld \(2017\)](#), who assessed the interlinkages between the different objectives and targets of the 2030 Agenda. For example, the high correlation found between maternal mortality and adolescent fertility can be interpreted as a conditioning aspect for sustainable development. This occurs in developing or low-income countries, which still exhibit a high prevalence of adolescent pregnancies (many of them unwanted). This statistical alignment suggests that reproductive health limitations may constitute an important structural barrier that constrains progress in other dimensions of sustainable development.

As suggested by the current cluster results, current patterns of gender development are closely linked to countries' income levels and stages of economic development. Low-income countries continue to face major challenges related to maternal mortality, adolescent pregnancy, and access to family planning, while middle-income countries have made notable progress in education and contraception but still lag in women's labor market participation and political empowerment.

Furthermore, this socio-economic stratification indicates that the prospects for achieving the SDGs by 2030 have now become significantly more difficult since the COVID-19 pandemic spread across the globe ([Eden and Wagstaff, 2021](#)). Several authors have highlighted the effects of the pandemic on the economies and societies of the various regions (e.g., [Ekwebelem et al., 2021](#); [González-Sánchez et al., 2021](#); [Pradhan et al., 2021](#); [Shulla et al., 2021](#); [Yuan et al., 2023](#)) and its impact on delaying fulfillment of the SDGs, emphasizing that COVID-19 aggravated inequalities between population groups, with women being one of the most affected groups, which may accentuate the already known gender gap.

4.2. *The Paradox of Educational Parity and Institutional Empowerment*

In contrast, the high correlation found between medium and high-income countries in terms of indicators that measure women's access to formal education and satisfied demand for family planning methods, suggests that the world is gradually advancing in the recognition that conditions of gender equality contribute to the development of nations and promote sustainable economies. However, public policy actions are still needed to facilitate the incorporation of women in the work force and their leadership in political representation positions. In these two aspects, the results of this study confirm that progress has been made, but that this progress is concentrated in developed countries. Therefore, as argued by [Yin, Zhao, Fu, Meadows and Pereira \(2023\)](#), the variations of the SDGs need to be analyzed with spatio-temporal patterns, in relation to economic status and educational levels.

[Kabeer \(2021\)](#) indicated that gender inequalities in society are perpetuated and reinforced by market forces in ways that block women's capacity to contribute to more inclusive forms of economic progress. Despite an increasing number of women starting and completing university and postgraduate-level studies, gender gaps in the labor market remain large. Substantial challenges persist regarding the political empowerment and representation of women and diverse gender identities, as even high-income developed countries remain far from achieving institutional parity.

This gap is empirically verified by the descriptive results of this study, which show that women hold, on average, only 26% of parliamentary seats across the countries analyzed. Among the countries analyzed, only 10 have more than parliamentary seats occupied by women, Bolivia, Cuba, Finland, Mexico, New Zealand, Nicaragua, Rwanda, South Africa, Sweden, and the United Arab Emirates. This finding is consistent with Kabeer's perspective by illustrating that educational access does not automatically translate into political or economic power, reinforcing the argument that separate institutional mechanisms restrict female leadership and that progress toward global targets remains limited ([Fellegi et al., 2023](#)).

4.3. *Regional Stratification and Heterogeneity in Gender Policies*

At the aggregate level, African countries exhibit lower average SDG 5 scores and greater variability than other regions, highlighting the coexistence of substantial challenges and remarkable differences in gender-related outcomes across the continent. In this context, persistent gender inequalities continue to constrain progress not only on SDG 5 but also on other Sustainable Development Goals, as disparities in education, economic participation, and decision-making undermine efforts toward poverty reduction, inclusive growth, and institutional development ([Chirawu, 2022](#); [Vyas-Doorgapersad, 2023](#)).

Nevertheless, in the African region there are also nations that have successfully implemented gender policies to favor the empowerment and leadership of women, as is the case of Rwanda, which is recognized for being the first country in the world to achieve the target of 50 percent of parliamentarians being women ([Abbott and Malunda, 2016](#)). For this reason, in this analysis, this country was classified along with nations such as Sweden, New Zealand, Finland, Norway, or Canada, characterized by having favorable conditions for women's empowerment in terms of political representation and access to the labor market. This cross-regional overlapping highlights the value of the DUAL-STATIS framework over simple indices, as it isolates exceptional institutional behaviors from their broader geographic limitations.

On the other hand, the best results in the SDG gender dimension were found in the European continent, mainly because of the high purchasing power of its countries and their higher level of development, in terms of gender and human development. Leading the world towards the Sustainable Development Goals (SDGs) is an ambition of the European Union (EU) and an important objective of the European Commission's proposal for Horizon Europe: the EU framework program for Research and Innovation (RandI) 2021–2027 ([Kastrinos and Weber, 2020](#)). Less progress was observed in the countries of the Americas, Asia and Oceania compared to Europe, and specifically major challenges in fulfilling the 2030 Agenda remain for the countries of Latin America and the Caribbean and southern Asia.

