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Women-led Sustainable Energy Initiatives, Renewable Energy Consumption and Environmental Sustainability: A Case of Pakistan

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Abstract:

The study presents an empirical investigation into the relationship among women-led sustainable energy initiatives, renewable energy consumption and environmental sustainability in Pakistan. A30 years' data was extracted from the World Bank for the period of 1990 to 2019. Estimates from the empirical investigation divulge that factors like women employment in energy sector and consumption of renewable energy tend to have a negatively significant impact on CO2 emissions. The patents led by production technology have still a positive impact on the environmental sustainability of Pakistan, which is alluding to the fact that Pakistani nationals are not contributing towards patent registration in the field of green energy. Lastly, the study also presents some policy recommendations that are critical and can help to mitigate the CO2 emissions in Pakistan and will ensure environmental sustainability.

Keywords: Women-led sustainable energy initiatives, Renewable Energy,CO2 Emission, Environmental Sustainability and Pakistan

I. Introduction

In developing nations, many women and girls are in charge of household energy. They often spend the majority of their days on household tasks because they lack access to modern energy like Solar and wind energy systems that are self-contained can offer communities clean, dependable, and cost-effective energy. They can also aid in the creation of jobs and the growth of rural economies. On the other hand, hydropower-based large-scale renewable energy systems, contemporary clean biomass, the wind, geothermal, and solar energy can help diversify energy supply, reduce energy imports, and bring major environmental benefits both locally and globally (UNIDO, 2009).

As a result, having access to clean, affordable, and sustainable energy is essential for economic growth and poverty reduction, as well as achieving internationally agreed-upon development goals including environmental sustainability and gender equality. Access to energy services, on the other hand, could be deemed a human right in

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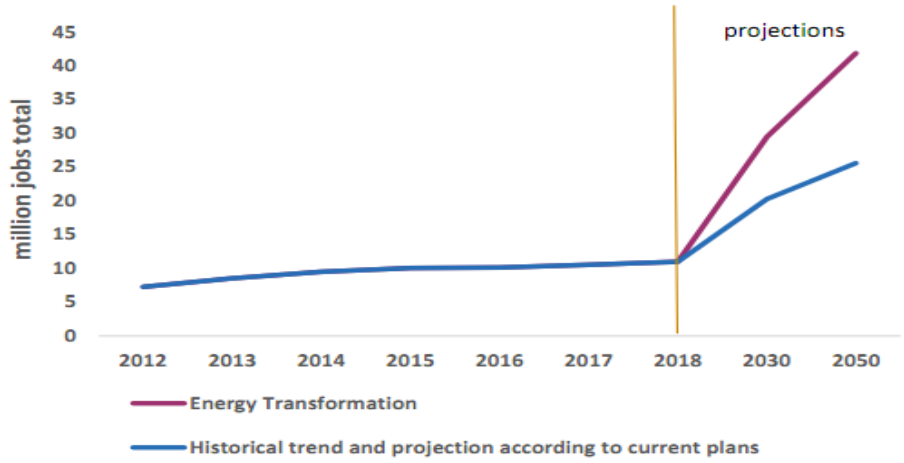
and of itself. It emphasises the importance of women as change agents in the transition to sustainable energy, and how their participation in the development, distribution, administration, and consumption of sustainable energy solutions is critical to achieving the MDGs, as well as the SE4ALL initiative's and The Future We Want's objectives. Women are frequently at the helm as entrepreneurs and producers of community-based sustainable energy solutions, and women-led sustainable energy initiatives and projects are effective in the new energy sector.

Figure 1: Estimates of global renewable energy employment from 2012 to 2018, as well as 2030 and 2050 forecasts



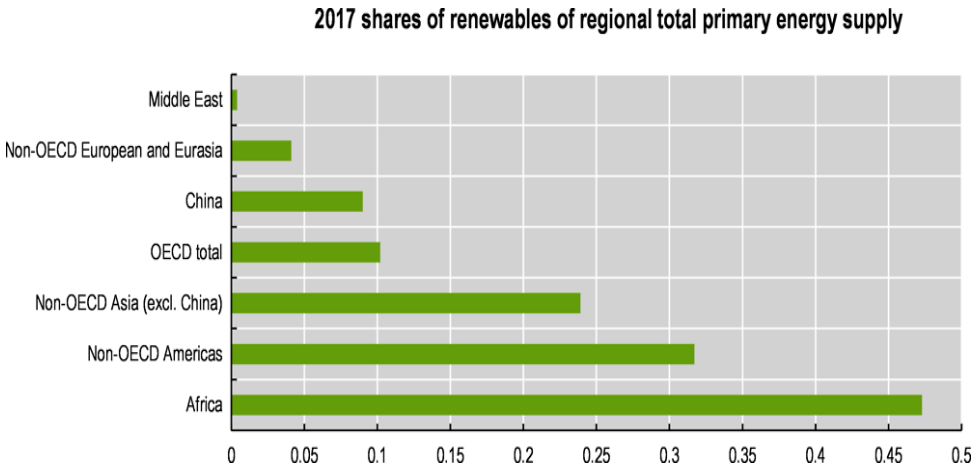
Source: (IRENA, 2018, 2019c)

