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Exploring The Nexus Between Energy Consumption & Pollution on Environment Quality and Customer's Health: Evidence from Panel Data Analysis of Developing Nations

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1. Introduction

Energy use and the safety of the country's health have been linked. For instance, a lack of clean, carbon-free air may expose individuals to a range of toxic gases that are emitted during the combustion of fossil fuels, especially in poor countries (Thrassou & Festa, 2023) The usage of too much energy can also have a negative impact on people's health in the form of air pollution, a

shortage of clean water, or inadequate medical services. The burning of fossil fuels increases the dangers to human health, future climate change, and other forms of environmental harm (Sudhir Rana, 2020).

Recent years have seen a thorough examination of energy use. India, which consumed 23% of the world's total energy consumption and 8060 million tonnes of oil equivalent in total in 2021, was without a doubt the world's top primary energy consumer (Chatterjee & Vrontis, 2022). It consumed this amount seven times more than Africa. India continued to produce less coal and oil while importing more of them. The average percentage of environmental air quality across all cities was 78.8%. India's quick economic growth has resulted in serious environmental and energy problems (Yadav & Sinha 2021). The Indian government has been creating energy-use regulations to support sustainable growth.

India now produces the most carbon dioxide emissions worldwide (Wang et al. 2021). The Indian government has established a number of emission reduction goals as part of an aggressive climate change strategy. India said in its INDC given to the UN in 2015 that its CO2 intensity will be reduced by 60-65% from 2005 levels and that its CO2 emissions will peak before 2030 as part of the battle against climate change (Tripathi & Kaur, 2021).

At the 2020 Climate Ambition Summit, India likewise promised a reduction in the carbon intensity of more than 65% from 2005 to 2030 (Bashir & Qureshi, 2022). To assist in achieving these goals, India has put in place several emission reduction policies, but there is still significant pressure to cut carbon emissions. India's use of coal continues to be a key factor in its economic development.

The economy of India is expected to increase consistently going forward. India's energy consumption will increase as the economy's energy requirements do as well. India's attempts to reduce its carbon emissions surely face challenges. The health and well-being of people around the world will be seriously threatened by global warming brought on by CO2 emissions (Watts et al. 2021; Shuai et al. 2019).

Due to their inadequate energy efficiency, lack of robust health infrastructure, and a higher proportion of fossil petroleum usage in their overall energy usage, developing countries face the most acute problems with this issue. Figure 1 shows an increase in the segment of fossil fuels to overall energy consumption in these countries between 1990 and 2020 (Khan & Bhat, 2020). These nations consumed more fossil fuels as a % of entire energy usage in 2020 approximately 90% than the majority of higher-edge developing nations globally.

Figure 1: Fossil Petroleum Usage (% of Entire) in Developing nations
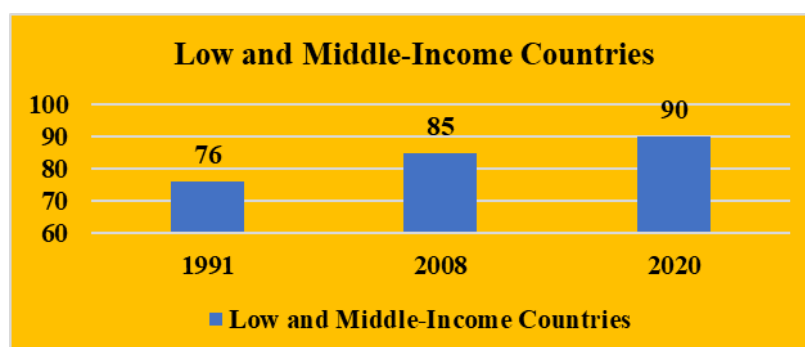
Increased air pollution in these nations is a result of rising fossil fuel consumption. The volume of CO2 discharges per capita in these countries increased from around 2.5MT per capita in 1992 to almost 3.7MT per capita in 2020, according to data gathered and analyzed by the World Bank, demonstrating that over the past 3 eras the problem of air contamination in these countries significantly increased.

Figure 2: CO2 Emissions by Low and Middle-Income Countries
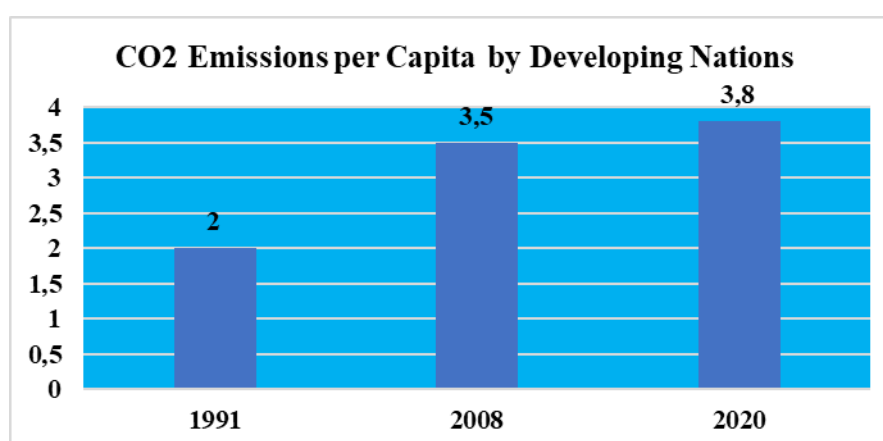
When equated to higher medium revenue earning countries, these nations' high death rates may be mostly attributed to their increased usage of fossil fuels and air pollution emissions. According to a Stanford University study from 2010, CO2 releases are strongly related to and treated as a major cause of human death. Generally speaking, the ensuing air pollution causes an additional 1,000 fatalities and a significant increase in respiratory sickness cases per year throughout the world. Figure 3 shows that between 1991 and 2020, the death proportion in developing nations continued to be greater than it was in higher mid-revenue earning nations.

