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Abstract

The transition to a green economy offers significant opportunities for sustainable development and economic resilience. However, the benefits of this shift are unevenly distributed, especially in the Middle East and North Africa (MENA), where deep-seated gender inequalities may hinder women's participation in emerging green sectors. This paper analyzes employment trends that women workers face in six Arab countries: Egypt, Jordan, Lebanon, Sudan, Tunisia, and the United Arab Emirates. Using national Labor Force Survey (LFS) data, the study highlights the persistent discrepancy between women's educational attainment in general and their limited access to high-skill, high-wage jobs in the green economy given their concentration in low skilled jobs. Addressing these disparities is essential for achieving economic growth, social equity, innovation, and environmental resilience in the region.

Keywords: Green economy; gender inequality; women's employment; inclusive growth; Arab countries; sustainability; occupational segregation; informal employment; wage gaps

JEL Classifications: Q5, O3, J1

ملخص

يُتيح التحوّل إلى الاقتصاد الأخضر فرصًا هائلة للتنمية المستدامة وتعزيز المرونة الاقتصادية. إلا أن فوائد هذا التحوّل لا تتوزع بالتساوي، لا سيما في منطقة الشرق الأوسط وشمال أفريقيا، حيث قد تُعيق أوجه عدم المساواة بين الجنسين المتجذّرة مشاركة المرأة في القطاعات الخضراء الناشئة. تُحلّل هذه الورقة البحثية اتجاهات التوظيف التي تواجهها العاملات في ست دول عربية: مصر، والأردن، ولبنان، والسودان، وتونس، والإمارات العربية المتحدة. وباستخدام بيانات المسح الوطني للقوى العاملة، تُسلّط الدراسة الضوء على التفاوت المستمر بين التحصيل العلمي للمرأة عمومًا ومحدودية فرصها في الحصول على وظائف ذات مهارات عالية وأجور مجزية في الاقتصاد الأخضر، نظرًا لتركزها في وظائف ذات مهارات منخفضة. ويُعدّ معالجة هذه الفوارق أمرًا بالغ الأهمية لتحقيق النمو الاقتصادي، والعدالة الاجتماعية، والابتكار، والمرونة البيئية في المنطقة.

1. Introduction

The global transition toward a green economy signifies a pivotal shift intended to harmonize economic development with environmental sustainability. The International Labour Organization (ILO) defines a green economy as one committed to three principles: resource efficiency, low-carbon emissions, and social inclusivity. This strategic approach aims to mitigate environmental degradation while fostering long-term economic resilience (ILO, 2016; 2023). This transformation encompasses more than producing environmentally friendly products; it incorporates significant advancements in sustainable processes, such as improved agricultural methods, effective recycling systems, and reduced water consumption (ILO, 2018). Despite its transformative potential, the distribution of benefits from this transition is inequitable, particularly in regions such as the Middle East and North Africa (MENA), where entrenched gender inequalities hinder women's participation in emerging green sectors (Beides and Maier, 2022; Deininger and Gren, 2022).

In the Arab world, the transition toward a green economy is of heightened urgency due to pronounced environmental vulnerabilities, including climate change, water scarcity, and land degradation. These stressors threaten critical economic sectors such as agriculture, energy, and construction, which provide significant employment opportunities and drive economic growth (OECD, 2011; UNDP, 2022). Women comprise a significant segment of the agricultural workforce in this region but encounter systemic barriers that limit their access to essential resources, including land, technology, and finance. Environmental challenges further compound these barriers, exacerbating food insecurity and deepening economic marginalization, particularly in rural areas (UN Women, 2021; Assaad et al., 2020). Despite the notable progress in women's educational attainment in MENA countries, there has been little improvement in women's labor market participation, especially in high-value sectors pivotal to the green economy transition. This phenomenon, termed the "MENA paradox", highlights the discrepancy between women's educational attainment and their limited access to substantial economic opportunities (Bulut and Carlson, 2020). This phenomenon is made worse by structural impediments, including the declining availability of public-sector employment. Public-sector employment has always been a significant source of employment for educated women. There is also the persistent underrepresentation of women in formal private-sector positions. Consequently, a significant proportion of working women in the region are unemployed, underemployed, or confined to informal and precarious employment (Assaad et al., 2020; UN Women, 2023).

The economic consequences of excluding women from the green economy are significant. According to the International Monetary Fund (IMF), eliminating gender disparities in labor market participation could substantially increase regional GDP by over 20% (World Economic Forum, 2024). Beyond economic benefits, actively involving women in green sectors strategically fosters innovation, inclusive economic growth, and climate resilience. Empirical evidence demonstrates that diverse, gender-balanced workforces substantially impact innovation capacity, leading to superior environmental and economic outcomes (World Bank, 2012; Deininger and Gren, 2022). On a global scale, the green transition could generate significant employment opportunities. The ILO projects that the adoption of sustainable economic practices could generate approximately 24 million new jobs by 2030, primarily

in sectors such as sustainable construction, water management, and waste management (ILO, 2018). However, the absence of deliberate, gender-sensitive interventions in the green transition could exacerbate existing gender disparities. The ongoing phenomenon of occupational segregation, compounded by limited access to educational opportunities, vocational training, and leadership roles, continues to impede women's ability to attain well-paid, highly skilled employment. In the MENA region, for example, women currently represent less than 15% of the renewable energy workforce, reflecting systemic barriers that limit their participation in influential positions critical to driving economic transformation (Maier et al., 2022; Islam et al., 2023).

As the existing literature indicates, including women in the green economy is essential to achieving sustainable development and inclusive growth (World Bank, 2012; ILO, 2022). However, the employment dynamics of women in green sectors, particularly in the MENA region, remain understudied. As UN Women (2023) has emphasized, fostering meaningful female participation in emerging green industries requires addressing systemic barriers such as educational disparities, skill mismatches, and exclusion from leadership roles. This study looks at job trends and gender issues in the green economy of six Arab countries: Egypt, Jordan, Lebanon, Sudan, Tunisia, and the United Arab Emirates (UAE). These countries were chosen based on their different levels of economic development, environmental problems, and institutions' ability to promote gender equality. The study uses data from the aggregated National LFS to examine key green sectors with significant employment growth potential. These sectors include agriculture, water management, and waste management (UNDP, 2022; ILO, 2023). The analysis reveals critical barriers, including educational disparities, occupational segregation, and institutional limitations, that collectively impede women's active participation and career advancement in these fields. The analysis provides empirical insights and actionable policy recommendations for regional stakeholders and policymakers.

The remainder of the paper is structured as follows: Section 2 provides a thorough review of existing literature on the subject. Section 3 presents the methodology employed, explicitly delineating the data sources and analytical approaches used. Section 4 outlines the principal findings. Section 5 discusses these findings within broader systemic contexts that shape women's participation. Section 6 sets forth the conclusions drawn, the policy implications deduced, and the strategies posited to foster gender-inclusive green growth in the MENA region.

2. Literature review

A growing body of literature underscores the critical importance of transitioning to a green economy as a global strategy to address climate change and promote sustainable development. In the Arab region, this transition is of particular importance due to pronounced environmental vulnerabilities, such as climate change, water scarcity, and land degradation. Additionally, the region's heavy reliance on natural resources necessitates economic diversification (OECD, 2011; UNDP, 2022, Kubursi and Abou-Ali, 2024). Key sectors identified as pivotal to this transition, including renewable

energy, sustainable agriculture, water management, waste management, and energy efficiency, offer significant potential for job creation, innovation, and enhanced environmental resilience (Maier et al., 2022). Furthermore, these sectors have the potential to challenge traditional gender roles by providing pathways for women to participate in historically male-dominated industries. This could lead to broader social transformations (Ahmad et al., 2019; Onyeaka and Akinsemolu, 2024).

Another strand of literature highlights the structural inequalities and deeply rooted sociocultural norms that significantly hinder women's full participation in the economy throughout the MENA region. As such, ongoing gender disparities in educational opportunities, employment, and access to critical resources impact women's participation in emerging green sectors. This undermines the objectives of inclusive and sustainable growth (Peng et al., 2024; Stöcker and Zintl, 2024). Agriculture is one of the sectors with high potential for greening, and women constitute a significant segment of the agricultural workforce but encounter systemic barriers that limit their access to critical resources, such as land, technology, and finance, disproportionately. Environmental stressors further exacerbate their economic marginalization, particularly in rural regions (Assaad et al., 2020; UN Women, 2021). These constraints are reinforced by patriarchal norms prevalent throughout the region, limiting women's autonomy and access to resources, especially in economically vulnerable contexts such as Sudan (Yassine-Hamdan and Strate, 2020). Addressing these systemic and normative barriers through targeted interventions is crucial to realizing the transformative potential of the green economy (Blaydes et al., 2021; Al-Qahtani et al., 2022).

Additionally, a substantial body of literature emphasizes the importance of education and skill development, especially STEM (science, technology, engineering, and mathematics) education, for women's successful integration into green economy sectors. Robust educational systems that prioritize gender inclusivity have been shown to increase innovation capacity, reduce labor shortages, and improve the cost-effectiveness of climate policies (Fabrizio et al., 2024). However, Arab countries face significant challenges in leveraging women's educational achievements and skill sets in green sectors. Despite considerable educational progress, women have not realized proportional labor market gains, especially in high-value technical sectors integral to the green economy transition. This phenomenon is known as the "MENA paradox" (Assaad et al., 2020; Bulut and Carlson, 2020; UN Women, 2023). For example, in Lebanon, women are primarily assigned administrative roles in the energy sector, reflecting systemic biases against their participation in technical positions (Ahmad et al., 2019). Addressing these discrepancies requires implementing targeted initiatives, such as mentorship programs and customized vocational training. Promising examples of such initiatives include the RENEW program, which promotes the professional development of women in renewable energy and sustainable construction (Maier et al., 2022; Kubursi and Abou-Ali, 2024; Peng et al., 2024; Pan et al., 2024).

Another strand of literature explores opportunities to advance gender inclusion in specific sectors, particularly green industries, through targeted interventions. Agriculture employs a significant proportion of women, especially in rural areas, and is highly vulnerable to climate impacts that disproportionately affect female agricultural workers. Therefore, it is imperative that agricultural

policies be designed with a gender-responsive, climate-smart approach to empower women as active agents of resilience and adaptation. This would require ensuring equitable access to training, technology, and financing (Altaeb, 2023; Baruah and Najjar, 2023). A similar argument can be made for the role of water management in advancing women's roles. This argument is based on the idea that women have traditionally been seen as the main caretakers of water resources. However, this assertion hinges on providing them with adequate support and leadership opportunities (Onyeaka and Akinsemolu, 2024). Furthermore, the formalization and technological advancement of the historically informal waste management sector create new opportunities for women to fill higher-paying technical and managerial roles (Ottmann, 2024).