Men are overwhelmingly dominating in the energy industry. Women make up less than a quarter of the workforce (22.1 per cent) in the energy sector in the EU, for example (EIGE, 2016). In the renewable energy industry, women make up 32% of the workforce, in comparison to 22% in the oil and gas industry, according to the International Renewable Energy Agency's global survey in 2018, indicating that women may be more interested in environmental sustainability professions (IRENA, 2019). Since 2012, global renewable energy employment has steadily expanded, in 2018, 11 million jobs will be created (Figure 1). This pattern is almost certain to persist in the future. By 2050, it's possible that 42 million people will work in renewable energy jobs around the world if ambitious plans are implemented (IRENA, 2019). Furthermore, transformation to a low-carbon economy implies a prospective shift of labour from fossil-fuel-intensive to low-carbon industries.

Women's needs must be recognised in energy interventions, and women's leadership and participation in sustainable energy solutions must be expanded, in order to achieve internationally agreed-on development goals and the transition to sustainable energy for all. Women are underrepresented in the energy industry, in ministerial offices, and as essential stakeholders in energy programmes. Women have an important role in the energy sector, which politicians must acknowledge and directly include into legislation and project design. Women's activities and positions in the energy industry, as well as their knowledge and influence within households and communities, could all help

to ensure that everyone has access to inexpensive and sustainable energy alternatives (ENERGIA, 2007). Women are predicted to make up roughly 20% of the workforce in the energy industry in developed countries, with the majority working in non-technical fields like administration and public relations, whereas women make up only 9% of construction labour and 12% of engineers globally (ILO, 2007).Around 19% of all ministerial positions in the globe are held by women, while just 7% of those in the environment, natural resources, and energy, and only 3% in research and technology are held by women (UN Women, 2012). Simultaneously, fewer women than men pursue STEM degrees, which give the necessary skills for a variety of green occupations while also contributing to innovation and technology development. Despite the fact that women make up more than half of university graduates in several OECD nations, just 30% of tertiary degrees in science and engineering are awarded to women, and women make up only 25% of researchers in the majority of OECD countries. Women presently hold 41% of PhDs in STEM areas in the United States, but just 28% of tenure-track faculty in the same fields.

Figure 2: Wind, Solar PV, bioenergy, hydropower, geothermal and CSP, as well as renewable heat and transport biofuels, are all examples of renewable energy in the overall primary energy supply of the region.



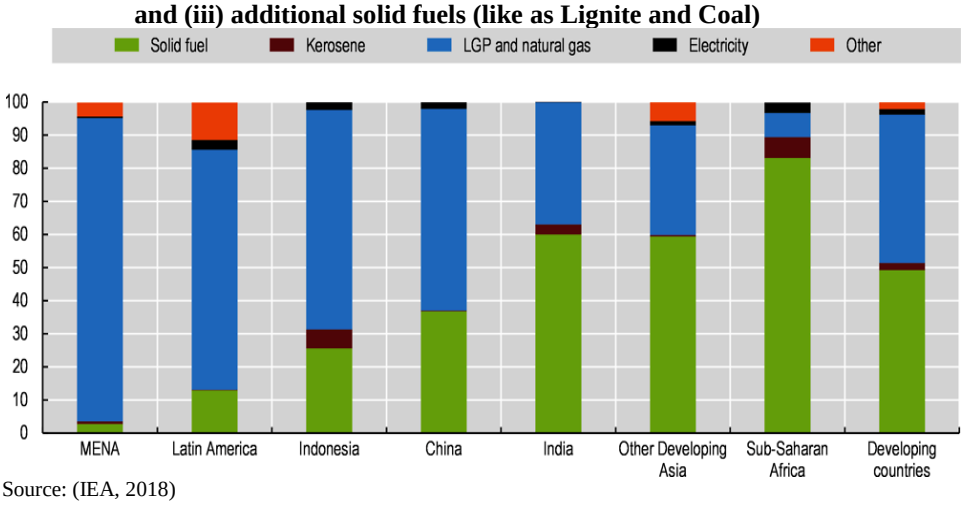
Source: (IEA, 2019).

