An Emperical Study on Awareness About Green Energy Systems and Association with Societal Development and Economic Growth with Reference to the Navi Mumbai Area

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Abstract

Green energy is power generated from natural, renewable resources like sunlight, wind, and water. Unlike fossil fuels, these sources discharge little to no greenhouse gases. It is the most essential device in the fight against climate change and is now often the cheapest source of new electricity globally. The growing concern over climate change, environmental degradation, and the depletion of conventional energy resources has significantly increased the importance of adopting green energy systems across the world. Green energy, generated from renewable sources such as solar, wind, hydropower, biogas, and emerging technologies like piezoelectric energy harvesting, offers an environmentally sustainable alternative to fossil fuels by producing minimal greenhouse gas emissions. Besides mitigating climate change, renewable energy contributes to energy security, economic growth, employment generation, and overall societal well-being. The present empirical study investigates the level of awareness regarding green energy systems and examines their association with societal development and economic growth in the Navi Mumbai area, with particular reference to the Panvel region.

The study is based on primary data collected from 228 respondents through a structured questionnaire designed to assess awareness, adoption, perceived benefits, and challenges related to renewable energy technologies. The research adopts a descriptive and analytical approach to understand public perception and the extent to which green energy systems influence sustainable development. The study covers awareness of various renewable energy sources, including solar energy, wind energy, biogas, and innovative piezoelectric micro-energy units, while also examining their role in reducing energy costs, improving environmental quality, and supporting local economic development.

The findings reveal that a majority of respondents possess a satisfactory level of awareness regarding green energy systems and recognize their significant contribution to environmental conservation, reduction of carbon emissions, household energy savings, and long-term sustainability. Respondents also perceive renewable energy as a catalyst for employment opportunities, technological advancement, and regional economic growth. However, the study identifies several barriers to wider adoption, including high initial installation costs, limited technical knowledge, inadequate financial incentives, and insufficient public awareness campaigns. The research concludes that strengthening government support, promoting public awareness programs, encouraging private sector participation, and investing in innovative renewable technologies can substantially accelerate the transition toward sustainable energy. The study provides valuable insights for policymakers, researchers, environmental planners, and stakeholders seeking to enhance renewable energy adoption and achieve inclusive societal development and sustainable economic growth in the Navi Mumbai region.The results show that most respondents are aware of green energy technologies and view them as beneficial for environmental protection, household cost savings, and employment generation.

Keywords: Green Energy Systems, Renewable Energy Adoption, Economic Growth, Piezoelectric Energy Harvesting

Introduction

The rapid growth of urban centers in India has significantly increased the demand for reliable, affordable, and sustainable energy. As one of Maharashtra's most planned and fast-developing urban regions Navi Mumbai represents a unique landscape where industrial expansion, commercial activities, and rising residential consumption place continuous pressure on conventional energy systems. Globally, renewable energy adoption has been associated with improved environmental quality, enhanced energy security, employment creation, and inclusive economic growth. The objective of this is to explore how green energy systems contribute to societal development (health, quality of life, community resilience) and economic growth (employment, income diversification, cost savings) within the Navi Mumbai area. The rapid industrialization, urbanization, and increasing energy consumption across the globe have created significant environmental challenges, including climate change, air pollution, depletion of fossil fuel reserves, and ecological imbalance. The excessive

dependence on conventional energy sources such as coal, petroleum, and natural gas has contributed to rising greenhouse gas emissions, resulting in global warming and adverse environmental consequences. Consequently, there has been an increasing global emphasis on transitioning towards sustainable and renewable sources of energy, commonly referred to as green energy systems. Green energy is derived from naturally replenishing resources such as solar radiation, wind, flowing water, biomass, geothermal heat, and other renewable sources that produce little or no harmful emissions during electricity generation. The adoption of green energy technologies has emerged as one of the most effective strategies for achieving sustainable development while simultaneously promoting economic growth and improving the quality of life.

