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Fostering a Sustainable Energy Future to Combat Climate Change: EESG Impacts of Green Economy Transitions

Dicao Tang [1,*] and Yasir Ahmed Solangi [2,*]

[1] Huanghe Jiaotong University, Jiaozuo 454950, China
[2] School of Management, Jiangsu University, Zhenjiang 212013, China
* Correspondence: 2004080004@zjtu.edu.cn (D.T.); yasir.solangi@nuaa.edu.cn or yasir.solangi@ujs.edu.cn (Y.A.S.)

Abstract: The transition to a green economy for any country is crucial for the sustainability development of the economy, environment, society, and governance (EESG). A green economy is a sustainable approach to combating climate change and promoting sustainable development through the adoption of sustainable energy. This research utilizes the Delphi and fuzzy analytical hierarchy process (AHP) methodologies to assess and rank the EESG criteria and policy options for transitions to a green economy. The factors and policy choices are identified using the Delphi approach for further analysis. These factors and policy alternatives for switching to a green economy for sustainable development are determined using the fuzzy AHP technique. According to the fuzzy AHP approach, environmental, social, and economic factors are best suited for green economy transitions. The findings also show that the most crucial policy options for the switch to a green economy are research and development, carbon pricing, and renewable energy targets. The findings are useful to guide the creation of policies and the selection of options for the implementation of a green economy. Finally, the conclusion can guide actions to combat climate change and develop a sustainable energy future.

Keywords: green economy; sustainable energy; climate change; sustainable development; Delphi method; fuzzy AHP

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1. Introduction

The idea of a green economy (GE) is receiving a lot of attention as a solution to the problems of both economic development and safeguarding the environment [1]. In order to reduce greenhouse gas (GHG) emissions and other negative environmental impacts, a GE must be low carbon, resource-efficient, socially inclusive, and support sustainable development [2]. Economic structures, production and consumption patterns, and governing institutions must all undergo radical change throughout the transition to a GE. As a result of this shift, we can tackle the urgent global problem of climate change while also boosting the economy, creating jobs, and reducing poverty [3].

The Intergovernmental Panel on Climate Change (IPCC) consistently stressed the critical need to diminish GHG emissions to prevent disastrous climate consequences [4]. A total of 196 countries signed the 2015 Paris Agreement, which aims to limit global warming to well below 2 degrees Celsius compared to pre-industrial levels and further aims to limit the temperature rise to 1.5 degrees Celsius [5]. Realizing this objective necessitates an expeditious and extensive transformation to a low-carbon economy, involving a significant pivot towards renewable energy (RE), enhanced energy efficiency, and ecologically sustainable land management practices. The transition to GE is not only imperative for climate change mitigation, but it also yields considerable supplementary benefits in terms of economic growth, job generation, and enriched environmental and social outcomes [6].

The financial advantages of adopting a GE are considerable. Transitioning towards RE resources, including wind, solar, and geothermal, can give rise to new industries and job prospects, while simultaneously diminishing reliance on fossil fuels and related energy import dependencies [7]. Investment in energy efficiency measures, such as improved insulation and more efficient appliances, can lower energy bills for households and businesses and reduce energy demand, freeing up resources for other purposes. Sustainable land use practices, such as agroforestry and regenerative agriculture, can increase soil health and productivity, improve the resilience of agricultural systems, and support local food systems. Moving to a GE can also generate new business opportunities in areas such as sustainable tourism, green finance, and eco-design [8]. However, the transition to a GE also presents significant challenges. One of the primary challenges is the need to overcome existing barriers and vested interests that support the status quo. For instance, there may be resistance from established industries, such as fossil fuel companies, to the transition to RE.

It is crucial to evaluate how switching to GE might impact the economy, environment, social concerns, and governance (EESG) in order to handle both the difficulties involved as well as its potential. For assessing the various effects of switching to GE, the use of a combined Delphi and fuzzy analytical hierarchy process (AHP) technique can provide an appropriate framework. As a result, converting to GE is a difficult operation that requires an all-encompassing issue due to its complexity and variety of processes. The analysis of challenges to GE transition in the EESG perspective would provide guidelines to speed up the GE transition and deal with challenges on the way to this transition. A combined Delphi and fuzzy AHP technique can be used to evaluate the multiple implications of converting to GE and choose the best course of action for halting climate change and creating a sustainable energy future.

2. Literature Review

With an emphasis on the EESG aspects, this literature review seeks to present an overview of the important ideas, hypotheses, and conclusions linked to the move to GE.

2.1. Economic Dimension

The economic implications of a shift to a GE received attention in the literature. The potential economic advantages of the shift, such as job creation, economic growth, and poverty alleviation, received significant attention. According to research currently available, switching to renewable energy sources and enacting energy efficiency measures can promote the formation of new sectors and job openings while also reducing dependency on fossil fuels and related energy imports [9]. Investing in sustainable land use techniques can improve soil productivity and health, fostering regional food systems and rural development. The literature emphasizes the potential financial costs of the transition, including the expenses of switching to RE sources and energy conservation measures, as well as the possible effects on industries including transportation, agriculture, and industry. That implies that there may be winners and losers in the transition across various industries and social classes [10]. There might be a trade-off between environmental sustainability and economic growth, as well as between immediate and long-term gains. The GE is a new strategy for growth and development that aims to advance the economy while improving people's lives in a way consistent with social and environmental well-being. Promoting the development and use of sustainable technology is one of the central tenets of GE strategy. Previous work discusses the difficulties in achieving sustainable technological progress and stresses the need for these issues to be comprehended by the decision-makers as well [11]. Furthermore, in order to achieve sustainable technological progress, the government and private sector need to reconsider their responsibilities and prioritize them accordingly. If the magnitude of technological change does not align with the green development level of the economy, then the magnitude of technical change could be an obstacle to include green growth [12].

