Int. J. Hum. Capital Urban Manage., 8(4): 499-514, Autumn 2023

International Journal of Human Capital in Urban Management
(IJHCUM)

Homepage: http://www.ijhcum.net/

ORIGINAL RESEARCH PAPER

The mediating effect of climate change on the relationship between energy resources and cost-saving sustainability and energy security in urban context

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ARTICLE INFO

Article History:
Received 19 February 2023
Revised 01 May 2023
Accepted 25 June 2023

Keywords:
Climate change
Cost-saving sustainability
Energy resources
Energy security
Sabah

DOI: 10.22034/IJHCUM.2023.04.05

ABSTRACT

BACKGROUND AND OBJECTIVES: Energy is widely acknowledged as a critical aspect of economic development, and a country's ability to sustain economic growth depends on the security of its energy supply. Malaysia's persistent energy demand and diminishing local energy supplies have recently increased energy industry operators' and policymakers' concerns about the country's energy supply security. Finding economical energy options with secure production and a minimum environmental impact has long been the key goal for developing countries. For developing countries, energy security is a challenging task to meet rising energy demands in a long-term, environmentally sustainable manner. The study aims to examine the mediating effect of climate change on energy resources to achieve cost-saving sustainability and energy security in Sabah, Malaysia.

METHODS: This study adopts quantitative research in which a public survey was conducted between April 28 and May 10, 2023, focusing on how Sabah's energy resources, including nuclear, fossil, and renewable fuels, relate to Sabah's cost-effective sustainability and energy security. In total, 100 questionnaires were distributed to different geographic or regional regions that are likely to differ from one another in terms of their beliefs or perceptions, educational backgrounds, income levels, and occupations. According to this study, the population of Sabah, Malaysia, will be 3.39 million in 2022. The sampling strategy used in the present research was non-probability convenience sampling. However, only 80 valid questionnaires were used as the sample size for this paper based on the Smart PLS sample size table. The response rate was 86.96%. A smaller sample was chosen in the study rather than a more thorough census due to the magnitude of the population.

FINDINGS: The findings showed that protection motivation, theory consistency theory, and behavioral reasoning theory play important roles in planned behavior when looking at practical, long-term solutions to the problems of cost-effective sustainability, energy security, and climate change as mediating factors. The results showed five (5) hypotheses have been accepted with p-value at 0.000 to 0.031. Unfortunately, there are twelve (12) hypotheses were not supported with p-value at 0.085 to 0. 0.563 due to most of Sabah's people had a poor understanding of and lack of acceptance of the need for energy.

CONCLUSION: The study empirically confirms and conceptually proves that policy on the conceptual framework of environmental literacy and pro-environmental behavior should be adopted and reviews the country's existing energy policy, the renewable energy policy, and the legal framework in resolving renewable energy sources that are still underutilized, environmentally responsible, and have a great deal of potential to satisfy the energy needs of both established and emerging nations.

NUMBER OF REFERENCES
88

NUMBER OF FIGURES
2

NUMBER OF TABLES
7

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Note: Discussion period for this manuscript open until January 1, 2024 on IJHCUM website at the "Show Article.