Figure 3: Low and middle-income countries' mortality rates
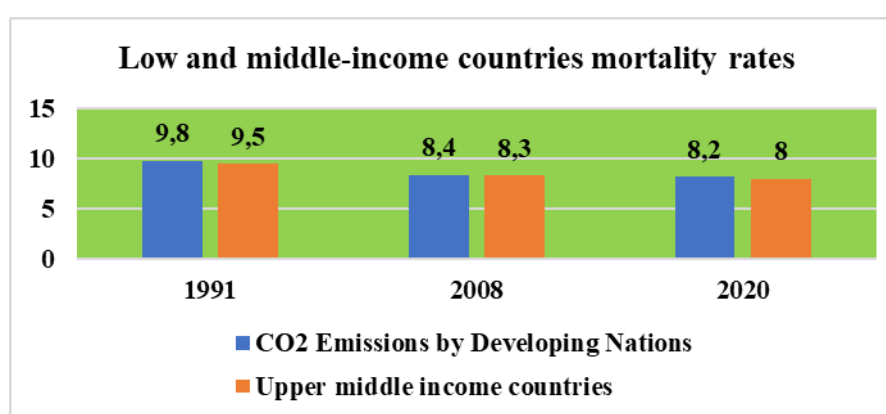
While undergoing a vast literature review, the researchers found that hardly any inclusive research was being conducted emphasizing the association between energy utilization, air pollution, and well-being/health issues in developing Asian nations, despite the few previous studies namely Probert (1987), Akhtar (2015), Bhattarai (2001), Chebbi and Boujelbene (2008), Ghosh (2011), Mayan and Wole-Rafael (2010), and Sohag (2017). The researcher believes that this particular research work will contribute to measuring the damaging impacts of energy usage and air contamination on mankind's overall fitness level in Asia. Thus, it is vital to address the implication of energy unpredictability and its impacts on health, particularly in developing Asian nations.

2. Literature Review

Carbon emissions and energy structure
Although there is currently a substantial amount of research on the factors affecting carbon emissions, this study focuses primarily on the research on the relationship between energy structure and carbon emissions (Chaturvedi & Karri, 2021). Shafiei and Salim (2022) conclude that using renewable energy decreased carbon dioxide emissions while using non-renewable energy increased them based on data from OECD nations between 1980 and 2011. The investigation conducted by Dogan and

Seker (2016) yielded the same findings. Furthermore, Dogan and Seker (2016) thought that there was a causal relationship in both directions between carbon dioxide emissions and renewable energy. The existence of a link between residential energy use and carbon emissions is the second issue of concern.

According to the majority of domestic specialists, different provinces are altering the energy structure in unique ways that will result in "high-carbon" and "low-carbon" scenarios (Bhattacharyya, 2020). According to a study by (Hanysha 2021) the energy consumption structure is a crucial leading and restricting factor determining regional carbon emissions.

Since domestic clean energy consumption is far lower than that of conventional fossil energy use, the growth of clean energy does not significantly reduce carbon dioxide emissions, claim (Ahuja & Pandit, 2020). The analysis of regional heterogeneity also reveals that while carbon dioxide emissions and clean energy are "S-type" in western India, they are "M-type" there. According to Narayan and Doytch's research from 2021, low-carbon clean energy might have a greater exogenous negative impact on economic growth than an endogenous beneficial impact (Nguyen and Kakinaka 2019). According to Chen et al., once the utilization of renewable energy reaches a certain level, the impact of promoting renewable energy on economic growth only becomes obvious (2020).

Carbon emissions, the digital economy, and energy structure

According to the State Internet Information Office, the value contributed by India's digital economy accounts for 36.2% of GDP. Without a doubt, the digital economy has a big impact on every aspect of our lives. According to Miller and Wilsdon (2020), the digital economy is what propels technological advancement and represents a technological revolution. Because of digital technology, the value chain of almost every industry has experienced a profound transformation (Yuan et al. 2021).

The energy system functions safely, efficiently, and with minimal environmental impact thanks to digital technology (Chen 2020). 2021; Soares and Tolmasquim 2000; Rademaker et al.). According to Alam and Murad (2020), using technology more frequently can advance the creation and application of renewable energy. With the help of precise 3D modeling of environmental and geographic factors, digital technology shortens the R&D cycle for renewable energy sources and increases R&D effectiveness (Allam and Jones 2021).

Digital technology is used in the new energy sector in a manner that is comparable to how fossil fuels have traditionally been used. These tools let employees analyze data more precisely, forecast weather patterns, and use renewable energy sources more frequently.

Energy conservation is significantly impacted by the use of digital transportation platforms in industries like smart homes, electrical appliances, and smart autos (Aydin et al. 2018). The dematerialization of human interactions and communication brought about by the digital economy lowers the demand for raw materials and energy (Heiskanen et al. 2021).

Air pollution and health issues-
A variety of gases and particle materials make up air pollution (PMs). To more accurately describe their pathogenicity, the latter are typically categorized according to their size. The most common subgroup of fine PMs that can enter narrow airways and induce toxicity is PM2.5, which has a diameter of 2.5 m. (Dominici et al. 2006).

Air effluence emerging from solid fuels consumed by residential citizens is considered the major reason leading to health risks in Southern Asia (Lim et al. 2012a). The cardiovascular structure, the reproductive arrangement, the endocrine scheme, and the pulmonary organism can all be impacted by high quantities of PMs from anthropogenic sources (Menyan, 2010). The mechanisms causing these effects have been evaluated in several investigations.

They affect cellular and mitochondrial DNA molecules, causing several alterations that ultimately lead to human diseases. Energy insecurity, which results from a lack of access to safe water, can have an impact on human health in addition to air pollution. Water sources may be impacted by energy insecurity due to global warming. Lack of access to clean water can put people at risk for both transmissible and non-communicable infections. Finally, access to conventional healthcare facilities is significantly influenced by the availability of contemporary energy sources. The most susceptible demographic groups are women and children.

