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Investigate the Economic and Environmental Impact of Transitioning to Renewable Energy Sources

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Abstract: *The transition to renewable energy sources has profound economic and environmental implications that resonate globally. On the economic front, this shift represents a catalyst for job creation, fostering growth in sectors like solar, wind, and hydropower. Investments in clean energy infrastructure and technology open avenues for innovation, stimulating economic development and creating a more resilient energy landscape. Moreover, by reducing dependence on finite fossil fuel reserves, nations enhance energy security and insulate themselves from the volatility of global oil markets. In the environmental sphere, the move towards renewables is a linchpin in the fight against climate change, significantly lowering greenhouse gas emissions. This transition also translates to improved air and water quality; as renewable sources produce energy without the harmful pollutants associated with conventional fuels. Furthermore, embracing renewable energy aligns with sustainability goals, promoting biodiversity conservation and fostering a more harmonious coexistence between human activities and ecosystems. Transitioning to renewable energy sources has significant implications for both economic and environmental landscapes. On the economic front, this shift sparks innovation and job creation, particularly in burgeoning sectors like solar and wind power. Investments in renewable technologies not only drive economic growth but also enhance energy security by diversifying the energy mix and reducing reliance on fossil fuels. Moreover, the renewable energy industry fosters a global market that presents new business opportunities and stimulates sustainable development. Environmentally, the adoption of renewables is a pivotal strategy in the fight against climate change, as it markedly reduces carbon emissions and air pollution. The shift to clean energy contributes to improved air and water quality, mitigating the adverse effects of pollution on ecosystems and human health. The transition to renewable energy sources is a pivotal moment with profound economic and environmental ramifications. Economically, this shift fuels job creation, technological innovation, and investment opportunities. The renewable energy sector emerges as a dynamic driver of economic growth, offering sustainability-focused employment and fostering a resilient energy infrastructure. Additionally, by decreasing reliance on fossil fuels, nations enhance energy security and reduce exposure to volatile energy prices. Environmentally, the move towards renewables represents a crucial strategy in combating climate change. The reduction in greenhouse gas emissions and the mitigation of air and water pollution contribute to improved environmental health. Biodiversity conservation and resource sustainability are further benefits, aligning with a global commitment to a greener and more sustainable future. Economic Indicators, Environmental Metrics, Technological Innovation, Social Equity and Life Cycle Analysis. Economic Impact, Environmental Impact, Greenhouse Gas Emissions Reduction, Air and Water Quality Improvement and Climate Change Mitigation and Adaptation. the Rank of GRA for Economic and Environmental Impact of Transitioning. Life Cycle Analysis is got the first rank whereas is the Technological Innovation is having the Lowest rank*

Keywords: *Economic Indicators, Environmental Metrics, Technological Innovation, Social Equity and Life Cycle Analysis.*

