Economic Development and CO_2 Emissions: A Household Level Study of Lucknow District in Uttar Pradesh

ABSTRACT
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1.1 The Context

Climate change is a global issue which is increasingly being manifested in the form of frequent natural disasters, melting glaciers, extremely varying rainfall patterns and increasing global temperatures[1]. It is a scientific phenomenon induced due to increasing concentrations of greenhouse gases which obstruct the path of infrared rays radiated back by the earth's surface. Rapid economic growth regardless of its resultant environmental impact is the main culprit of climate change (Hegerl 2007: 727). Various assessment reports of IPCC have increasingly emphasized on the role of humans in climate change (Table 1.1)

Table 1.1: IPCC's Attribution of Drivers of Climate Change

Sl. No.	IPCC Assessment Report	Attribution of global warming to human activities
1	IPCC (1992: 6)	"Largely due to natural variability and **little** due to human activities"
2	IPCC (1995: 4)	"**Largely** due to human activities"
3	IPCC (2001: 51)	"**Consistent** evidence for an anthropogenic signal in the climate record of the last 35 to 50 years"
4	IPCC (2007: 39)	"**Very likely** due to the observed increase in anthropogenic GHG concentrations"
5	IPCC (2014: 5)	"**Extremely likely** …… caused by the anthropogenic increase in GHG concentrations and other anthropogenic forcings together"

The rationality of economic growth and its relationship with environment has been a matter of research for over a century now. However, no consensus has been reached till date on this issue. A very common view is that economic growth leads to environmental pollution. Contradicting the earlier view, the Environment Kuznet's Curve (EKC) hypothesis, suggests that economic growth itself leads to improvement in environment quality, once a threshold

[1] https://www.climate.gov/news-features/understanding-climate/climate-change-glacier-mass-balance

level of income per capita is reached (Grossman and Krueger 1995: 353-377). Another dominant view emerged with the publication of '*The Limits to Growth'* by Meadows et al (1972: 17-185). Its central idea was that the 'earth is finite' and over- pollution will lead to the collapse of the economy itself. Yet another view is that pollution abatement will lead to loss in economic growth.

Hussen (2013: 192) classifies these economic thoughts into three broad categories viz. the 'business as usual (BAU)' approach, the 'gradualist' approach and the 'precautionary' approach. The believers of BAU approach argue that the abatement costs of climate change are way too much, largely ignoring the damage cost of climate change (ibid: 192-193). Gradualists, on the other hand, follow a balanced approach by considering both damage costs and abatement costs in cost benefit analysis (ibid: 194). Unlike the gradualists, the believers of precautionary approach take a strict stand on actions needed to mitigate climate change.

Earlier, most of the environmental policies targeted the supply side for reduction in emissions, but with increasing research on the role of households in GHG emissions, the demand side approach is gaining more and more attention (Kok et al 2006: 2744). The demand side must be held equally accountable for its environmental impact.

1.2 Demand Side Carbon Emissions: Household Carbon Emissions

Households play an extremely crucial role in the GHG emissions by their consumption activities (Zhang et al 2015b: 874). Rapid urbanization-led increasing living standard has resulted into increased household energy consumption. The GHG emissions by households can be categorized as direct and indirect emissions. Direct or on-site emissions are related to direct household fuel use, such as electricity, heating, gas and other liquids. While, the embedded/embodied/indirect emissions, are those that are generated in the production and distribution processes of goods and services for households, such as emissions that occur in

the manufacturing of food, clothes, furniture and services (Zhang et al 2015b: 874; Druckman and Jackson 2016: 185).The direct and indirect household carbon emissions together are responsible for 60% to 80% of a country's total greenhouse gas emissions (Edgar et al 2009: 6417; Benders et al. 2006: 3612).

In China, a large number of studies have been carried out on this issue (Wang et al. 2015: 257-272; Zheng et al. 2011: 761-792). The direct and indirect CO2 emissions from household consumption accounted for more than 40% of total carbon emissions from primary energy utilization in China during 1992-2007 (Liu et al 2011: 1758).