Over 290,000 women worldwide may be away each year from pregnancy-related or delivery-related problems, and roughly 35 percent of the entire demises takes place in the Southern part of Asia, according to a WHO factsheet. The majority of these fatalities might be avoided with basic blood transfusion, illumination, and operating services (Mills 2012).

Ambient/Household Air Pollution-
Human health can be impacted by air pollution in several ways. For example, PMs can straightway touch mitochondria, which ultimately leads to cellular metabolism (Pao, 2011). The 2 key rudiments of air contamination that might damage the pulmonary organism are PMs & ozone (UNEP, 2018). The consequence may be either severe pulmonary syndromes or may exacerbate the situation. Past studies had correlated air toxic waste to numerous breathing diseases. To quote a few, longstanding exposure to household air pollution can lead to prolonged obstructive pulmonary ailment, to illustrate, the use of conventional stoves. Second, in children with hyperactive airways, air contamination pointedly donates to the growth of asthma and persistent wheezing (Modi, 2009).

Further, persons suffering from rhinosinusitis might confront deteriorating indications as a result of air contamination (WHO 2018). On the same lines, pneumonia can be carried on by air effluence through flagging the resistant system and power. (Kreyling, Semmler, and Möller 2004). The twofold major components of air contamination that are connected to the cardiovascular structure are particulate matter (PMs) and nitric oxide (NO).

Previous research had proposed a correlation between air contamination and psychological disorders like sorrow/unhappiness & nervousness (Taguchi, 2012). Pasaran (1999) emphasized how inadequate adaptation can be a result of poor indoor air quality. Indoor air effluence, as per Sohag (2017), can influence psychological and emotional reactions in two diverse ways: primarily, by distressing mental effectiveness and by inducing raising heart and breathing rates. The latter could cause a subliminal feeling of tension, terror, or fright.

Moreover, numerous forthcoming studies have observed the association between prolonged air toxic waste exposure and type 2 diabetes mellitus (Andersen 2012; Wang 2014). The added theory emphasizes mitochondrial dysfunction, which fallouts to glucose intolerance (Benavides, 2017). Despite the paucity of information supporting this claim, the data that is now available identifies air contamination as a threat element for type 2 diabetes mellitus. The investigation has revealed that exposure to air effluence upsurges the danger of evolving cancer. Undoubtedly, exposure to air contamination positions almost all organs at risk.

According to the research done by Fetterman, Sammy, and Ballinger (2017), air contamination is the main issue in the growth of cancers. For this connotation, abundant devices have been put forth in the literature. It is vital to primarily describe the most significant organ of human cells, the mitochondria, to understand how air contamination contributes to and plays the role of a carcinogen. These serve as the main controllers of cellular breakdown.

Moreover, they play a key role in organizing the biochemical pathways within the cell. ROSs affect cellular mitochondrial activity, which links air pollution to cancer (Fetterman, Sammy, and Ballinger 2017). By limiting genomic stability, ROSs that target mitochondria may lead to the emergence of cancer (Ishikawa et al. 2008).

Gametogenesis in both males and females is susceptible to this effect. The amount or quality of gametes can be impacted by a variety of air pollution factors. Additionally, they may impair embryonic growth, resulting in a higher chance of miscarriage. Four hypothesized pathways for air pollution-induced reproductive diseases are universal oxidative trauma, hormonal disorder, genetic and epigenetic idiosyncrasies, and genetic and epigenetic alterations (Carre 2017). Given how air contamination affects gametes' genetic and epigenetic characteristics, adverse consequences on embryonic development are to be predicted. Numerous studies have made an effort to investigate this connection. For example, the impact of air contamination on low birth weight has been noted by Pederson et al. (2013).

Additionally, Shades-Gonzales et al. (2015) observed that perinatal exposure to PMs, NO2, and PAHs had a detrimental impact on youngsters' neuropsychiatric growth. Costa (2018) analyses further detail its significant influence on the emergence of autistic illnesses.

Water shortage/ Uncertainty and Medical Care Special effects-
There are various connections between energy insecurity and the delivery system for healthcare. First, it can offer the bare minimum requirements for receiving harmless medicinal attention. Additionally, energy is crucial for carrying out several analytical practices (for instance; workshops, clinical imaging, and electrocardiography). The use of energy for therapeutic purposes is another aspect of medical care (for instance; radiotherapy). It is essential for maintaining the cold manacle while storing lifeblood, vaccinations, and medications (Bhattarai, 2011). Water insecurity is a significant additional factor. This circumstance directly contributes to the spread of numerous infectious diseases, such as cholera, as well as the emergence of nutrient uncertainty.

The second factor may result in micronutrient deficiencies, development anomalies, or growing syndromes, which can lead to a multiplicity of lingering diseases (such as anemia osteoporosis, and immunological deficiencies) (Maggini, Pierre, and Calder 2018). Additionally, a lack of nourishment during pregnancy may lead to worry and despair (Laraia, Siega-Riz, and Gundersen 2010).

3. Materials And Methods

Research Objectives
To examine the relationship between energy consumption & health problems from the database of 20 developing countries. To examine the correlation between air pollution (PM10) and mental health. To explore emerging technologies and sustainable solutions for curbing air contamination in India.

For Attaining Objective 1- The study has used secondary data. The principal component analysis (PCA) technique was used to break down the four selected dependent health variables into two constituents: lung and respiratory illnesses, and under and malnutrition and death ratio. The PCA technique assisted the authors to simplify the further process of analysis and drawing inferences. Further based on the two constituents LRD & UDR, the author finalized two prototypes, which are put forth below.