Renewable energy development can directly address the needs of women in the following categories: 1) A scarcity of fuel, as well as health and safety considerations, worsen the biomass cooking dilemma. Women demand renewable energy to meet their basic cooking energy requirements. Cooking energy that is less time consuming, more convenient, and safe is required by women. 2) Women's time and labour go unnoticed in the human energy crisis. To meet women's labor-saving and human energy needs, renewable energy is required for drinking water pumping, food processing and grain grinding, and transportation.3) Microenterprise energy: livelihoods and income Renewable energy is needed by women to increase profitability and safety in their energy-intensive microbusinesses while also lowering labour expenses. 4) Factors such as fuel substitution, efficiency, and transportation are all part of modern energy. Because they impact direct and indirect energy use in their homes, as well as educate and mould

their children's future energy conservation and consumption behaviour, women must participate in renewable energy and energy efficiency programmes.

By 2030, using clean, renewable energy to provide universal energy access might result in a triple win: Economic factors (employment and investment in renewable energy), social (improved health outcomes and women's empowerment), and environmental (investment and employment in renewable energy) factors all have a role (in pollution and lower emissions). Energy infrastructure that is more environmentally friendly, in particular, is a key indicator of progress in combating climate change and reducing pollution. Many countries are taking steps to reduce their dependency on fossil fuels. In 2017, renewable energy sources supplied 13.5 per cent of total primary energy (Statistical Office of the European Communities, 2019). Currently, non-OECD countries provide 71.5 per cent of worldwide renewable energy (see Figure 2). However, in developing countries, much of the renewable energy is not clean. Since 1990, charcoal and solid biofuels have accounted for more than 61% of global energy production, with no major changes (IEA, 2019). Countries must use the opportunity to switch from brown to green technologies, solar and wind energy is being used to build low-cost renewable energy facilities.

Figure 3: Traditional biomass is included in solid fuels (charcoal, wood, dung and agricultural residues), (ii) processed biomass (briquettes and pellets), and (iii) additional solid fuels (like as Lignite and Coal)



Source: (IEA, 2018)

Women in both developed and developing countries are significant energy managers in their houses may have a key role in promoting the use of renewable energy and accelerating the switch to renewable energy. Women appear to be more responsible energy users than males, according to research. Women are more ecologically concerned and engage in pro-environmental family behaviour, according to a 2015 Canadian study on the relationship between customers' environmental concerns, carbon footprint, and socioeconomic status. According to the study, women-led households have a reduced carbon footprint due to smaller housing sizes and less vehicle ownership and use (Kennedy et al., 2015). Figure 3 presents the share of the population relying on different fuels in different regions.

Women reported engaging in activities with a bigger energy footprint than males, according to a recent study in the United Kingdom, yet used less power (Grunewald & Diakonova, 2020).According to other European studies, Men consume up to 22% more energy than women when they are single, either directly or indirectly. Women may be more receptive to energy conservation techniques than men, and they may be more willing to make lifestyle changes to save energy (Raty& Kanyama, 2010). Women's participation in energy efficiency efforts will require targeted action. Connecting potential clean technology customers with financing options provided by financial institutions and non-governmental organisations (NGOs) is a critical step toward addressing energy poverty and gender inequality (IRENA, 2019).

II. Literature Review

Construction, manufacturing of electrical apparatus, copper mining, renewable energy generation, biomass crop cultivation, transportation, and services all benefit from the green transition in terms of employment (European Commission, 2019b). During the green transition, the Americas will see the greatest increase in employment (ILO, 2018). Magoulios and Kydros investigated women's entrepreneurship: problems and financing options in 2021, emphasising the importance of providing incentives to SMEs, especially women entrepreneurs, and compiling a list of financial instruments available in the EU and Greece that are relevant to SMEs, particularly women who own or plan to start a business. Despite recent progress, the financial tools available in Greece to promote women's business remain limited. The instruments utilized by women entrepreneurs are generally the same as those used by all businesses. Women-led energy projects and renewable energy use have an adverse effect on CO2 emissions (Zaman *et al*, 2021), while patents effect CO2 emissions in a positive way (Li *et al*, 2019). Furthermore, these well-known female executives are more likely to make environmentally favorable executive decisions and to support renewable energy and green technology use in both in the home and on a national scale.