Das and Paul (2014: 90-103) studied the CO_2 emissions from household consumption in India between 1993–94 and 2006–07 using input-output analysis. CO_2 emissions were found to have increased by 86% during this period. During 1993–94 and 2006–07, direct emissions from households have increased from usage of primary energy (6%) and secondary energy (171%). Rapid urbanization and changing lifestyles influenced the substitution of coal with diesel and electricity. Both Liquefied Petroleum Gas and electricity were being used for cooking. Increasing number of private vehicles led to rise in usage of petrol/motor gasoline for transport. Electricity usage for home illumination and entertainment has also gone up during this period. The study observed a switch towards cleaner energy sources. The results for indirect emissions from household consumption reveal that maximum increases have been brought about by consumption of "transport" (21%), followed by "food, beverage, tobacco and primary goods" (20%), "recreation" (12%) services, house building (5%) and other personal services (4%) followed next with lower increase in emissions.

Ahmad et al. (2015: 11312-11318) used the micro-data of 60 largest cities of India to map the direct energy use of urban households in India and their GHG emission pattern and its determinants. The study found that income, access to electricity, and education level are

driving forces of emissions, while emissions reduced with household size and population density.

Zhang et al. (2015b: 877-879) identified seven major factors influencing the household carbon emissions, including household income, size, age structure, gender of the head, education, location and rebound effects.

1.3 Research Gap and Significance of the Study

After review of literature, the following research gaps have been observed. Firstly, the issue of climate change is well researched in physical sciences. However, studies on its socio-economic costs and appropriate mitigation policies are still in a novice phase. Most research has concentrated on uncertainties about the natural sciences (climate modelling and carbon cycle).

Secondly, maintaining an inventory of GHG emissions is a fundamental building block in a country's climate policy. However, there is no up-to-date stock of carbon emissions data at decentralized level in India at present (India's Second Biennial Update Report to UNFCCC (2018: 14)

Third is the geographical gap. The researches on estimation of carbon cost and emissions have largely been limited to China, US and UK. Attention in this area is needed in India as well, as India is the fourth largest emitter of GHG in the world.

Fourthly, as consumers are the major target group of the carbon emission reduction drive. More studies are needed to assess people's willingness to reduce their emissions, in view of their varying locations, income levels, education level, etc.

Lastly, the rise of fossil fuel led CO_2 emissions in 2018 was mainly driven by higher energy demand (Fawzy et al 2020: 2070). As the current global climate mitigation policy is

primarily focused upon supply side approaches of reducing emissions, which are very cost intensive and difficult to implement for developing nations, it is important to see demand side policies as a potential alterative.

Based on the above research gap, following objectives and hypotheses are formulated for the present study.

1.4 Objectives of the Study

- To assess the linkages of economic growth with various social, demographic and environmental factors among top twenty CO_2 emitting countries in the world during the period 1960-2017.
- To assess the extent of residential energy consumption, CO_2 emissions and their monetary value and the socio-economic factors impacting on total residential emissions in 22 major states in India for the year 2018-19.
- To estimate the total CO_2 emission by household fuel consumption and its economic value and the impact of socio-economic factors on the annual direct carbon emissions from households in Lucknow city.
- To estimate the extent and dimension of environment awareness, community participation and willingness to sacrifice in Lucknow city.

1.5 Hypotheses of the Study

- The socio-economic factors (population and per capita GDP) affect the level of CO_2 emissions in the top twenty CO_2 emitting nations.
- Per capita gross state domestic product and population density have positive and negative relationship respectively with the state's CO_2 emissions.
- Households with higher income tend to emit more CO_2 as compared to households with lower income level.

- Household's environmental awareness does not ensure its environment-friendly actions.

1.6 Methodology

1.6.1 Data Source and Study Area

In the present study both secondary and primary level data has been used. Numerous volumes of secondary data are taken from World Bank, Maddison Project Database version 2018, Ministry of Statistics and Programme Implementation, Census 2011, Statistical Diary Uttar Pradesh 2017, etc. An international level study is undertaken, including top twenty CO_2 emitting nations for the period from 1960 to 2017. A national level study comprising of major 22 states of India is carried out for the year 2018-19. State wise CO_2 emissions by the households and their monetary values are also estimated. Lastly, a primary study is carried out in the city of Lucknow.