Table 1: Principal Component Analysis Method Outcome

	Original Eigenvalues			Sums of Squared Loadings		
Constituent	**Total**	**% of Deviation**	**Accumulative percentage**	**Total**	**% of Deviation**	**Accumulative percentage**
1	**2.640**	46.671	54.871	1.741	44.650	46.850
2	**1.221**	31.349	74.879	1.320	31.349	76.887
3	**.638**	14.322	86.337			
4	**.520**	10.681	99.000			

Table 2: Constituent Calculation of Principle Component Analysis

Constituent

	I	II
Variable 1	–.538	–.689
Variable 2	–.370	.747
Variable 3	.947	–.069
Variable 4	834	–.087

In addition to setting up the dependent variables, the study also selects explanatory variables namely, Variable 5-CO2 releases, Variable 6-fossil fuel consumption, Variable 7-GDP, Variable 8-health care spending per capita, and Variable 9-Metropolitan inhabitant's evolution. The above data was collected from secondary sources from reliable databases of the World Bank, British Petroleum 2021, etc. for the period 1990 to 2020 across a sample of 20 developing nations.

Table 3: Descriptive data of the selected Attributes

Attributes	Component	Observation	Mean	Standard Deviation	Maximum	Minimum
Tracheal Lung Cancer	%	550	1.146	2.65	1.645	0.0023
Respiratory Diseases	Demises (daily basis)	550	189,435	5.8	352,912	8,093
Prevalence of Undernourishment	%	550	22.4	46.58	18.18	22.04
Death Ratio	%	550	20.19	44.03	38.57	11.03
CO2 releases	Metric tons per capita	550	9.19	14.15	23.83	6.12
Fossil petroleum firewood usage	%	580	94.27	131.27	100	24.55
Gross Domestic Product	Present US Dollar	580	6,848.68	2,201.82	22,126.56	52.35
Metropolitan inhabitants' development	%	580	32.30	52.25	25.65	2.64
Well-being outlay	Current US$	580	526.85	2,723.44	2,824.81	43.80

According to the pertinent literature, the study anticipates that mounting CO2 releases, fossil petroleum usage, and urbanization will increase various diseases, whereas we anticipate that rising GDP per capita and well-being outlay per capita, which serve as gears for development, will result in a decrease in diseases. The anticipated coefficients for the variables are listed in Table 4.

Table 4: Predictable Symbols of Attributes

Attribute	Predictable Symbol of Constant
CO2 releases	+
Fossil petroleum firewood usage	+
Gross Domestic Product	-
Metropolitan inhabitants' development	+
Well-being outlay	-

Based on our two dependent variable components and the five explanatory factors indicated above, the following Prototype was empirically investigated: The prototype I founded on Constituent 1: Lung and Breathing Illnesses = Gross domestic Product, fossil petroleum firewood usage, CO2 releases, metropolitan inhabitants' upsurge, and well-being outlay. Prototype II was founded on Constituent 2: Malnutrition/ Starvation and Death Ratio= Gross domestic Product, fossil petroleum firewood usage, CO2 releases, metropolitan inhabitants' upsurge, and well-being outlay

The generalized method of moments is used. Some preliminary tests were carried out to obtain trustworthy empirical estimations. The variance inflation factor test is used as the initial pre-estimation test to check for correlation amongst the sequences. The Hausman evaluation is conducted to look for heterogeneity, which would reveal if our panel has random or fixed effects. Another pre-prediction assessment is conducted to examine interdisciplinary cross-segment-wise reliance amid the

sequences, taking into account that the economies of the chosen sample have been subject to a variety of exogenous and endogenous shocks. The concluding initial examination to decide if the sequences are motionless or mobile forms the next cohort unit root assessment.

For Attaining Objective 2: The authors use primary data. The research model is developed and the hypothesis framed is put forth. The researcher also made an effort to look at how air contamination affected the factors that determine mental well-being and welfare. A demonstrative sample of 300 Indian adults was used, with a gender split of 54% females & 46% males and an age category of 20 to 85 years. To get at outcomes, multivariate linear regression analysis was employed. Each regression model took into consideration the individual's income, age, and gender.

Statistical Procedure: To analyze the data, SPSS statistics 23 version 5 was used. With the help of mean figures, standard deviancies, and occurrences, sample characteristics were examined. To determine how air pollution PM10 will affect factors that contribute to subjective mental well-being, multivariate linear regressions were computed. Regression analysis and t-statistics were determined. Age and individual income were additional factors. For the complete sample, we calculated models that took age and income into account. To further understand gender impacts, independent analyses on gender sub-samples are carried out.

3. Results and Discussion

For objective 1: Empirical Outcomes for the Energy Consumption, Air Contamination & Well-being Connection: A Panel Data Analysis-Evidence from developing countries

To determine the consistency of the GMM technique, the Variance Inflation Factor and Hausman tests were conducted.

Table 5: Variance Inflation Factor and Hausman assessment outcome (Prototype I)

Samples	Independent attributes						
	Lung & respiratory disorders	**0.20**	2.21	2.54	2.14	2.20	2.45
	CO2 releases	1.14	--	2.22	2.30	2.25	2.65
	Fossil petroleum firewood usage	**2.25**	2.42	--	2.45	2.40	2.60
20 Developing countries	Gross Domestic Product	**2.30**	2.42	2.55	–	2.38	2.42
	Metropolitan inhabitants' growth	**2.02**	2.21	2.54	2.14	2.20	2.45
	Well-being related outlay	**2.22**	--	2.22	2.30	2.25	2.65
	Mean VIF	**2.25**	2.53	2.45	2.52	2.42	2.46
	Chi2(5)	**42.32**					

Table 6: VIF and Hausman Assessment Outcome (Prototype II)

