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Analyzing the Influence of Standard of Living on CO_2 Emissions: A Case Study of District Mardan, Khyber Pakhtunkhwa, Pakistan

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Abstract
Households' income is a crucial factor to determine the households' standard of living. Nevertheless, as the standard of living of the households' increases, environment degradation also increases. This study empirically examines the influence of standard of living on CO_2 emissions in district Mardan. It also estimates the influence of other pertinent factors such as household size, household location (rural or urban), and household education level. The study employs primary data of 267 households, descriptive statistics, and regression analysis for the estimation of results. The conclusion of the study shows that with increase in households' income, CO_2 emissions increases as well in the study area. It is also found that there is a positive association between household size, education, and CO_2 emissions. Further, the results of the study reveals that the Environmental Kuznets Curve (EKC) hypothesis is valid in district Mardan. Therefore, the present study suggests formulation of an effective environmental policy that would be conducive to combat CO_2 emissions in the selected District.

Keywords: Household Income, CO_2 emissions, Emission factors, EKC.

1. Introduction

Households' income is a crucial factor to determine the households' standard of living. Their standard of living rise when their income rises (Perry, 2013). It is also commonly known that when people's living standards rise, they increase their food expenses, use more cars, air conditioners, freezers, and other electrical and fuel-consuming equipment and appliances, which in turn results in an increase in the quantity of carbon dioxide emissions (CO_2) into the environment. Similarly, the studies of Li and Wang (2010) and Baiocchi, Minx, and Hubacek (2010) found that besides household income, number of members in a family, urbanization, the age of the primary income producer, and location (urban or rural area) of household where they are located are the major determinants of CO_2 emissions.

The GDP per capita grew from US $631 in 2004 to US $1024 as of 2010.On the other hand, it is estimated that the annual cost of environmental degradation and natural resource depletion will be 365 billion rupees, or around 6% of GDP. Due to this, per-capita emissions surged from 0.84 metric tons in 2004 to 0.93 metric tons in 2010(World Bank, 2014).

In Mardan, a typical Pakistani district, 98% of the households utilized electricity to light their homes in 2013, with little rural-urban variations. While 1% and 2% of the households used gas/oil to light buildings in rural and urban areas respectively. In the same way, in 2013 gas consumption was 92% and 18% in urban and rural areas, respectively, while the consumption of wood/charcoal was 7% and 56% in both areas, respectively. In the Khyber Pakhtunkhwa province, the consumption of gas per person increased from 1422 cubic meters in 2004 to 2494 cubic meters in 2010 (Government of Khyber Pakhtunkhwa, 2014). In the urban areas of District Mardan, 65% of households consumed gas or oil for the purpose of cooking in the year 2006–07, but by 2012–13, that number had risen to 92%. Like urban areas, 9% of the households in rural areas consumed gas or oil for cooking in 2006–07, rising to 18% in 2012–13 (Government of Pakistan, 2014). According to the Government of Khyber Pakhtunkhwa (2014), this District had 115814 registered motor vehicles in total in 2012 compared to 98576 in 2011 (Government of Khyber Pakhtunkhwa (KPK), 2012). Along with these changes, the district's population has grown dramatically as well.

Following these statistics, the current study evaluates environmental degradation (CO_2 emissions) in urban and rural areas of District Mardan, along with the effect of household income and non-income factors on CO_2emissions at the household level. The past attempts have been made to link environmental degradation (carbon dioxide emission) with economic growth. However, there is no study in the literature about the environmental impacts of the standard of living in rural-urban areas using the household's carbon dioxide emissions data in district Mardan. To bridge this gap in the literature, the current study investigates the influence of standard of living on environmental degradation in district Mardan.

2. Material and Methods

2.1 Data

The present study is based on primary data that was gathered via a questionnaire and aims to analyses the influence of standard of living on the environment. The households are chosen randomly to get the required information. The questionnaire asks about the household's consumption of various kinds of energy comprising electricity, firewood, natural gas, liquefied petroleum gas (LPG) cylinders, electrical appliances (such as freezers, refrigerators, fans, air coolers, air conditioners, washing machines, energy savers, bulbs, electric heaters, geysers, irons, vacuum cleaners, televisions, desktop computers, laptop computers, and microwave ovens), fuel (such as gasoline and compressed natural gas (CNG)) used in personal vehicles, and other energy sources (car and motorcycle). In addition, the survey also asks about the socioeconomic and demographic characteristics of the household comprising of family size, household income, location (rural or urban), the education of the household's main income earning member and the household wastes.