Lucknow city in Uttar Pradesh has been selected as study area. Ghoshal and Bhattacharya (2008: 41-73) found Uttar Pradesh to be the leading CO_2 emitting state in the country during the period from 1980 to 2000, followed by Madhya Pradesh and Maharashtra. GHG Platform-India (2017) analyzed GHG Emissions in India from 2005 to 2013 and found maximum overall emissions to arise from the states of Uttar Pradesh, Andhra Pradesh, Maharashtra, Gujarat, and Odisha in 2013. Garg et al (2017: 117) found UP, Maharashtra and Andhra Pradesh to be top three CO2 emitting states in the country in the year 2013. Uttar Pradesh is a state in northern India. It is the most populated state of India with fourth largest GSDP (constant 2011-12 prices) as of 2018-19. As of August 2020, Uttar Pradesh accounts for sixth largest installed capacity of power stations (7% of all India installed capacity), of which 79% is contributed by coal, 12% by renewable energy sources, 5% by gas, 1.7% by

hydropower and 1.5% by nuclear energy[2]. As of 31st March 2016, Uttar Pradesh had third largest number of registered motor vehicles (10% of total) in India (Appendix Table 1.2A). Lucknow district is the state head quarter of Uttar Pradesh. As of 2017, Lucknow city has the highest number of registered motor vehicles (19.78 Lakh) in Uttar Pradesh (Road Transport Year Book 2019: 18). Further, as of March 2019, Lucknow city has the largest number of electricity consumers (9.9 Lakh) and third highest connected load (2763 MW) in UP (UPPCL, Statistics 2018-19: 139-140). Also, it is one of the top 10 most polluted cities in the world.[3]

1.6.2 Sampling Method and Size

In order to select a representative sample for the study, Multi-Stage Sampling Method is used for selecting area and households for data collection. In the first stage, Lucknow district is selected based on the above mentioned reasons (provide the justification above). In the second stage, Lucknow tehsil is selected (provide the reasons). In the third stage, all the zones are covered based on proportionate sampling method, i.e., sample size in each zone is proportion to the total population of respective zone. In the last stage, systematic sampling method is adopted to capture the household in the specific ward/locality (which is selected randomly).

For estimating the sample size, Cochran (1977) and Yamane (1967) method has been used. According to UN World Population Prospects, the estimated population of Lucknow in 2020 approximately 3.6 million. Taking the average household size to be 5 persons per household (from census 2011), the number of households in Lucknow in 2020 is estimated to be 6.6 lakhs.

[2] https://npp.gov.in/publishedReports
[3] https://www.iqair.com/world-most-polluted-cities

- Cochran's formula (1977) when population size is finite:

$$n = \frac{n_0}{1 + \frac{(n_0 - 1)}{N}}$$

Where, n is the required sample size, n_0 is the sample size derived from Cochran's formula of sample size for unknown population and N is the total population.

- Yamane (1967:886) suggested the following formula:

$$n = N/(1 + N(e^2))$$

Where e is the margin of error and N is the population size.

Table 1.2: Estimation of Sample Size

Cochran's method (95% confidence)	Population Size	Error Margin	Sample size	Yamane's Method (95% confidence)	Population Size	Error Margin	Sample size
	Unknown	5%	385		6.6 lakh	5%	400
	6.6 lakh	5%	385		6.6 lakh	6%	278
	6.6 lakh	6%	267				

Source: Self estimation

Considering the results of Table 1.5 and other practical difficulties for primary data collection, a sample size of 270 households is taken to be appropriate for this study.

1.6.3 Statistical Techniques and Model

The secondary data have been statistically processed using STATA 13 version. Mean, Standard Deviations and Compounded annual growth rate (CAGR) have been used. Fully Modified OLS (FMOLS) and dynamic OLS (DOLS) panel data regression has also been carried out. Further, in order to estimate CO_2 emissions, emission coefficient method (Tier-2) has been used. ANCOVA model has been used for the analysis. Lastly, index method based on Principal Component Analysis (PCA) based weighting approach has been utilized.

1.7 Organization of the Thesis

The thesis has been divided into seven chapters. The first chapter titled **Economic Development and Environment: Debate and Methods,** which is the background of the study comprises of the general introduction, context of economic growth and environment debate and the relevance of CO2 in mitigating climate change by literature review. The chapter brings out the organization of the research report including the research gap and its significance, objectives, hypotheses, and methodological framework of the study.