1. Introduction

The transition to a more sustainable and environmentally friendly economy has far-reaching economic and environmental impacts. As societies shift away from traditional, resource-intensive industries toward cleaner and more efficient alternatives, there is a potential for significant economic growth and job creation. Investments in renewable energy, energy efficiency, and green technologies can stimulate innovation and provide new opportunities for businesses and workers. However, the transition also poses challenges for industries that rely heavily on fossil fuels, leading to job displacement and economic restructuring. From an environmental perspective, the shift towards sustainability is crucial for mitigating the impacts of climate change and reducing ecological degradation [1]. Increased adoption of renewable energy sources helps reduce greenhouse gas emissions, mitigating the adverse effects of global warming. Moreover, transitioning to circular economies and sustainable practices can minimize waste generation, conserve natural resources, and promote biodiversity. On the flip side, the initial costs of implementing eco-friendly technologies and practices may present economic challenges for some industries. Renewable energy sources play a pivotal role in addressing the dual challenges of energy security and environmental sustainability [2]. These energy sources, which include biomass, geothermal, hydropower, solar, and wind, take advantage of the natural processes occurring on Earth to provide clean, long-lasting electricity. Whereas wind power uses turbines to capture the motion energy of the wind, solar energy uses photovoltaic cells to turn sunlight into electricity. Hydropower converts flowing water into electrical power, while geothermal energy uses the heat that exists within the Earth. Because it is made of organic elements, biomass can be utilized to generate both heat and electricity [3]. By using sources of renewable electricity, emissions of greenhouse gases are reduced, reliance on finite oil and gas is lessened, and the effects of climate change are lessened. The success of the transition depends on effective policy measures, international collaboration, and public awareness. Governments play a crucial role in providing incentives for green investments, regulating harmful practices, and supporting affected communities during the transition. The transition from limited fossil resources to renewable energy is inevitable, considering its positive impact on the environment. However, it is crucial that such changes are consistent and environmentally friendly in the long term [4]. A Life Cycle Assessment (LCA) perspective reveals that different energy sources have varying effects on the environment. Therefore, a study was conducted in Singapore, Malaysia, and Brunei (SMB) to evaluate different power generation systems and their potential environmental impacts collectively as a region. The global scarcity of non-renewable fossil fuels is on the rise, leading to an increase in greenhouse gas emissions and indicating climate change. The inevitable shift towards renewable forms of energy is driven by their cleanliness, green appearance, and greater stability compared to fossil fuels and nuclear energy [5]. As the world moves towards 100% renewable energy-based power systems, the socio-economic benefits of this diversification become apparent. Renewable energy systems contribute to less pollution at their point of operation compared to fossil fuels. However, it is essential to consider the environmental impact throughout the life cycle of these systems. For instance, solar photovoltaics (PVs), although promoting renewable energy, pose challenges as they contain toxins, rare earth metals, and hazardous chemicals. The increasing use of solar PVs may result in heightened exposure to toxic metals and chemicals, leading to environmental hazards if not managed properly [6]. Currently, renewable energy contributes only a small portion to the global final energy consumption, with the potential to meet human needs in 164 countries as of 2014. While many nations have adopted policies with ambitious renewable energy goals, such as the European Union aiming for 20% of total energy requirements, the productivity of renewable energy and its impact on biodiversity conservation are often overlooked. Interactions between renewable energy pathways and ecosystem processes can disrupt biodiversity, leading to significant negative impacts on environmental services [7]. Several synthesis studies confirm the potential environmental impact of individual renewable technologies, including solar, hydropower, bioenergy, and ocean energy, when compared to conventional energy technologies. Although widespread acceptance of renewable Energy can improve resource effectiveness and reduce the release of greenhouse gases. Ecosystem services, the third foundation of the green economy, and biodiversity protection could also face difficulties as a result of these two major pillars. The prevailing economic model, characterized by a linear take-make-waste approach, relies on the assumption of limitless natural resources a notion established during the industrial revolution. However, this model has brought contemporary civilization to the brink of disaster, proving economically, socially, and environmentally disruptive [8]. The linear economic model, contributing to environmental crises such as climate change, biodiversity loss, and resource scarcity, has spurred various economic sciences to explore alternative ideas and development models over the past four decades. In response to the pressing need to alleviate economic pressure on the environment, alternative models and development ideas have been sought. The goal is to contribute to a global solution for complex climate and environmental issues. Environmental economics and sustainable development theories have given rise to the concept of a "green economy," aiming to address the imbalance between the economy and the environment [9]. The economic development of Croatia is primarily shaped by national politics, followed by European Union policies, World Trade Organization regulations, and the influence of international entities such as the International Monetary Fund. The country is distinctly impacted by global economic trends and its integration into European and global markets, driven by the syncretism evident in the admission process to the European Union, liberalization, and free trade. Key sectors of the Croatian economy include tourism, industry, civil engineering, and agriculture. The six-year recession affected all sectors, except for tourism. However, the current state of the Croatian economy reveals structural weaknesses, regional inequality, low competitiveness, and long-term demographic challenges, highlighting the need for a thorough and formal approach to future development [10]. One proposed model for future development involves incorporating inclusive principles of the Green Economy. Croatia anticipates substantial EU funds for the 2021-2027 period, amounting to approximately 22 billion euros. A significant portion, 9.4 billion euros, is earmarked for COVID-19 recovery and the Next Generation EU initiatives, with the remaining 12.7 billion euros allocated from the EU Multiannual Financial Framework (MFF). Energy consumption across the life cycle is exacerbated by utilization, particularly in copper production. This involves various stages such as mining, beneficiation, melting, and refinement, impacting both direct and indirect processes, including the production of inputs like electricity [11]. Globally, the annual energy requirement for copper production stands at 600 million Gj, contributing 0.21% to greenhouse gas emissions for all metals (IEA, 2009). The demand for copper has surged in the past decade and is expected to continue growing due to population expansion, infrastructure development, and the use of copper-intensive technologies. This escalating demand poses environmental challenges, leading to severe pollution and biodiversity loss in mining sites, including water-quality degradation [12]. A popular technique for assessing how products and materials will affect the environment over the course of their life cycle is life cycle analysis, or LCA. Research examining the effects on the environment per unit of metal production, such as steel, aluminum, zinc, and lead, have been conducted based on various authors' publications. However, some LCA studies, particularly those focusing on iron ore mining and processing, highlight incomplete data due to limitations, as pointed out and others. Numerous scholars have delved into the environmental impacts of mining processes using LCA, identifying rare earths as key contributors to high impact categories [13]. LCA studies on copper production have explored different production routes (primary pyro metallurgical and hydrometallurgical) and secondary production, comparing their environmental impacts. Scholars have examined specific technologies within copper production processes to measure their environmental impacts, energy use, and potential strategies for reducing environmental pressure. Assessing the environmental impacts of copper production extends beyond considering just one kilogram of copper. To comprehensively evaluate these impacts, the total volume of copper produced must be taken into account [14]. The Life Cycle Sustainability Analysis (LCSA) employs a holistic approach, considering a broad perspective that encompasses diverse environmental impacts, economic factors, and community effects. This method evaluates large systems spatially and over an extended temporal scale, aiming to assess future environmental impacts and improvements. LCSA not only analyses environmental impacts but also includes economic considerations and community implications, providing a comprehensive view of the overall sustainability of copper production. This approach considers various types of impacts and intends to incorporate future developments in the economy, materials, and goods usage. Numerous publications have utilized LCSA as a method to scrutinize multiple aspects of the environment, society, or the production of goods, offering a well-rounded assessment of the environmental implications and economic consequences associated with copper production [15]. Renewable energy technologies, focusing on optimizing clean resources, are regarded as environmentally friendly energy sources. Their application aims to minimize environmental impacts, reduce the generation of waste, and maintain stability. These technologies address both current and future economic and social community needs. The Sun serves as the ultimate source for all energies. Solar energy, in its primary forms of heat and light, undergoes transformations and is absorbed by the environment in various ways. Renewable energy, such as biomass and wind energy, stems from these transformations, resulting in stable energy flows [16].