Green energy systems play a vital role in reducing carbon emissions, conserving natural resources, enhancing energy security, and creating environmentally sustainable communities. Renewable energy technologies not only address environmental concerns but also contribute significantly to economic development through employment generation, technological innovation, industrial growth, and investment opportunities. Countries across the world are increasingly investing in renewable energy infrastructure to meet their climate commitments under international agreements such as the Paris Agreement and the Sustainable Development Goals (SDGs), particularly Goal 7, which emphasizes affordable and clean energy for all, and Goal 13, which focuses on climate action.

India, being one of the fastest-growing economies in the world, has witnessed a tremendous increase in energy demand due to rapid industrial expansion, population growth, and urban development. Traditionally, India's energy requirements have been fulfilled primarily through fossil fuels, leading to environmental degradation and dependence on imported energy resources. Recognizing the urgent need for sustainable development, the Government of India has launched several initiatives to promote renewable energy adoption, including the National Solar Mission, PM-KUSUM Scheme, Rooftop Solar Programme, Green Hydrogen Mission, wind energy development initiatives, and various state-level renewable energy policies. These initiatives aim to increase the share of renewable energy in the country's total energy mix while reducing carbon emissions and promoting energy independence.

Among the various renewable energy technologies, solar energy has emerged as one of the most promising and widely adopted sources due to India's abundant sunshine throughout the year. Wind energy has also shown significant growth in several states with favorable climatic conditions. Biogas plants, biomass energy systems, hydroelectric projects, and waste-to-energy technologies are increasingly contributing to decentralized and sustainable energy production. Furthermore, innovative technologies such as piezoelectric energy harvesting, which converts mechanical vibrations and pressure into electrical energy, have opened new opportunities for generating clean energy in urban environments. Piezoelectric systems can be installed in roads, railway stations, shopping malls, footpaths, educational institutions, and other high-footfall areas to generate micro-electricity from human movement and vehicular traffic, thereby contributing to smart city development and sustainable urban infrastructure.

Awareness and public acceptance are among the most important determinants of successful renewable energy adoption. While technological advancements and government incentives have accelerated the development of green energy systems, the effectiveness of these initiatives largely depends upon people's awareness, knowledge, attitudes, and willingness to adopt renewable technologies. Public awareness influences investment decisions, household energy consumption behavior, environmental responsibility, and participation in sustainability initiatives. Lack of awareness, misconceptions regarding renewable technologies, high initial installation costs, limited technical knowledge, and inadequate financial support often hinder the widespread adoption of green energy systems despite their long-term economic and environmental benefits.

The Navi Mumbai region represents one of India's rapidly developing urban centers, characterized by expanding residential complexes, industrial establishments, commercial hubs, educational institutions, and transportation infrastructure. As urbanization continues to accelerate in Navi Mumbai, the demand for reliable and sustainable energy sources has increased substantially. Simultaneously, environmental concerns such as air pollution, waste management, increasing electricity consumption, and carbon emissions have highlighted the need for adopting cleaner and more sustainable energy alternatives. The strategic development of Navi Mumbai as a smart city provides an ideal opportunity to integrate renewable energy technologies into urban planning and infrastructure development.

Green energy adoption in Navi Mumbai has the potential to generate multiple socio-economic benefits. Environmentally, renewable energy contributes to improved air quality, reduced dependence on fossil fuels, conservation of natural resources, and mitigation of climate change. Economically, green energy systems stimulate investments, create employment opportunities in manufacturing, installation, operation, and maintenance of renewable energy technologies, reduce electricity costs for households and industries, and encourage technological innovation. Socially, renewable energy enhances public health by reducing pollution, improves energy accessibility, promotes community participation in sustainable practices, and supports inclusive development. Thus, renewable energy serves as an important catalyst for balanced economic growth and societal transformation.

Despite increasing governmental efforts and technological progress, the actual level of awareness and adoption of green energy systems among residents varies considerably depending on educational background, income level, occupation, accessibility to information, and perceived economic benefits. Understanding public awareness and perceptions is therefore essential for designing effective policies and awareness campaigns that encourage greater participation in renewable energy initiatives. Empirical research assessing public awareness provides valuable insights into existing knowledge gaps, barriers to adoption, and opportunities for promoting sustainable energy

practices.