In 2014, there were 330,544 households, according to estimates (Government of Khyber Pakhtunkhwa, 2014). The required sample size is 267 households, as determined by a survey sample calculator provided by a "Survey System," while keeping a confidence interval of 6% and a confidence level of 95%. The sample is proportionately divided among the Takhtabhai and Mardan sub-districts. As a result, each sample comprised 193 and 74 households, respectively. Furthermore, in each sub-district, the sample size is allocated proportionally between rural and urban areas. As a result, the estimated sample sizes for sub-districts Mardan's urban and rural areas are 45 and 148 households, respectively. While there were 9 and 65 houses, respectively, in sub-districts Takhtabhai's urban and rural areas. Randomly chosen respondents came from both the urban and rural areas of the two sub-districts.

The present study uses household income to gauge standard of living of households (Government of New Zealand, 2007;Feng, Zou, and Wei, 2011; Buchs and Schnepf, 2013; OECD, (2013; Perry, 2013). Besides income, we also estimate the effects of other variables on environment comprising the numbers of persons in a family (household size), the location of residence of household (rural or urban) and the education of the leading income provider in a household. The data for carbon dioxide emission is not available at household level. So, the present study follows the earlier studies of Zhao and Cui (2013),Kavi and Viswanathan (2013) and Carbon Neutral Company (2014) to compute carbon dioxide emission from the household consumption of various kinds of energy and household appliances via carbon emission factors. The conversion method is specified in equation 1 as:

$$CO_{2e}^{hh} = \sum C_i * EF_i \tag{1}$$

Where CO_{2e}^{hh} is carbon dioxide emissions of the household, $C_i$isi^{th} the consumption of various types of energy, which are discussed above. While EF_i show the carbon dioxide CO_2 emission factors of the i^{th}energy. The CO_2 emission factors for thei^{th}consumption of various types of energy are given in Appendix-1.

2.2 Econometric Model

The present study employs regression analysis to estimate the link between standard of living, other socioeconomic factors, demographic factors, and the environment (carbon dioxide emissions). The regression model is specified as follows:

$$lnCO_{2ei}^{hh} = \beta_0 + \beta_1 Y_{ih} + \beta_2 Y_{ih}^2 + \beta_3 HS_i + \beta_4 HS_i * Y_{ih} + \beta_5 ED_i + \beta_6 ED_i * Y_{ih} + \mu_i \tag{2}$$

Where the subscript i represent the i^{th} household and μ is the error term. The detail description of the model variables is given in Table 1.

Table 1: The Description of the Variables

Variables	Description	Expected Sign
CO_{2ei}^{hh}	Household carbon dioxide emissions	Na
Y	Income of the Household	+
Y^2	Squared term of household income	-
HZ	Household size (number of members in family)	+
HZ*Y	Interaction term of households' size and households 'income	+
ED	Education of the main income provider in a household	-
ED*Y	Interaction term of education and income	-

The model is first estimated for the entire district Mardan, and henceforth for rural and urban households' respectively.

3. Results and Discussions

The descriptive statistics of the study variables are shown in Table 2. These results depict that in urban areas, the usage of refrigerator, freezer and air conditioner results in higher CO_2 emissions. This infers that urban households follows an energy-intensive lifestyle that as a profound adverse impact on the environment. Similarly, using personal vehicles produces more CO_2 emissions. This is because the majority of households have personal transportation available to them.

Table 2: Average Income of Households and CO_2 Emissions in District Mardan

Variables	Unit	Urban	Rural
Household Income per month	PKRs.	66727.300	46285.211
Household size	Number	5.722	6.671
Education of the main income provider	Years	12.056	11.427
CO_2 Emissions of Household (kgs)/month			
Sui Gas	kg CO_2e	0.842	0.734
Firewood	kg CO_2e	15.748	164.645
LPG	kg CO_2e	4.892	13.035
Personal Transport	kg CO_2e	68.997	535.769
Waste	kg CO_2e	8.639	17.431
Electrical Appliances			
Fans	kg CO_2e	16.726	38.689
Air Conditioner	kg CO_2e	129.016	106.951
Air Cooler	kg CO_2e	18.180	19.358
Energy Saver	kg CO_2e	7.357	6.522
Bulb	kg CO_2e	25.629	37.706
Washing Machine	kg CO_2e	1.559	2.506
Refrigerator	kg CO_2e	96.582	96.810
Freezer	kg CO_2e	123.082	64.773
Television	kg CO_2e	15.768	22.554
Iron	kg CO_2e	8.759	8.301
Vacuum Cleaner	kg CO_2e	6.993	37.297
Geyser	kg CO_2e	75.528	54.703
Electric Heater	kg CO_2e	55.158	31.648
Computer	kg CO_2e	13.203	20.975
Laptop	kg CO_2e	12.110	10.949
Microwave oven	kg CO_2e	46.000	44.757