Pueyo and Maestrein 2020 used observational data from over 1,000 rural enterprises to look into gender and energy opportunities for everyone.They discovered that, until recently, women were not thought to be capable of being successful entrepreneurs. Women's involvement in the energy sector, on the other hand, has the potential to greatly improve energy access for the most marginalized.The researcher utilizes data from Nuru Energy, a social organisation that delivers solar lighting to the world's poorest people, to demonstrate how female sales agents can increase sales and how strategic adjustments to the social enterprise model might help female-led businesses succeed. According to the report, women sold significantly more units than men.Women who operate solo enterprises or lead groups of people outsell men who own solo or group firms. According to the statistics, women outperform males even more while working in groups than when conducting solitary proprietorships.

Even in this advanced environment, female engagement in the labour is lower than male participation on a global scale. Zaman et al, in 2021 takes the data of 25 years from China and investigates the nexus among female employers, education expenditure and renewable energy consumption for mitigating CO2 emissions and finds that female employment have negative impact on CO2 emissions and female employers can be chosen as a best employers for energy initiatives which is the core for this research study

also. He also found that more than 2.7 billion women around the world do not work in the economy, which means they are not contributing to productivity. China has the highest female labour force participation rate in the Asia Pacific area however it has declined from 73.2 percent in the 1990s to 60.5 percent in 2019.

Nieva investigated social women's entrepreneurship in Saudi Arabia in 2015 and discovered that women are driving social transformation and innovation. Women's economic involvement is high on the Kingdom of Saudi Arabia's national development plans and a list of strategic priorities. One of the political agendas for empowering women in this country is to promote the development of the entrepreneurial sector. Access to capital, entrepreneurship culture, tax and regulatory reform, education and training, and coordinated support were all mentioned as strategic strategies for promoting women's entrepreneurship in the Kingdom of Saudi Arabia.

In 2012, Nagayya and Shahina researched women's entrepreneurship and small companies in India, concluding that no country can be deemed developed if half of its citizens are disadvantaged in terms of empowerment. India's Gender-Equality Index (GEI) score is 0.748, ranking it 122nd out of 168 nations in the 2010 Human Development Report. Women's empowerment is a big topic in countries like India. Women's entrepreneurship has proven to be an effective method of empowering women in terms of employment and revenue generation.

In 2009, Deshpande and Sethi looked into women's entrepreneurship in India and we've learned that we're in a better situation presently, Women's participation in the sphere of entrepreneurship is increasing at a rapid pace and that at economic and global levels, efforts are being undertaken to expand participation of women in the entrepreneurship sector. This is related to a shift in mentality, among other reasons, a change from a conservative to a modern perspective in society, women's risk-taking talents, as well as society's support and cooperation, government policies are changing and relaxing, and the providing women entrepreneurs with a variety of upliftment programmes. Thus, it is now important to maintain the previously described altered trend, concentrating on teaching the female population, raising awareness and consciousness among women for them to shine in the sphere of business, educating children about their abilities and the importance of their position in society, and this research study focuses on the important contribution they can make to their sector as well as the overall economy. This research study tackles the following research problems based on the above-mentioned literature.

RQ1: Does women-led sustainable energy initiatives helps in mitigating CO2 emission for ensuring environmental sustainability?

RQ2: Does use of renewable energy helps in mitigating CO2 emissions for ensuring environmental sustainability?

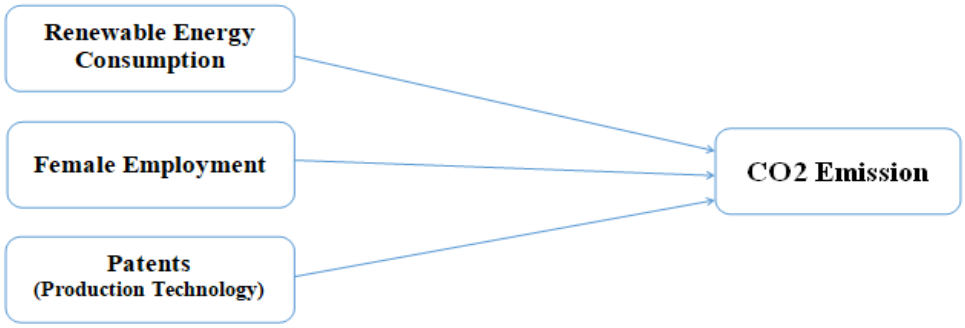
RQ3: Dopatents led by production technologies help in mitigating CO2 emission for ensuring environmental sustainability?