The present empirical study focuses on examining the awareness of green energy systems among residents of the Navi Mumbai area and explores their association with societal development and economic growth. The study includes various renewable energy technologies such as solar energy, wind energy, biogas, and piezoelectric micro-energy harvesting systems. Primary data have been collected from 228 respondents through a structured questionnaire to assess their level of awareness, perceptions, adoption patterns, perceived benefits, and challenges associated with renewable energy technologies. The study also evaluates respondents' opinions regarding the contribution of green energy systems toward environmental conservation, employment generation, energy security, technological advancement, reduction in household electricity expenditure, and sustainable regional development.

The findings of this research are expected to contribute significantly to the existing literature on renewable energy awareness and sustainable development by providing empirical evidence from the Navi Mumbai region. The study will assist policymakers, urban planners, government agencies, educational institutions, environmental organizations, and renewable energy developers in formulating strategies to improve public awareness, strengthen policy implementation, encourage investments in green technologies, and accelerate the transition toward a low-carbon economy. Furthermore, the study emphasizes that increasing awareness, combined with supportive government policies, technological innovation, financial incentives, and community participation, can play a pivotal role in achieving sustainable societal development and long-term economic prosperity.

In conclusion, green energy systems have become indispensable for ensuring environmental sustainability, enhancing energy security, promoting inclusive economic growth, and improving societal well-being. As urban regions like Navi Mumbai continue to expand, understanding public awareness and acceptance of renewable energy technologies becomes increasingly important for achieving sustainable development goals. This study seeks to bridge this knowledge gap by empirically examining the awareness of green energy systems and their relationship with societal development and economic growth, thereby offering meaningful recommendations for promoting renewable energy adoption and building a cleaner, greener, and more sustainable future.

Literature Review

- Adam Faiers and Charles Neame (2005) accomplished a study on “Consumer Attitudes towards Domestic Solar Power Systems in the UK”. They stated that the success of the UK policy to reduce carbon emissions was partly dependent on the ability to persuade householders to become more energy efficient, and to encourage installation of domestic solar systems. They investigated householder attitudes towards characteristics of solar systems and identified some of the barriers to adoption. They concluded, if consumers cannot identify the relative advantage of solar power over their current sources of power, which is supplied readily and cheaply through a main system, it was unlikely that adoption would follow.
- Stefan Gossling et.al (2005) conducted a study on “A Target Group-Specific Approach to Green Power retailing: Students as Consumers of Renewable Energy”. The target group specific marketing was evaluated as a strategy to increase the share of residential customers of green power. A sample of students in the city of Freiburg, Germany was interviewed in order to assess their awareness of environmental issues, their willingness to change to green power products, and to better understand individual hindrances in changing the power supplier. The analysis showed that students were 81 highly positive towards green power products, but for several reasons difficult to reach in marketing campaigns. Aspects to be considered in addressing this consumer group include the student‟s particular expectations towards green products, their living conditions, price sensitivity, and their perception of the relative effort involved in changing the power provider.
- Rafaj Peter (2005) studied baseline scenario of adoption of energy technologies, future availability of energy, development of energy demands to the next generations and policy strategies. Portfolios of renewable policies for support of new technologies with realistic Renewable Portfolio Schemes (RPS), policies that will gradually internalize external costs incurred from energy production, were suggested. These combined policies leads to reduced dependency on fossil fuels and more resilient renewable energy and social systems improving local and global environments.
- Ugo Farinelli (2005) stressed that Italy had to promote renewable energy sources like solar, hydro, wind, biomass, etc, through policy intervention, like market oriented instruments. They were constructive and adverse bureaucratic and institutional barriers, namely, insufficient information to the public, funding for renewable energy sector R&D, etc., requiring revisit of policy and programmes regarding renewable energy sector in Italy.
- Khan, Faraz& Zahra, Talat& Ahmad, Noman&Bajpai, Shrish. (2019). The study Present manuscript is a statistics-based approach towards the progression of Renewable Energy Technologies in the financial capital of India, Mumbai and the metro-city ecosystem that is based around Mumbai termed as the Mumbai Metropolitan Region.
- Dr. Anit Kaur, Tanveersingh, Gagneeshsingh Dr. Shankar Singh(2025) This study examines the relationship between green energy and economic prosperity, green economic recovery, and long-term sustainability.
- Molla (2008) explained Green IT from 4 different but interrelated perspectives - sourcing, operations, services and end of life management. From a sourcing perspective, Green IT implies the practice of environmentally preferable IT purchasing. From an operation perspective, Green IT implies improving energy efficiency in powering and cooling corporate IT assets and reducing IT induced greenhouse gas emissions. From a service perspective, Green IT refers to the role of IT in supporting a business‟s overall sustainability initiatives. From end of IT life management perspective, Green IT refers to practices in reusing, recycling and disposing IT hardware (Molla, 2008: 661-662).