INTRODUCTION

Sabah's capacity is primarily made up of antiquated, expensive, and unreliable diesel plants, and the state's energy demand is growing at a rate of over 7% a year. Driven by the expansion of both the commercial and household sectors, unexpected breakdowns in Sabah result in costly service interruptions, especially on the east coast, which is almost dependent on diesel plants (McNish *et al.,* 2010). In addition, Sabah and Sarawak, two states in East Malaysia (also known as Malaysian Borneo), only have rates of 77.00% and 67.00%, respectively. Peninsular Malaysia has a high electrical access rate of 99.72%. Nearly 0.8 million Malaysians, the majority of whom live in East Malaysia's rural areas, lack access to electricity (Liang, 2016). The National Renewable Energy and Action Plan of 2009 and the Fifth Fuel Diversification Strategy of 2001 feature renewable energy (RE) targets that Malaysia has been ineffective in meeting due to RE's excessive price and a lack of private investment (Bujang *et al*., 2016). The statistic showed that almost 0.8 million Malaysians do not have access to power supply, and most reside in East Malaysia's rural districts (Liang, 2016). While working on alternative types of energy, it regrettably did not address any issues relating to Nuclear Energy (NE) (Ghazali *et al*., 2019). Energy is recognized as one of the factors in economic development, and a country's ability to maintain its economic growth depends on the security of its energy supply. Due to Malaysia's relentless energy demand and depleting domestic energy resources, energy industry players and policymakers have recently become more concerned about the country's energy supply security. The main goal has always been to identify economical energy options, secure supply, and have little influence on the environment. According to Kumar and Tewary (2022), the world is currently working to achieve Energy Security (ES), which is disrupted by population growth and unprecedented urban development. Natural gas, coal, and oil make up the majority of Malaysia's conventional power generation system and the total national primary energy supply. According to Ludin *et al*. (2018), Malaysia's challenges include Climate Change (CC), fossil fuel extraction, resource depletion, and a lack of renewable energy sources. Malaysia must develop ways to provide a sustainable and reasonably priced power supply in the future because energy demand rises proportionally to growth in the development product and economic growth. Coal and natural gas are the primary fuels used in Malaysia's power sector, which is dependent on fossil-based energy sources. Finding a way to attain sustainability, or to guarantee the security and dependability of the energy supply, while taking the effects of energy production on the environment into account, is a problem. On the path to a sustainable future, the energy sector's two primary problems are securing the energy supply and reducing energy's role in climate change (Abbasi and Abbasi, 2011; Kaygusuz, 2012). It is staggering to learn that 1.4 billion people today lack access to electricity, with 85% of them living in rural areas. As a result, it is anticipated that from 2.7 billion now to 2.8 billion in 2030, there will be more rural populations reliant on the traditional use of biomass (Kaygusuz, 2012). Climate change is one of the main problems of the twenty-first century (Puno *et al.,* 2021; Payus and Sentian, 2022; Arredondo-Trapero et al., 2023; Frimawaty *et al.,* 2023; Jaishree *et al.,* 2023; Soeprobowti *et al.,* 2023). In the context of Sabah, climate change needs to be addressed towards cost savings and energy sustainability using cleaner energy resources, i.e., renewable energy and nuclear energy, apart from fossil fuel usage. One of the 13 states in Malaysia, Sabah, regularly has a catastrophic power outage. Additionally, in the majority of Sabah's territory, the power network is not connected to any other power networks. The energy mix in Malaysia is contributed by five major sources in this strategy: natural gas, coal, oil, hydroelectricity, and renewable energy. With a well-balanced energy mix, the economy and the power sector are less vulnerable to changes in the fuel supply. Even today, just a small portion of the electricity produced comes from renewable sources. The government had set a goal to generate at least 5% of the nation's electricity from renewable sources before the implementation of this programme, but this objective has never been met (Bujang *et al*., 2016). The study aimed to fill the knowledge gap about the variables affecting energy resources, Cost-Saving Sustainability (CSS), and Energy security in Sabah, Malaysia, in 2023.