III. Data and Methodology

A. Theoretical Model

Figure 4 depicts the theoretical framework model for this research investigation. Female employment, renewable energy usage, and patents (manufacturing technology) have an adverse effect on CO2 emissions, according to the theoretical framework. Figure 4 shows that Environmental issues affect female employees more than male employees (Zaman et al., 2021), Individual consumption of renewable energy or government level reduces CO2 emissions (Waheed et al., 2018), and patents (production technology) in Pakistan are not still contributing to CO2 emission reductions (Dinda, 2018).

Figure 4: Theoretical Framework Model



B. Data Source and Variables

The research study uses the secondary source data from World Bank Development Indicators (WDI) and takes data of 30 years covering the period of 1990 to 2019. The current study check the female employment (FEM), renewable energy consumption (REC), and Patents (production technologies) (PT) on CO2 emission in Pakistan.CO2 emissions are employed as a dependent variable to ensure environmental sustainability, whereas FEM, REC, and PT are used as independent variables. Table 1 presets variable names, symbols, proxies used for variables, measuring units and data sources.

Table 1: Description of studied variables

Variable	Symbol	Proxy Used	Measuring Unit	Source
CO2 Emissions	CO2	---	Kg per 2010 US$ of GDP	WDI
Female Employment	FEM	---	ILO estimates (% of total labor force)	WDI
Renewable Energy Consumption	REC	---	% of Total Final Energy Consumed	WDI
Patents	PT	Production Technology	Total Patents of Pakistan	WDI

Source:WDI (World Development Indicators)

C. Econometric Model

For this study, both empirical and experimental research methods were used. The goal of the study is to see if women-led energy initiatives, renewable energy and patents have impact on environmental sustainability while mitigating CO2 emission in Pakistan. In the functional form the research model can be presented as:

$$(CO_2)_t = f(FEM_t, RNC_t, PT_t) \dots (i)$$

The research study uses the variables in logarithmic form for avoiding the estimated results complexities (except variable female employment and Patents). Zaman, *et al,* in 2021 uses CO2 emission as a dependent variable while female employment, education expenditure and renewable energy resources as explanatory variables. General econometrical model equation after applying the natural log, the equation can be written as in equation *(ii)*.

$$(LNCO_2)_t = \beta_0 + \beta_1 FEM_t + \beta_2 LNRNC_t + \beta_3 PT_t + \epsilon_t \dots (ii)$$

Here, LNRNC is a logarithmic form of renewable energy consumption, and LNCO2 is a logarithmic form of CO2 emission.

IV. Results and Discussion

Unit root tests, such as Phillips Perron and Augmented Dickey-Fuller (ADF) unit tests, were used in this study (Phillips, 1991; Dickey and Fuller, 1979), the tested results shows that the study data is stationary and is free from co-integration problem. So ordinary least square method is used to test the empirical relationships among female employment (FEM), renewable energy consumption (REC), and Patents (production technologies) (PT) on CO2 emission in Pakistan.Table 2 shows the summary statistics for the studied determinants. CO2 emission has a mean of.808 and a standard deviation of 0.0296, with a minimum of.724 and a maximum of .882 (Kg per 2010 US$ of GDP). Female employment has a mean of 18.90 and a standard deviation of 3.909, with a minimum of 12.87 and a maximum of 25.09 (ILO estimates (% of the total labour force).

Table 2: Summary of Descriptive Statistics

	Obs.	Minimum	Maximum	Mean	St. D
CO2	30	.724	.882	.808	.0396
FEM	30	12.87	25.09	18.90	3.909
REC	30	40.25	58.091	49.143	4.485
PT	30	524	1738	1007.90	312.153

Renewable energy consumption has a mean of 49.143 and a standard deviation of 4.485, with a minimum of 40.25 and a maximum of 58.091. (percent of Total Final Energy Consumed). And Patents (producing technologies) have a mean of 1007.90 and a standard deviation of 312.153, with a minimum of 524 and a maximum of 1738 (Total Patents of Pakistan).