2. Materials and Method

Economic indicators: Economic indicators encompass a range of quantitative measures that offer insights into the overall health and performance of an economy. These include metrics such as GDP growth, unemployment rates, inflation, and trade balances.

Environmental metrics: Environmental metrics focus on assessing the impact of human activities on the environment. This involves monitoring factors such as carbon emissions, air and water quality, biodiversity, and the sustainable use of natural resources.

Technological innovation: Technological innovation refers to the development and implementation of new technologies, processes, or ideas that contribute to progress and efficiency in various sectors. This can involve advancements in research and development, digitalization, and the adoption of cutting-edge technologies.

Social equity: Social equity is a concept that evaluates the fairness and justice within a society. Indicators of social equity include income distribution, access to education and healthcare, social mobility, and the reduction of disparities based on gender, race, or socioeconomic status.

Life cycle analysis: Life cycle analysis assesses the effects a process, the final product, or activity has on the surrounding environment over the course of its whole life cycle. This all-encompassing method takes into account the procurement of raw materials, manufacturing, distribution, utilization, and disposal. aiming to promote sustainability and environmentally responsible decision-making.

Economic Impact: Economic impact refers to the influence that a particular action, project, or policy has on the overall economic conditions of a region or country. This impact can be measured through indicators such as changes in GDP, employment rates, and investment levels.

Environmental Impact: Environmental impact assesses the effects of human activities on the environment. This includes considerations of biodiversity loss, habitat degradation, and the overall health of ecosystems affected by industrial, agricultural, or urban development.

Greenhouse Gas Emissions Reduction: Initiatives to reduce greenhouse gas emissions seek to limit the amount of gases released into the atmosphere, including the gases carbon dioxide, methane, and nitrous oxide. These efforts contribute to mitigating climate change and minimizing the adverse effects of global warming.

Air and Water Quality Improvement: Air and water quality improvement measures focus on enhancing the cleanliness and safety of the air we breathe and the water we use. Strategies may involve reducing pollutants, controlling industrial emissions, and implementing waste management practices to safeguard public health and the environment.