Chapter two, titled **Economics of Climate Change: A Theoretical Background** traces the origin of climate change and environmental issues in economic theory. The purpose of the chapter is to present the contemporary climate change debate and validate the objectives of the present study.

Chapter three titled **Economic growth and Carbon Emissions: A Global Scenario** gives the global picture of economic growth and carbon emissions tracing the history since the industrial revolution based on secondary data. It further presents the inter-linkages of socio-economic and demographic variables and CO2 emissions in the top twenty CO2 emitting countries of the world.

Chapter four titled **State-wise Domestic Energy Consumption and CO2 Emissions Scenario in India,** studies the energy consumption and CO2 emission trends in 22 major states of India and analyses the various socio-economic factors affecting them based on secondary data.

Chapter five titled **Assessment of Direct Household Carbon Emissions in Lucknow City,** deals with the analysis of primary data collected from the field survey. The chapter presents socio-economic profile of the surveyed households. Lastly, their energy consumption behavior and consequent CO2 emissions are analyzed.

Chapter six titled **Impact of Environmental Awareness, Social and Personal Norms and Willingness to Sacrifice on Environmental Pollution,** presents the role of socio-economic along with psychological factors in causing as well as mitigating climate change. Based on survey data, an environment awareness index is constructed and analyzed.

Chapter seven titled, **Major Findings and Conclusions,** includes the key findings and conclusions to the objectives of the thesis and also provide relevant suggestion and recommendation based on the results and finding of the research.

1.8 Summary and Major Findings of the Study

Chapter 1 titled as **"Economic Development and Environment: Debate and Methods"** explores the environment-economy linkages, the reasons behind the focus on CO_2 in the climate change debate, sectoral contributions of CO_2 emissions more specifically households' CO_2 emissions at global and national level, and their measurement methods. Based on the review of existing literature, few important observations are as follows. Firstly, despite being accepted as a challenge for humanity by a large number of experts, climate change is still not unanimously accepted as a real problem by everyone. Second, nearly all government reports show that the energy sector is responsible for the highest share of emissions via electricity and heat production. As of 2015, heat and electricity production accounted for 41% of global CO_2 emissions, followed by transport (24%), industries (20%) and residential sector (6%)[4]. The residential sector emissions here, include emissions from electricity usage and cooking fuel usage. While households actually emit much more, given their personal vehicle usage, public transport and consumption of various goods and services like clothes, food, entertainment, cosmetics, etc. Third, income of the household is observed to be most important factor in determining the household's CO_2 emissions. Other relevant factors are the

[4] https://www.iea.org/subscribe-to-data-services/co2-emissions-statistics

household size and urbanization. Fourth, Uttar Pradesh is found to be a leading contributor to CO_2 emissions as well as the most vulnerable state to climate change. Thus, there is a need to focus on the role of households in causing emissions as well as in mitigating it. Therefore, using the emission coefficient method, the present study estimates the direct CO_2 emissions by the households via electricity consumption, cooking fuel and personal vehicle usage. The estimation of indirect emissions requires the availability of secondary-level data. Given the limited data availability at decentralized level and primary nature on the study, the estimation has been limited to direct household emissions only. Further, household level survey is conducted comprising 270 sample households in the city of Lucknow to capture various dimensions of CO_2 emissions.

Chapter 2 entitled, **"Economics of Climate Change: A Theoretical Background"** traces the origin of climate change and environmental issues in economic theory. The debate on scientific and economic background of climate change is covered. The issue of environment and economics can be traced back to the origin of economic theory itself. First, beginning with the classical economists, Malthus and Ricardo suggested the 'limits to growth approach', i.e., the inability of the economy to grow infinitely due to limited natural resources. Whereas, Neo-Malthusians believed excess population, huge income and technology to be the prime culprit behind environmental damage. The Neo-classical school of thought however, believed that environment and economy work in coordination with each other. But, after witnessing the two world wars and the great economic depression, the debate on economic growth changed drastically, giving way to the concept of sustainable economic development. Later, years of intellectual discourse led to the emergence of sustainability debate which talked about inter-generational inequality in resource consumption and with the beginning of 21st century, economists agreed to the fact that climate change is real but differed on the degree of its seriousness. Hussen (2013: 192) classifies these economic