Source: Authors' computations

On the other hand, compared to the urban areas of district Mardan, using personal transportation causes the largest CO_2 emissions. This occurs because rural residents are located far off various amenities including schools, universities, hospitals, and other facilities that are found in urban areas. As a result, majority of people have personal vehicles at home for easy access to these amenities. The adverse environmental impacts of firewood are also higher. It is also evident from Table 2 that such adverse environmental impacts of firewood are profound in rural as compares to urban areas due to lack of access and provision of Sui gas facility to rural areas. Apart from firewood emissions, large household size in rural area is also responsible for higher average CO_2 emissions of waste as compared to the urban areas. Further, the descriptive analysis reveals that Sui gas results in the lowest CO_2 emissions.

Estimated results of the regression model are reported in Table 3. There are three different specifications in this Table 3. First specification shows estimated regression results for the whole district Mardan. Whereas second and third specifications describes regression results for urban and rural areas respectively.

First, we discuss the estimated results for the whole district Mardan. In the first specification, the coefficient of household income is positive. The positive coefficient of household income depicts that as household income increase; it triggers CO_2 emissions as well. Such findings of positive and significant association between income and CO_2 emissions are in confirmation with the results ofNair, Bhatia, and Chandrakar (2019), Wang, Cardon, Liu, and Madni (2020) and Osadume (2021). The coefficient of the squared term of household income is negative and significant. Such negative coefficient of the squared term of household income implies an inverted U-shaped association between income of the households and CO_2 emissions. This reveals that as households' income rises, so does environmental degradation. However, after reaching a certain level of income they start to prefer environmental improvement. These findings support the existence of EKC hypothesis at household level in district Mardan.

The result of positive coefficient for household size are well in line with those of Wu, Liu, and Tang (2012), Olaniyan, Sulaimon, and Ademola (2018), and Nair et al. (2019). However, such results contrast with the findings of Li and Wang (2010). The positive coefficient household size indicates that large households consume more energy such, electricity, sui

gas, firewood, and electrical appliances which results in higher CO_2 emissions. While the interaction term of income, and household size yields a negative and statistically significant coefficient.
The positive coefficient of education reveals the fact that as households gets more and more education, they achieve a higher standard of living and adopt a more carbon-intensive lifestyle and consumption pattern. Such carbon-intensive lifestyle exerts a profound negative influence on the environment and results in higher CO_2 emissions. These findings contrast with the results of Baiocchi et al. (2010) but are in line with those of Ahmad, Baiocchi, and Creutzig (2015) and Olaniyan et al. (2018).

Table 3: Regression Results of the Impact of Household Income on CO_2 Emissions

Variables	(i) Coefficients	(ii) Coefficients	(iii) Coefficients
Income	0.0000177*** (0.00000478)	0.0000173** (0.00000773)	0.0000152** (0.00000682)
Income^2	-0.00000000002** (0.00000000000868)	0.0000000000019 (0.0000000000213)	-0.000000000036*** (0.0000000000113)
Household size	0.1304098*** (0.0274463)	0.120808** (0.0477284)	0.1278079*** (0.0339542)
Income*Household size	-0.00000105** (0.000000351)	-0.00000121** (0.000000537)	-0.00000081* (0.000000474)
Education	0.0261412* (0.0139536)	0.0472491** (0.0241272)	0.000293 (0.015955)
Income*Education	-0.000000401** (0.000000189)	-0.000000688* (0.000000383)	-0.0000000973 (0.000000231)
Constant	5.636288*** (0.3004329)	5.718356*** (0.441574)	5.803158*** (0.358966)
R^2	0.1371	0.0825	0.1822
F-Statistics	10.220	2.730	7.650
Probability F-Statistics	0.00000	0.01460	0.00000

Note: ***, **, and * shows 1%, 5% and 10% level of significance, respectively.