Previous work examined how the board's corporate social responsibility approach, strategy, global reporting initiative (GRI), and national specific characteristics affect European corporations' environmental, social, and governance (ESG) disclosure practices [13]. The education of future leaders who will help spread the ideals of the sustainable development goals is a crucial function that higher education institutes may serve in promoting sustainability [14]. The green economy framework provides several ideas, strategies, and instruments that enable varying degrees of trade-offs and substitutability between environmental and financial gains. It calls for various degrees of structural modifications to our way of life [15]. Moreover, earlier research established three discourse categories that offer insight into the definition and ramifications of "greening": "almost business as usual", "greening", and "all change" through a systematic qualitative examination of textual material [2]. Three interconnected patterns may be seen when these categories are compared to Dryzek's description of environmental discourse. These mainly include scarcity and limits, means and ends, and reductionism and unity. These patterns help explain the significance and consequences of greening for sustainable development by highlighting the conflicts between developing hypotheses. Furthermore, these patterns draw attention to the economization and polarization of discourses, the continuation of a faulty understanding of sustainable development, and the conflict between modifying or changing the predominant socioeconomic assumptions that support its conceptualization.

2.2. Environmental Dimension

Much focus was also given in the literature to the environmental aspect of the switch to a GE. The potential environmental advantages of the transition, including the reduction in carbon emissions, improved air and water quality, and decreased reliance on fossil fuels, received significant attention [11]. According to research, switching to renewable energy sources and enacting energy-saving measures can significantly reduce GHG emissions, thus reducing the impacts of climate change [16,17]. Given the different global and local difficulties, the experts and practitioners increasingly call for a fundamental shift in the energy system. Leaders and other stakeholders are developing energy plans using energy visions that outline the intended future energy system [18]. To properly prepare for climate change adaptation, it is critical to consider the technical issues and those who will be affected by decisions made now and in the future. A comprehensive approach to adaptation planning involves a mix of top-down and bottom-up activities fueled by an inclusive and collaborative action research process. This holistic approach emphasizes the interconnectedness between administrative decision-making and community-driven efforts to guarantee that adaptation planning is equitable and prosperous for all [19]. Furthermore, Campos et al. [20] aim to give insights into the problem of supporting a sustainable energy transition and achieving carbon neutrality targets through a participatory and democratic approach. The findings show general agreement that decarburization should be a top priority and should be undertaken inclusively and democratically. Transparency and information sharing are essential for new lithium mining operations, large-scale solar ventures, and green hydrogen investments, while decentralization, energy communities, and solar energy are highly valued.

2.3. Social Dimension

The switch to renewable energy sources and energy-saving practices can open up new job opportunities and encourage the acquisition of new skills, thereby reducing poverty and promoting social inclusion [21]. The research does, however, also draw attention to the social costs of the transition, including its possible effects on various social groups, including women, young people, and indigenous populations. In particular, it points out the displacement of the disadvantaged households and individuals due to the development of RE projects infrastructure [22]. Since people now want green investments produced in local communities, such as wind power, to support regional growth, employment, and other social goals, the regional aspect of sustainable development plays a vital role and offers difficulty [23]. The growing assertion of people's rights, especially indigenous rights, and demands for greater participation in decision-making processes can be linked to the increased emphasis on the distributional consequences at the regional level. However, despite the potential advantages of new green technology, it could not significantly influence local and regional revenue and employment. The link between the economy and the renewable energy sector changed due to technological advancement. The investment capital needs of facilities, such as windmill parks and biofuel production facilities, dramatically grew due to scale economies and increasing capital intensity [11]. Weber and Cabras [24] examined the socio-environmental tensions that exist in order to examine the economic and social implications of low carbon emissions. These conflicts result from neoclassical economic policies that target the planning and behavior of businesses. Stakeholder organizations that oppose companies with a high carbon footprint also contribute significantly to these disputes. The outcome is that the research underlines the need for more inclusive and sustainable policies that may successfully resolve these conflicts and the drawbacks of unsustainable policies that emphasize economic growth above environmental concerns. Social movements battling for a low-carbon economy and a more just society are often involved in these battles. Today's globe is plagued with crises and difficulties ranging from poverty and environmental degradation to political and economic issues. In this setting, the green economy appears as a feasible strategy for improving economic circumstances while lowering environmental hazards, conserving the environment, fostering human equality, and improving social welfare [25]. Vallejos-Romero et al. [26] identified three key areas of research related to green hydrogen and the future challenges confronting the social sciences: (a) risks, socio-environmental impacts, and public perception; (b) public policies and regulation; and (c) social acceptance and willingness to use associated technologies. According to the findings, Europe and Asia are at the forefront of study on this subject, particularly emphasizing public policy, regulation, and societal acceptability. However, research on the social and environmental consequences of hydrogen on local communities and indigenous people and the engagement of local governments in rural regions needs to be improved. Furthermore, more integrated studies that include technical and societal aspects are required to assess hydrogen and greener energy transitions accurately. Finally, unfamiliarity with this technology may restrict its adoption in some situations [26].

2.4. Governance Dimension

The creation of institutions to promote innovation, investment, and knowledge transfer, as well as the creation of appropriate legal frameworks and policy incentives are all indicated in the literature as being vital to supporting and assisting the shift [27]. Effective governance also requires engagement with stakeholders from all industries and socioeconomic groups in order to guarantee that their needs and interests are taken into account in decision-making [28]. Consumers who are contented with their lifestyles and purchasing habits may be hesitant to change their habits and behavior. The literature also emphasizes the necessity of making sure that the transition is socially equitable and inclusive, with the interests of marginalized and vulnerable people being highlighted [29]. The government uses the green economy to obstruct collective contemplation and action toward effectively repairing ecosystems and addressing the underlying socio-ecological concerns that threaten the globe. Instead, it counters insurgency and supports the state and capital, stifling movement towards long-term solutions [30]. Furthermore, with the ultimate goal of ensuring a more secure and equitable future for individuals who run the danger of being marginalized owing to limited access to, use of, and control over land, fisheries, forests, and water resources, the main goal for the governments is to go beyond simple transition and towards transformation. If the concession model of land-based investments is kept up, this becomes even more crucial. They depend on these resources to support their way of life. Thus, it is critical to defend their rights and interests [31]. On the way to transition to a GE, the environmental governance, institutional quality, and technological innovations are important to enable the economies to achieve sustainable development [32].