Climate Change Mitigation and Adaptation: The goals of initiatives to mitigate and adapt that climate change are to deal with its challenges. Mitigation is cutting back on or eliminating greenhouse gas emissions, whereas adaptation entails modifying environment as well as societal norms to address the effects of climate change, especially rising seas and harsh weather. events.

Method: the GRA (Grey Relational Analysis) approach at its inception, focusing on the concept of the gray gadget. This technique is particularly effective for selection problems involving multiple attributes within a component. The current literature highlights its applicability in addressing problems associated with multiple factors and variables, especially when dealing with complex relationships. The GRA approach is well-suited for resolving issues related to fixing problems, and various types of GRA techniques have been proposed in the field. The introduction of the GRA approach is both straightforward and environmentally friendly, making it a practical choice for addressing complex problems involving multiple variables [17]. Gray Relational Analysis (GRA) serves as a valuable tool for addressing problems in Multi-Criteria Decision Making (MCTM). Originally introduced by Deng, GRA has proven effective in troubleshooting various MCTM issues. It functions as an evaluative model, employing a method for analyzing records that indicates relationships through a geometric approach. Categorized as a gray communication evaluation technique, GRA aims to study communication between the collection and variation series, making it a versatile method for understanding and evaluating complex relationship [18]. Derived from the concept of gray systems, GRA represents a quantitative method for detecting correlations among different levels of information utilization. The fundamental idea behind GRA lies in evaluating the intimacy of communication through the analysis of series curves. It places significant importance on the combination of series magnitudes, which are inversely determined. GRA is particularly well-suited for assessing problems in communication that involve two factors and varying levels of complexity between variables. It proves effective in addressing a range of issues, including adjudication in various Multi-Criteria Decision Making (MCTM) scenarios and labor selection [19]. Gray Correlation Analysis (GRA) and simulation offer a suitable approach for determining optimal regulatory alternatives. Both methods serve as the gold standard in yielding parameters at various levels, such as a 10µm particle size, 5% reinforcement, 8mm diameter device, 710rpm speed, 20mm/min. feed pressure of 139.48N, cross-feed force of 63.92N, thrust force of 42.6N, temperature of 68.96oC, and ground hardness of 0.198µm. Significance is attributed to the effects of these parameters on response parameters, as each variable's impact is assessed throughout the entire process [20]. Gray Correlation Analysis (GRA) version, each unit is assessed by comparing indicators related to one-dimensional vibrational statistics with those of neighboring entities. Upon obtaining the one-dimensional Local Binary Pattern (1D-LBP) signals, statistical solutions are computed based on these indicators. These processes, well-documented in the literature, are classified using programs designed for GRA. Notably, the 1D-LBP technique has undergone recent modifications in response to vibration alerts, marking its first application in various types of vibrational signals within the GRA framework [21]. The GRA method is employed by decision-makers as it incorporates a fuzzy set approach, taking into account information for addressing decision-making problems. Multiple standards play a crucial role in achieving success in decision-making tasks but can be challenging due to their inherent uncertainty. Consequently, the GRA method is a common tool for job evaluation, dealer selection, factory location, and various manufacturing structures, where numerous criteria are decisive amidst uncertainty [22]. The primary purpose of GRA is to elucidate the comparative ranking of alternatives based on their performance. In this method, known as Gray Relative Analysis, a super target sequence is established in accordance with specific scenarios. Subsequently, each alternative in the rows undergoes evaluation using the Carey correlation coefficient against the satisfying target collection. Finally, the gray correlation is computed by applying coefficients, revealing the correct target sequence and determining the size of gray contact for each variant sequence [23]. GRA proposes an incorporated GRA for distribution network and AHP technique reconstruction to plan hydropower technology. Particle reinforced stem Electric discharge apparatus GRA to improve the method Provide a sample fabric. Proposes GRA to estimate the relative have an impact on of fuel fee, gross domestic product variety motors and vehicle kilometres travelled to electricity growth. Taiwan uses the Fuzzy-GRA technique to assess the economic overall performance of box lines. Proposes an incorporated GRA approach for provider evaluation of environmental know-how management abilities. Examine and rank the energy performance of office homes the usage of GRA [24]. Gray Correlation Analysis (GRA) is frequently utilized in Asia and serves as a version for outcome evaluation, particularly on an absolute basis. It focuses on determining the similarity among rows or the degree of difference in dating measurements. GRA primarily aims to examine influencing factors through its purpose and frameworks [25]. Gray Relational Analysis (GRA) is The Facts Appraisal technique, also known as the geometric method, assesses the relationship between arrays of a specific type, as proposed in the GRA technique. The primary objective of GRA is to gauge the level of similarity among interelements based on the degree of their relationship. Studies have applied GRA to evaluate the impact of environmental factors, such as the erosion of used oil pipes in gas wells. Policy implications have been identified through the application of GRA factors, considering overall performance characteristics. In the United States, the Electro Discharge Machining Method has utilized GRA, and GRA has been employed for assessing expatriate assignments, including scenarios involving added water in Beijing. A composite approach for resource security assessment involves the use of GRA and related techniques. Jodi has mentioned the use of GRA in phrases for a given product image, determining the optimal settings for sweetness based on the corresponding components. Furthermore, GRA has been introduced in the context of Brand New Faith Activities, proposing a system for struggle reform. In the field of Electrocardiogram (ECG) analysis, GRA is applied as a Heart Rate Discriminator, utilizing different ECGs and proposing a technique to obtain the degree of frequency components in beats. Additionally, a GRA prediction-integrated approach has been proposed for round releases [26]. The organization known as GRA (Reference/Aspiration Level optional) involves the comparison of various factors and elements through substitution, illustrating relationships. Within the GRA model, the calculation concepts and processes are briefly examined. GRA, based on the color gadget principle, is a selection technique developed by Deng. It is inherently gray in color, with black symbolizing incomplete information containing statistics. The white gadget, on the other hand, represents complete truths. The gray relationship within GRA pertains to incomplete facts and connections between rows, serving as an indicator of size. This allows for the individual measurement of element spacing. In cases where tests are ambiguous or the execution of test techniques is precisely impossible, a gray scale in statistical regression is employed to rectify defects [27].