Finally, the literature emphasizes digital technology and financial inclusion as critical factors that enable greater female participation and empowerment in the green economy. Digital platforms have been shown to create entrepreneurial opportunities for women. For example, Saudi women entrepreneurs have leveraged e-entrepreneurship to overcome traditional barriers. Nevertheless, challenges persist due to limited financial access, inadequate digital literacy, and structural inequalities. This underscores the need for tailored financial products, mentorship programs, and supportive governmental policies to foster inclusion, innovation, and growth (Saviano et al., 2017; Abdelwahed et al., 2022; Alzamel, 2024).

3. Data and methodology

This study's methodological approach is based on an analysis of the gender dynamics of the employment in green sectors of female workers in six Arab countries. These countries are Egypt, Jordan, Lebanon, Sudan[1], Tunisia, and the United Arab Emirates. Using a multidimensional framework, the analysis examines gendered employment trends and dynamics in green economy sectors within these countries.

3.1. Data sources and scope

The study uses aggregated National LFS data from each of the six countries. These datasets provide in-depth insights into employment characteristics, such as gender, educational attainment, skill level, employment status (wage employment versus self-employment), employment formality, establishment size, and economic sector. The analysis period extends from 2009 to 2023 (please note that the availability of data is not the same for the same years for countries), enabling the examination of long-term trends and the identification of the impact of significant socioeconomic changes, including the COVID 19 pandemic.

[1] Given the outbreak of the war in Sudan in April, 2023, the data and dynamics presented represent past trends rather than current trends.

The six countries were selected based on the availability of comprehensive labor force data, diverse socioeconomic contexts, and varying stages of green economy development. This regional scope enables meaningful cross-country comparisons while highlighting country-specific dynamics. Focusing on aggregated LFS data allows the analysis to capture macro-level patterns with large sample sizes, reducing potential biases associated with small-scale surveys and ensuring robust representation of national labor market conditions (Bryman, 2016). However, it is important to note that using aggregated data prevents the examination of micro-level factors, such as individual career trajectories or firm-specific practices.

3.2. Definition of green economy sectors

The green economy is defined as a set of economic activities that prioritize mitigating environmental risks and ecological scarcities while promoting sustainable development. It emphasizes environmental protection and economic growth, creating employment opportunities that promote ecological balance, as defined by the International Labour Organization (ILO, 2022; 2023). This study uses the International Standard Industrial Classification of All Economic Activities (ISIC) in its fourth revision at the two-digit level to identify and analyze green economy sectors. The ISIC classification is a standard tool for cross-country comparisons and ensures consistency with labor market data from national labor force surveys (LFS).

The examined sectors encompass activities offering direct, quantifiable environmental benefits, aligning with the green economy's core principles. Specifically, the analysis of this paper includes crop and animal production (ISIC Rev. 4 code A01), forestry and logging (A02), fishing and aquaculture (A03), water collection, treatment, and supply (E36), sewerage (E37), waste collection, treatment, and disposal (E38), and remediation and other waste management services (E39). These sectors are pivotal in that sustainability practices and innovations are intrinsic to economic activity, providing a robust foundation for analyzing green employment patterns.

A significant challenge in green economy research is classifying sectors such as energy and construction, which include both green and non-green activities. For example, renewable energy production and sustainable construction align with the goals of a green economy. However, at the 2-digit level, ISIC Rev.4 aggregates these with conventional fossil fuel energy generation and traditional construction activities. This lack of granularity makes it impossible to differentiate between green and non-green sub-sectors within those categories using the available data. To maintain the validity of the analysis, broader energy and construction categories are excluded because it is not possible to reliably separate their green components. By focusing on activities where the environmental contribution is clearly defined and unambiguous, the study ensures methodological precision and avoids conflating green employment trends with unrelated data. The retained sectors encompass most green economy employment in the selected countries, offering valuable insights into gendered employment dynamics in regions undergoing the green transition.

3.3. Analytical framework

The analytical framework captures the multidimensional nature of gendered employment dynamics in the green economy. Table 1 summarizes the key variables and indicators used to examine inequalities and opportunities.

Table 1. Key variables and indicators for analyzing gender dynamics in the green economy

Variable	Description	Indicators and definitions
Trends in gender representation	Employment share of women and men in green economy sectors compared to those in the total economy.	The share of female and male workers employed in each green economy sector compared to their overall share of the total workforce.
Educational level	Distribution of occupational skill levels (low, medium, or high) by gender within green economy sectors, compared to the total economy.	The distribution of female and male workers across four education levels (less than basic, basic (primary or lower secondary education), intermediate (upper secondary or post-secondary non-tertiary education), and advanced) in green sectors, compared to the distribution in the total economy.
Skill level differences	Distribution of occupational skill levels (low, medium, or high) among men and women employed in green economy sectors and the overall economy.	The share of female and male workers classified by skill level[2]. Low-skilled occupations typically require minimal formal education and involve routine manual tasks and limited training (e.g., elementary occupations). Medium-skilled occupations require secondary education, vocational training, or equivalent practical experience (e.g., technicians, clerical workers, and craft workers). High-skilled occupations require advanced educational qualifications, specialized training, significant professional expertise, or managerial responsibilities (e.g., engineers, scientists, and senior professionals).
Establishment size	Distribution of employed women and men in establishments by size category.	The share of female and male workers employed in green sectors within micro (1–4 employees), small (5–49 employees), medium (50–249 employees), and large (250+ employees) enterprises.
Employment status dynamics	Differences in wage employment and self-employment patterns for women and men.	The share of female and male workers whose main status in employment is wage employment (employees receiving a wage or salary, irrespective of formality) compared to those whose main status is self-employment (own-account workers and employers) in green sectors, relative to the same distribution in the total economy.
Gender wage gap analysis	Wage differentials between women and men in green economy sectors.	A comparison of the average monthly earnings of female and male workers in green economy sectors compared to earnings differences in the broader economy.
Formality vs. informality	Prevalence of formal and informal employment among women and men in green economy and total economy sectors.	The share of informal employment (jobs not covered by formal contracts or social protection) among female and male workers in green economy sectors, compared to the overall rate of informality in the total economy.

3.4. Methods of analysis

The study primarily uses descriptive, comparative, and trend analyses. Descriptive analysis provides an overview of employment patterns and highlights key indicators, such as gender representation, skill levels, educational attainment, wage differentials, and job formality (Bryman, 2016; Creswell and Creswell, 2017). Comparative analysis examines cross-country differences in gendered employment

[2] The low, medium and high skill categories used in the paper are constructed from ISCO-08 occupational groups and follow the ILO skill level concept. The definitions in Table 1 are the authors' summary of the ISCO-08 skill level criteria rather than a verbatim quotation.

patterns, drawing on established comparative social research methodologies (Collier, 1993; Hantrais, 1995; Ragin, 2014). Trend analysis examines temporal shifts in women's employment within green economy sectors, including changes in representation, formal employment status, and wage equality (Beech, 1962). These methodologies are integrated to provide a comprehensive picture of the evolution of women's employment in green sectors and the disparities between men and across national contexts. Triangulating these approaches enables the analysis to more reliably identify persistent gaps and emerging trends while accounting for country-specific factors.

4. Findings

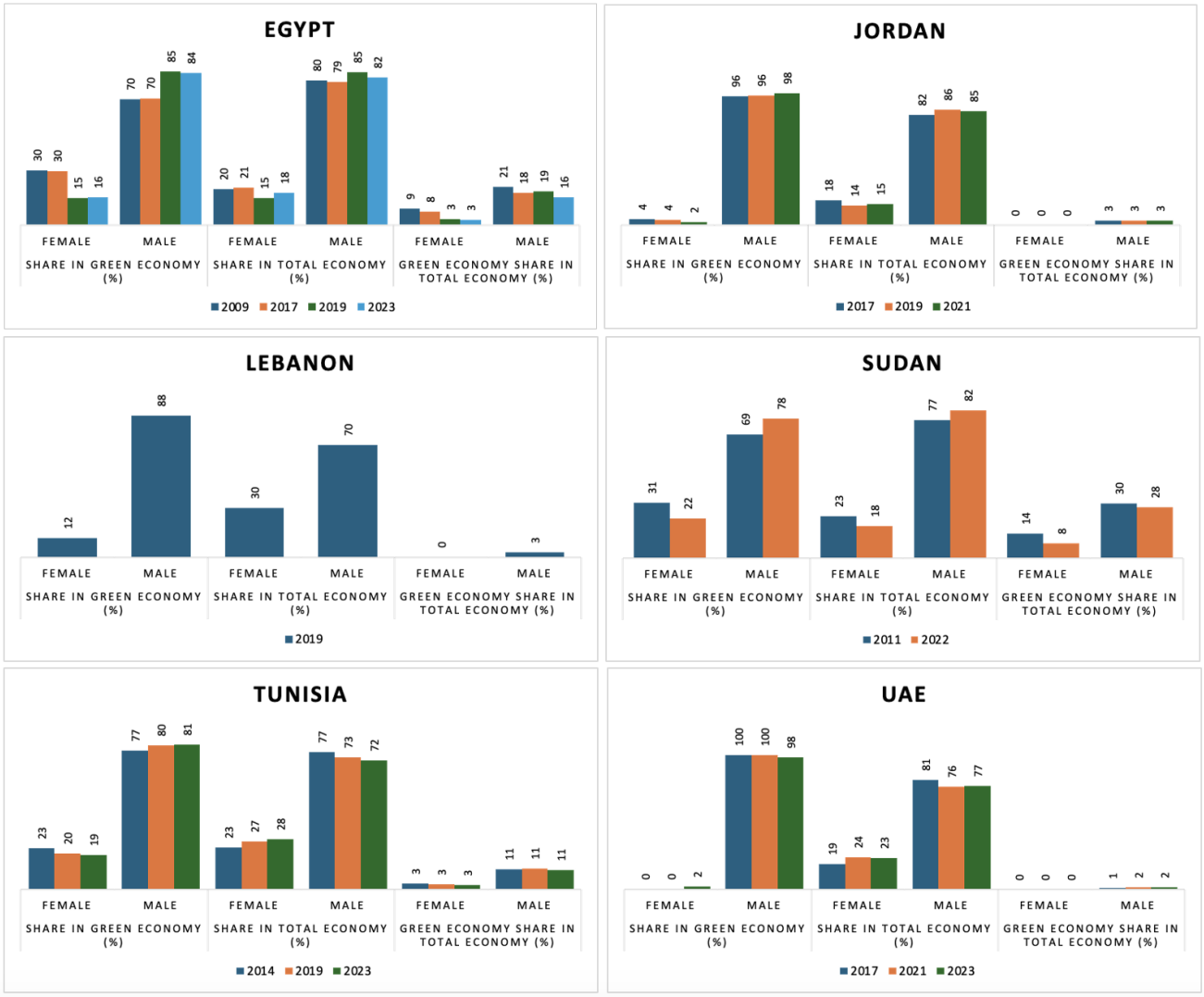
4.1. Persistent gender gaps in green economy participation