● (Victor & Kumar, 2010: 118).Excessive use of electrical and electronics products has led to the rapid obsolescence rate of electronic equipment causing generation of "electronic-waste" or simply called as e-waste. With the presence of deadly chemicals and toxic substances in the electronic gadgets such as lead mercury, cadmium, chromium etc., disposal of e-waste is becoming an environmental and health issue. Improper disposal can be extremely hazardous for the environment and human health. Documented health hazards include various kinds ailments from coming in contact with toxins such as cadmium, mercury, lead dioxins, furans among others, emitted when land filled or incinerated.

Objectives Of The Study

1. To study the awareness level of green energy systems among people in Navi Mumbai.
2. To analyse the role of green energy technologies in societal development and environmental protection in Navi Mumbai.

Limitations of the study: This study is limited to selected areas in Navi Mumbai and selected sample on random basis.

Research Methodology

The present paper analyses the data collected from primary sources and converts them into some useful information. This paper includes assembling of primary data that is collected through personal interview of individual residing in Navi Mumbai from selected areas. Based on collection and analysis of data observations are made. Secondary data collected from Journals, government reports, online research articles (energy, sustainability). The data were analysed by using Statistical Package for Social Sciences version 20.0 and MS-Excel 2010. Percentage Analysis, Bar and Pie Charts, Chi-square Test used for Hypothesis testing and analyse data. This study is descriptive and analytical in nature where Convenience sampling method used . respondents Age Group is , from 18 to 40 & above (18–25, 26–30, 31–40, 40 & above). Total respondents considered for the study are 228 respondents in Navi Mumbai from Panvel, Kamothe, Kalamboli, Taloja, Kharghar (Navi Mumbai Region). Present paper also collect data from secondary sources and come to the conclusion of the information.

Data analysis and observations:

Demographic distribution:

Gender ise frequency distribution					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Female	144	63.2	63.2	63.2
	Male	84	36.8	36.8	100.0
	Total	228	100.0	100.0	

Table No.1 Source : Primary Data

b) Occupation ise distribution					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Berozgar	4	1.8	1.8	1.8
	Business	40	17.5	17.5	19.3
	Homemaker	28	12.3	12.3	31.6
	Student	120	52.6	52.6	84.2
	Working Professional	36	15.8	15.8	100.0
	Total	228	100.0	100.0	

Table No.2 Source : Primary Data

c) Education Level wise distribution					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Graduate	160	70.2	70.2	70.2
	Nikamma	4	1.8	1.8	71.9
	Postgraduate	28	12.3	12.3	84.2
	School	8	3.5	3.5	87.7
	Technical/Engineering	24	10.5	10.5	98.2
	Undergraduate	4	1.8	1.8	100.0
	Total	228	100.0	100.0	

Table No.3 Source : Primary Data

d) Area of Residence in Navi Mumbai				
	Frequency	Percent	Valid Percent	Cumulative Percent

Valid	Airoli	8	3.5	3.5	3.5
	Kharghar	12	5.3	5.3	8.8
	Nerul	4	1.8	1.8	10.5
	Other	12	5.3	5.3	15.8
	Panvel	180	78.9	78.9	94.7
	Vashi	12	5.3	5.3	100.0
	Total	228	100.0	100.0	