Samples	Independent Variables						
	Lung & respiratory disorders	–	2.54	1.62	1.28	1.45	3.35
	CO2 releases	2.28	–	2.36	2.44	3.65	2.48
	Fossil petroleum firewood usage	2.52	2.54	–	2.38	3.26	2.38
20 Developing countries	Gross Domestic Product	2.48	4.52	3.46	–	3.49	2.58
	Metropolitan inhabitants' growth	2.25	2.35	2.45	2.34	–	2.25
	Well-being related outlay	2.35	2.25	2.36	2.38	3.52	--
	Mean VIF	2.38	2.39	2.48	2.35	2.38	2.39
	Chi2(5)	25.25					

The above Tables reveal that there exists slight multicollinearity amongst the cross-segments. The outcomes of the Hausman assessment reveal that the panel data has random impacts. The outcomes of the cross-segments dependence assessment for the selected variables are put forth in the table below:

Table 7: Cross-segment Reliance Assessment Outcomes

Samples	Attributes	CSD Assessment	Correlation	Abstract Correlation	Substantial at 1%
20 Developing countries	Lung & respiratory diseases	8.25	0.452	0.456	Yes
	The proportion of demises to malnutrition	9.28	0.514	0.521	Yes
	CO2 releases	12.02	0.481	0.481	Yes
	Fossil fuel consumption	7.32	0.587	0.577	Yes
	Gross domestic product	9.17	0.428	0.449	Yes
	Urban inhabitants' growth	9.45	0.568	0.469	Yes
	Healthcare spending per person	9.27	0.586	0.560	Yes

The CSD assessment outcomes, shown in the above table, demonstrate that cross-segments exist in all sequences, demonstrating that the samples selected in the study have similar properties. It is important to determine multicollinearity and cross-section dependence. Thus, using Pesaran's 2007 cross-sectional test null hypothesis. The test's results are shown in the Table below, which confirms that all series are stationary -I (0).

Table 8: Pesaran (2007) Panel Unit Root Assessment Outcomes

Samples	Attributes	Exclusive of inclination tendency	Inclusive of inclination tendency
20 Developing Countries	Tracheal Lung Cancer	1.622	2.520
	Respiratory Diseases	1.594	2.530
	CO2 releases	1.536	–1.920
	Fossil Fuel Consumption	1.480	–1.820
	Gross Domestic Product	1.450	–1.840
	Urban Population Growth	1.560	–1.790
	Health Expenditure	1.650	1.590

Table 9: Prediction Outcome for Prototype I (Dependent Variable: Lung & Respiratory Disorders)

Descriptive Attributes	Constants	Substantial at 1%
Constant	0.20	Rejected
Carbon releases	1.85	Accepted
Fossil Fuel Petroleum and Firewood usage	1.48	Accepted
Gross Domestic Product	–0.21	Accepted
Metropolitan Inhabitants growth	0.65	Accepted
Well-being related to outlay	–0.52	Accepted
Total number of comments	580	
Category	1992–2020	
Total segments covered	30	
Chi2	725.40	Accepted

In low and middle-income Asian countries, CO2 emissions are linked to a rise in lung & respiratory disorders. A 1% increase in CO2 emissions per person causes a 1.85% rise in disorders. The

estimation demonstrates that using fossil fuels increases the risk of respiratory and lung disorders. Lung and respiratory disorders in these countries may advance by over 1.48% with every 1% rise in fossil fuel usage.

Table 10: Prediction Outcome for Prototype I (Dependent Variable: URD)

Descriptive Attributes	Constants	Substantial at 1%
Constant	1.40	Rejected
Carbon releases	2.35	Accepted
Fossil Fuel Petroleum and Firewood usage	2.25	Accepted
Gross Domestic Product	1.45	Accepted
Metropolitan Inhabitants growth	1.60	Accepted
Well –being related to outlay	1.40	Accepted
Total number of comments	580	
Category	1921–2021	
Total segments covered	40	
Chi2	825.40	Accepted

The projected constants of attributes for undernourishment and the death rate are shown in the Table above. The findings show that higher CO2 emissions and fossil petroleum and firewood usage increase the threat of undernourishment and mortality. Undernourishment and death ratios increase by roughly 1.24% with every 1% increase in Carbon releases. Additionally, well-being-related outlay and per-capita Gross Domestic Product decline in the death and undernourishment ratios. According to the estimation, undernourishment and the death rate in developing countries may decrease by roughly 0.60 and 0.40 percent, respectively, with a 1% upsurge in GDP and well-being-related outlay.

Robustness Analysis: The study uses a different panel data technique, modified least squares, to examine the results using the GMM technique, to assess the robustness of key conclusions. The estimation findings are not significantly different, indicating the reliability of the findings.

Table 11: Robustness via FM-OLS for Prototype I (Dependent Attribute: LRD)

Sample	Independent Attributes				
Developing countries	Carbon releases	Fossil Petroleum Firewood usage	GDP	Metropolitan Inhabitants growth	Wellbeing related Outlay
	1.02 ***	0.98***	-0.02***	0.15***	–0.05***

Table 12: Robustness via FM-OLS for Prototype II (Dependent Attribute: URD)

Sample	Independent Attributes				
Developing countries	Carbon releases	Fossil Petroleum Firewood usage	GDP	Metropolitan Inhabitants growth	Wellbeing related Outlay
	1.41***	1.20***	–0.04***	0.06**	–0.15***

For objective 2: Empirical results of the survey conducted

For the survey, responses from 300 Indian adult citizens were collected. Out of the entire sample, 54% were female, while 46% were male. The ages of the participants range from 17 to 85. Table 13 provides a sociodemographic summary and a list of relevant attributes. To predict the influence of air contamination on health factors, multivariate linear regression models were used.

First, each determinant of mental health was investigated throughout the entire sample. The existing consequences revealed that Particulate Matter was not substantially connected with nervousness (p=0.252) or unhappiness (p=0.294), contradicting previous studies that found inconsistent links between air contamination and unhappiness or nervousness. Without gender-specific analysis, a prototype with Particulate Matter on trauma and pressure resilience (p0.011), life fulfillment (p=0.124), and self-worth (p = 0.012) produced relevant findings. Except for the age-self-esteem model (p =0.177), all models included age and income as significant factors. The model that predicted

trauma and pressure resilience explained the most variance, or 7.4%, trailed by the prototype that predicted life happiness, which explained 6.8% of the variance.