A comparative analysis of gender representation across Egypt, Jordan, Lebanon, Sudan, Tunisia, and the UAE reveals significant and persistent gender disparities in green economy employment, as illustrated in Figure 1.. Despite global and regional advocacy for inclusive green growth, structural barriers and exclusionary dynamics continue to limit women's participation. Egypt and Jordan, for instance, exhibit particularly pronounced gender inequalities in their green sectors, with women experiencing declining employment shares over the observed period. In Egypt, the female share of green economy employment declined sharply, from around 30% in 2009 to approximately 15% in 2023. Concurrently, the male share exhibited an opposite trend, rising from around 70% to 85%. Similarly, Jordan is a salient example of gender disparity. The employment share of women in green employment decreased from around 4% in 2017 to just 2% in 2021. By 2021, men constituted nearly 98% of the green workforce.

In contrast, the gender representation gap in green economy sectors in Lebanon is less pronounced than in other countries, though it remains substantial. In 2019, women accounted for 12% of green jobs, compared to 88.% for men. This statistic contrasts with the relatively higher representation of women in the broader economy, where they accounted for 30.5% of total employment. That same year, the green sector accounted for only 0.5% of women's total employment, compared to 3.5% for men. Although women make up a higher percentage of the total labor force in Lebanon, they have limited opportunities in green economy sectors.

It is noteworthy that Sudan and Tunisia, despite having relatively higher shares of women in green economy employment compared to Egypt, Jordan, and the UAE, still face significant gender disparities and show declining or stagnant female participation trends over time. In Sudan, the proportion of women in parliament reached its zenith at 31.01% in 2011, subsequently declining to 22.23% in 2022. Notwithstanding this decline, women in Sudan maintain a stronger presence in green sectors relative to the overall economy. In 2022, women constituted 8.12% of total employment in the green economy, in comparison to 28.40% for men. The observed downward trend indicates mounting obstacles confronting women in maintaining their involvement, particularly in the context of economic and institutional constraints. In Tunisia, the female population's share decreased from 22.77% in 2014 to 19.32% in 2023, while the male population's share increased to 80.68% over the same period. In 2023, women represented a mere 2.62% of total employment in green sectors, a figure that stands in stark contrast to the 10.92% of

Figure 1. Gender representation in the green economy compared to the total economy



Source: Authors' calculations based on national LFS.

men in the same category. This phenomenon is particularly salient in light of the increasing trend of women's representation in the Tunisian workforce, which reached 28.10% in 2023. The persistent gap indicates that the growth in women's overall employment has not translated into improved access to opportunities in the green sector.

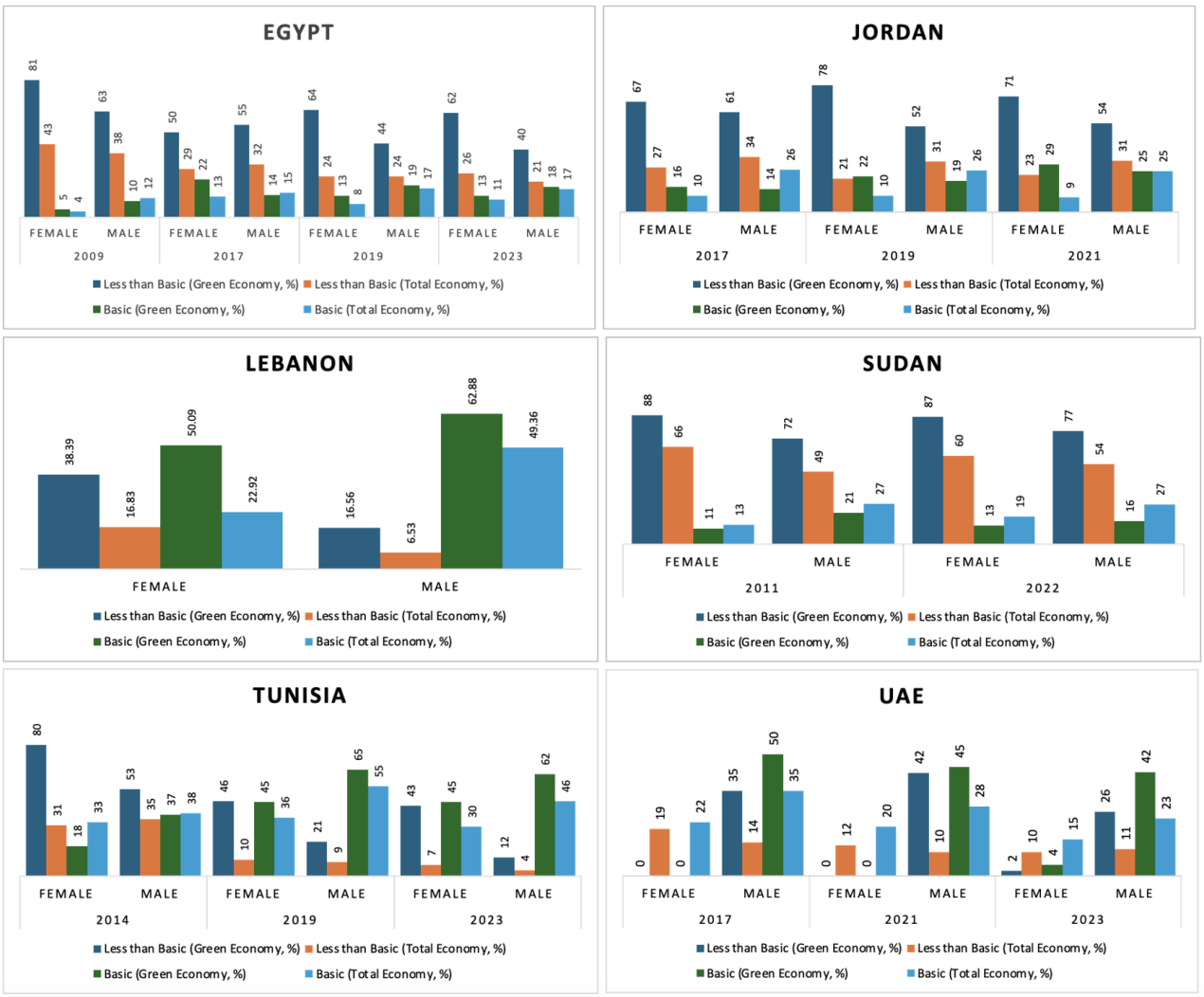
Among the countries that were studied, the UAE exhibited a distinctive paradox. In 2017, women constituted a mere 0.47% of employment in the green economy, a figure that increased only marginally to 1.84% by 2023. Conversely, males have exhibited a consistent domination of these sectors, maintaining a share of over 98% throughout the observed period. In 2023, women's employment in the green economy accounted for an almost negligible 0.034% of their total employment, compared to 1.82% for men.

Across all countries, the analysis reveals a consistent trend of male dominance in green economy sectors, with women's participation significantly lower than in the broader economy. Notably, Egypt, Jordan, and the UAE exhibit pronounced disparities, with a decline in women's participation over time or persistently low rates. Lebanon and Sudan have relatively higher levels of female participation, but these remain insufficient to challenge the prevailing disparity. Tunisia has shown modest progress in this area, yet significant gender disparities persist. A comparison of the proportion of women employed in green economy sectors to the total economy highlights the exclusionary nature of these industries, which, despite their growing importance in national labor markets, fail to provide equitable opportunities for women.