Table No.4 Source : Primary Data

Analyse the role of green energy technologies in societal development and environmental protection in Navi Mumbai.

e) Relationship between awareness of green energy systems and the perception that they create job opportunities:

		Opinion about green energy systems create job opportunities in installation, maintenance, and research?			
		No	Not Sure	Yes	Yes;No
Awareness of Green Energy systems (solar, wind, bioenergy, piezoelectric)?	No	0	32	52	8
	Yes	8	40	84	0
	Yes;No	0	0	4	0
Total		8	72	140	8

Table No.5 Source : Primary Data

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	20.709a	6	.002
Likelihood Ratio	27.437	6	.000
McNemar-Bowker Test	.	.	.b
N of Valid Cases	228		

Table No.6 Source : Primary Data

The Pearson Chi-Square test yielded a value of 20.709 with 6 degrees of freedom and a p-value of 0.002. Since the p-value is less than 0.05, the relationship between awareness of green energy systems and the perception that they create job opportunities is statistically significant.
This finding suggests that awareness of green energy systems significantly influences respondents' perceptions regarding employment opportunities in installation, maintenance, and research. Therefore, respondents with greater awareness are more likely to recognize the job creation potential of green energy technologies.

f) Association between awareness of green energy systems and the perception that piezoelectric technology can generate clean energy in urban areas.

Crosstab					
Count					
		Opinion about piezoelectric technology has the potential to generate clean energy in urban areas			
		No	Not Sure	Yes	Total
Awareness of Green Energy systems (solar, wind, bioenergy, piezoelectric)?	No	4	36	52	92
	Yes	4	36	92	132
	Yes;No	0	4	0	4
Total		8	76	144	228

Table No.7 Source : Primary Data

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	12.188a	4	.016
Likelihood Ratio	13.010	4	.011
McNemar-Bowker Test	.	.	.b
N of Valid Cases	228		

Table No.8 Source : Primary Data

The Pearson Chi-Square test produced a value of 12.188 with 4 degrees of freedom and a p-value of 0.016. Since the p-value is less than 0.05, there is a statistically significant association between awareness of green energy systems and the perception that piezoelectric technology can generate clean energy in urban areas.

g) association between awareness about Green Energy systems (solar, wind, bioenergy, piezoelectric and Opinion abot piezoelectric energy reduce long-term infrastructure costs

		Opinion abot piezoelectric energy reduce long-term infrastructure costs			
		Agree	Disagree	Neutral	Strongly Agree
awareness about Green Energy systems (solar, wind, bioenergy, piezoelectric	No	40	0	20	32
	Yes	56	4	36	36
	Yes;No	0	0	4	0
Total		96	4	60	68

Table No.9 Source : Primary Data

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	15.908a	6	.014
Likelihood Ratio	16.796	6	.010
McNemar-Bowker Test	.	.	.b
N of Valid Cases	228		

Table No.10 Source : Primary Data

As the p-value (0.014) is less than 0.05, the null hypothesis (H_0) stating that there is no significant association between the two variables is rejected, and the alternative hypothesis (H_1) is accepted. Therefore, it can be concluded that there is a statistically significant relationship between the variables analyzed.

h) Association between awareness of piezoelectric energy technology and respondents' belief that it has the potential to generate clean energy in urban areas.

Crosstab					
Count					
		Perception about piezoelectric technology has the potential to generate clean energy in urban areas			
		No	Not Sure	Yes	Total
Awareness about Piezoelectric Energy Technology (energy generated through pressure or movement)?	No	8	64	72	144
	Yes	0	12	72	84
Total		8	76	144	228

Table No.11 Source : Primary Data

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	29.857a	2	.000
Likelihood Ratio	34.175	2	.000
McNemar-Bowker Test	.	.	.b
N of Valid Cases	228		