Existing research suggests that making the switch to a green economy has advantages for the environment, the economy, society, and government. Yet, there are major expenses associated with this transformation, and there may be trade-offs between various goals. Effective governance, which includes creating suitable legal frameworks, policy incentives, and institutions to support innovation, investment, and knowledge transfer, is crucial to easing the transition. In this study, a combination method utilizing fuzzy AHP and Delphi can be useful in evaluating the effects of shifting to a green economy and identifying efficient policy solutions for creating a sustainable energy future and tackling climate change.

2.5. Research Gap

Despite the fact that there is a wealth of information on the switch to GEs, several issues still need more research to be addressed. The neglect of considering how many components overlap, particularly how EESG factors interact, is one of the major gaps. While studies looked at each of these elements separately, few examined the intricate relationships that exist between them. There is a need for greater study that analyzes the transition to GE using an interdisciplinary and integrative approach. The need for more empirical studies that assess the effects of switching to GE for a particular purpose is another research gap. While some studies assessed the effects of the shift in particular industries or nations, there is a dearth of research that offers a thorough and comparative analysis of the repercussions of the transition in various circumstances [18]. Such research would be helpful for figuring out the best course of action for aiding the transition and dealing with the opportunities and obstacles related to the transition in various circumstances. Although several studies examined the performance of individual policy measures, there is a lack of a thorough and comparative examination of the efficacy of different governance structures and institutional arrangements in facilitating the transition. The ideal institutional and governance frameworks to facilitate the transition and deal with the opportunities and challenges it presents could be determined with the help of such a study. This study employs the Delphi and fuzzy AHP techniques in order to close a knowledge gap and pave the way for further research.

3. Methodology

To determine the most important criteria and possible policy solutions, the Delphi approach is utilized. The relative weights of the indicated criteria are assessed, as well as the overall effects of various policy alternatives, using the fuzzy AHP approach. In order to achieve the decision goal of the study, the fuzzy AHP procedure entails creating a hierarchical structure that includes the criteria, sub-criteria, and alternatives [33]. The study's research methodology is shown in Figure 1.

The suggested study methodology offers a thorough and integrated strategy for analyzing the many effects and policy alternatives of switching to GE. The incorporation of EESG elements is made possible by the use of a combined Delphi and fuzzy AHP technique, which also offers a helpful framework for determining the best course of action for combating climate change and developing a sustainable energy future.

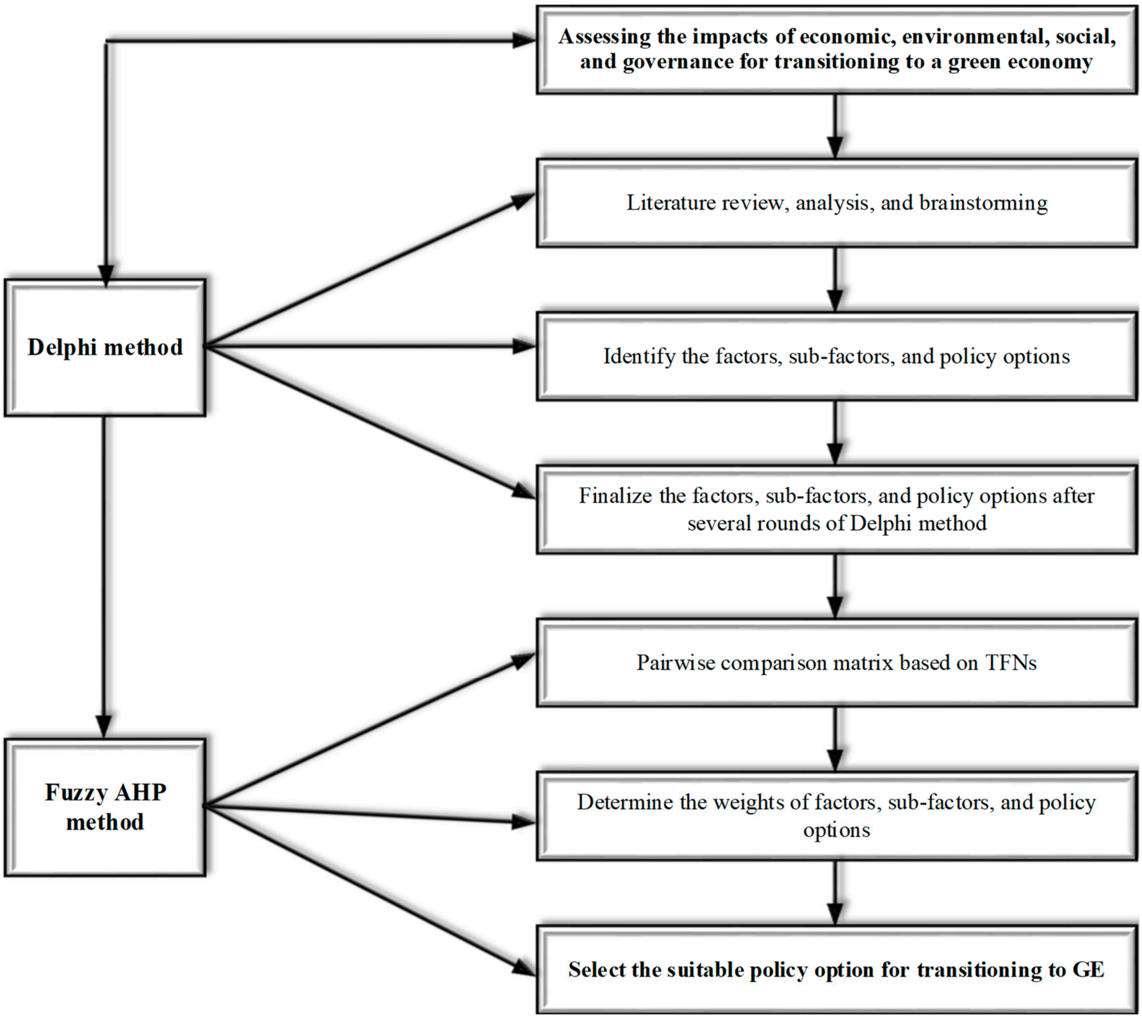

Figure 1. Proposed research methodology.