4.2. Educational barriers to women's access to green economy sectors

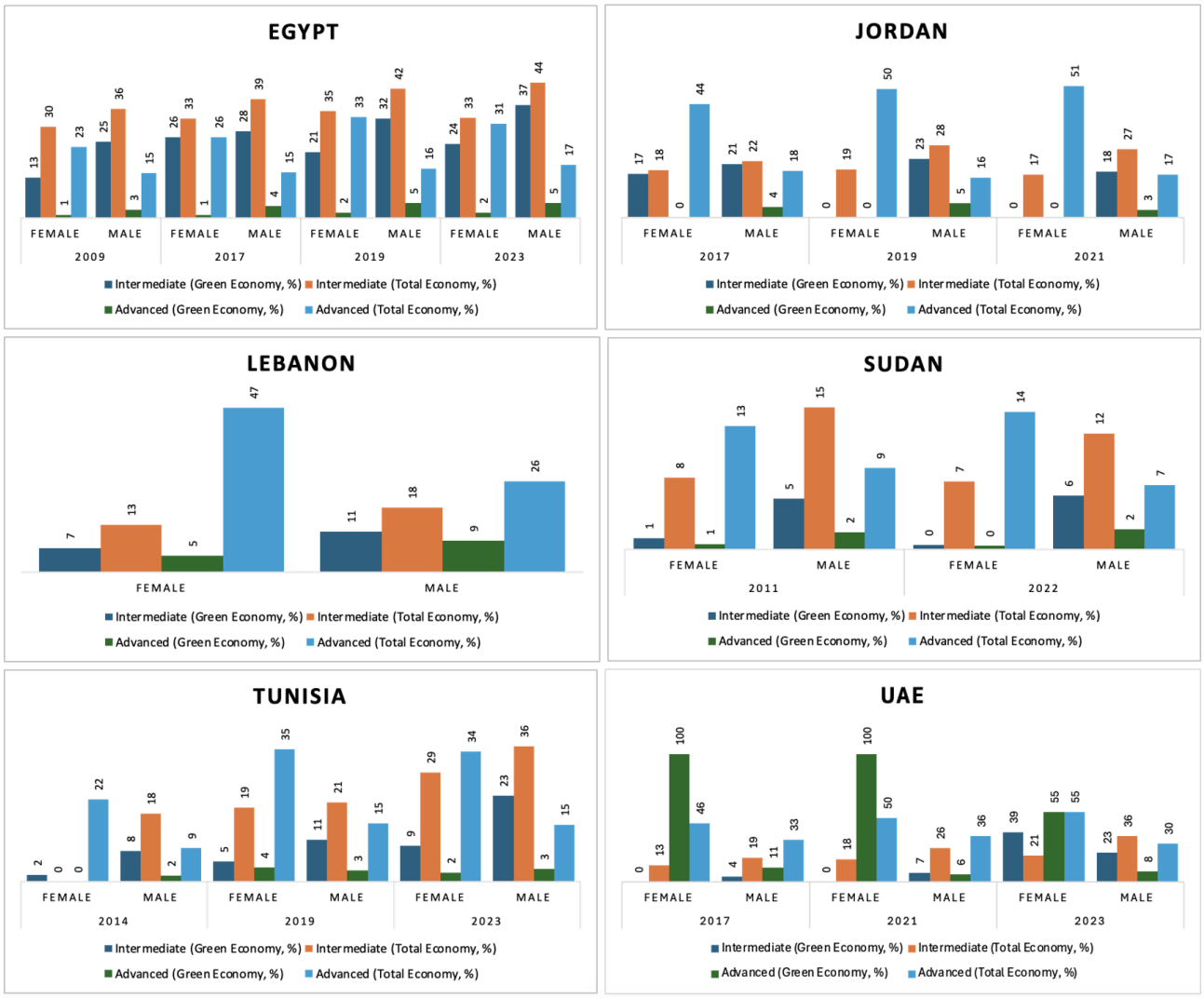
An analysis of educational attainment among workers in green economy sectors reveals persistent gender disparities that restrict women's access to advanced roles. Across Egypt, Jordan, Lebanon, Sudan, and Tunisia, women in green jobs are often characterized by a lower level of educational qualification in comparison to their male counterparts and to women employed in the broader economy, as illustrated in Figure 2. In Egypt, despite a gradual improvement, a substantial proportion of female green-sector employees (approximately 62% in 2023, down from 81% in 2009) still possess less than basic educational qualifications (see Figure 2). This figure stands in stark contrast to the broader labor market, where women tend to have more substantial educational attainment. In contrast, men in Egypt demonstrate a substantially more balanced educational profile within green sectors,. Jordan faces analogous challenges, with women's employment in the green economy being predominantly characterized by those with the least substantial educational qualifications (approximately 71% in 2021). It is noteworthy that, despite the significant presence of women in higher education—who account for over half of advanced degrees in the overall economy—their representation in high-level green-sector positions remains virtually non-existent.

Figure 2A. Employment distribution by gender, education level and economic activity: Green Economy vs. Total Economy



Source: Authors' calculations based on national LFS.

Figure 2B. Employment distribution by gender, education level and economic activity: Green Economy vs. Total Economy



Source: Authors' calculations based on national LFS.

Lebanon and Tunisia present somewhat contrasting cases, each exhibiting unique dynamics that nevertheless underscore persistent educational mismatches and structural barriers. In Lebanon, the educational distribution of women in green sectors appears to be more balanced in comparison to Egypt and Jordan; however, substantial gaps persist. It is noteworthy that women with advanced qualifications constitute less than 5% of the green economy workforce, despite representing approximately 47% of individuals with advanced education in the broader economy. In contrast, Tunisia has shown a significant decrease in the employment of women in the least educated categories within green sectors—from approximately 80% in 2014 to approximately 43% by 2023.. However, Tunisian women with advanced education are underrepresented in the green sector, comprising approximately 2.4% of the workforce, despite their substantial presence (approximately 34%) in the broader economy.

In Sudan, the educational divide within the green economy remains pronounced, and there has been minimal improvement over time. The data indicates that women continue to be predominantly represented in the least prestigious educational categories, with over 86% of the female workers falling into these categories in 2022. Conversely, individuals in possession of advanced qualifications exhibit a conspicuous absence from employment opportunities within the green sector. The preeminence of agriculture in Sudan, frequently characterized by informality and a reliance on unskilled labor, exerts an additional constraint on women's prospects for educational advancement and upward mobility within the green economy.

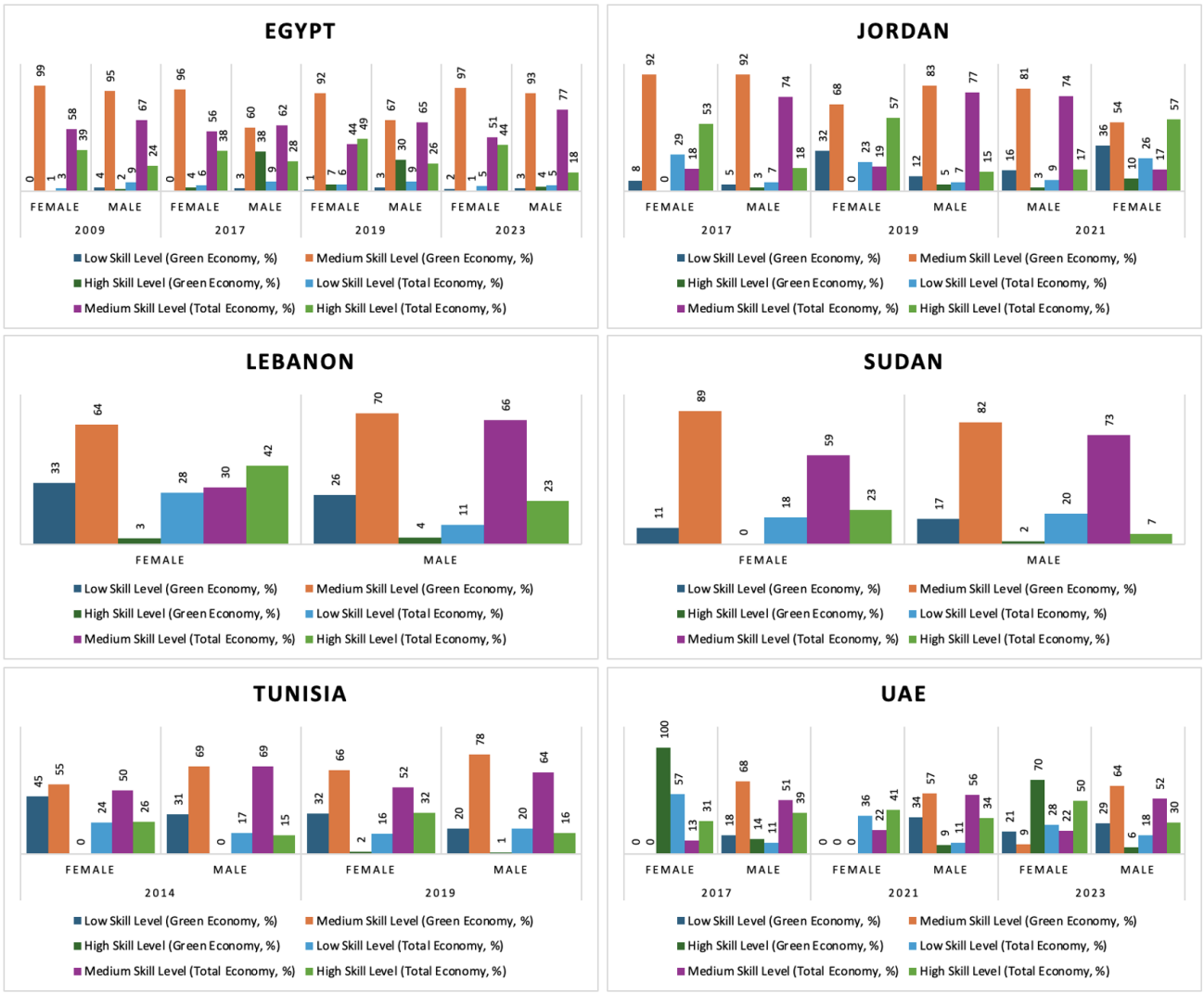
While noting the overall low presence of women in the green sector, the UAE presents a distinctive case compared to other Arab countries, characterized by an initially high representation of women with advanced education in green sectors. The female green workforce was composed of women who had obtained advanced education in 2017. However, by 2023, this proportion underwent a substantial decline, reaching approximately 55%, which point to a diversification of the female green workforce toward intermediate and basic education categories. Conversely, men continue to predominate in lower education levels within the green economy.

Across the six countries, the data reveals a common dynamic that disproportionately affects women. In Egypt, Jordan, Sudan, and Tunisia, the preponderance of women in the "less than basic" education category underscores systemic barriers that impede access to employment opportunities that demand higher levels of skill and expertise. Lebanon and the UAE have demonstrated comparatively superior educational distribution for women. While men tend to possess more balanced profiles, they also encounter constrained opportunities to apply advanced educational competencies in green sectors.

4.3. Gendered skill gaps in green economy employment

The distribution of skill levels within green economy sectors reveals significant gender disparities, with women concentrated in medium- and low-skilled roles and largely excluded from high-skilled positions. The findings indicate the presence of systemic challenges in all countries, albeit with nuanced differences, as illustrated in Figure 3.

Figure 3. Employment distribution by gender, skill level and economic activity: Green Economy vs. Total Economy



Source: Authors' calculations based on national LFS.

In Egypt, medium-skilled employment is predominant in the green sector for women. As demonstrated in Figure 3, the proportion of medium-skill roles occupied by women increased from 92.11% in 2019 to 97.00% in 2023. However, the representation of women in high-skill roles remains disproportionately low, with a mere 0.92% of women occupying such positions in 2023. This figure stands in stark contrast to their 43.80% share in the broader economy, underscoring a significant disparity. In contrast, the male demographic exhibits a marginally superior distribution, with 4.23% of males occupying high-skill roles in 2023. Notwithstanding this marginal discrepancy, green economy sectors persist in their heavy reliance on middle-skill labor for both genders, resulting in the underutilization of high-skill positions.

In Jordan, the proportion of women employed in medium-skill roles is increasing, while the proportion in low-skill positions is also rising. In 2021, medium-skill roles constituted 53.97% of female employment

in the green sector, while low-skill employment increased to 36.05%, up from 31.60% in 2019. It is evident that high-skill roles continue to be predominantly unattainable for women, as they constitute a mere 9.98% of their overall employment. This figure stands in stark contrast to their representation in high-skill roles within the broader economy, which stands at 56.67%. The male demographic exhibits a parallel imbalance, with a mere 2.93% of their employment in the green economy being classified as high-skilled, thereby accentuating the inherent structural limitations of the sector.

