The Environmental Philips Curve from a gender perspective: empirical evidence from India

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Abstract
The trade-off between environmental degradation and unemployment has been recently termed as Environmental Philips Curve (EPC). This research attempts to investigate the presence of EPC in the Indian context utilizing time series data for the period 1990–2019. Besides contributing to the meagre empirical literature on this issue, the present study makes a novel contribution by introducing a gender dimension to this investigation. In particular, this study investigates whether the nexus between environmental degradation and unemployment is different for men and women. We examine the presence of the EPC by estimating a model that considers growth in CO2 emission as a function of economic growth, trade openness, and gender segregated unemployment rates. Our findings based on autoregressive distributed lag, fully modified ordinary least squares, and dynamic ordinary least squares estimators generate robust evidence for a negative impact of male unemployment rate on growth in CO2 emission that validates the existence of the Environmental Philips Curve for the male unemployment rate. However, there is no trade-off between environmental quality and women’s employment. In fact, the results point to a favourable effect of reduction in female unemployment on environmental quality. The results of the Block Exogeneity test indicate a unidirectional causality from male unemployment rate to environmental degradation. However, a bidirectional causal relationship exists between female unemployment and environmental degradation. The existence of a trade-off between environmental quality and male employment suggests that India is yet to find viable technologies that can curtail pollution without compromising its livelihood. An optimistic conclusion emanating from our findings is the existence of a virtuous cycle between female employment and environmental quality. An integrated approach to improve environmental quality and increase women’s economic activity may facilitate a speedy realization of sustainable development goals for India as both the goals complement and reinforce each other.

Keywords Environmental Philips Curve · Unemployment · Gender · India · ARDL · FMOLS · DOLS · Block exogeneity test

Introduction

Environmental degradation is one of the defining challenges of our times that has attracted both local and global attention. In response to the issues caused by deteriorating environmental quality, a general consensus on the need to achieve environmental sustainability has risen. A major challenge confronting policymakers is to curtail environmental pollution without compromising the livelihood of the masses.

A voluminous literature indicates a positive relationship between economic growth, energy consumption, and pollution (see e.g., Grossman and Krueger 1995; Farhani and Rejeb 2012; Farhani and Ozturk 2015; Mohapatra and Giri 2015; Shastri et al. 2020) suggesting that higher
output generates higher pollution. Given that employment generation is directly linked with output growth, a trade-off between controlling environmental degradation and sustaining livelihood arises. This nexus or the trade-off between environmental degradation and unemployment is termed as Environmental Philips Curve (EPC) by Kashem and Rahman (2021).

The present study investigates the existence of EPC utilizing annual time series data for the period 1990–2019 for the Indian economy. Besides contributing to the meagre empirical literature on this issue, the present study makes a novel contribution by introducing a gender dimension to this investigation. In particular, this study investigates whether the nexus between environmental degradation and unemployment is different for men and women. The motivation for this investigation stems from the proposition that environmental degradation and the consequent climate change are experienced differently by men and women (Jerneck 2018). Women are not inherently vulnerable; however, the intersection between gender, socio-economic structures, societal norms, and expectations lead to differential climatic impacts on women (Andrijevic et al. 2020). Environmental degradation affects labour market outcomes through two channels: deterioration in workers’ own health and burden of caregiving to the dependents (Montt 2018). Whilst the first effect is common in both men and women, the second effect is particularly relevant to women. When pollution is high, children and elder people fall sick more often (Montt 2018). Global evidence suggests that the distribution of care work is highly gender-biased, with the bulk of care work falling on women (Ferrant et al. 2014). The gender bias in the distribution of care work significantly affects women’s ability to participate in the labour market and the type and quality of employment opportunities available to them. Every minute that a woman devotes to unpaid care work implies a minute less that she could potentially spend on labour market activities or invest in her educational and vocational skills which in turn adversely affect women’s employment prospects. Another linkage between environmental degradation and women’s employment opportunity is the depletion of natural assets caused by air pollution. Airborne pollutants affect plant growth and agricultural productivity (Unsworth and Ormrod 1982). This may, in turn, reduce the availability of work in the agriculture sector where women are overrepresented.

The arguments suggest that rather than presenting a trade-off, efforts to reduce environmental degradation may in fact be conducive to women’s employment. Hence, it is pertinent to examine the validity of EPC using gender disaggregated unemployment data.

In view of the above discussion, the objective of the study is to examine the relationship between environmental degradation and male and female unemployment in India. In particular, the study seeks to assess whether the environmental quality and unemployment trade-off is different for men and women in India.