3. Results and Discussion

TABLE 1. Economic and Environmental Impact of Transitioning

	Economic Impact	**Environmental Impact**	**Greenhouse Gas Emissions Reduction**	**Air and Water Quality Improvement**	**Climate Change Mitigation and Adaptation**
Economic Indicators	31.08	139.53	29.15	22.05	36.05
Environmental Metrics	29.12	142.97	33.69	27.30	6.00
Technological Innovation	24.08	122.58	29.18	23.10	45.36
Social Equity	23.17	128.28	24.60	17.59	34.00
Life Cycle Analysis	33.33	186.41	27.96	18.89	45.00

Table 1 shows the Economic and Environmental Impact of Transitioning for Grey relational analysis (Economic Indicators) 31.08 is showing the Highest Value for Economic Impact and (Social Equity) 23.17 is showing the lowest value. 142.97 (Environmental Metrics) is showing the Highest Value for Environmental Impact 122.58 (Technological Innovation) is showing the lowest value. 33.69 (Environmental Metrics) is showing the Highest Value for Greenhouse Gas Emissions Reduction Lowest Value: 24.60 (Social Equity) is showing the lowest value. 27.30 (Environmental Metrics) is showing the Highest Value for Air and Water Quality Improvement 17.59 (Social Equity) is showing the lowest value. 45.36 (Technological Innovation) is showing the Highest Value for Climate Change Mitigation and Adaptation 6.00 (Environmental Metrics) is showing the lowest value.