LITERATURE REVIEW

The utilization of renewable and non-renewable energy sources in Malaysia for energy security (ES) and climate change mitigation has been studied (Ghazali *et al*., 2019; Drobyazko *et al.,* 2021; Ramli *et al.,* 2022; Moghadam and Samimi, 2022). Numerous inconsistent and fragmented views of energy security can be found in the academic and policy literature (Cherp and Jewell, 2014). The ambiguity suggests that the lack of an operational definition of energy security hinders public and scientific discourse. A lack of clarity directly translates into a lack of distinct indicators for energy security. As a result, further research is needed to solve the problems of cost-effective sustainability and energy security in the context of using renewable and non-renewable energy sources to mitigate climate change. Renewable energy sources derive their power from the continuous and natural flow of energy that occurs in our immediate environment. These consist of bioenergy, solar energy from direct sources, geothermal energy, hydropower, wind, and ocean energy (tide and wave). Badsar and Karami (2021) conducted a study in Zanjan County, Iran, investigating the direct and indirect effects of knowledge on farmers' willingness to employ renewable energies. The findings showed that farmers' motivation to employ renewable energies was influenced by their knowledge, both directly and indirectly. The study identified reaction cost and internal rewards as the two variables that contributed the most significantly. Energy or fuel consumption per capita, energy or fuel (oil) expenditures, and the price elasticity of demand for energy or a particular fuel are all examples of demand-side indicators. An increase in energy security, such as through increased supply and demand energy efficiency through demand response or demand-side flexibility, would boost the energy system's resistance against unanticipated energy price spikes of foreign origin. Increasing energy security can be accomplished by lowering the macroeconomic growth-dampening impact of price shocks (Couder, 2015). Climate change and energy security are global issues that are regularly discussed in public policy debates all over the world (Toke and Vezirgiannidou, 2013). Malaysia is now doing pre-feasibility studies, policy studies, regulation reviews, and probable site selection as part of the evaluation process. There are some serious concerns regarding Malaysia's readiness to use nuclear power. The primary issues have always been nuclear waste disposal, challenges with nuclear power plant (NPP) decommissioning, and the potential risks and hazards of NPP. Traditional fossil fuel-based energy sources like coal, oil, and natural gas are what drive economic growth. Fossil fuel combustion for power generation to meet residential, commercial, and industrial demand accounts for over 40% of it (Abdul Latif *et al*., 2021). Burning fossil fuels to produce electricity to power homes and businesses Fossil fuels accounted for 82.9% of Malaysia's energy mix in 2017, according to capacity data from the Energy Commission of Malaysia (Abdullah *et al*., 2019). The percentages of coal, natural gas, and fuel oil/diesel in the fossil fuel input are 44.2%, 38.0%, and 0.6%, respectively, and industrial demand accounts for over 40% of it (Abdul Latif *et al*., 2021). The current climate change policy is substantially behind the available scientific evidence. One of the most urgent issues with climate change policy is the gap between research and policy. Long-term stock and flow links cause many of the detrimental effects of climate change to be delayed (Chan *et al*., 2022; Malla *et al*., 2022); in addition, slow institutional responses to climate change are a result of underlying causes and effects in the climate system (Munck af Rosenschöld *et al*., 2014). Despite the recent increase in scientific interest in climate change adaptation as a governance challenge requiring measures from civil society, business, and especially government, nation-states have not universally adopted climate adaptation policies (Ford and Berrang-Ford, 2011). Climate change adaptation has been described as a "wicked problem par excellence" by some (Anderson and Walters, 2023; Wohlgezogen *et al*., 2020), one that cannot be accurately articulated or solved due to vested interests and widely divergent problem formulations. It is a crucial field of study for two reasons. First, reducing energy-related emissions will be critical for climate mitigation. Furthermore, many governments regard energy as a priority policy subject because it is a key generator of economic growth and prosperity. This issue is gaining attention because of the consequences of climate change and the need to shift security paradigms away from military security and towards human security; concerns about the role of sustainability and environmental degradation in human security also play a role (Dalby, 2002; Peoples and Vaughan-Williams, 2020; Samimi and Shahriari Moghadam, 2020). In this case, energy is acknowledged as one of the key factors in economic development, and a country's ability to maintain its economic growth depends on the security of its energy supply. Due to Malaysia's relentless energy demand and depleting domestic energy resources, the security of Malaysia's energy supply has recently come to the attention of energy sector players and policymakers (Flouros, 2022; Maulidia *et al*., 2019; Sahid *et al*., 2013; Salleh *et al*., 2020).