India offers an interesting case for this investigation. Over the past few decades, India has registered impressive economic growth. India’s economic performance has however been clouded by a degrading environment. The evidence clearly suggests that India has not augured well on environmental norms (Chauhan 2021). The air pollution levels in India are amongst the highest in the world, posing a heavy threat to the country’s health and economy. Almost the entire population is exposed to unhealthy levels of ambient PM 2.5—the most harmful pollutant—emanating from multiple sources. In 2018’s Environmental Performance Index, India ranked 177 out of 180. Dragged down by the poor score on air quality, India also performed miserably on other measures including biodiversity protections.

Besides the environmental degradation, unemployment is another enormous challenge for the country. During the last four decades, the population of India has grown in leaps and bounds resulting in more and more people joining the labour force. The policymakers simply assumed that the economic growth would suffice to generate employment for the masses. However, the various development projections set by the planners continued to fail to create the employment opportunities necessary to keep pace with the number of people seeking jobs (Singh and Shastri 2020). Thus, unemployment continued to grow and assumed a gigantic proportion. In the case of the rural sector, both disguised unemployment and seasonal unemployment prevail. In the urban sector, there is both educated and industrial unemployment. Over the past three decades, unemployment in the industrial sector has increased due to the extremely low growth rate of employment in the organized manufacturing industry.

Over the last three decades (1988–2018), the unemployment rate has been fluctuating between 3 and 5% which shot up to over 8% during the post-COVID 19 pandemic period (Singh and Shastri 2020; CMIE 2022). As per recent reports, India has 53 million unemployed people as of December 2021 and a major chunk of this unemployed population is women. The unemployment for women stood at 12.39%, whereas for men it stood at 6.23% (CMIE 2022). India represents a peculiar case when it comes to the labour market activities of women. Despite the impressive economic growth during the last few decades, India’s female labour force participation (around 20%) has been showing a declining trend and stands amongst the lowest in the world, with only parts of the Arab world performing worse than the country.

Battling the twin challenges of environmental degradation and unemployment, an investigation of the nexus between environmental degradation and male and female
unemployment may provide relevant insights to the policymakers to formulate appropriate policies.

The contribution of the present study to the literature is twofold. (i) The study contributes to the thin empirical literature on the newly developed idea of EPC in the environmental economics literature. (ii) It is the first-ever study of its kind, to the best of our knowledge, that examines the validity of the EPC using gender-segregated data to examine whether the trade-off between environmental quality and employment is different for men and women.

The remainder of the paper is organized as follows. Section two reviews the existing literature. In section three, we describe the empirical model, data, and econometric methods employed. Section four discusses the empirical findings. Section five concludes the study with policy recommendations.

**Review of literature**

The EPC is a novel concept with limited empirical validation. In the past, studies have tried to investigate society’s perception of the trade-off between environmental objectives and reduction in the standard of living (see e.g., Veisten et al. 2004; De Silva and Pownall 2014). A few survey-based studies look at the relationship between employment status and pro-environmental behaviour of individuals (see e.g., Torgler and García-Valinas 2007; Kahn and Kotchen 2011; Meyer 2016). For instance, Kahn and Kotchen (2011) used two different sources of data to investigate the association between unemployment rates and public concern about climate change. The authors examined the relationship between Google keyword searches within a state and a state’s unemployment rate and found that on average, an increase in a state’s unemployment rate decreases searches for “global warming” and increases searches for unemployment. Also, using information from the national surveys, the authors reported that higher unemployment rates are also associated with people’s views that they should do less with respect to policies designed to reduce global warming. Meyer (2016) using survey data from European countries found a positive impact of unemployment on time and effort-intensive pro-environmental behaviours. At the same time, unemployment decreases income and hence reduces the pro environmental behaviours requiring monetary contributions. However, not much effort has been made to quantify the trade-off between environmental quality and employment on the macro level. To the best of the authors’ knowledge, only three studies have attempted to empirically examine the existence of EPC. Kashem and Rahman (2021) for a panel of thirty OECD and newly industrialized Asian economies confirmed the existence of EPC. Anser et al. (2021) investigated the presence of EPC in the context of a panel of BRICS countries and Turkey and affirmed a significant trade-off between unemployment and environmental degradation. Tariq et al. (2022) explored the case of South Asian countries. Using both panels as well as country-specific estimations, the authors validated the conflict between reducing environmental degradation and sustaining employment in South Asian countries.