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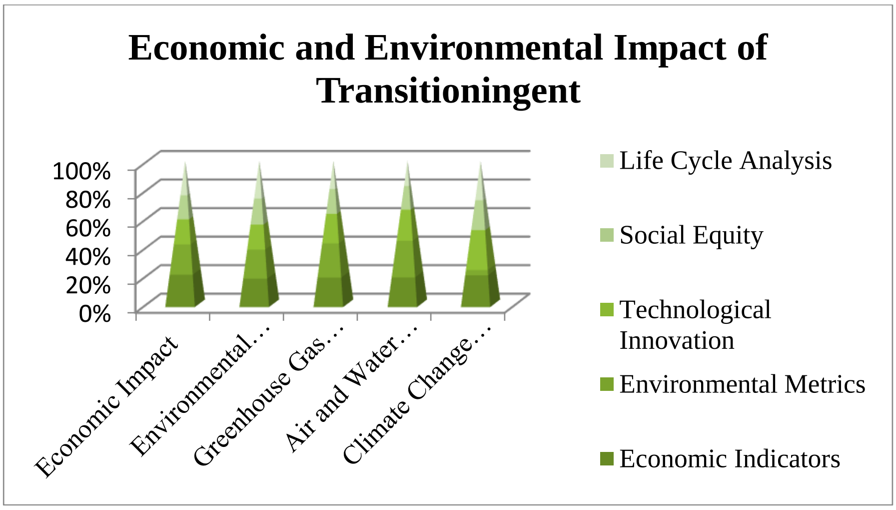
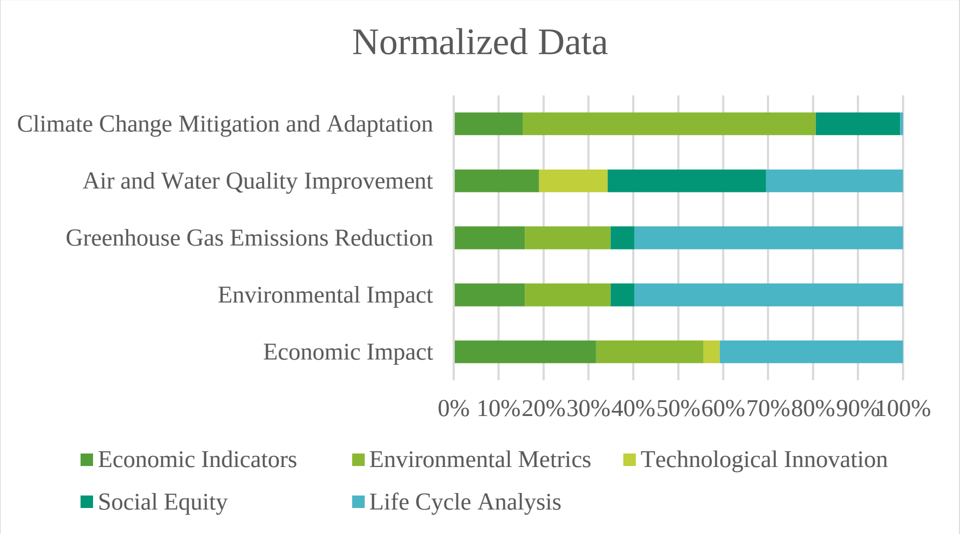


FIGURE 1. Economic and Environmental Impact of Transitioning

TABLE 2. Normalized Data

	Economic Impact	**Environmental Impact**	**Greenhouse Gas Emissions Reduction**	**Air and Water Quality Improvement**	**Climate Change Mitigation and Adaptation**
Economic Indicators	0.7785	0.2655	0.2655	0.5407	0.2365
Environmental Metrics	0.5856	0.3194	0.3194	0.0000	1.0000
Technological Innovation	0.0896	0.0000	0.0000	0.4325	0.0000
Social Equity	0.0000	0.0893	0.0893	1.0000	0.2886
Life Cycle Analysis	1.0000	1.0000	1.0000	0.8661	0.0091

Table 2 shows the Normalized data for Economic and Environmental Impact of Transitioning. Economic Impact, Environmental Impact, Greenhouse Gas Emissions Reduction, Air and Water Quality Improvement and Climate Change Mitigation and Adaptation in Economic Indicators, Environmental Metrics, Technological Innovation, Social Equity and Life Cycle Analysis it is also the Normalized value.



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Change Mitigation and Adaptation in Economic Indicators, Environmental Metrics, Technological Innovation, Social Equity and Life Cycle Analysis it is also the Normalized value.

TABLE 3. Deviation sequence

Deviation sequence				
Economic Impact	**Environmental Impact**	**Greenhouse Gas Emissions Reduction**	**Air and Water Quality Improvement**	**Climate Change Mitigation and Adaptation**
0.2215	0.7345	0.7345	0.4593	0.7635
0.4144	0.6806	0.6806	1.0000	0.0000
0.9104	1.0000	1.0000	0.5675	1.0000
1.0000	0.9107	0.9107	0.0000	0.7114
0.0000	0.0000	0.0000	0.1339	0.9909

Table 3 shows the Deviation sequence for Economic and Environmental Impact of Transitioning. Economic Impact, Environmental Impact, Greenhouse Gas Emissions Reduction, Air and Water Quality Improvement and Climate Change Mitigation and Adaptation in Economic Indicators, Environmental Metrics, Technological Innovation, Social Equity and Life Cycle Analysis it is also the Maximum or Deviation sequence value.