3.1. Delphi Method

The Delphi method is a methodical strategy that entails compiling and analyzing data from a group of experts on a certain subject [34]. When it is necessary to make decisions that are supported by the advice and insights of authorities in a given subject, the Delphi method is employed. A series of questions are utilized throughout the procedure to obtain the experts' comments [35]. The Delphi method was utilized in the study, with the first step being the selection of an expert panel based on their knowledge of the subject matter. For the second round of the questionnaire, a summary of the replies is sent back to the experts. Lastly, based on the findings of the first round, the panel of experts receives the second round of the questionnaire [36]. On the basis of the outcomes of the first round, the experts are asked for their thoughts on the crucial elements that must be taken into account. Until the experts reach an agreement, this process is repeated.

3.2. Fuzzy AHP Method

A decision-making technique called the fuzzy AHP enables decision-makers to rank the relative importance of many criteria, sub-criteria, and alternatives [37,38]. It is an improvement on the standard AHP approach, which uses the idea of fuzziness to address the ambiguity and imprecision that come up in difficult decision-making problems [39]. The AHP method's beginnings can be found in the 1970s, when Saaty first proposed it [40]. Table 1 shows the triangular fuzzy numbers (TFNs) scale for this study.

Table 1. Triangular fuzzy numbers scale [25].

Code	Linguistic Variable	TFNs
1	Equally dominant	(1,1,1)
2	Equally to the average dominant	(1,2,3)
3	Averagely dominant	(2,3,4)
4	Averagely to strongly dominant	(3,4,5)
5	Strongly dominant	(4,5,6)
6	Strongly to very strongly dominant	(5,6,7)
7	Very strongly dominant	(6,7,8)
8	Very strongly to extremely dominant	(7,8,9)
9	Extremely dominant	(9,9,9)

This study calculated the fuzzy pairwise comparison matrix's inconsistency ratio using Gogus and Boucher's approach [41]. This computation used the following steps:

Step 1. Converting a triangular fuzzy matrix into two independent matrices is shown below:

$$X_i = (l_i, m_i, u_i). \tag{1}$$

A middle fuzzy triangular matrix can be used to create the first triangular fuzzy matrix.

$$X_m = [x_{ijm}] \tag{2}$$

The upper and lower boundaries of the triangle fuzzy numbers can be determined using a geometric mean method to construct the second triangular fuzzy matrix.

$$X_g = [\sqrt{x_{iju} x_{ijl}}] \tag{3}$$

Step 2. Create the weight vector using the Saaty technique and the lambda max calculation.

Step 3. Create the consistency index (CI) for each matrix as follows:

$$CI_m = \frac{\lambda_{max}^m - n}{n - 1} \tag{4}$$

$$CI_g = \frac{\lambda_{max}^g - n}{n - 1}. \tag{5}$$

Step 4. Calculate the consistency ratio (CR) of each matrix by dividing its consistency index (CI) by its corresponding random index (RI).

$$CR_m = \frac{CI_m}{RI_m} \tag{6}$$

$$CR_g = \frac{CI_g}{RI_g}. \tag{7}$$

To ensure the validity of the pairwise comparison, it is essential that CR_m and CR_g must be less than 0.10 [42]. Thus, the fuzzy AHP approach is used to evaluate the EESG consequences of various policy alternatives in the context of the transition to a GE and to pinpoint the most practical options for combating climate change and constructing a sustainable energy future.

The specific research questions and objectives, as well as the scope and circumstances of the inquiry, were used as the basis for the selection criteria for specialists to take part in the study [43]. In the study, a diverse range of experts from academia, industry, and government, as well as economists, environmental experts, and social experts were included to provide a comprehensive and integrated perspective on the transition to a GE for a sustainable energy future to tackle climate change. The selection of experts was based on their expertise, experience, and knowledge of the different dimensions of the transition to GE. The experts were selected based on their ability to work collaboratively and engage in constructive dialogue with the other experts. In the study, we consulted with eight Chinese experts to provide their meaningful insights and assess the identified factors, sub-factors, and policy options for shifting to GE in China. All the experts were consulted via email and provided with a questionnaire to rate the importance of each factor relative to one another. The obtained results were analyzed using a Microsoft Excel spreadsheet.

4. Identification of Factors, Sub-Factors, and Policy Options

The determination of factors, sub-factors, and policy options for the study relied on the particular research inquiries and goals, as well as the extent and circumstances of the investigation. Nevertheless, the assessment of the effects associated with the adoption of the GE could take into account the subsequent factors, sub-factors, and policy options in a general sense. This study identified the most crucial factors and policy options through a literature review and the Delphi method. Thus, in the following sub-sections, we briefly describe each of the factors, their sub-factors, and policy options for transitions to a GE.

4.1. Economic Factors (GEF1)

Job creation and employment opportunities in the RE sector (GEF11)

This sub-factor refers to the number and types of jobs that could be created as a result of the transition to a GE. It includes both direct and indirect jobs in the RE sector and related industries, such as manufacturing and installation of RE technologies [44].

Investment in RE infrastructure and technology (GEF12)

It refers to the amount of investment that is required to build the necessary infrastructure and technology for the transition to a GE. It includes investment in RE sources, such as solar, wind, hydro, and geothermal, as well as the distribution and storage infrastructure [45].

Cost savings due to less energy use and high energy efficiency (GEF13)

This shows that cost saving is crucial for the development of a GE, since it provides cost saving methods to reduce the consumption of energy use and simultaneously increases energy efficiency. Therefore, it has potential benefits for saving energy for businesses, homes, and governments [46].

Competitiveness and economic growth (GEF14)

This sub-factor indicates that competitiveness and economic development are very important for the development of GE and sustainable development. This shows that the potential for new business opportunities, innovation, and the emergence of new markets is available [47].