Table No.12 Source : Primary Data

As the p-value is less than 0.05, the null hypothesis (H_0) is rejected, and the alternative hypothesis (H_1) is accepted. Therefore, it can be concluded that awareness of piezoelectric energy technology is significantly associated with respondents' belief that it has the potential to generate clean energy in urban areas. Respondents who have heard about the technology are significantly more likely to perceive it as a promising source of clean urban energy.
Awareness about Piezoelectric Energy Technology (energy generated through pressure or movement and association with green energy systems create job opportunities in installation, maintenance, and research

		Opinion about green energy systems create job opportunities in installation, maintenance, and research?			
		No	Not Sure	Yes	Yes;No
Awareness about	No	4	48	84	8

Piezoelectric Energy Technology (energy generated through pressure or movement)?	Yes	4	24	56	0
Total		8	72	140	8

Table No.13 Source : Primary Data

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	6.243a	3	.100
Likelihood Ratio	8.906	3	.031
McNemar-Bowker Test	.	.	.b
N of Valid Cases	228		

Table No.14 Source : Primary Data

Observations:

1. The gender distribution of the respondents indicates that out of the total 228 respondents, 144 (63.2%) were female and 84 (36.8%) were male. This shows that female respondents constituted the majority of the sample, accounting for nearly two-thirds of the total participants, while male respondents represented just over one-third. Therefore, the study findings are based on a sample with a higher representation of females than males, which may influence the overall perspectives and responses obtained in the research.
2. The occupational profile reveals that 120 respondents (52.6%) were students, making them the largest occupational group in the study. This was followed by 40 respondents (17.5%) engaged in business, 36 working professionals (15.8%), and 28 homemakers (12.3%). Only 4 respondents (1.8%) were unemployed. The findings indicate that the sample is predominantly composed of students, suggesting that the opinions and responses largely reflect the views of the younger and educationally active population.
3. The educational profile of the respondents shows that 160 respondents (70.2%) were graduates, making them the dominant educational group in the study. This was followed by 28 postgraduates (12.3%), 24 respondents with technical/engineering qualifications (10.5%), 8 respondents with school-level education (3.5%), and 4 undergraduate respondents (1.8%). Additionally, 4 respondents (1.8%) were recorded under the category "Nikamma." Overall, the findings indicate that the majority of respondents possess graduate-level education, suggesting that the study sample is relatively well educated, which may contribute to informed and reliable responses.
4. The distribution of respondents by area of residence indicates that 180 respondents (78.9%) resided in Panvel, making it the most represented area in the study. Kharghar, Vashi, and Other areas each accounted for 12 respondents (5.3%), while Airoli contributed 8 respondents (3.5%) and Nerul had the lowest representation with 4 respondents (1.8%). This suggests that the study findings are largely based on the perceptions of residents from Panvel, with comparatively limited representation from other parts of Navi Mumbai.
5. Awareness of green energy systems significantly influences respondents' perceptions regarding employment opportunities in installation, maintenance, and research.
6. There is a statistically significant association between awareness of green energy systems and the perception that piezoelectric technology can generate clean energy in urban areas.
7. There is a statistically significant relationship between awareness of green energy systems and Opinion about piezoelectric energy reduce long-term infrastructure costs
8. Awareness of piezoelectric energy technology is significantly associated with respondents' belief that it has the potential to generate clean energy in urban areas.
9. Green energy improves household savings, reducing long-term electricity bills.
10. Green systems contribute to clean air, reducing pollution levels in urban locations.
11. Respondents feel green energy increases employment in renewable sectors.
12. Public awareness is high, but practical implementation is low because of cost barriers.
13. Citizens support government initiatives for renewable energy.

Conclusion

Green energy is power generated from natural, renewable resources like sunlight, wind, and water. Unlike fossil fuels, these sources discharge little to no greenhouse gases. It is the most essential device in the fight against climate change and is now often the cheapest source of new electricity globally. This study examines how green energy systems such as solar power, biogas, wind energy, and piezoelectric micro energy units affect economic growth and societal development in the Navi Mumbai region, The study concludes that green energy systems have a significant positive impact on economic growth and societal development in Navi Mumbai. Adoption of renewable energy leads to environmental protection, increases job opportunities, and supports sustainable urban planning.

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