thoughts into three broad categories viz. the 'business as usual (BAU)' approach, the 'gradualist' approach and the 'precautionary' approach. The believers of BAU approach argue that the abatement costs of climate change are too much, largely ignoring the damage cost of climate change (ibid: 192-193). Gradualists, on the other hand, follow a balanced approach by considering both damage costs and abatement costs in cost benefit analysis (Hussen 2013: 194). Unlike the gradualists, the believers of precautionary approach take a strict stand on actions needed to mitigate climate change. Second, Economists view climate change as a market failure problem caused by the negative externalities of human activities, considering climate to be a common property resource. An equilibrium in this situation can occur at a point where marginal damage cost equals the marginal control cost. A number of models referred to as Integrated Assessment Models and a number of approaches viz. economic, non-economic and legal approaches have been developed to analyze and solve the problem of climate change. Thus, the discipline of economics and environment is deeply connected with each other and economic solutions may help to mitigate the phenomenon of climate change. Lastly, India's stand on climate change issue has transitioned from being the leader of 'climate justice' debate, urging developed nations to pay for their historical emissions, to being a climate responsible nation pledging to improve the emissions intensity of its GDP by 33 to 35 per cent by 2030 below 2005 levels and being the only nation to have 2^0 C compatible targets (Climate Transparency Report 2020: 23).

The third chapter, **"Economic Growth and Carbon Emissions: A Global Scenario"** presents the inter-linkages of socio-economic and demographic variables with CO_2 emissions in the top twenty CO_2 emitting countries of the world. The economic growth and environmental history of the twenty nations are traced since 1000 AD till the 21st century, divided into four phases. Following observations are made from this chapter. First, for the entire period from 1000 to 1820 A.D., India and China together accounted for nearly half of

the world's population and over 45% of the world's GDP, with India being ahead of China in terms of GDP till 1700 AD. Western powers were far behind India and China in terms of total GDP. However, in per capita GDP terms, India and China lagged behind owing to their large population. The landmark event which occurred in the late 18th century in Britain, i.e., the Industrial Revolution, marked the beginning of a new era called as 'the Anthropocene Era'. Up to 1785, United Kingdom was responsible for 100% of the global CO_2 emissions. Later, France, Germany and Poland joined in the process of industrial revolution. Second, during the period from 1820 to 1960, the Western world flourished. Asia and Africa observed meager growth in this period. Post World War-II, USA emerged as the largest economy. The top four economies, viz., USA, UK, France and Germany, which had 12% of the world's population, accounted for nearly 43% of the global GDP. USA by 1950 turned out to be the largest emitter, contributing to over 43% of CO_2 emissions of the world. The energy consumption doubled over nineteenth century sourced mainly by coal. Third, a rapid increase in global CO_2 emissions is observed after 1950s. World population increased by more than three times in the last seven decades. Global average life expectancy increased from 46 years in 1950 to over 71 years by 2015. Also, in the post-world war era also the global urban population increased from nearly 29% of world population in 1950 to more than 50% in 2015 and touched to 56% in 2020. After late 1980s, the developing nations like India, China, Russia, Brazil and Indonesia emerged as new growth centers. Fourth, between 1960 and 2018, the share of CO_2 emissions and GDP of China increased most rapidly in this period, while that of USA declined by nearly half. Saudi Arabia and South Korea depict massive rise in per capita emissions by nearly 19 times and 12 times respectively. Fifth, other than the socio-economic and demographic factors, the shift to service sector economy in majority of the 22 nations and decline in the use of non-renewable energy sources has also impacted their emissions. Sixth, population and GDP are found to be the most relevant factors in

determining a nation's CO_2 emissions. Increase in per capita income, literacy rate, gender empowerment, promotion of public health (such as life expectancy, reduction total fertility rate, maternal mortality rate, and child mortality rate) are major targets through economic growth, resulted in heavy pressure on natural resources.