4.2. Environmental Factors (GEF2)

Reduction in GHG emissions and air pollution (GEF21)

This sub-factor focuses on the reduction in GHG emissions and air pollution that might be attained by switching to a GE. It takes into account the possible decrease in carbon dioxide emissions as well as other air pollutants, such as sulphur dioxide and particulate matter [48].

Protection of biodiversity and ecosystems (GEF22)

This sub-factor focuses on the possible safeguarding of ecosystems and biodiversity that could be accomplished through the switch to GE. It may result in a decrease in habitat loss and the preservation of threatened species [49].

Conservation of natural resources (GEF23)

This sub-factor is concerned with the potential preservation of natural resources that could result from the switch to a GE. It may involve reducing the consumption of nonrenewable resources, such as fossil fuels, and preserving natural resources, such as water and land [50].

Water and land management (GEF24)

The possible enhancements in water and land management that could be attained through the switch to GE are discussed in this sub-factor. It could result in a decrease in water use and better management of land resources [51].

4.3. Social Factors (GEF3)

Social equity and access to energy for all (GEF31)

The improvement in social fairness and universal access to energy that could be attained through the switch to a GE is the subject of this sub-factor. It could lead to a decrease in energy poverty and better access to electricity for disadvantaged and vulnerable communities [52].

Health benefits from reduced air pollution (GEF32)

The possible health advantages that could be attained by reducing air pollution are covered by this sub-factor. It involves the possible lowering of cardiovascular and respiratory illnesses, as well as the enhancement of general public health [53].

Impacts on vulnerable and marginalized communities (GEF33)

This sub-factor addresses the possible effects of the switch to a GE on weaker and underprivileged communities. It covers potential repercussions for low-income households and communities relying on sectors that could be impacted by the transformation [22].

Impacts on indigenous peoples and local communities (GEF34)

This sub-factor to consider is the potential effects of the shift to a GE on indigenous populations and nearby communities, which could involve impacts on customary practices and safeguarding cultural patrimony [29].

4.4. Governance Factors (GEF4)

Institutional and regulatory frameworks to support the transition (GEF41)

The institutional and regulatory frameworks that must exist in order to support the switch to a GE are referred to in this sub-factor. It entails creating laws and guidelines to ease the transition, such as RE targets and incentives [54].

Political will and commitment to the transition (GEF42)

The political commitment and will needed to facilitate the switch to a GE are referred to in this sub-factor. It entails their assistance and direction during the transition, as well as that of politicians and policymakers [55].

Public engagement and participation (GEF43)

The significance of public engagement and participation in the switch to a GE is discussed in this sub-factor. It entails involving the public and stakeholders in the creation and execution of transition-related policies and programs [56].

International cooperation and collaboration (GEF44)

This sub-factor refers to the importance of international cooperation and collaboration in the transition to a GE. It includes the collaboration and coordination of policies and programs at the national and international levels to facilitate the transition [57].

These factors and sub-factors provide a comprehensive and integrated perspective on the different dimensions of the transition to a GE. The identification and evaluation of these factors and sub-factors using a Delphi and fuzzy AHP method will allow for the identification of the most critical factors and the most effective policy options for building a sustainable energy future and tackling climate change.

4.5. Various Policy Options for Transitions to a Green Economy

The transition to a green economy involves a shift towards sustainable production and consumption patterns, which requires a comprehensive policy framework. Figure 2 presents the various policy options of the study. Moreover, some of the policy options for the transition to a green economy that focus on sustainable energy are provided in Table 2.

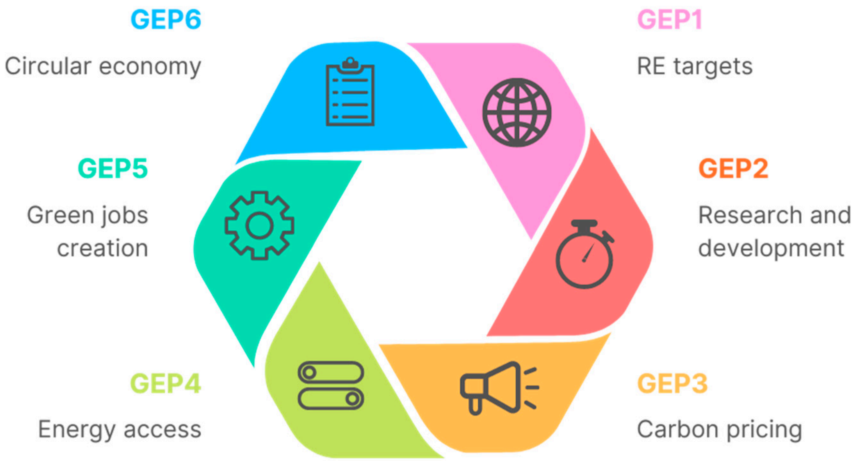

Figure 2. The various policy options diagram.

Table 2. The different policy options for transitions to GE.

Code	Policy Option	Description
GEP1	RE targets	Governments can set targets for the share of RE in the energy mix to promote the development and deployment of RE sources [58].
GEP2	Research and development	Governments can support research and development in sustainable energy technologies, such as energy storage, advanced biofuels, and carbon capture and storage [23].
GEP3	Carbon pricing	Policies that include carbon pricing, such as carbon taxes and emissions trading programs, can offer incentives for reducing GHG emissions and creating a sustainable energy system [59].
GEP4	Energy access	Policies that enable universal energy access, particularly in developing nations, can aid in the creation of a just and sustainable energy system [60].
GEP5	Green jobs creation	The shift to a green economy requires the development of a variety of skills, including those of renewable energy specialists, energy auditors, and sustainable transport planners [61].
GEP6	Circular economy	To reduce waste and advance resource efficiency, governments can support a circular economy approach that encourages the reuse, recycling, and repurposing of materials [62].

5. Results and Analysis

The results and analysis of the study provide a comprehensive evaluation of the consequences of making the transition to GE. The factors, sub-factors, and policy options for GE transitions were identified and analyzed using the fuzzy AHP method.