The aforementioned survey of the literature shows that the empirical literature on quantification of unemployment and environmental degradation is of recent origin and thus quite thin. Although a good number of recent studies point to the direct association of environmental degradation and output growth (see e.g., Chen et al. 2022; Karaaslan and Çamkaya 2022; Osuntuyi and Lean 2022) that may also hint at the inverse relationship between environmental quality and employment. To the best of our knowledge, no study has so far investigated the validity of EPC using gender-segregated data. The present study intends to fill this gap.

**Data, model, and econometric methodology**

Following Kashem and Rahman (2021), we define an estimable model in which environmental degradation is defined as a function of unemployment and a set of control variables.

The popular models of environmental degradation posit a positive relationship between income and pollution levels as

\[ p = a + by \] (1)

where \( p \) is pollution and \( y \) represents output.

According to Okun’s Law, unemployment is postulated as an inverse function of output or income

\[ u = c − dy \] (2)

where \( u \) represents the unemployment rate.

With the above two relationships, we purport that pollution levels/environmental degradation and unemployment are inversely related

\[ p = e − gu \] (3)

Following earlier literature, we consider output growth and trade openness as additional control variables in the model (see e.g., Batool et al. 2022; Yousaf et al. 2022; Khalid et al. 2021; Kashem and Rahman 2021; Dogan and Seker 2016; Mercan and Karakaya 2015; Hamilton and Turton 2002; Hossain 2012; Rahman et al. 2017). The data for all the variables is for the period 1990–2019. A summary of the data is provided in Table 1.

To begin with, we investigate the presence of unit root with the help of Augmented Dickey Fuller (ADF) and the KPSS test by Kwiatkowski et al. (1992). The long-run relationship between the series is examined through
Table 1 Summary of data

| Abbreviation | Indicator name                      | Measurement                                                                 | Source                          |
|--------------|-------------------------------------|-----------------------------------------------------------------------------|---------------------------------|
| GCO₂         | Growth in CO₂ emission              | Carbon dioxide emissions produced during consumption of solid, liquid, and gas fuels and gas flaring in metric tons per capita | World Development Indicators    |
| UNEMP_M      | Male Unemployment Rate               | Percentage of the male labour force that is without work but available for and seeking employment | World Development Indicators    |
| UNEMP_F      | Female Unemployment Rate             | Percentage of the female labour force that is without work but available for and seeking employment | World Development Indicators    |
| GDP_GR       | Economic Growth                      | Growth in GDP per capita (constant 2010 USD) | World Development Indicators    |
| TO           | Trade Openness                       | Sum of exports and imports of goods and services as a share of GDP          | World Development Indicators    |

Table 2 Results of ADF and KPSS tests

| Variable    | ADF test | KPSS test |
|-------------|----------|-----------|
|             | Lags     | t-statistics | Bandwidth | LM statistics |
| GCO₂        | 0        | 3.751      | 4         | 0.189         |
| ΔGCO₂       | 0        | -5.655***  | 2         | 0.079         |
| UNEMP_M     | 1        | -2.863     | 3         | 0.073         |
| ΔUNEMP_M    | 0        | -4.378***  | 1         | 0.072         |
| UNEMP_F     | 2        | -0.819     | 4         | 0.528         |
| ΔUNEMP_F    | 1        | -8.173***  | 8         | 0.183         |
| GDP_GR      | 0        | -1.668     | 0         | 0.159         |
| ΔGDP_GR     | 0        | -4.747***  | 0         | 0.085         |
| TO          | 0        | -0.380     | 4         | 0.141         |
| ΔTO         | 0        | -4.892***  | 0         | 0.134         |

Δ represents first difference. *** represents significance at 1 %. For ADF test, the null hypothesis is of unit root. For KPSS test, the null hypothesis is of stationarity of series.
tested by the joint significance of the coefficients of each of the other lagged endogenous variables in that equation. The short term significance of sum of the each lagged explanatory variables (θ's and δ's) can be exposed either through joint F or Wald $\chi^2$ test” (Singh and Shastri 2020 pp.669).

Empirical findings and discussion

The empirical analysis of time series data conventionally begins with an examination of the order of integration of the series. Towards this end, we apply the ADF and KPSS tests. As shown in the Table 2, all the series are integrated of order one as per the ADF test. The results of KPSS test reveal that whilst unemployment rate for men (UNEMP_M) and trade openness (TO) are stationary at levels, the rest of the series are I(1).

After ensuring that none of the variables is I(2), we conduct the cointegration analysis in the ARDL Bounds framework.