Second, regression models tailored to each gender were created and are shown in Tables 15 for men and Table 16 for women. Only wealth was a reliable predictor of anxiety, sadness, or self-esteem in males; neither age nor any other factor was found as responsible. Age, income, and PM10 are noteworthy forecasters of stress resilience, each accounting for 9.4% of the variance (p 0.012, p=0.024, and p=0.026). Only age (p=0.006) and revenue (p0.002) were revealed to be relevant in terms of life satisfaction.

Results for women are a little bit different than those for guys. Income alone strongly predicted anxiety, just like it did for men (p=0.012). Age and revenue were shown to be significantly important (p=0.014) in the depression model for females. Similar to men, females' stress resilience models are forecasted by age (p=0.018), income (p=0.017), and PM10 (p=0.016), which accounts for 9.1% of the variance. Age and revenue are revealed to be significant forecasters of life satisfaction in men (p=0.016 and p=0.06, respectively). In disparity with the male prototype, revenue was strongly associated with female self-worth (p=0.006). and PM10 (p=0.028), yet the corrected R2 shows a small amount of variance.

Table 13. Research attributes and descriptive data.

Attributes	Conformed/Active cases	Min	Max	Mean	Standard Deviation
Demographic elements					
Sex	300			1.65	
Masculine	162			56%	0.49
Feminine	138			65%	
Age	300	18	92		
Individual revenue	3000				
Less than 20,000	535			17.07%	
20,000-80,000	943			31.2%	
80,000-1,50000	834			27.6%	
More than 1,50,000	271			9.0%	
Pollution					
Particulate Matter 10	300	13	39	26.83%	5.05%
Mental well-being					
Resilience (RS-11)	4033	22	82	60.52	22.54
Life fulfilment	3836	-85	252	70.48	46.22
Nervousness (GAD-2)	4000	1	7	84.22	2.24
Unhappiness (PHQ-2)	2800	1	8	1.98	2.34
Self-worth (RSES)	4200	3	70	54.80	9.85

Resilience Scale 11 items, Patient Health Questionnaire 2 questions, General Anxiety Disorder, 2 items of the RSES.

Table 14: Regression analysis forecasting psychological well-being and welfare factors.

Prototype/ Attributes	Un-Uniform coefficient	Uniform regression coefficient	t-statistics	p-value	Adjusted R-square
Nervousness					0.018
Age	1.114 (0.00)	1.138	3.45	0.018*	
Revenue	0.072 (0.02)	1.258	−8.46	<0.005***	
PM$_{10}$	1.112 (0.00)	1.149	2.45	0.170	
Unhappiness					0.038
Age	1.014 (0.00)	1.25	2.45	<0.002	
Revenue	1.345 (0.02)	1.29	−7.25	<0.051*	
PM$_{10}$	1.118 (0.00)	1.68	2.18	0.372	

	Un-Uniform coefficient	Uniform regression coefficient	t-statistics	p-value	Adjusted R-square
Stress resilience					**0.074**
Age	−1.65 (0.01)	1.69	−25.14	<0.021***	
Revenue	3.25 (0.20)	1.28	20.12	<0.003***	
PM_{10}	−1.68 (0.03)	−1.45	−2.44	<0.006***	
Life fulfilment					0.068
Age	−1.35 (0.04)	−1.25	−5.74	<0.002***	
Revenue	6.86 (0.72)	1.48	13.48	<0.001***	
PM_{10}	−1.56 (0.13)	−1.36	−3.80	0.011*	
Self-worth					**0.034**
Age	−1.24 (0.01)	−1.56	−2.48	0.254	
Revenue	2.45 (0.17)	1.78	8.50	<0.002***	
PM_{10}	−1.78 (0.03)	−1.98	−3.78	0.012*	

Dependent variables include stress, sadness, anxiety, satisfaction, and self-worth. 10 g/m3 of PM10 particulate matter.

Table 15: Regression analysis forecasting emotional well-being & welfare factors for men

Prototype/ Attributes	Un-Uniform coefficient	Uniform regression coefficient	t-statistics	p-value	Adjusted R-square
Nervousness					0.009
Age	0.00 (0.00)	0.03	1.30	0.19	
Revenue	−0.11 (0.03)	−0.10	−3.68	<0.001***	
PM_{10}	−0.00 (0.00)	−0.00	−0.13	0.893	
Unhappiness					**0.028**
Age	0.00 (0.00)	0.01	0.44	0.658	
Revenue	−0.21 (0.03)	−0.17	−6.34	<0.001***	
PM_{10}	0.00 (0.00)	0.00	0.33	0.737	
Stress resilience					**0.085**
Age	−0.01 (0.01)	−0.18	−6.72	<0.001***	
Revenue	2.50 (0.28)	0.23	8.70	<0.001***	
PM_{10}	−0.15 (0.05)	−0.07	−2.87	0.004**	
Life fulfilment					**0.124**
Age	−0.15 (0.05)	−0.07	−2.81	0.005**	
Revenue	2.01 (0.24)	0.22	8.34	<0.001***	
PM_{10}	−0.04 (0.04)	−0.02	−1.03	0.299	
Self-worth					**0.050**
Age	−0.00 (0.01)	−0.00	−0.22	0.826	
Revenue	2.01 (0.24)	0.22	8.34	<0.001***	
PM_{10}	−0.04 (0.04)	−0.02	−1.03	0.299	

Dependent factors include stress, anxiety, depression, satisfaction, and self-esteem. PM10 particle matter 10 g/ m3,

Table 16: Regression analysis predicting mental health & well-being factor for females