5.1. Ranking of Factors

It is evident that the environmental (GEF2) and social factors (GEF3) have the highest weights, indicating their importance in the evaluation of the impacts of transitioning to a GE. Economics and governance are the next important factors in the evaluation process. The ranking of the main factors is useful in identifying the most critical dimensions of the transition to GE and can be used to guide policy development and decision-making. Table 3 shows the results of factors for transitions to a GE. However, the findings of the current analysis should be used carefully, as the importance and weights of these factors may vary with the inputs of the experts and relevant stakeholders. Moreover, these factors may also have different impacts in different regions and economies based on the structure and patterns of GE transitions.

Table 3. The ranking of factors for transitions to GE.

Code	Factor	Weight	Rank
(GEF1)	Economic factors	0.231	3
(GEF2)	Environmental factors	0.293	1
(GEF3)	Social factors	0.273	2
(GEF4)	Governance factors	0.202	4

The results were used to inform the development and implementation of policies and programs related to the transition to a GE and to support efforts to build a sustainable energy future and tackle climate change [63].

5.2. Ranking of Sub-Factors

The study also presents the outcomes of sub-factors related to each primary criterion. Within the economic (GEF1) factors category, it is found that competitiveness and economic growth (GEF14) hold the top position as a significant sub-factor in the transition towards a sustainable energy future. Investment in RE infrastructure and technology (GEF12) emerges as the second most crucial sub-factor. Meanwhile, cost savings due to less energy use and high energy efficiency (GEF13), along with job creation and employment opportunities in the RE sector (GEF11), are deemed less critical sub-factors for a shift to GE. Figure 3 illustrates the weights and ranking of these economic sub-factors.

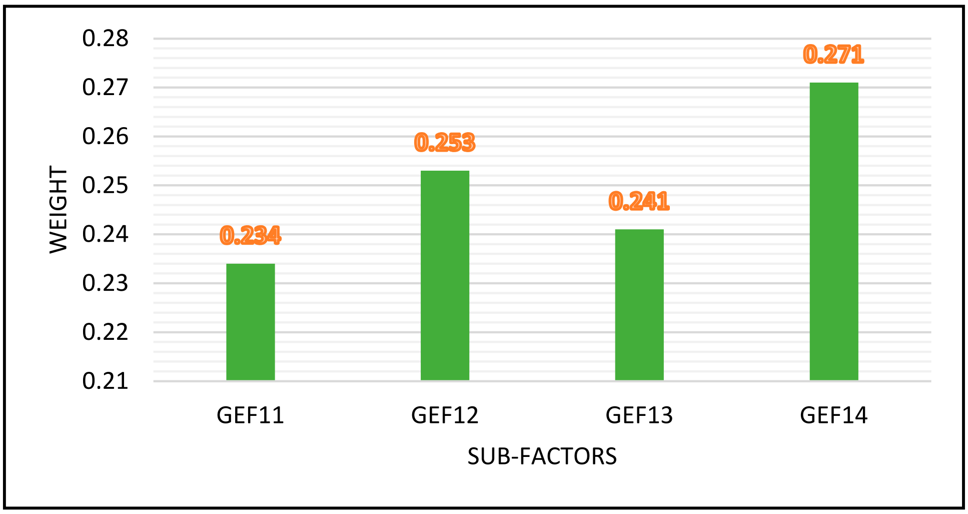

Figure 3. The sub-factors ranking based on GEF1.

Within the environmental (GEF2) category, the findings reveal that the sub-factor of reducing GHG emissions and air pollution (GEF21) attained the utmost significance in transitioning to GE for sustainable development. Biodiversity and ecosystem protection (GEF22) is ranked as the second most essential sub-factor, followed by natural resource conservation (GEF23) and water and land management (GEF24) for a shift to a GE. Figure 4 showcases the weights and rankings of environmental sub-factors.

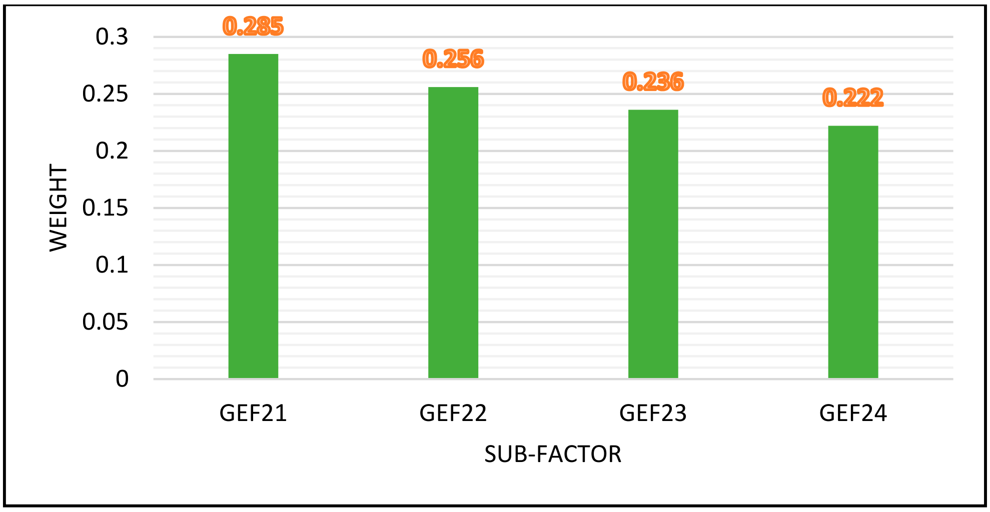

Figure 4. The sub-factors ranking based on GEF2.

Within the social (GEF3) category, the results indicate that social equity and universal access to energy (GEF31) are the most appropriate sub-factor for transitioning to a GE. The effects on vulnerable and marginalized communities (GEF33) are ranked as the second most important sub-factor, followed by health benefits from reduced air pollution (GEF32) and impacts on indigenous peoples and local communities (GEF34). Consequently, these sub-factors are deemed highly significant for transitioning to GE and addressing climate change. Figure 5 depicts the weights and rankings of the social sub-factors.