The interaction term of income is negatively related to education and statistically significant which is also in line with the findings of Grunewald, Harteisen, Lay, Minx, and Renner (2012).
The second specification in Table 3 compiled estimated results for urban areas of district Mardan. The results show that households' income carries a positive and significant coefficient in urban areas as well. These results are in line with those of Aye and Edoja (2017), Liu et al. (2020) andKhan, Khan, and Rehan (2020). Similarly, the squared term of household income also has a positive coefficient in urban areas of district Mardan. However, since its coefficient is insignificant, the Environmental Kuznets curve (EKC) hypothesis cannot be applicable to the urban areas of the Mardan district. This conclusion is consistent with that reported by Kavi and Viswanathan (2013). This is attributed to the fact that a large proportion of urban households continue to live carbon-intensive lifestyles, which limits the link between income and CO_2 emissions at the EKC's upward slope and prevents it from plunging downward. The coefficient of household size is found positive and statistically significant. In urban regions, the interaction term of income and household size is likewise negative and statistically significant, indicating that higher income household and larger household size contribute to lower CO_2 emissions. For the reason that when a family's wealth grows, they seek to prefer cleaner environment. In urban areas, the education coefficient is both positive and statistically significant. By the same token, in urban regions, the coefficient of interaction term of household income and education is negative and substantial.
The third specification in Table 3 compiled estimated results for rural areas, as expected the coefficients of income and the squared term of household income are positive and statistically significant. This suggests an inverted U-shaped link between income and CO_2 emissions, demonstrating the efficacy of the EKC hypothesis in district Mardan's rural areas. The estimated coefficient of household size in rural areas is also found positive and statistically significant. The income-household-size interaction term displays a negative and significant coefficient. In rural areas, the education coefficient is positive but insignificant. The coefficient of the income-education interaction term is found negative and statistically insignificant. In collaboration, education and the interaction term of income and education are statistically insignificant. This shows that households in rural areas are less educated which results in a lower social status, less energy intensive lifestyle and, therefore, contributing to a lower level of CO_2 emissions.

4. Conclusion and Policy Recommendations

This study investigates the influence of standard of living on environmental deterioration. The presents study employs multiple regression analysis to empirically assess the relationship between standard of living and environmental degradation. The main economic variables in this study includes household income, size of the household and level of education. The estimated results of the study show that improvement in standard of living increases households CO_2 emissions. Households size and level of education also revealed a positive and significant impact on CO_2 emissions in district Mardan. According to the findings of the current study, households must be conscious of the environmental consequences of their spending decisions and everyday activities in order to maintain a sustainable standard of living. Public campaigns and the media can be used to accomplish this objective. Incentives should be provided to consumers to select energy-efficient appliances. Such incentives can be provided to the consumers in various forms such as tax cutbacks for recompensing them to choose energy efficient products.

Credit author statement

Asma Saeed and Khadim Hussain: Conceptualization, Methodology, Formal analysis, Software, Data curation, Writing-original draft preparation. Sabahat Akram: writing-review & editing, Variable Construction, Visualization, References.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix-1

Conversion Method of Households' Energy Consumption into CO_2 Emissions

Categories of the Households' Energy Consumption	Formula
Electricity	$\frac{Emissions(kgCO_{2e})}{Month} = \frac{Average\ Use\ of\ Electricity}{Month} * EF\ (\frac{kgCO_{2e}}{kwh})$
Electrical Appliances	$Daily\ (kWh)\ consumption\ of\ electricity\ by\ the\ appliance = (Wattage\ of\ the\ appliance * average\ hourly\ usage\ per\ Day) \div 1000$ $1\ kilowatt\ (kW) = 1{,}000\ Watts$ $\frac{Emissions(kgCO_{2e})}{Month} = Daily\ Kilowatt\ hour\ (kWh)\ consumption * 30 * Electricity\ EF\ (\frac{kgCO_{2e}}{kwh})$
Natural Gas	$\frac{Emissions(kgCO_{2e})}{Month} = \frac{Average\ use\ of\ natural\ gas\ (kwh)}{Month} * EF\ (\frac{kgCO_{2e}}{kwh})$
Personal Transportation	$\frac{Emissions(kgCO_{2e})}{Month} = \frac{Average\ use\ of\ fuel\ (Litre)}{Month} * EF (\frac{kg\ CO2_{2e}}{litre})$
Waste	$\frac{Emissions(kgCO_{2e})}{Month} = \frac{Average\ waste\ (kg)\ produced}{week} * 4 * EF (\frac{kg\ CO2_{2e}}{kg\ waste})$
Firewood	$\frac{Emissions(kgCO_{2e})}{Month} = \frac{Average\ use\ of\ firewood(kg)}{Month} * EF (\frac{kgCO_{2e}}{kg\ firewood})$
LPG	$\frac{Emissions(kgCO_{2e})}{Month} = \frac{Average\ use\ of\ LPG\ (kg)}{Month} * \frac{EF(kgCO_{2e}}{kg\ LPG})$