Since we have annual time series data, we consider two as the maximum order of lags in the model (Narayan 2017). The Akaike information criterion is used to determine the optimal number of lags. The results contained in Table 3 reveal that the $F$-statistic exceeds the upper bound critical value at all the conventional levels of significance. Therefore, the null hypothesis of no cointegration is rejected, and we conclude that the variables are cointegrated.

Table 4 and 5 report the estimated long-run and short-run coefficients of the model. As evident from Table 4, there is a significant negative impact of male unemployment rate (UNEMP_M) on the growth in CO₂ emission in the long run. In particular, a one percentage point increase in male unemployment rate results in 0.0073 percentage point reduction in CO₂ emission growth. The results thus confirm the presence of trade-off between male employment and pollution control. In other words, a decrease in CO₂ emission growth may be achieved at the expense of employment of male workers.

Interestingly, the coefficient associated with female unemployment rate is significant and positive in the long run. A one percentage point increase in unemployment of women in India leads to increase in the environmental pollution by 0.011 percentage points. In other words, a reduction in female unemployment results in lower environmental degradation, and there is no trade-off relationship between female employment and environmental quality in the long run. The results also indicate that in the long run, whilst the GDP growth tends to increase the CO₂ emission growth, the trade openness does not exert any impact on environmental degradation.

All the variables retain their sign and significance in the short run as well. As shown in Table 5, the coefficient associated with male unemployment rate is negative indicating a short-run trade-off between male employment and environmental quality. In the short run too, the regression coefficient on female unemployment rate is positive suggesting that a reduction in female unemployment is associated with lower CO₂ emission in the short run.

The negative and significant error correction term in Table 5 confirms the cointegration amongst the variables. The ECT suggests that the system corrects its previous

| Variable   | Coefficient | t-statistics | p value |
|------------|-------------|--------------|---------|
| UNEMP_M    | -0.0073     | -2.964       | 0.009   |
| UNEMP_F    | 0.0114      | 2.964        | 0.009   |
| GDP_GR     | 0.199       | 6.088        | 0.000   |
| TO         | 0.060       | 1.228        | 0.230   |
| \(R^2\)    | 0.88        | Breusch-Godfrey LM Test for Serial Correlation \(F=0.413 (p val = 0.669)\) |
| Adj \(R^2\) | 0.78       | Breusch-Pagan-Godfrey Test for Heteroskedasticity \(F=0.247 (p val = 0.987)\) |

| Variable   | Coefficient | t-statistics | p value |
|------------|-------------|--------------|---------|
| UNEMP_M    | -0.014      | -2.092       | 0.016   |
| UNEMP_F    | 0.005       | 3.2014       | 0.005   |
| GDP_GR     | 0.183       | 2.083        | 0.050   |
| TO         | 0.292       | 1.516        | 0.153   |
| ECT        | -1.568      | -10.548      | 0.000   |
period’s disequilibrium at a speed of 156.8% annually. This speed may appear over adjusted as ECT conventionally lies between one and zero. According to Narayan and Smyth (2006), an ECT lying between one and two suggests that instead of a monotonic convergence to the equilibrium path, the error correction process fluctuates around the long-run value in a dampening manner. Once the path is complete, there is a rapid convergence to the equilibrium path (Singh and Shastri 2020).

Various diagnostic tests were applied to assess the appropriateness of the specification of the model. The Breusch Godfrey LM test for autocorrelation and Breusch-Pagan-Godfrey Test for Heteroskedasticity fail to reject the null hypothesis of no autocorrelation and homoskedasticity respectively. Further, the Ramsay reset test suggests that the functional form of the model is appropriate. Finally, Fig. 1 presents plots of CUSUM and CUSUMSQ test statistics that fall inside the critical bounds of 5% significance suggesting that the parameters in the model are stable.

In the interest of checking the robustness of the above evidence, we also apply fully modified least square (FMOLS) and dynamic ordinary least squares (DOLS) estimators. The results of FMOLS and DOLS (contained in Table 6) provide the same evidence for a negative, significant impact of male unemployment rate on CO2 emission growth and a positive impact of female unemployment rate on CO2 emission growth.

All three methods, namely, ARDL, FMOLS, and DOLS provide approximately the same outcomes, which validate existence of Environmental Philips Curve for male unemployment rate. The results for male unemployment thus support the findings of Kashem and Rahman (2021), Anser et al. (2021), and Tariq et al. (2022). However, our findings reveal that the Environmental Philips Curve does not exist for women unemployment.