In Lebanon, medium-skill positions are predominant in employment across both male and female workers in green economy sectors. In 2019, women constituted 63.92% of medium-skill positions, in comparison to 30.47% in the broader economy. Conversely, low-skill employment constituted 32.86% of women's roles in the green sector, while high-skill positions remained marginal at 3.22%. A similar concentration is exhibited by men, with 70.00% in medium-skill roles and only 3.58% in high-skill positions. This pattern suggests that while Lebanon offers relatively more balanced employment opportunities, women still face significant barriers to upward mobility in the green sectors.

In Sudan, medium-skill roles predominate in female employment, reflecting broader trends in the green economy. As demonstrated in Figure 3, in 2022, 89.05% of women employed in green sectors occupied medium-skill roles, while high-skill positions were virtually non-existent. Within the broader economic landscape, women occupy a mere 22.72% of high-skill positions, underscoring a pronounced disparity between educational attainment and employment outcomes. A similar pattern is observed among men, with only 1.74% of their employment in the green sector classified as high-skilled. This dearth of skill diversity underscores Sudan's heavy reliance on low-value, labor-intensive work in the green sector.

In Tunisia, the prevalence of medium-skill roles for women in the green economy is accompanied by a significant proportion of low-skill employment. In 2019, 32.06% of women employed in green sectors were in low-skill roles, which is double the percentage of women in the broader economy in the same category. A substantial proportion of women's employment roles were in medium-skill positions, constituting 65.98% of the total. In contrast, high-skill positions represented a relatively modest share of 1.96%. A similar trend is observed in male participants, with 78.38% of them occupying middle-skill positions and only 1.34% being classified as high-skill. This overreliance on labor with fewer marketable skills underscores the systemic impediments to cultivating a workforce equipped to facilitate the shift towards high-value green economic activities.

The UAE offers a compelling example of this phenomenon, as evidenced by the substantial increase in the participation of women in high-skill positions. Figure 3 demonstrates that the proportion of high-skill roles occupied by women in the green sector increased to 69.6% in 2023, signifying a substantial shift from their complete absence in 2017. However, this growth is accompanied by a decline in middle-skill positions, which decreased to 8.9% in 2023. Conversely, the male demographic predominantly occupies roles that require low to medium-level skills, with a mere 6.5% of males

falling into the high-skill category in 2023. Notwithstanding this progress for women, the data signals a persistent gender imbalance, particularly as men remain underrepresented in high-skill positions.

The distribution of skill levels in green economy sectors reflects a common reliance on medium- and low-skilled labor across countries, with women bearing the brunt of limited access to high-skill opportunities. The UAE is an exception to this trend, demonstrating substantial progress in enhancing women's access to high-skilled employment opportunities. However, challenges persist for men in this regard. On the other hand, the most pronounced exclusion of women from high-skill roles is evident in Egypt, Jordan, and Sudan, while Lebanon and Tunisia demonstrate a somewhat more balanced participation, albeit with an ongoing skewed representation.

4.4. Gendered employment patterns by establishment size

An examination of employment distribution according to the size of the employing entity reveals a predominant reliance on small enterprises within the green economy sectors, particularly among female workers, as illustrated in Figure 4. A comparative analysis of employment patterns across small (1-4 employees), medium (5-49 employees), and large (50+ employees) enterprises reveals substantial gender disparities in the countries under study, as compared to the broader economic landscape.

Egypt and Jordan serve as prime examples of these trends, exhibiting a pronounced concentration of women's employment in small enterprises within their respective green economy sectors. In Egypt, the vast majority (nearly 87%) of women in green economy employment are found in establishments with fewer than five employees, a figure that is significantly higher than the approximately 56% observed in the broader economy. There is an underrepresentation of women in medium-sized (8%) and large establishments (5%) in Egypt's green sectors. A similar phenomenon is observed in Jordan, where the employment distribution exhibits a pronounced bias toward small enterprises, with nearly 74% of female green economy workers being employed in micro establishments. While women's employment in medium-sized establishments (approximately 17%) is marginally higher than in Egypt, their access to large enterprises remains significantly constrained (approximately 9%).

Lebanon exhibits certain parallels with Egypt with respect to this matter. In Lebanon, small establishments predominate in women's employment within the green economy to an even greater extent. As demonstrated in Figure 1, in 2019, 83.48% of women were employed in small establishments, which is nearly double the 43.17% observed in the total economy. Medium-sized establishments absorbed the remaining 16.52%, while large establishments exhibited an absence of female representation in the green sector. For men, employment patterns exhibited a comparable trend, with 83.62% working in small enterprises, 13.45% in medium enterprises, and only 2.93% in large enterprises. These figures underscore Lebanon's substantial reliance on small enterprises for employment opportunities in the green sector, a phenomenon that effectively excludes women and men from larger organizational structures. In Sudan, women's employment in the green sector is predominantly concentrated in small enterprises. As illustrated in Figure 4, in 2022, 86.68% of women were employed in establishments

Figure 4. Employment distribution by gender, establishment size and economic activity: Green Economy vs. Total Economy

Source: Authors' calculations based on national LFS.

with fewer than five employees, in contrast to 72.26% within the broader total economy. Medium-sized establishments provided employment for 13.32% of women, while large establishments were completely absent for female workers in the green sector. The male workforce was predominantly concentrated in small establishments, with 89.81% of male employment occurring in establishments with fewer than five employees and only 0.59% in large establishments. This extreme reliance on small enterprises is indicative of the structural constraints of Sudan's green economy.

Tunisia, on the other hand, exhibits a more diversified employment distribution pattern compared to other countries. In 2019, approximately 50.23% of women in the green sector were employed in small enterprises, while medium enterprises accounted for a significant 44.34%. Conversely, large enterprises exhibited a notably lower percentage of female employees, with a mere 5.42% of the workforce comprising women. The distribution exhibited a notable predominance in small enterprises,

with 67.50% of the male population employed in establishments with fewer than five employees, 27.51% in medium-sized enterprises, and 4.98% in large enterprises. Tunisia's relatively balanced distribution of female and male entrepreneurs suggests greater opportunities in medium-sized enterprises than in other countries. However, it also highlights their persistent underrepresentation in large enterprises.

A review of employment trends across various countries reveals a predominance of small establishments in terms of employment opportunities within the green economy, a phenomenon that is particularly evident in the context of women's employment. A notable finding is the high proportion of women and men employed in establishments with fewer than five employees in Egypt, Lebanon, Sudan, and Jordan. This suggests a structural reliance on small enterprises for labor absorption in green sectors. In contrast, Tunisia exhibits a more diversified distribution of employment, with medium-sized enterprises playing a substantial role in women's employment. The underrepresentation of women and men in major enterprises across most countries is indicative of systemic barriers that impede their access to formal, higher-paying opportunities within the green economy. While there is a slight improvement in the representation of men in medium-sized enterprises, there is also a limitation in their access to employment opportunities in large enterprises. This suggests a more extensive structural problem in the labor market dynamics of green sectors.

4.5. Contrasting employment status of women and men in green sectors

An analysis of employment status within the green economy reveals various gender differences across the countries studied, with different patterns of wageemployment and self-employment. The outcomes of this phenomenon are significantly influenced by structural factors, labor market characteristics, and socio-economic conditions.

In Egypt, Figure 5 demonstrates a high degree of concentration of women's employment in the green economy within the category of self-employment. In 2023, 83.2% of women in the green sectors were self-employed, a figure that significantly exceeds the 43.7% observed for men. This substantial gender disparity stands in contrast to the overall employment landscape, where the rate of women's self-employment (27.4%) remains marginally lower than that of men (26.3%).. Conversely, men exhibit a higher propensity to engage with wage employment channels, suggesting their more pronounced integration into structured labor markets.

The case of Jordan provides a counterpoint, with employment status showing a higher level of gender balance. As demonstrated in Figure 5, in 2021, 88.9% of women in Jordan's were employed in the green economy, in contrast to the 83.1% of men who were in the same category. This level of wage employment is consistent with broader trends in Jordan's overall economy, where wageemployment is dominant for both genders. The higher proportion of women in wage employment in green sectors in Jordan compared to other countries is indicative of the country's emphasis on regulated labor markets.

Figure 5. Employment distribution by gender, employment status and economic activity: Green Economy vs. Total Economy

Source: Authors' calculations based on national LFS.

In Lebanon, women exhibit a pronounced tendency to rely on self-employment within the green economy. In 2019, 73.8% of women in the green sector were self-employed, a rate that exceeds the 66.10% observed for men in the same year. This phenomenon stands in stark contrast to the broader economic landscape, where wage employment is predominant for both genders.

Sudan exhibits an even greater reliance on self-employment, particularly among female population. As demonstrated in Figure 5, the data indicates that 85.2% of women in Sudan's green economy were self-employed in 2022, compared with 68.5% of men. While self-employment is also prevalent in Sudan's total economy, with 56.6% of women and 43.9% of men being self-employed, the gender gap in the green sectors is pronounced.

In Tunisia, the employment status within the green economy reveals a unique balance. As demonstrated in Figure 5, the employment of women in the green sector in 2019 exhibited a nearly equal distribution, with 51 % of the workforce categorized as employees and 49% designated as self-employed. Conversely, a higher percentage of men were self-employed, with 60.3% of the male population falling into this category. This distribution deviates from the Tunisian economy as a whole, where wage employment is predominant, with 84% of women and 70.6% of men employed in formal roles.

In the UAE, employment status within the green economy is characterized by a e structure that depends distinctively on wage employment, with 100% of women occupying wage employment positions during the period between 2017 and 2023. Furthermore, a significant proportion of the male population is wage employed, with 96.2% of males holding formal positions in 2023. These trends stand in stark contrast to those observed in other countries in the region, reflecting the UAE's highly regulated labor market, in which wage employment structures predominate.

A comparison of employment status across countries reveals contrasting trends in wage and self-employment. In countries such as Egypt, Sudan, and Lebanon, women are largely limited in wage employment opportunities. This has resulted in a significant reliance on self-employment as a means of survival. In Jordan and the UAE, wage employment channels are more accessible to women, likely reflecting more regulated labor markets. Tunisia presents a hybrid model, offering a combination of wage employment and self employment for women in green sectors. These various patterns underscore the gendered dimensions of employment structures in the green economy, which are shaped by broader labor market dynamics and institutional frameworks in each country.