Table 3 presents the results of dependent and independent variables. Model 1 presents results when we use *FEM* and *LREC* as independent variables. Both are statistically significant at 1 per cent level, Equation *(ii)* states that if all explanatory variables are zero constant emission of CO2 will be 1.331 (Kg per 2010 US$ of GDP). According to first hypothesis,women-led sustainable energy initiatives help in mitigating CO2 emission for ensuring environmental sustainability in Pakistan. Results of model 1 states that Female employment has a negative significant impact on CO2 emission, with one unit increase in female employment, 0.008 (Kg per 2010 US$ of GDP) CO2 emission will be reduced, which is clear explanation of first hypothesis of study conducted, it

means our null hypothesis is accepted. Zaman et al, in 2021 for a study on China found that a one per cent increase in female employment reduces 1.45 (Kg per 2010 US$ of GDP) and has a significant value at a 5 per cent level.

Table 3:Dependent variable is *LCO2* Emission while *FEM, LREC* and *PT* are independent variables

	Model – 1	Model – 2
FEM	-.008***	-.007***
LREC	-.756***	-.611***
PT		3.122***
Intercept	1.331***	1.041***
F Test	21.923***	33.315***
R^2	.619	.80
Adj. R^2	.591	.77
Obs.	30	30

****, **, and * represents significance level at 1%, 5% and 10% respectively.*

$$(LNCO_2)_t = 1.331 - .008FEM_t - .756\ LNRNC_t \ldots (iii)$$

$$(LNCO_2)_t = 1.041 - .007FEM_t - .611\ LNRNC_t + 3.122PT_t \ldots (iv)$$

According to the second premise, using renewable energy reduces CO2 emissions, ensuring Pakistan's environmental sustainability. The results of model 1 reveal that renewable energy consumption has a negative significant influence on CO2 emissions, with one unit increase in renewable energy consumption reducing CO2 emissions by 0.756 (Kg per 2010 US$ of GDP) and accepting the null hypothesis. According to several researches, increasing renewable energy technology reduces CO2 emissions and enhances environmental sustainability (Zaman et al, 2021; Waheed et al, 2018).

Equation (iii) and model 2 uses patents related to production technology. Third hypothesis of research study does not hold its justifications, as patents led by production technologies help in mitigating CO2 emission for ensuring environmental sustainability in Pakistan.From model 2 results states that patent variable has a statistically significant value at 1 per cent level but has a positive impact on CO2 emissions, which can be said that the Patents in production technology by Pakistan are still not up to the mark, for modern green energy technology, which is negating the null hypothesis and we will accept the alternative hypothesis that Pakistan should produce green technology patents for mitigating CO2 in economy for environmental sustainability. Su, *et al*, in 2021, has also found that technology has a positive impact on CO2 emissions in developing countries. Danish in 2019 while studying the countries along belt and road founds that ICT (information and communication technology) have positive effect on CO2 emissions.

V. Conclusions and Policy Recommendations

An empirical study is undertaken in Pakistani context to examine the relationship between women-led sustainable energy projects, renewable energy use, and environmental sustainability, using data from the year 1990 to 2019. Despite the fact that Pakistani nationals' patents do not relate to green energy, estimates from the empirical investigation demonstrate that women's employment in energy

sector, Patents based on production technology, as well as renewable energy consumption, have a negative significant influence on CO2 emissions, whereas patents based on renewable energy consumption have a positive significant impact on Pakistan's environmental sustainability. Female employment has a significant negative influence on CO2 emissions; for every unit increase in female employment, CO2 emissions are reduced by.008 (Kg per 2010 US$ of GDP). Renewable energy consumption has a large negative impact on CO_2 emissions; for every unit increase in renewable energy consumption, CO_2 emissions are reduced by.756 (Kg per 2010 US$ of GDP). At the 1% level, the patent variable is statistically significant, although it has a favourable effect on CO2 emissions, showing that Pakistan's patents in industrial technology are still missing in contemporary green energy technology. The study alludes to some policy recommendations to promote synergies between women-led energy programmes and long-term environmental goals. These are provided below:

- Women's needs should be taken into account while developing energy policies, especially in countries where there is a lot of energy poverty.
- Policymakers may think about the impact of their energy policy on other countries, as well as the impact they have on long-term sustainability goals.
- In all levels of energy planning and policymaking, a female perspective should be considered. Women, notably indigenous women, must be encouraged to engage in local politics, decision-making bodies at the national and international levels, as well as in the energy industry at all stages of policy formulation.
- Donors should push for gender equality in climate change assistance, because improving opportunities for women to participate in the green economy is still a work in progress, specifically, by guaranteeing that women benefit equally from clean technology and renewable energy development projects.
- Pakistan should concentrate on green energy patents so that new industrial technologies can be developed, which will contribute to Pakistan's environmental sustainability by reducing CO2 emissions.

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