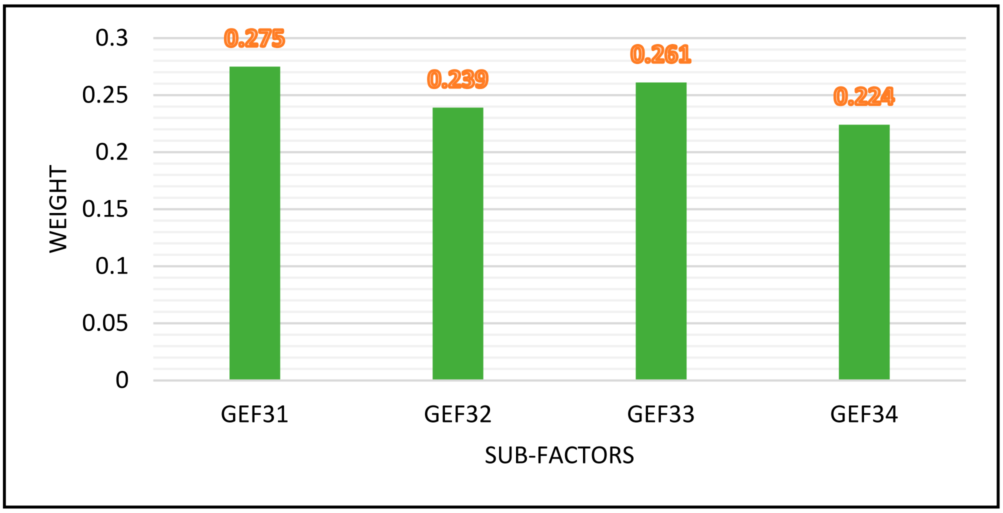

Figure 5. The sub-factors ranking based on GEF3.

In the governance (GEF4) category, the results reveal that institutional and regulatory frameworks supporting the transition (GEF41) are the most crucial sub-factor. International cooperation and collaboration (GEF44) are regarded as the second most important sub-factor, while political will and commitment to the transition (GEF42) and public engagement and participation (GEF43) hold moderate to lower significance. Figure 6 illustrates the weights and rankings of the governance sub-factors.

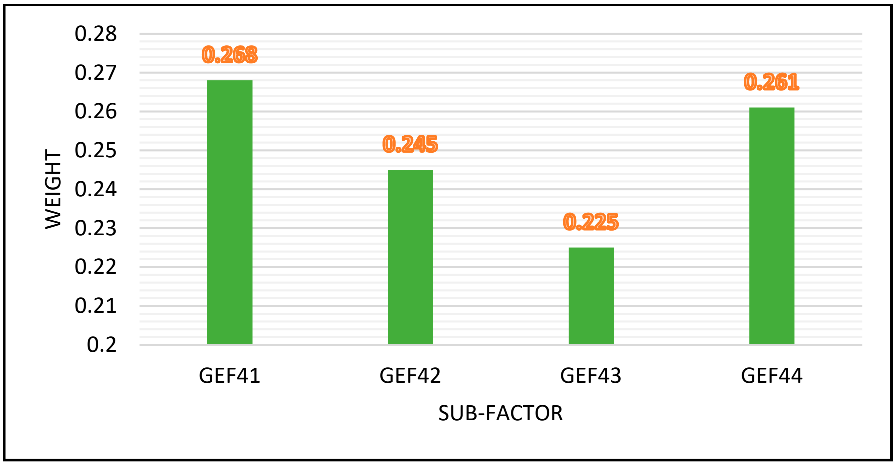

Figure 6. The sub-factors ranking based on GEF4.

5.3. Ranking of Overall Sub-Factors

The ranking of factors and sub-factors would allow for the identification of the overall sub-factor results that need to be considered in the evaluation of the impacts of transitioning to a GE, and would help to identify the most effective policy options for building a sustainable energy future and tackling climate change. Table 4 presents the ranking of overall sub-factors for shifting to a GE. The results show that reduction in GHG emissions and air pollution (GEF21) is the favorite sub-factor towards a sustainable energy future and GE. The protection of biodiversity and ecosystems (GEF22) and social equity and access to energy for all (GEF31) obtained the same weight, so both are equally important for the transition to a GE. The least important sub-factor was public engagement and participation (GEF43).

Table 4. The weights and rankings of sub-factors in relation to the study's objective.

Code	Sub-Factor	Weight	Rank
GEF11	Job creation and employment opportunities in the RE sector	0.0540	12
GEF12	Investment in RE infrastructure and technology	0.0584	9
GEF13	Cost savings due to less energy use and high energy efficiency	0.0556	10
GEF14	Competitiveness and economic growth	0.0626	7
GEF21	Reduction in GHG emissions and air pollution	0.0835	1
GEF22	Protection of biodiversity and ecosystems	0.0750	2
GEF23	Conservation of natural resources	0.0691	4
GEF24	Water and land management	0.0650	6
GEF31	Social equity and access to energy for all	0.0750	2
GEF32	Health benefits from reduced air pollution	0.0652	5
GEF33	Impacts on vulnerable and marginalized communities	0.0712	3
GEF34	Impacts on indigenous peoples and local communities	0.0611	8
GEF41	Institutional and regulatory frameworks to support the transition	0.0541	11
GEF42	Political will and commitment to the transition	0.0494	14
GEF43	Public engagement and participation	0.0454	15
GEF44	International cooperation and collaboration	0.0527	13

5.4. Ranking of Multiple Policy Options

The results of the analysis are typically based on a range of factors that are considered important for achieving sustainable development. Thus, the results of the fuzzy AHP analysis indicate that research and development (GEP2) was found to be the most important policy option (alternative) for transitioning to a sustainable energy future and addressing climate change, followed by carbon pricing (GEP3), RE targets (GEP1), circular economy (GEP6), energy access (GEP4), and green jobs creation (GEP6). The final ranking of different policy options for transitioning to a sustainable energy future and addressing climate change is presented in Table 5.