Model/ variables	Un-Uniform coefficient	Uniform regression coefficient	t-statistics	p-value	Adjusted R-square
Nervousness					0.022
Age	0.02(0.01)	1.22	2.65	0.054	
Revenue	1.25 (0.04)	1.25	3.39	<0.002***	
PM_{10}	1.05 (0.01)	−1.04	2.78	0.050	
Unhappiness					**0.044**
Age	0.006 (0.01)	1.24	3.23	<0.002***	
Revenue	−0.25 (0.05)	1.28	2.22	<0.003***	
PM_{10}	0.02 (0.01)	1.05	2.00	0.258	

Stress resilience					0.092
Age	0.24 (0.02)	2.15	8.24	<0.002***	
Revenue	2.89 (0.40)	1.24	6.86	<0.001***	
PM_{10}	1.24 (0.04)	1.08	3.68	0.001*	
Life fulfilment					
Age	0.36 (0.04)	2.48	3.45	<0.011***	
Revenue	3.86 (2.20)	1.25	3.45	0.12*	
PM_{10}	1.22 (0.22)	2.56	1.12	0.17	
Self-worth					0.008
Age	1.42 (0.02)	−1.05	−0.25	0.082	
Revenue	1.62 (0.28)	1.24	3.97	0.003**	
PM_{10}	1.02 (0.03)	−1.08	−1.15	0.033*	

Dependent variables include stress resilience, sadness, anxiety, life satisfaction, and self-worth. 10 g/m3 of PM10 particulate matter

Emerging Technologies and Sustainable Solutions for Reducing Air Pollution:
Although we can control stopping the burning of fossil fuels, crops in particular locations, and vehicular mobility to a significant extent, a sustainable solution needs to be looked into to control this issue over the long run. Smart technology solutions to reduce pollution at its source and in larger affected areas is the sole factor that might be a thrust area for attention. One of the most discussed social, economic, sociological, and environmental issues is how to reduce air pollution and environmental hazards while also developing natural resources sustainably and recycling natural resources. Minimization and mitigation remain effective methods for reducing pollution, and data computing and technology advancements have had a significant impact on these strategies as well.

Titanium Dioxide Technology: It also goes by the name Crystal Active Technology and aids in reducing the number of pollutants released during combustion. The method works well in power generation facilities. As a DeNOx catalyst, ultrafine titanium dioxide (TiO2) is used to remove up to 80% of the NOx released during the burning of coal, gas, or fossil fuel used to generate power. Titanium Oxide catalyzes the process, turning dangerous gases and other emissions into harmless nitrogen and water vapor. Since it has been in use for 30 years, this technology has established itself as one of the best and most productive ways to reduce air pollution.

Pocket Sensors: One of the social alerts to people personally is the user-friendly device that fits in our pockets. These gadgets have been produced by a few different companies, including French Plume Lab and I-Sniff, in a variety of forms. Through this tool, users can gauge the level of pollution to which they are regularly exposed.

Fig 4: Air excellence Pocket device

Source: - https://www.mikroe.com/blog/air-quality-4-click-pocket-size-pollution-sensor
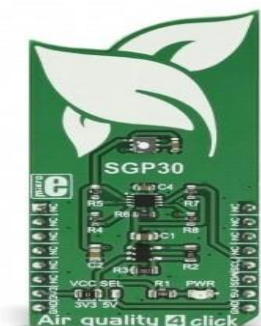
The gadget can be linked anywhere, including to a vehicle, wrist, backpack, etc., thanks to the leather strap that holds it. Information on NO2, fine particles, organic and inorganic compounds, air humidity, and ambient temperature are all provided by the precise sensor. The system is set up for

mobile, and the application shows the concentration of the various pollutants. Individuals may develop self-regulating mechanisms as a result of this. For instance, if someone takes a certain route to work and measures are taken to reduce their exposure during transit, they may also prepare an alternate route.

Artificial Intelligence: AI can forecast the level, and quantity of pollution in any place before it occurs, making it a crucial tool for addressing this issue. Since the problem's source is well known and recurrent every year, corrective actions are often conducted after the problem arises. So why not take the appropriate action before the problem manifests its effects?

Machine learning and inductive learning, data mining algorithms, case-based reasoning, and optimization techniques, algorithms are some of the AI methodologies that can be used. Artificial intelligence technologies have helped cities like Beijing to reduce their pollution levels. Connected sensors are used in IBM's green horizon project in Beijing to gather information about weather, humidity, traffic, and exhaust fume levels. The degree of pollution in the upcoming days is predicted using this combination of historical pollution data and cognitive forecasting systems, and appropriate corrective measures are then conducted. Artificial intelligence systems make it easier to analyze data even when it may be too complex for human systems to do so.

These sensors can be placed around the city to monitor air quality and pollutants in real-time, allowing government agencies to take action and implement corrective measures before the air quality index deteriorates. If you cannot measure it, you can solve it, according to Peter Drucker, and artificial intelligence can assist in solving this. India is the fifth-most polluted country in the world and 22 of the 30 most polluted cities, according to (WE Forum, 2021).

Algorithms are used by artificial intelligence to investigate problems. Machine learning, a branch of artificial intelligence that works with training AI systems to eventually be able to represent the problem at hand, is the act of modeling a system to predict its behavior.

Fuzzy Logic Technique: The methods are effective for managing indoor air quality, and they combine some air pollution standards, including PM2.5, PM10, CO, NO2, NOP, and temperature to determine comfort and the Air Quality Index. Users are given access to the index, which shows the toxicity levels of particular contaminants together with the allowed air quality.

Breeze Technology: It is centered on the creation of wind-driven environmental sensors. Here, the usual pollutants including carbon and nitrogen oxides, ozone, and particle matter can be measured using small-scale air quality monitors. The system, which is based on machine learning and big data, leverages Cloud Calibration to improve the quality and dependability of the data. The breeze cloud platform enables very high data resolutions and can facilitate the management, scientists, municipalities, and governments to understand air quality.