TABLE 4. Grey Relation Coefficient

Grey Relation Coefficient				
Economic Impact	**Environmental Impact**	**Greenhouse Gas Emissions Reduction**	**Air and Water Quality Improvement**	**Climate Change Mitigation and Adaptation**
0.6930	0.4050	0.4050	0.5212	0.3957
0.5468	0.4235	0.4235	0.3333	1.0000
0.3545	0.3333	0.3333	0.4684	0.3333
0.3333	0.3544	0.3544	1.0000	0.4128
1.0000	1.0000	1.0000	0.7888	0.3354

Table 4 shows the Grey relation coefficient for Economic and Environmental Impact of Transitioning. Economic Impact, Environmental Impact, Greenhouse Gas Emissions Reduction, Air and Water Quality Improvement and Climate Change Mitigation and Adaptation in Economic Indicators, Environmental Metrics, Technological Innovation, Social Equity and Life Cycle Analysis it is also Calculated the Maximum and minimum Value.

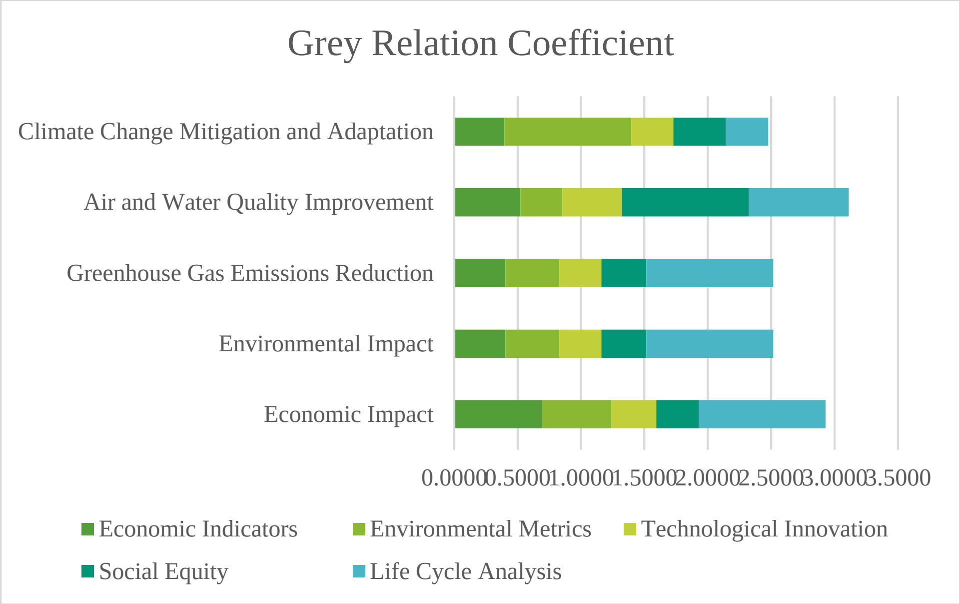

FIGURE 3. Grey Relation Coefficient

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Climate Change Mitigation and Adaptation in Economic Indicators, Environmental Metrics, Technological Innovation, Social Equity and Life Cycle Analysis it is also Calculated the Maximum and minimum Value.

TABLE 5. Result of final GRG Rank

	GRG	Rank
Economic Indicators	0.4840	4
Environmental Metrics	0.5454	2
Technological Innovation	0.3646	5
Social Equity	0.4910	3
Life Cycle Analysis	0.8248	1

Table 5 shows the Result of final GRG Rank of GRA for Economic and Environmental Impact of Transitioning. GRG Rank Life Cycle Analysis is showing the highest value for GRG Rank and Technological Innovation is showing the lowest value.