Chapter 4 entitled, **"State-wise Domestic Energy Consumption and CO_2 Emissions Scenario in India"**, explores the extent of residential electricity, cooking and private vehicle induced fuel consumption and the consequent emissions under domestic consumption at state level in India and assesses the impact of population, per capita GSDP and population density on household emissions across major 22 states for the year 2018-19. First, there has been a rapid increase in electricity consumption, with increasing shift to cleaner sources of cooking and lighting in India in both rural and urban regions. Second, people prefer personal transport over public transport, as understood from the fact that non-transport vehicles accounted for the 91.1 % of total registered vehicles in 2016-17. Further, two-wheelers comprise of over 80% of personal vehicles. Third, Maharashtra is the highest CO_2 emitting states from electricity consumption as well as personal vehicle usage, followed by Uttar Pradesh. In case LPG led emissions for cooking purpose, Uttar Pradesh tops the list, with Maharashtra at second rank. Fourth, the direct household emissions are found to account for 60% of the total emissions, which shows that the role of households in CO_2 emissions is extremely significant. Further, Chhattisgarh, Haryana, Punjab, Delhi and Gujarat, due to their high per capita income and greater dependency on coal for power generation, are found to be the top five CO_2 emitting states in terms of per capita direct household CO_2 emissions. Fifth, population and per capita GSDP are observed to have a significant positive relation with CO_2 emissions from electricity consumption, personal vehicle use, LPG use for cooking and total emissions. Population density, on the other hand is observed to have negative but not significant relation with CO_2 emissions from electricity consumption and vehicle usage. While, in case of LPG

emissions, population density is observed to have a significant positive relation. Lastly, the monetary value of total CO_2 emissions from direct HH energy consumption is estimated be nearly 2% (1.7 billion US $) of the average GSDP (88.5 billion US $) of all the major 22 states.

The fifth chapter, **"Assessment of Direct Household Carbon Emissions in Lucknow City"** attempts to analyze the domestic fuel and electricity consumption by the households in Lucknow and their consequent emissions. The following observations are drawn from this chapter. First, large income inequality among the surveyed households is observed. While 25% of the households own 54% of the total income, 75% of the households own only 46% of the total income. Top 6% of the households alone own 22% of total income. Second, in case of electricity consumption, general category households consume highest average electricity. Further, households with own house and joint family households consume much higher electricity as compared to rented households and nuclear households respectively. Third, as the income of the household increases, its average electricity consumption also increases. Fourth, over 95% of the households have light, fan, TV and fridge. While the penetration of AC, geyser and RO is nearly 50-60%. Fifth, electricity consumption is responsible for highest share of CO_2 emissions from the households, followed by LPG consumption and personal vehicle usage. Sixth, as the income of the household increases, its emissions via electricity consumption and personal vehicle use increases, while that from LPG consumption decreases. HH income is found to be the most relevant factor affecting a household's CO_2 emissions. Seventh, per household annual CO_2 emissions is observed to be 6523.3 Kg and the monetary mean value of annual CO_2 emissions by all the HHs is observed to be Rs.11.6 thousand which is approximately 2% of the mean annual income of all the surveyed HHs.

Chapter 6 entitled, **"Impact of Environmental Awareness, Social and Personal Norms and Willingness to Sacrifice on Environmental Pollution"** assess the extent and dimensions of household's awareness on climate change. Nearly all the households (99%) agreed that the pattern of weather and rainfall is visibly changing in last few decades and increasing temperatures are being witnessed. Over 80% of the households believed that climate change is harmful and could feel its side-effects in their day to day lives. In terms of purchasing behavior, 44% of the households kept price as their first priority, while purchasing any vehicle or home appliances. Energy efficiency is yet not a priority for majority of households. Only 14% of the households were concerned about energy efficiency while purchasing home appliances while only 25% of the households are concerned about mileage while purchasing vehicles. This observation suggests that most of the households prefer immediate gains over long run benefits or savings provided by eco-friendly appliances/vehicles. Few of the significant observations are as follows:

First, over 90% of the respondents agree that everyone should contribute to solve the issue of climate change. Nearly 51% of the respondents are ready to do their bit in protecting the environment, irrespective of what others do. 70% of the respondents believe that they still have time to beat climate change. 80% of the respondents express their fear of the consequences of climate change (CC). Over 80% of the respondents agree that they felt a moral duty to protect the environment and were actively aware of the issues of environment. They also agree that humans have no right to modify the environment as per their suitability. Further, 50% to 70% of the respondents agree that their family members, friends, neighbours and other close ones also have a positive attitude towards environmental issues and contribute to environmental protection is any possible way in their day-to-day choices and activities. 24% to 30% of the respondents are unwilling to make any personal sacrifice for environment and believed that their job is more important than environment protection even if it pollutes

the surroundings. Thus, it is observed that majority of the people are concerned towards environmental issues but are not able to do much regarding it due to time and money limitations.

Second, as far as people's willingness to sacrifice is concerned, nearly 80% of the respondents are found to be willing to pay a higher amount to purchase environment friendly products. Further, 88% of the respondents are willing to make life comfort sacrifices for environment protection. However, only 70% of the respondents are ready to pay tax for environment protection. The main reason for this, is the low trust of people in the government on the actual allocation and utilization of the tax revenue. A more detailed analysis shows that only 17% to 27% of the respondents are strongly willing to make any kind of sacrifice for environment.

Third, the less developed zones are observed to be more aware, concerned and willing to sacrifice for environment protection, given their higher vulnerability to climate change due to lack of resources. Lastly, huge gap between environment awareness and action is observed, suggesting that awareness alone will not lead to the adoption of environment friendly practices. Various other factors need to come together to motivate people to come forward to take environment friendly initiatives, such as community participation and other means.

1.9 Policy Recommendations

The findings of the study lead to the following important policy suggestions:

Firstly, in developing nations like India, which are faced with dual challenges of development and environment protection, the focus should be more on the cost-effective climate change mitigation policies, such as, promoting climate friendly daily life practices, encourage the use of energy efficient home appliances, public transport, etc. Secondly, mechanisms need to develop to reward small environment friendly behaviours and to demotivate environment

polluting behaviors. For example, giving certain incentives to people who buy five-star rating appliances or electronic vehicles, using social media platforms to reward individuals, households and companies with lowest footprints, etc. Thirdly, measurement of emissions at state-level, district-level and further in decentralized levels should be done and published at regular intervals. This will help in the easy implementation of policies such as cap-and-trade among states as well as districts. This will also motivate low carbon development and will generate funds for those willing to reduce their emissions. Fourthly, people should be made to involve themselves more in community environment friendly activities like, tree plantation drives, or taking care of local water bodies, parks etc. Such activities should be made compulsory part of school curriculum as well as in higher education institutes and government and private offices too as it is well prevalent in Philippines. Lastly, but most importantly, as zero pollution is neither possible not desirable, none of the above policies should compromise with the basic living amenities required to lead a healthy life.

1.10 Limitations of the Study

There are a few limitations of the present study, which are as follows.

Firstly, only urban households are covered in the study. Emissions from rural households are of different nature and therefore should be studied separately as well. Secondly, along with emissions, households also contribute to creating sinks by maintaining gardens and other activities. This aspect has not been included in the study. Thirdly, only the direct emissions from the households are covered in the study due to limited data availability. Various indirect emissions such as from the household's demand for food, clothing, footwear, cosmetics, entertainment, etc. are not included in the present study. Fourthly, the emissions in case of official and commercial vehicles possessed by a household have not been included in the study. Lastly, few of the important variables such as floor area of the household, vehicle model, emissions from waste disposal, etc. have not been covered in the study.

1.11 Further Scope of the Study

There are very few studies on household emissions, and even fewer studies on household's emission behavior. Further, in case of India, the research is scanty. The residential sector is usually shown to account for a meagre share, as only the emissions from the heat and electricity consumed by the households. Emissions from the use of personal vehicles and indirect emissions via the consumption of various goods and services by the households is not included in it. This emphasis on the supply side emissions and negligence of demand side emissions leads to undermining the role of households in CO_2 emissions. Also, measurement of CO_2 emissions at the most decentralized level is needed. Availability of accurate data will help in policy framing as well as getting benefits of approaches like carbon credit. Thus, a lot more studies on the quantitative as well as qualitative aspects of demand side carbon emissions are required, particularly in developing nations.

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