Table 5. The final ranking of various policy options.

Code	Policy Option	Weight	Rank
GEP1	RE targets	0.174	3
GEP2	Research and development	0.215	1
GEP3	Carbon pricing	0.187	2
GEP4	Energy access	0.142	5
GEP5	Green jobs creation	0.124	6
GEP6	Circular economy	0.157	4

The fuzzy AHP analysis is a sophisticated decision-making instrument that assists in determining and prioritizing crucial policy alternatives for transitioning to a GE and promoting a sustainable energy future. Consequently, the results indicate that a multi-faceted approach, encompassing R&D, carbon pricing, and renewable energy goals, may be necessary to effectively move towards a sustainable energy future and address the challenges of climate change.

5.5. Discussion

The findings offer a thorough and well-rounded perspective on the effects on EESG of switching to a GE for sustainable energy. The most important elements, sub-factors, and policy choices could be identified and weighted in the evaluation of the effects of switching to a GE thanks to the employment of the Delphi and fuzzy AHP methods. The findings indicate that environmental and social elements, rather than economic and governance aspects, are the most important ones to consider when assessing the effects of switching to a GE. This shows that promoting social fairness, ensuring everyone has access to energy, and reducing air pollution and GHG emissions must be given top priority during the switch to a GE.

The significance of environmental concerns in the switch to a GE is consistent with earlier research that recognized environmental protection as a crucial element in the switch [49]. Social fairness and access to energy were recognized in earlier research as crucial transitional elements, and this supports the significance of social issues in the GE transition. According to the previous study, promoting social fairness and ensuring everyone has access to energy were crucial transitional elements [64]. It is a little surprising that economic and governance concerns were ranked lower in the evaluation of the effects of switching to a GE. This might be because environmental and social issues are more concrete and easier to measure than economic and governance factors [65]. Nonetheless, it is significant to emphasize that economic and governance aspects are extremely important and should not be undervalued when developing and implementing policies and programs connected to the switch to a GE [27].

The findings of this study are largely in line with earlier research that identified social and environmental elements as being crucial in the transition to a GE [66,67], yet prior research placed economic and governance variables above environmental and social elements in terms of importance [68]. The changes in the precise research questions and objectives, as well as the scope and context of the studies, may be the cause of the differences in the rankings of the components between this study and earlier investigations. Nevertheless, the findings of this study make a significant contribution to the literature on the switch to GEs and emphasize the significance of environmental and social aspects in assessing the effects of doing so. The study's findings offer a thorough and well-rounded perspective on how switching to a GE will affect EESG. The ranking of the elements and sub-factors provides direction for formulating policies and making choices for the switch to a GE. According to the findings, the transition to a GE should emphasize reducing air pollution and GHG emissions, promoting social fairness and universal access to energy, and protecting the environment.

The interpretation and comparison with earlier research emphasizes how crucial environmental and social elements are for the conversion to a GE. The development and implementation of policies and programs associated to the transition are heavily influenced by economic and governance considerations, but their weight should be balanced against that of social fairness and environmental protection. The study emphasizes the importance of taking into account the EESG consequences of such a transition, making a substantial contribution to the body of knowledge on the transition to a green economy. The study's conclusions and analyses may help decision-makers and politicians create policies for transforming to a green economy and support programs to build a sustainable energy future and combat climate change.

6. Conclusions and Recommendations

Building a sustainable energy future and combating climate change requires a switch to a GE. This study used the Delphi and fuzzy AHP methods to assess the effects of the switch to a GE on the EESG. According to the study's findings, the most important aspects, sub-factors, and policy alternatives were identified and weighted in the evaluation of the effects of switching to a GE for sustainable energy in the future.

According to the fuzzy AHP results, the environment and social elements play the biggest roles in the transition to a GE. The development and implementation of policies and programs associated to the transition are heavily influenced by economic and governance considerations, but their weight should be balanced against that of social fairness and environmental protection. Furthermore, the findings show that the main policy alternatives for converting to a GE for a sustainable energy future and combating climate change are research and development, carbon pricing, and RE targets. These findings provide strong support for the arguments that environmental and social factors are crucial to the progress of the GE process. The study's findings and analyses add significantly to the body of knowledge on the process of switching to a GE and can be utilized to guide transition-related policy formulation and decision-making. The study is intended to aid efforts to combat climate change and develop a sustainable energy future.

6.1. Policy Implications for Sustainable Energy Future

A sustainable energy future has important policy implications. Several policy initiatives, such as the following, can achieve this:

- Governments and the corporate sector should encourage the creation and application of sustainable energy sources. This can promote economic growth and job possibilities in addition to reducing air pollution and GHG emissions;
- It is important to put policies and programs into place to promote energy conservation and lower energy use in buildings, transportation, and industry. Costs will go down, energy security will increase, and GHG emissions will decrease;
- Policies that support social equality and universal access to energy, especially for disadvantaged and marginalized populations, should be put into place. This can be accomplished by offering energy services that are both inexpensive and accessible and by promoting social welfare measures;

- Governments should build and put into place institutional and regulatory frameworks that aid in the shift to a GE, including the creation of green finance institutions, the development of RE policies, and the encouragement of public–private partnerships.

6.2. Limitations and Future Research Studies

The analysis was based on the inputs provided by the stakeholders and the experts; however, the lack of inputs from a large range of stakeholders, such as policymakers, practitioners, and the general public, could be insightful. Nevertheless, such extensive data insights can be considered in future research to have much broader insights regarding the issue and framing out solutions. The study is context-specific and may not be generalizable to countries or regions. Therefore, future research studies should be conducted in different regions and countries to evaluate the impacts of transitioning to GEs in different contexts. Furthermore, the study focused on the EESG impacts of transitioning to a GE. However, other dimensions, such as technological, cultural, and psychological factors, may also be important in the evaluation of the impacts of transitioning to a GE. Therefore, future research studies should consider a broader range of factors in the evaluation of the impacts of transitioning to a GE.

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