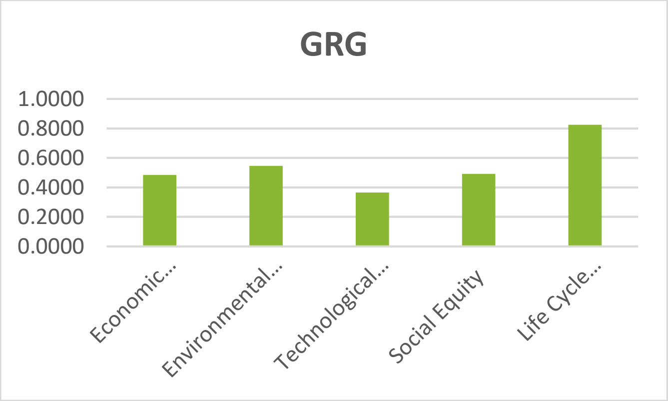

FIGURE 4. GRG

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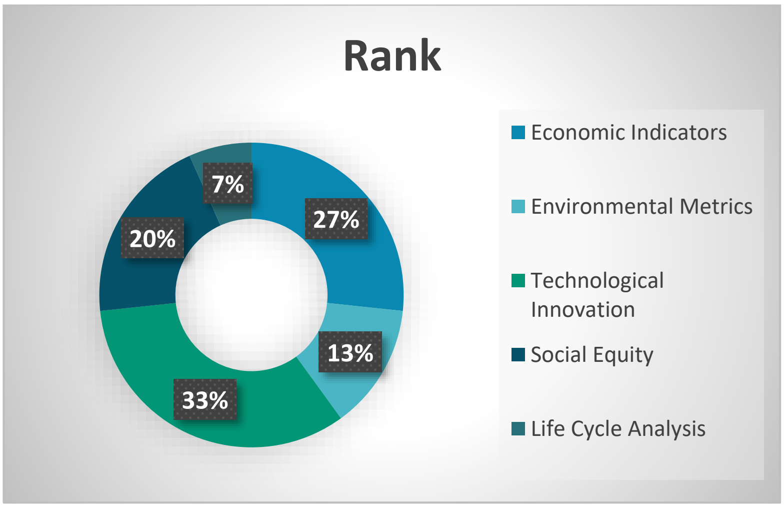

FIGURE 5. Shown the Rank

Figure 5 shows the Rank of GRA for Economic and Environmental Impact of Transitioning. Life Cycle Analysis is got the first rank whereas is the Technological Innovation is having the Lowest rank.

4. CONCLUSION

The transition to renewable energy sources has profound economic and environmental implications that resonate globally. On the economic front, this shift represents a catalyst for job creation, fostering growth in sectors like solar, wind, and hydropower. Investments in clean energy infrastructure and technology open avenues for innovation, stimulating economic development and creating a more resilient energy landscape. Moreover, by reducing dependence on finite fossil fuel reserves, nations enhance energy security and insulate themselves from the volatility of global oil markets. In the environmental sphere, the move towards renewables is a linchpin in the fight against climate change, significantly lowering greenhouse gas emissions. This transition also translates to improved air and water quality; as renewable sources produce energy without the harmful pollutants associated with conventional fuels. Furthermore, embracing renewable energy aligns with sustainability goals, promoting biodiversity conservation and fostering a more harmonious coexistence between human activities and ecosystems. As the world moves towards 100% renewable energy-based power systems, the socio-economic benefits of this diversification become apparent. Renewable energy systems contribute to less pollution at their point of operation compared to fossil fuels. However, it is essential to consider the environmental impact throughout the life cycle of these systems. For instance, solar photovoltaics (PVs), although promoting renewable energy, pose challenges as they contain toxins, rare earth metals, and hazardous chemicals. The increasing use of solar PVs may result in heightened exposure to toxic metals and chemicals, leading to environmental hazards if not managed properly. Currently, renewable energy contributes only a small portion to the global final energy consumption, with the potential to meet human needs in 164 countries as of 2014. While many nations have adopted policies with ambitious renewable energy goals, such as the European Union aiming for 20% of total energy requirements, the productivity of renewable energy and its impact on biodiversity conservation are often overlooked. Interactions between renewable energy pathways and ecosystem processes can disrupt biodiversity, leading to significant negative impacts on environmental services. Additionally, by decreasing reliance on fossil fuels, nations enhance energy security and reduce exposure to volatile energy prices. Environmentally, the move towards renewables represents a crucial strategy in combating climate change. The reduction in greenhouse gas emissions and the mitigation of air and water pollution contribute to improved environmental health. Biodiversity conservation and resource sustainability are further benefits, aligning with a global commitment to a greener and more sustainable future. Economic Indicators, Environmental Metrics, Technological Innovation, Social Equity and Life Cycle Analysis. Economic Impact, Environmental Impact, Greenhouse Gas Emissions Reduction, Air and Water Quality Improvement and Climate Change Mitigation and Adaptation. the Rank of GRA for Economic and Environmental Impact of Transitioning. Life Cycle Analysis is got the first rank whereas is the Technological Innovation is having the Lowest rank.

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