In general, based on the findings of this study, it can be said that the countries facing the most significant challenges in achieving progress on the gender dimension of the SDGs are low-income or developing countries, which still need to improve their performance on indicators related to women's sexual and reproductive health. Among these nations, it is worth mentioning Chad, Guinea, Haiti, Afghanistan, Yemen, Bosnia and Herzegovina, and Romania.

Contrastingly, the countries with the highest scores for the indicators of women's access to formal education, the labor market, and political representation were the countries that, based on the clustering results, were classified in the third group. This includes among others: Botswana, Cabo Verde, Namibia, Rwanda and South Africa in the African continent; Costa Rica, Chile, Canada, Uruguay and the United States in the Americas; Australia, China, New Zealand, Singapore and Uzbekistan in Asia and Oceania; and Belgium, Denmark, Finland, Norway, Spain and Sweden in Europe.

A structural limitation of these global assessments is that this report does not include indicators on violence against women and the non-availability of indicators related to the rights of people with diverse gender identities. Even though both aspects are within the scope of the SDGs, due to limitations in the consolidation of information at the world level they tend to be relegated to survey-based studies that do not always enable cross-national or global comparisons. However, it is necessary to acknowledge the importance of reducing violence and related deaths among women, girls, and LGBTQI+ people, covering deaths caused by domestic violence, which are rampant in many developing countries. These are human rights violations necessitating criminal accountability ([Lubaale and Budoo-Scholtz, 2022](#)).

In light of the relationship between the findings of this study and global progress toward the SDGs, it should be noted that the differences found between countries should be viewed as an opportunity to establish public policy actions that promote equality, despite the structural differences that exist between the world's

various economies. This paper assessed the gender indicators as a specific subset of SDGs, intending to illustrate the need to continue designing governance strategies that promote gender equality and that women's empowerment should be understood as a necessary condition for sustainable development.

4.4. Methodological Relevance of Multi-Way Multivariate Approaches

Lastly, from a methodological perspective, multi-way multivariate techniques prove highly useful for analyzing gender indicators. These methods facilitate the interpretation of complex, simultaneous associations between variables and country characteristics, moving beyond restrictive univariate approaches. By examining joint structures of variance and covariance, such techniques go beyond analyses limited to one or two variables or purely univariate approaches. Accordingly, multivariate methods have proven particularly suitable for gender research and broader sustainability studies, as they allow the simultaneous analysis of complex, interrelated social, economic, and environmental dimensions across countries and policy domains ([Leal-Filho et al., 2023](#)).

Additionally, this study analyzed data organized as three-way matrices to quantify the vector correlations among continents or regions. This approach was motivated by the recognition, following [Scholte \(1996\)](#), that countries are embedded within regional contexts characterized by shared historical, social, and institutional features. In this regard, the DUAL-STATIS framework preserves the three-way structure of the data and facilitates the examination of regional similarities and differences that may be partially obscured when using conventional dimensional reduction approaches based on pooled observations. Consequently, the cluster analysis revealed that, despite differences in socioeconomic development among continents, each region includes countries exhibiting incipient, moderate, and substantial progress toward SDG 5 targets.

6. Conclusions

In conclusion, this study shows that progress toward gender equality is an interdependent and uneven process across regions, meaning that global patterns cannot be fully evaluated through isolated metrics or solely through univariate descriptive analyses. The application of the DUAL-STATIS technique shows that while countries approach parity in terms of access to formal education, significant gaps remain in variables related to reproductive health and labor force participation. These differences exist even when controlling for countries' income levels or geographic locations. Furthermore, the results indicate that even within high-income clusters, persistent gaps in political representation remain visible, demonstrating that economic development does not automatically resolve disparities in institutional power.

From a methodological perspective, the results confirm that analyzing data through three-way matrices prevents the loss of information regarding regional and continental contexts. Unlike traditional dimensional reduction techniques that omit or obscure these variations by ignoring the specific continental frameworks where nations are embedded, this multivariate approach enables the identification of distinct performances and specific regional heterogeneities within the international system. This structure confirms that despite shared development categories, countries within the same region coexist with different stages of progress toward the 2030 Agenda.

From a practical standpoint, these findings indicate that governance strategies and public policy design should move from aggregate global targets to regionalized and integrated frameworks. This transition is particularly necessary given that external global shocks, such as the pandemic, have delayed progress toward the Sustainable Development Goals and intensified existing inequalities, with women being disproportionately affected. To be effective, public gender policies should address reproductive health limitations and barriers to female political leadership and institutional representation simultaneously, recognizing that advancements in one dimension do not automatically lead to progress in other areas of women's empowerment.

About the authors

Edith Johana Medina-Hernández

Assistant Professor at the Universidad del Tolima, Ibagué, Colombia. Ph.D. in Applied Multivariate Statistics from the Universidad de Salamanca, España.

ejmedinah@ut.edu.co <https://orcid.org/0000-0003-4207-0333>

Data Availability

The author declares that the article contains all the data necessary to understand and verify the findings reported in this study.

Disclosure statement

The author declares that there are no conflicts of interest related to this article.

Disclaimer

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