4.6. Systemic gender wage gaps in green economy sectors

The gender wage gap in green economy sectors reveals significant disparities that reflect systemic inequalities in earnings across the countries studied. Despite variations in size and evolution, women consistently receive lower wages compared to men, highlighting the persistent challenges in achieving gender wage equality.

In Egypt, the wage gap remains substantial. As demonstrated in Figure 6, the mean monthly earnings of women in green sectors amounted to $193.7 in 2023, which is considerably lower than the mean monthly earnings of men, which were $241. While this disparity is significant, it is less pronounced in the broader economic context, where women's earnings stand at $110.5 compared to $129.8 for their male counterparts. A notable trend suggests that green economy sectors may offer relatively superior pay parity, though this is insufficient to fully address the existing disparity. The persistent gap between the sexes in this area is likely attributable to structural challenges, including the concentration of women in low-paying, informal roles.

Figure 6.Comparison of average monthly earnings by gender and economic activity: Green Economy vs. Total Economy

Source: Authors' calculations based on national LFS.

Jordan exhibits a distinctive pattern of wage dynamics, characterized by intermittent reversals in the gender wage gap. In 2016, the median earnings of women in the green economy surpassed those of men, reaching $852.1 compared to $849.3. However, this trend undergoes a precipitous reversal by 2022, with women's average monthly earnings declining to $260.2, significantly below men's earnings of $854.7. This precipitous decline is indicative of the volatility inherent in earnings in Jordan's green sectors. Potential factors contributing to this volatility may include economic restructuring or the precarious nature of women's employment in these industries. The variability in the gap suggests the presence of systemic vulnerabilities that disproportionately impact women during periods of economic turbulence.

In Lebanon, the gender wage gap is pronounced in green economy sectors and remains among the highest in the region. In 2019, the mean monthly earnings for male individuals were $1,022, which is almost double the mean monthly earnings for female individuals, which were $570.5. This discrepancy

stands in contrast to the broader economic landscape, where the earnings gap is comparatively narrower, with women earning $806.0 compared to men's $769.6.

Sudan exhibits a pronounced gender wage gap within green economy sectors. As demonstrated in Figure A6c, the mean monthly earnings of women in 2022 amounted to $94.8, which is a mere fraction of the mean monthly earnings of men, which stood at $507.7. A significant wage gap exists even across the economy as a whole. On average, women earn $125.3 per month , whereas men earn $312.3 per month. In Tunisia, the gender wage gap in green sectors is comparatively narrower than in other countries, yet it remains substantial. In 2019, the mean earnings of women employed in green sectors equaled $383.04, a figure that closely approximates the mean earnings of men, which stood at $395.35. In contrast, the broader economy exhibits a more pronounced disparity, with women's earnings amounting to $231.10, as compared to men's earnings of $266.00. This relative wage parity in Tunisia's green economy reflects a more balanced distribution of opportunities, although systemic challenges persist. The underrepresentation of women in higher-skilled and managerial positions is a significant factor that hinders the achievement of full wage equality for women.

Across the countries examined, the gender wage gap in green economy sectors underscores both systemic inequalities and country-specific patterns. In nations such as Egypt, Sudan, and Lebanon, women's earnings continue to lag significantly behind those of men, suggesting a pervasive exclusion from higher-paying technical and managerial roles. Jordan offers a distinctive illustration of wage volatility, thereby accentuating the vulnerabilities associated with economic fluctuations. Tunisia exhibits relative wage parity; however, imbalances persist, indicating women's constrained access to quality employment prospects. These wage trends point to persistent gender inequalities that shape women's participation and earnings in green sectors, reflecting broader societal and economic barriers.

4.7. Structural and educational inequalities in informal green employment

The division between formal and informal employment in green economy sectors highlights significant gender inequalities in the countries studied. A comprehensive examination of three pivotal dimensions is imperative to attain a nuanced understanding of the gender inequalities that persist in green sectors. These dimensions encompass the overall prevalence of informal employment, the educational profiles of workers in informal roles, and the sectoral distribution of informal employment.

In Egypt, informal employment in the green economy remains disproportionately high, particularly among women, reflecting systemic challenges in formalizing work opportunities for female workers. As demonstrated in Figure 7, the rate of informal employment among women in the green economy has exhibited remarkable stability, with a slight increase from 97.7% in 2009 to 97.9% in 2023. Conversely, the proportion of men in informal employment increased from 88.8% in 2009 to 94.3% in 2023, marking a slight yet statistically significant decline. This persistent gap underscores the fact that women's and men's employment opportunities in green sectors are predominantly characterized by informality, with limited access to job security and benefits.

Figure 7. Comparison of average monthly earnings by gender and economic activity: Green Economy vs. Total Economy

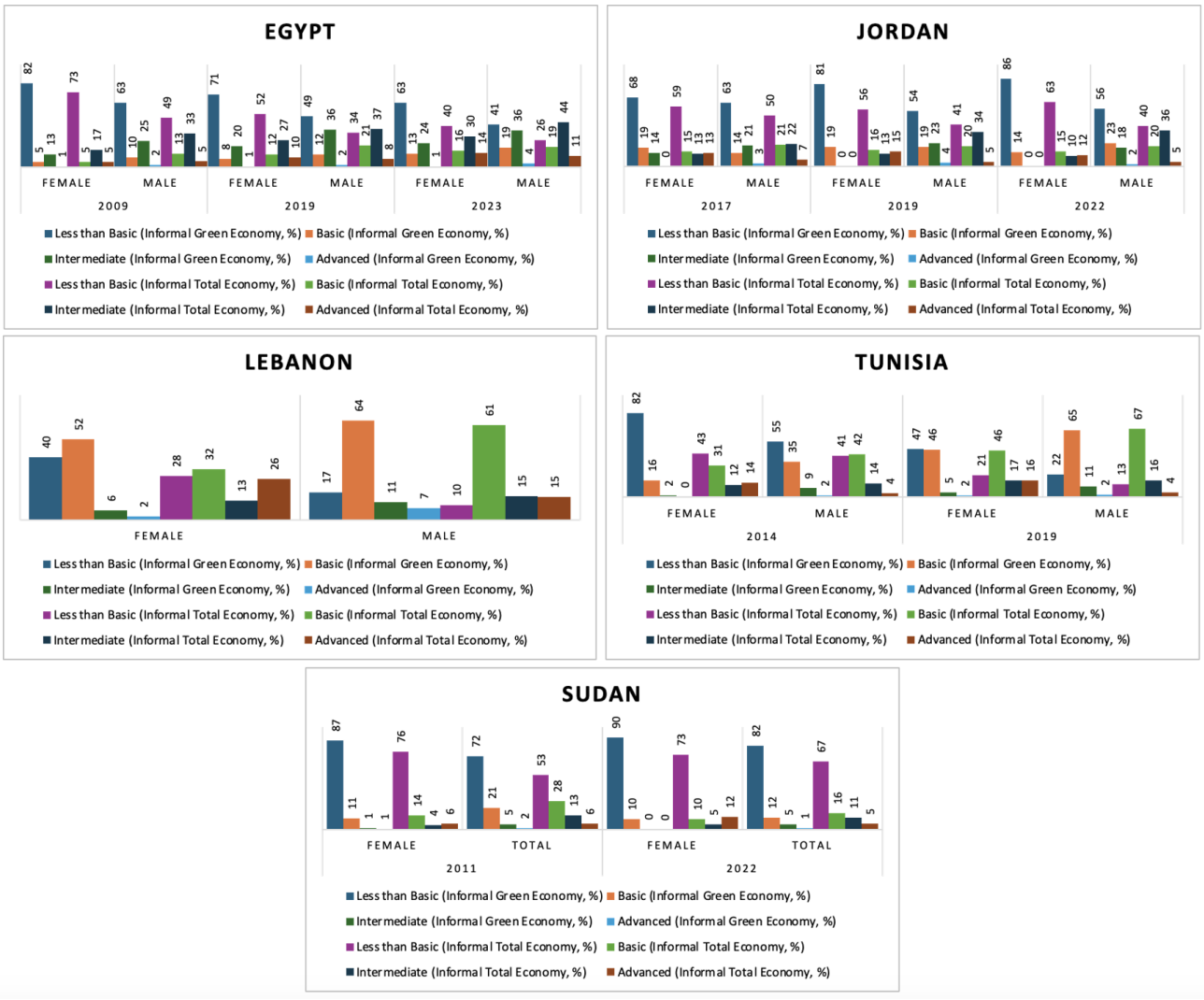
Source: Authors' calculations based on national LFS.

When analyzing educational attainment, Egypt reveals profound disparities in access to education between men and women in informal green employment. According to Figure 8, in 2023, 62.66% of women engaged in informal employment within the green sector possessed a level of education that was less than basic, marking a significant decline from the 81.90% observed in 2009. While this finding suggests a degree of advancement, the proportion remains disproportionately high compared to men, where only 41.44% of informal green workers had received less than a basic education. Conversely, in 2023, 39.96% of men had received either intermediate or advanced education, while this figure was only 24.45% for women. This imbalance underscores the systemic barriers that impede women's access to education and higher-skilled opportunities, thereby perpetuating their concentration in low-value, informal roles. The sectoral distribution of informal employment offers additional insights. As demonstrated in Figure 9, informal green employment in Egypt is predominantly concentrated in the private sector for both men and women. In 2009, 99.95% of women and 99.81% of men in informal

green employment were employed in the private sector, and this pattern persisted through 2023. It is noteworthy that the informal presence of women in the public sector, while marginal, was slightly higher than that of men, at 2.18% compared to 0.86%. This finding suggests that, although they are uncommon, women have slightly better access to informal roles in public institutions in the overall economy, even if these avenues remain inaccessible in the green sectors.