A few reasons explain this discrepancy and the absence of trade-off between female employment and environmental quality. First is the occupational distribution/segregation between men and women in India. The NSSO data (1970 – 2018) exhibits that women have largely been undertaking labour-intensive and informal work, concentrated in low-productivity sectors. Whilst nearly 77% of rural women are employed in the agriculture sector, for the urban women, the service sector is the key employment provider with its share in employment rising from 35% in 1977–1978 to 60% in 2017–2018. In this sector, women are largely concentrated in professions such as teaching and nursing considered to be the cleaner sectors of the economy. Hence, women’s employment does not directly result in environmental degradation.

Not only that we find the absence of any trade-off between environmental quality and employment, but we also find a positive effect of women’s employment on pollution control. As female unemployment decreases, environmental degradation also reduces. The favourable effect of female employment on the environment may emerge from two channels. First, with the reduction in unemployment or access to work, women tend to go for family planning and birth control and wish to have children later in life. This may slow down population growth and relieve stress on the environment.

Second, the employment of women increases women’s autonomy towards economic resources and results in women empowerment (Guinée 2014; Peinado and Serrano 2018) giving them a greater role in decision-making at various

### Table 6  Long-run coefficients under alternative estimators

| Variable | FMOLS Coefficient | t-statistics | DOLS Coefficient | t-statistics |
|----------|-------------------|--------------|------------------|--------------|
| UNEMP_M  | −0.0060           | −2.208       | 0.0059           | −2.309       |
|          | (0.037)           |              | (0.025)          |              |
| UNEMP_F  | 0.0115            | 2.244        | 0.016            | 2.458        |
|          | (0.034)           |              | (0.022)          |              |
| GDP_GR   | 0.179             | 2.908        | 0.193            | 5.666        |
|          | (0.050)           |              | (0.000)          |              |
| TO       | 0.061             | 1.545        | 0.075            | 1.695        |
|          | (0.134)           |              | (0.102)          |              |
| $R^2$    | 0.855             |              | 0.871            |              |
| Adj $R^2$| 0.753             |              | 0.742            |              |

Figures in parenthesis are p values.
levels. Research show that in the capacity of decision makers, women are more sensitive towards environmental issues. For instance, illustrating the case of the agriculture sector, O’Connor (2019) observes that giving women leadership roles leads to increased innovations to make farming more sustainable. Women often possess valuable knowledge and potential for sustainable innovation particularly regarding agriculture technology. Desrochers et al. (2019) opine that since women are more conscientious (i.e., goal directed, organized) than men, they are more likely to support environmental protection and indulge in pro environment decisions. Hence, an increase in women’s economic activity is conducive to more environment friendly decision making at various levels.

We next employ the block exogeneity Wald test (based on VECM) to examine causal relationship between the series. From the results presented in Table 7, it is evident that there is a unidirectional causality from male unemployment rate and GDP growth rate to environmental degradation. Interestingly, there is a bidirectional causality between female unemployment rate and environmental degradation. This implies that in the Indian context, it is not only the female employment that may reduce the environmental degradation, but an improvement in environment also facilitates reduction in female unemployment. This effect may come from two channels. First, an improvement in environmental quality is associated with lesser care work (as children and elders have lower probability of falling sick). This results in a greater availability of time to be invested in educational and vocational skills which in turn favourably affect women’s employment prospects. Also, environmental degradation often leads to curtail women’s employment opportunity owing to the reduction in natural assets caused by air pollution (Unsworth and Ormrod 1982). An improvement in environmental quality may in turn increase availability of work in agriculture sector where women are overrepresented.

Furthermore, we find that all three variables, namely, trade openness, unemployment rate for males and females cause CO₂ emission growth via the GDP growth channel. Also, we find a bidirectional causality between trade openness and male unemployment rate as well as between trade openness and female unemployment rate. Bidirectional causality also exists between GDP growth and both male and female unemployment rates. Additionally, there is a unidirectional causality running from male unemployment rate to female unemployment rate.

### Conclusion and policy implications

A major challenge confronting policymakers across the globe is to curtail environmental pollution without compromising the livelihood of the masses. The trade-off between environmental degradation and employment has been recently termed as Environmental Philips Curve (EPC). This study is a novel attempt to investigate the presence of the Environmental Philips Curve in the Indian context using time series data for the period 1990–2019. Besides contributing to the meagre empirical literature on this issue, the present study makes a novel contribution by introducing a gender dimension to this investigation. This study investigates whether the nexus between environmental degradation and unemployment is different for men and women.