ICT Solutions: It can be used extensively in industry, agriculture, electrical grids, and transportation. ICT can offer a workable option to lower carbon footprints, which are responsible for 1.5% of the world's CO2 emissions. We are aware that continual monitoring is necessary to control air pollution.

Autonomous Vehicles: The self-driving automobiles are one of the industry's major themes. This might significantly alter how cars use the road system, reducing the stop-start aspect of traffic. Numerous studies have suggested that autonomous vehicles could reduce greenhouse gas emissions and increase fuel efficiency by 15-40%.

Smog Free Towers: Installation of the Smog Free Tower, which can absorb pollution and exhale clean air, is another effort that might be taken into consideration.

Fig 5: Smog Tower in Beijing

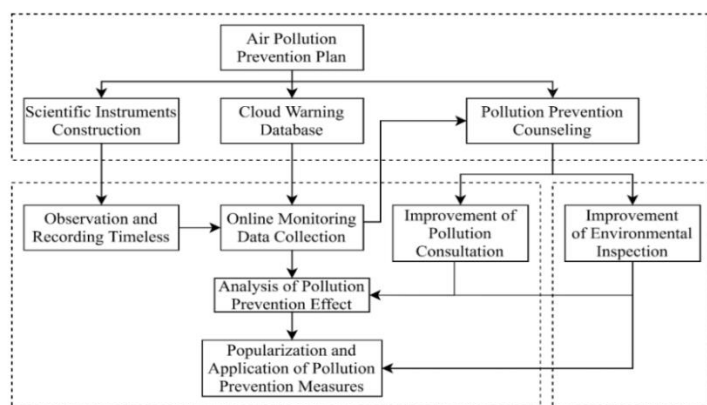**Figure 6:** Execution flowchart of pollution scrutiny controller

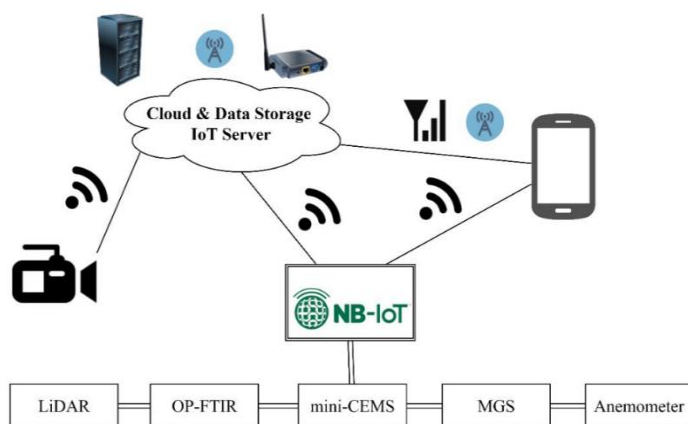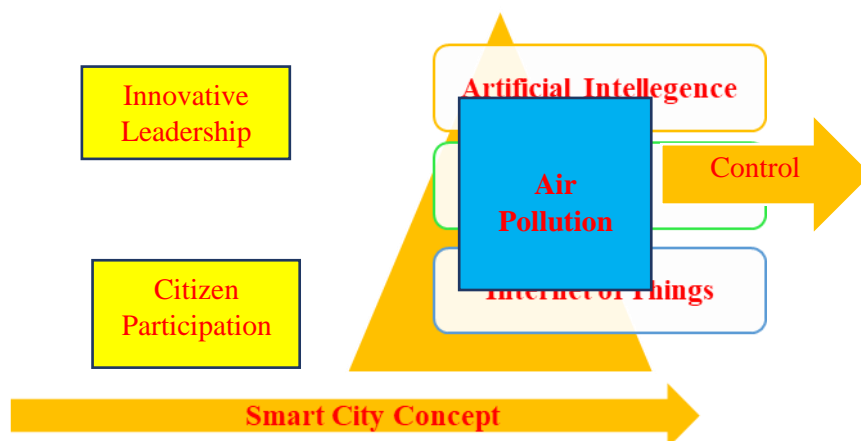**Figure 7:** Air contamination monitoring framework of IoT:

Figure 8: A proposed research model of the present study:

4. Conclusion

It Based on the findings; we have concluded that rising lung and respiratory disorders are a result of rising CO2 emissions in Asian countries. Furthermore, the estimation has shown that the use of fossil fuels promotes lung & respiratory conditions. In Asian countries, we discovered a substantial correlation between the growth of the urban population and the rise in lung and respiratory disorders. The findings have shown how rising levels of undernourishment and mortality are a result of CO2 emissions and fuel consumption. The ratio of deaths and undernourishment has also been observed to decrease with GDP healthcare care spending.

Therefore, advise developing nations to implement various policies to enhance the energy transition, which calls for a switch from fossil fuel to renewable energy sources. The use of fossil fuel energy results in the destruction of human habitats and the growth of deadly diseases like cancer. Additionally, these nations implement policies to enable easy access to renewable sources as well as an increase in the supply of renewable energy through improved technologies, in daily social life. It is strongly advised that urban lifestyles be improved, since this may result in better human health in cities. The present study's data collection, which included subjective psychological characteristics and was linked with accurate pollution data, is a key strength (PM10).

The study reveals correlations between mental health indicators and air pollution. Poor air quality affects a significant portion of Indians because the country has not yet attained WHO air quality guidelines. Despite the minor impacts of PM10 on specific mental health factors in the current study, the implications for the Indian population and the health system as a whole can be significant. Additionally, it is thought that the main pathophysiological processes through which air pollution causes brain injury are inflammation and oxidative stress. Therefore, the consequences of air pollution on mental health should be taken into consideration by policymakers, Governments, and experts in health sciences.

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