A similar pattern of gendered informality is exhibited by Jordan, albeit with subtle variations. As demonstrated in Figure 7, informal employment prevails in green economy sectors for both men and women, exhibiting persistently high rates. For women, the proportion of informal employment was 92.65% in 2017, declining slightly to 88.01% in 2021. For men, the proportion of informal employment in the green sector is marginally lower but remains substantial at 89.32% in 2021. These trends indicate

Figure 8. Informal employment by gender, education level, and economic activity: Green Economy vs. Total Economy



Source: Authors' calculations based on national LFS.

that women's employment in green sectors remains predominantly informal, suggesting limited progress towards formalization. An analysis of the educational profile of informal green workers in Jordan reveals particularly stark disparities. As demonstrated in Figure 8, in 2022, 86% of informal female workers in green sectors had received less than a primary education, representing an increase from 67.56% in 2017. This increasing concentration at the lowest level of education points to the persistent barriers that impede educational advancement and skills development for women. Conversely, the male demographic exhibited a more balanced distribution, with 56.47% possessing less than a basic education and 22.78% possessing basic qualifications. This relatively balanced distribution underscores the structural challenges women face in accessing intermediate or advanced skills training, which are prerequisites for formal, higher-paying green jobs. An analysis of the sectoral distribution of informal employment in Jordan reveals a preponderance of private sector employment. As illustrated in Figure 9, no women or men reported informal green employment in the public sector between 2017 and 2022.

Figure 9. Informal employment by gender, institutional sector, and economic activity: Green Economy vs. Total Economy

Source: Authors' calculations based on national LFS.

For women, 100% of informal green employment was in the private sector throughout this period. A cursory review of broader economic data reveals a modest increase in the representation of women in the public sector, with a recorded percentage of 11.56% in 2022, as compared to the 4.20% observed in 2017. These findings underscore structural impediments that hinder women's access to more formal, stable public sector roles within green economy sectors.

Lebanon is distinguished by its pronounced gender disparities in informal green employment. As demonstrated in Figure 7, in 2019, 93.79% of women employed in green sectors were informally employed, compared to 86.18% of men in the same category. Conversely, the informal employment rate for women in the economy as a whole was 55.59%, indicating that green economy roles are considerably more precarious for women than in the broader labor market. The analysis of educational attainment in Lebanon illuminates the intricate patterns that characterize the nation's educational landscape. As illustrated in Figure 8, women engaged in informal green jobs were predominantly concentrated in the basic education category, accounting for 51.56% of employment in 2019. Furthermore, 40.28% of women had received less than a basic education, while men were more strongly represented in both the basic (63.90%) and advanced (7.26%) levels. This finding indicates that while women in this country have a slightly higher educational profile compared to other countries such as Sudan and Egypt, they remain underrepresented in occupations that require intermediate or advanced skills. The sectoral distribution of informal employment in Lebanon underscores the country's reliance on the private sector for employment opportunities within the green economy. As illustrated in Figure 9, in 2019, the private sector accounted for 100% of informal green employment for both men and women. However, when considering the broader economic landscape, women exhibited a marginally higher presence in the public sector, with a percentage of 7.25%, in contrast to the 2.66% observed among men. This discrepancy underscores the absence of formalized pathways for integrating informal green jobs into Lebanon's public sector employment structure, which could otherwise offer more stable opportunities.

Sudan is a prime example of the high levels of informality that characterize its green economy sectors. As demonstrated in Figure 7, the proportion of women in informal employment increased from 99.74% in 2011 to 100% by 2022, indicating a complete absence of formal employment opportunities for female workers. The informal employment rate for men exhibits a similar trend, reaching an extreme 99.35% in 2022. This near-complete informality is indicative of the broader structural fragility of Sudan's labor market, particularly in the emerging green sectors. Educational attainment in Sudan is indicative of systemic inequalities. According to Figure 8, in 2022, 89.76% of women engaged in informal employment in green jobs had received less than a primary education, representing an increase from 87.33% in 2011. The male demographic exhibited a marginally improved educational profile, with 82.28% lacking a formal education beyond the basic level, and 11.82% having received only a basic education. These figures underscore the acute challenges Sudan faces in improving access to education and skills training, particularly for women. A sectoral analysis of informal green employment reveals a modest yet diminishing presence in the public sector. As demonstrated in Figure 9, in 2011, 2.14% of women were employed in informal green jobs in the public sector, a figure that decreased to 0.22% by 2022. A similar trend was observed among men, with public sector employment decreasing from 3.79% to 2.97% over the same period.

Tunisia, on the other hand, has shown more promise in this regard, with gradual progress in reducing informality in green economy sectors. Figure 7 demonstrates a decline in the proportion of women employed in green sectors. Specifically, the figure reveals a shift from 100% in 2014 to 88.90% in 2019. A parallel decline was observed among men, from 85.58% to 73.05%, suggesting a modest advancement toward formalization. The educational profile of informal green employment has been shown to exhibit clear improvements for women. As demonstrated in Figure 8, the proportion of women with less than a basic education decreased from 82% in 2014 to 47.25% in 2019, while the proportion of women with basic education increased to 46.35%. A similar pattern was observed among men, with a significant decline in low educational attainment from 54.54% to 21.97%. However, the sectoral distribution remains concentrated in the private sector. Figure 9 demonstrates a precipitous decline in informal employment in the public sector, with the female demographic's share diminishing from 3.88% in 2014 to 0.22% in 2019.

Across the countries examined, salient trends emerge that underscore the systemic nature of gender inequalities in informal green employment. Informal employment remains the predominant mode of participation in green economy sectors, with women being disproportionately concentrated in these precarious roles. Educational attainment continues to play a critical role in shaping employment outcomes, with women in Sudan, Jordan, and Egypt particularly concentrated in the lowest educational categories. While advancements have been witnessed in Tunisia and Lebanon, particularly with regard to enhancing access to fundamental education, the persistent gender disparities at the intermediate and higher levels of education impede opportunities for upward mobility. The sectoral composition of informal green employment demonstrates an overwhelming concentration in the private sector, with minimal representation in the public sector. In Egypt, Sudan, and Tunisia, women occupy a marginally higher proportion of informal public sector jobs within the broader economy. However, this trend does not extend to green economy sectors.

5. Discussion

The results of the study emphasize a systemic and persistent underrepresentation of women in green economy sectors in all countries that were studied. This disparity is particularly pronounced in Egypt, where the participation of women in green sectors decreased from 30.25% in 2009 to 15.59% in 2023, despite their relatively stable representation in the overall economy, which remained at approximately 19%. A similar decline in female participation was observed in Jordan, with a decrease from 4.22% in 2017 to 2.19% in 2021, indicative of a more general pattern of stagnation or regression. Although Sudan and Tunisia have higher relative shares of female employment, these figures fall considerably short of achieving true equity and are inadequate in addressing the persistent gender imbalances that persist in these societies. In Tunisia, for instance, the female participation rate in the green economy remained at 2.62% in 2023, despite significant educational progress. The case of the UAE further illustrates the persistence of structural barriers. Despite advancements in women's education and formal employment, their representation in green sectors remains disconcertingly low, constituting

less than 2% of the workforce. These findings demonstrate that gender disparities cannot be mitigated solely through educational interventions, as systemic inequalities and occupational exclusion persist in impeding progress.

Moreover, educational inequality persists as a substantial impediment, impeding women's access to opportunities within the green economy, particularly in technical and higher-value roles. The findings reveal significant disparities in educational attainment between men and women in the green sectors. In Sudan, the proportion of women employed in green sectors who had received less than basic education in 2022 was 86.57%, a figure that stands in stark contrast to the proportion observed among men, who constituted a significantly lower percentage of the workforce. A parallel can be drawn between Egypt and Jordan, as both countries exhibit analogous trends, with women being overrepresented in lower education categories. This phenomenon serves to impede their capacity to secure skilled employment. The findings are consistent with those of Deininger and Gren (2022), who emphasize the necessity of investing in green-focused education and vocational training to address the skills gap. In Lebanon, despite women's 46.80% representation in higher education, their participation in green economy sectors remains marginal at 4.70%. This indicates a clear mismatch between education and labor market opportunities. However, Tunisia offers a promising example of this transition. The proportion of women who have received basic education in green sectors increased to 53.01% in 2023, underscoring the potential impact of targeted educational policies. Nevertheless, sustained efforts are needed to ensure that education systems are aligned with the needs of the green sector, particularly in preparing women for technical and managerial roles, as highlighted by the OECD (2011) and ILO (2022).

The analysis show that women predominantly concentrated in low- and medium-skilled positions in all countries. In Egypt, for instance, the representation of women in high-skilled green economy jobs remains minimal, with a percentage of 0.92% in 2023, in contrast to the 43.80% observed in the broader economy. This discrepancy is indicative of systemic challenges, including constrained access to training, mentorship, and pathways into technical roles. Occupational segregation perpetuates the exclusion of women from emerging green sectors, including renewable energy, waste management, and green construction. Maier et al. (2022) underscore this underrepresentation as a pivotal barrier to achieving an inclusive transition, observing that the absence of women from leadership and technical roles undermines the innovation potential of green sectors. While the UAE is an exception, with women's representation in high-skilled roles improving to 69.62% in 2023, such successes remain isolated. This phenomenon underscores the necessity of addressing institutional biases and establishing structured pathways for women to acquire and apply advanced skills. In the absence of concerted efforts to address this imbalance, women will continue to be confined to lower-value roles, thereby perpetuating their economic vulnerability.

The findings indicate the presence of structural and institutional barriers that disproportionately impede women's participation in green sectors. In nations such as Egypt and Sudan, a significant proportion of women are employed in the informal sector. For instance, 83.21% of women in Egypt and 85.16% in Sudan are self-employed in green sectors. These patterns are indicative of systemic

institutional deficiencies, wherein constrained formal employment prospects and regulatory lacunae serve to augment women's marginalization. These barriers are further compounded by cultural norms and legal restrictions that restrict women's mobility and career choices, particularly in male-dominated industries such as energy and construction (Beides and Maier, 2022; UN Women, 2023). As Assaad et al. (2020) observe, declining opportunities in the public sector, a historically significant employer for women, have further contributed to this exclusion, as the private sector remains less accessible due to systemic biases. Conversely, Jordan and the UAE exemplify more formalized employment structures. In Jordan, women constituted 88.86% of formal employment in the green sector in 2021, indicating the potential for institutional reforms to foster more inclusive labor markets. Nevertheless, considerable challenges of a cultural and normative nature persist, necessitating profound institutional transformations to mitigate impediments to gender equality in green industries.

Furthermore, the analysis underscores a conspicuous gender wage gap and disparities in job formality, which serve to further constrain women's economic empowerment within the green economy. In Sudan, for instance, the mean monthly earnings of women in the green sectors amount to $94.76, in contrast to the mean monthly earnings of men, which are significantly higher at $507.69. This discrepancy is indicative of both the wage gap and the precarious nature of women's employment. A similar trend is observed in Lebanon, where women's earnings in green sectors amount to $570.53, compared to men's earnings of $1,021.97. These findings are consistent with those of the International Labor Organization (ILO) in 2018, which identifies informality and occupational segregation as key drivers of wage inequality in the MENA region. The exclusion of women from higher-paying technical and managerial positions serves to exacerbate these disparities and limits their access to stable, formal employment. In Tunisia, however, a narrowing wage gap demonstrates the potential benefits of formalization, with women's wages in the green sector reaching $383.04 compared to men's $395.35 in 2019. The persistence of wage disparities is indicative of underlying systemic issues in labor markets, underscoring the necessity for comprehensive reforms to address gender bias, wage discrimination, and informality.