Our empirical results based on ARDL, FMOLS, and DOLS estimators generate robust evidence that validates the existence of the Environmental Philips Curve for male unemployment rate whilst there is no trade-off between environmental quality and women’s employment. In fact, the results point to a positive effect of reduction in female unemployment on environmental quality. The results of the Block exogeneity test indicate a unidirectional causality

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**Table 7 Results of causality test**

| Excluded | Chi-square | p value |
|----------|------------|---------|
| GCO₂     |            |         |
| UNEMP_M  | 3.750      | 0.050   |
| UNEMP_F  | 6.331      | 0.011   |
| GDP_GR   | 7.437      | 0.006   |
| TO       | 0.011      | 0.913   |
| GCO₂     |            |         |
| UNEMP_M  | 1.115      | 0.290   |
| UNEMP_F  | 0.0484     | 0.486   |
| GDP_GR   | 14.569     | 0.000   |
| TO       | 15.006     | 0.000   |
| GCO₂     |            |         |
| UNEMP_M  | 8.511      | 0.014   |
| UNEMP_F  | 7.001      | 0.008   |
| GDP_GR   | 6.370      | 0.041   |
| TO       | 6.751      | 0.009   |

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1 An ARDL-based regression shows a positive effect of environmental degradation on female unemployment. The results are not reported to conserve space.
from the male unemployment rate to environmental degradation. A bidirectional causal relationship, however, exists between female unemployment and environmental degradation. This implies that in the Indian context, it is not only female employment that may reduce environmental degradation, but an improvement in the environment also facilitates a reduction in female unemployment. This effect may come from two channels. First, an improvement in environmental quality is associated with lesser care work (as children and elders have a lower probability of falling sick). This results in greater availability of time to be invested in educational and vocational skills which in turn favourably affect women’s employment prospects. Also, environmental degradation often leads to curtailing women’s employment opportunities owing to the reduction in natural assets caused by air pollution. An improvement in environmental quality may in turn increase the availability of work in the agriculture sector where women are overrepresented.

The results of the study offer some important implications for literature as well as policymakers. From the viewpoint of literature, the results underscore the importance of conducting a gender segregated analysis whilst investigating the trade-off between environmental quality and standard of living. For policymakers, the following implications may be drawn from our empirical analysis. First, the existence of trade-off between environmental quality and male employment suggests that India is yet to find viable technologies that can curtail pollution without compromising its livelihood. To sustain employment and facilitate the process of poverty reduction, India must strengthen its efforts to devise technologies that are less polluting and employment generating at the same time. An optimistic conclusion emanating from our findings is the existence of a virtuous cycle between female employment and environmental quality. Women’s workforce participation and economic empowerment have not received much public attention as a climate solution in India. Our results suggest that the strategies to improve environmental quality in India must also consider women’s economic activity as a potential tool. At the same time, efforts to improve the workforce participation of women must also focus on improvement in environmental quality. An improvement in environmental quality (resulting in improved health of families) reduces the care burden of women and gives them greater time to hone their vocational skills and improve their employment prospects. Also, an improvement in environmental quality may in turn increase the availability of work in the agriculture sector where rural women are overrepresented. An integrated approach to improve environmental quality and increase women’s economic activity may facilitate a speedy realization of sustainable development goals for India as both the goals complement and reinforce each other. Government policies, therefore, must aim at making interventions that may help create this virtuous cycle. It has often been claimed that women use resources more efficiently than men. If women are given secure land rights, not only will it increase their productive activities but also incentivize the usage of technologies that ensure environmentally sound use of the land resources. Providing women with the opportunity to own land will increase their sense of empowerment and help women to assert themselves more in various pro environmental initiatives. Women play an important role in the management of natural resources, including soil, water, forests, and energy, and often have a profound traditional and contemporary knowledge of the natural world around them. In view of this, the efforts to include women as farm managers will help in creation of a more diverse and talented informed pool having knowledge of environmentally sustainable cropping and planting patterns.

Author contribution All authors contributed to the study conception and design. Material preparation, data collection, and analysis were performed by all the authors together. The first draft of the manuscript was written by SS, and all authors commented on the versions of the manuscript. All authors read and approved the final manuscript.

Data availability All the data that support the findings of the study has been amassed from the open sources and are available from corresponding author on reasonable request.

Declarations

Ethics approval We declare that this manuscript is original, has not been published before, and is not currently being considered for publication elsewhere.

Consent to participate Not applicable.

Consent for publication Not applicable.

Competing interests The authors declare no competing interests.

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