Finally, the results indicate substantial disparities in gender dynamics across sectors of the green economy. Participation rates for women are comparatively higher in agriculture, water management, and waste management, where cultural constraints are less pronounced. In Sudan, for instance, women constituted 22.23% of green sector employment in 2022, predominantly attributable to their contribution to agriculture. Conversely, technical and high-value sectors such as renewable energy, energy efficiency, and construction remain predominantly male-dominated. This phenomenon is indicative of systemic barriers, including gendered skill disparities and societal norms, as previously documented by Maier et al. (2022) and the OECD (2011). In Jordan, for instance, the participation of women in the field of energy efficiency remains below 3%, while men predominate in technical and managerial roles. These disparities underscore the necessity for systemic changes within various sectors to address gender biases and promote inclusivity. The degree of success that has been achieved in sectors such as water resources management demonstrates the possibility of implementing targeted initiatives to replicate these accomplishments in other industries.

6. Conclusion, policy implications and limitations

6.1. Conclusion

The transition to a green economy offers significant opportunities to strengthen women's economic roles in Arab countries. However, significant barriers persist. This article uses an analytical approach to examine employment trends and gender dynamics in the green economy in six Arab countries: Egypt, Jordan, Lebanon, Sudan, Tunisia, and the United Arab Emirates. The research yielded seven primary findings. First, despite educational improvements, women's participation in green economy sectors remains low due to the persistence of structural and societal barriers. Second, the "MENA paradox" persists: heightened educational achievements among women are not accompanied by proportional employment outcomes. Third, women are predominantly employed in low- and medium-skilled occupations with limited opportunities to advance to high-skilled positions. Furthermore, women predominantly occupy positions in small enterprises, which limits their access to formal and stable employment opportunities. Additionally, women are disproportionately represented in informal self-employment, which can be attributed to their exclusion from formal labor markets. However, there are encouraging examples from countries such as Jordan and the UAE that offer a glimmer of hope. Significant gender wage disparities persist, reflecting systemic inequalities and occupational segregation. Women are underrepresented in higher-paying roles. Finally, elevated levels of informality and insecure employment conditions disproportionately affect women, especially in countries with low educational attainment and inadequate institutional support.

6.2. Policy implications and recommendations

6.2.1. Addressing persistent gender gaps in green sectors

The findings indicate a significant underrepresentation of women in key sectors of the green economy in the examined Arab countries. Closing these gaps requires a multifaceted approach emphasizing systemic reforms and gender-inclusive policies tailored to the population's specific needs. In their 2022 study, Beides and Maier emphasize the importance of employment quotas targeted towards women in sectors traditionally dominated by men, such as renewable energy. These quotas aim to enhance women's participation. According to the World Economic Forum's (WEF) 2024 findings, implementing gender-responsive policies with institutional support has been shown to improve economic outcomes and promote gender parity. Policymakers must establish explicit gender targets for hiring and promotion in sectors such as energy efficiency, waste management, and construction. Additionally, investing in awareness campaigns that challenge cultural biases limiting women's roles is crucial for promoting inclusivity (ILO, 2018). Cross-country comparisons, such as Tunisia's relatively balanced participation in water management, highlight the importance of regional benchmarks and collaboration to achieve measurable progress.

6.2.2 Strengthening women's education and skills in green sectors

Education is key for the women's access to technical and managerial roles in the green economy. As Deininger and Gren (2022) have observed, closing these gaps requires implementing gender-responsive education systems and integrating green-focused technical training programs. For example, the findings highlight the disproportionate representation of women in "less than basic" education

categories, hindering their ability to obtain quality green jobs. In line with ILO recommendations (2022), governments should incorporate green economy curricula into STEM education and vocational training programs. Fabrizio et al. (2024) emphasize the importance of encouraging women to enroll in STEM fields, as this has been shown to accelerate innovation and mitigate labor shortages during the green transition. Additionally, establishing specialized green training centers, especially in rural areas, could provide female workers with the practical skills needed for sectors such as renewable energy and agriculture.

6.2.3. Overcoming occupational segregation and structural barriers

The findings suggest distinct gender segregation in employment opportunities, with women primarily holding low-value, informal jobs. Women in these regions face numerous challenges, including structural barriers such as social norms conducive to gender inequality, restrictive labor regulations, and a lack of institutional support (Assaad et al., 2020; UN Women, 2023). In Egypt and Sudan, for example, more than 80% of women working in the green sector are self-employed informally, which suggests limited formal opportunities for high-skilled positions. To overcome these barriers, targeted, gender-sensitive reforms are imperative. According to the OECD (2011), workplace equality policies should promote inclusive hiring practices, enforce anti-discrimination regulations, and foster supportive work environments. Furthermore, collaboration between the public and private sectors is essential for formulating gender-responsive labor policies congruent with the objectives of the green transition (ILO, 2023).

6.2.4. Promoting formal employment and reducing wage inequality

Wage disparities across sectors, as seen in Sudan and Lebanon, indicate systemic inequalities in job quality and formal employment opportunities. Informality limits women's access to labor protections, social benefits, and career advancement opportunities (ILO, 2018). To address these disparities, green jobs must be formalized through legal and institutional frameworks that prioritize pay equity and labor rights. The World Bank (2012) suggests offering tax incentives to companies that create formal employment opportunities for women in green sectors. Furthermore, UN Women (2023) indicates that regulations promoting wage transparency can address gender-based pay inequities by requiring reporting on wage differentials. In countries such as Tunisia, where wage disparities are less pronounced, formal labor markets effectively reduce economic inequalities and empower women.

6.2.5. Sector-specific interventions to promote gender inclusion

The findings indicate substantial disparities among the sectors. Implementing targeted interventions that leverage sector-specific opportunities is key to increasing women's participation. For example, the United Nations Development Program (UNDP) advocated for investments in climate-smart agriculture in 2022. These investments have the potential to empower rural women to promote sustainable practices and mitigate the negative impacts of climate change. In renewable energy, mentorship programs and skills development networks, such as the RENEW initiative (Maier et al., 2022), provide women with opportunities to enter and advance in high-value roles. Similarly, Peng et al. (2024) highlight the ability of retrofitting and energy efficiency initiatives to create technical job opportunities, especially for women. The waste management sector, currently characterized by informal and low-wage employment, offers significant opportunities for formalization and inclusion.

Programs designed to transition informal waste workers into organized cooperatives, as recommended by the ILO (2022), could enhance job quality and ensure women's inclusion in leadership roles.

6.2.6. Harnessing technological innovation and financial inclusion

Digital platforms and financial inclusion strategies have the potential to dismantle the barriers impeding women's participation in the green economy, especially for women entrepreneurs. Alzamel (2024) shows how digital entrepreneurship helps women overcome traditional barriers, such as limited mobility and access to markets, and encourages the development of innovative green business solutions. However, challenges such as limited access to financing and low digital literacy persist. Saviano et al. (2017) emphasize the need for customized financial instruments, mentorship programs, and expanded credit options tailored to women's specific needs in emerging green markets. Government-led initiatives, such as subsidies and grants for women-owned green businesses, could further incentivize women's entrepreneurship and investment in sustainable solutions (Abdelwahed et al., 2022).

6.2.7. Institutionalizing gender-responsive policies

To achieve meaningful gender parity in the green economy, it is essential to establish policy frameworks that address gender disparities. According to UN Women (2023), gender-related considerations must be incorporated into national climate action plans, workforce strategies, and economic policies. To this end, governments must establish monitoring and accountability mechanisms to ensure that gender targets are met during green transitions. Integrating gender considerations into green procurement policies can further promote inclusivity by prioritizing women-owned businesses for public and private sector contracts. Additionally, establishing gender advisory committees to guide national and regional green transition strategies can help ensure that policies address the diverse needs of women from all socioeconomic backgrounds.

6.3. Limitations and future research

The present study has its limitations. First, the uneven availability and varying granularity of gender-disaggregated labor force survey (LFS) data across Egypt, Jordan, Lebanon, Sudan, Tunisia, and the United Arab Emirates (UAE) limited the extent to which cross-country comparisons could be made. Differences in data collection and categorization processes across countries necessitate meticulous data interpretation. These discrepancies extend to the definition of "green" jobs and the level of detail in informal employment information. In some cases, this impedes uniform analysis of indicators. Second, using aggregated datasets hindered investigating micro-level factors such as individual experiences, motivations, and barriers women face in green economy workplaces. Consequently, while the study identified broad patterns, it was unable to capture personal or community-level dynamics that might influence women's employment. Third, due to classification constraints within ISIC, certain critical green sub-sectors, particularly renewable energy and sustainable construction, were excluded from the analysis. This exclusion may result in an underestimation of overall green employment and the omission of sectors with distinct gender dynamics. Furthermore, sectors such as crop and animal production encompass both sustainable and conventional activities, making it difficult to distinguish

"green" employment precisely using current statistical classifications. The fourth issue pertains to data availability gaps, including missing years or suppressed data due to confidentiality concerns. These limitations constrained the researchers' ability to conduct longitudinal analyses in all the countries under study. Moreover, they precluded the use of advanced econometric modeling techniques, which are essential for establishing causal relationships between variables.

Given these limitations, future research should prioritize developing and standardizing data collection methods that capture detailed gender dynamics at the sub-sector level of the green economy. Collaborating with national statistics offices to incorporate more nuanced inquiries about green jobs, job quality, and gender into surveys would be advantageous. Additionally, qualitative research, such as interviews or case studies with women in green sectors, employers, and policymakers, could improve our understanding of the structural and cultural barriers that affect women's participation in the green labor market. These qualitative insights could reveal the reasons why certain patterns persist and how women navigate these challenges. Comparative studies across regions beyond Arab countries could also provide valuable insights into effective strategies and policies. Given the growing importance of technology, it is crucial to examine the impact of digital innovations and financial inclusion mechanisms on women's participation and empowerment in emerging green economy sectors. This exploration could yield tangible solutions to promote women's inclusion and empowerment in these sectors.

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