MATERIALS AND METHODS

Survey design and data collection

The study investigates how the effects of climate change might impact the Sabahan people in terms of energy resources (ER), cost-saving sustainability, and energy security by using quantitative approaches. According to Rahi (2017), the explanatory research design was used to examine how the residents of Sabahan were affected by climate change in terms of energy security, cost-saving sustainability, and resource availability. Given this, the quantitative approach is a scientific methodology, and the positivist paradigm serves as its foundation. This approach focuses on gathering new data from a wide population on the issue at hand and analysing the data without considering the emotions and sentiments of the individual or the context of their environment. The deductive approach, where theory is not derived from observation but is based on conceptual and theoretical frameworks, can also be used to describe research that is based on empirical observation and theory that has been developed through conceptual and theoretical frameworks (Ngulube *et al*., 2015). The population of Sabah, Malaysia, will be 3.39 million in 2022 (Statista Research Department, 2022), depending on the geographic and regional location. Non-probability sampling was the chosen sample method for the current research. Convenience sampling will be used in this study because it allows the researcher to include people who are easy to reach through an instant text messaging mobile platform like WhatsApp. A total of 100 questionnaires were distributed to respondents, with a minimum sample size of 80, across Sabah's interior, south, and north regions. Samples were collected over 1 month in April 2023, with respondents being given checkboxes for informed consent, demographic questionnaires, and a list of questions. Cohen (1992) illustrates the minimum sample size needed to detect minimum R2 values of 0.10, 0.25, 0.50, and 0.75 in any of the endogenous constructs in the structural model for significance levels of 1%, 5%, and 10%, considering the typically employed level of statistical power of 80% and a specific number of arrows pointing at a construct in the PLS path model. In this conceptual framework model study, the maximum number of independent variables and mediating variables in the measurement and structural models is seven. That being the case, to reach 80% for detecting R2 values of at least 0.25 (with a 5% margin of error), With seven pointing arrows in the framework of this research, the recommended minimum sample size would be 80 to reach a statistical power of 80% for detecting R2 values of 0.25 with a 5% probability of error. The two fundamental categories into which data gathering procedures are commonly classified are primary data collection techniques and secondary data collection methods.

Analytical framework

Fig. 1 shows the mediating effect of climate change on the relationship between energy resources on the cost saving sustainability and energy security

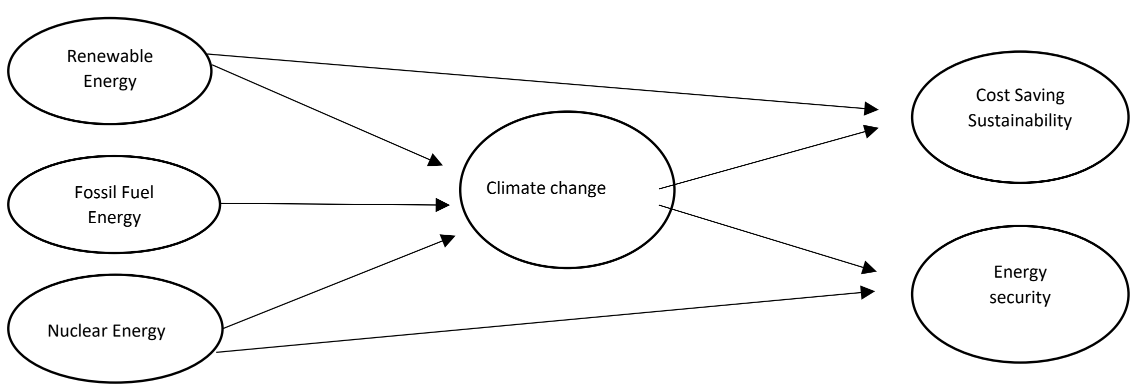

Fig. 1: Conceptual Framework of climate change on the relationship between energy resources on the cost saving sustainability and energy security

in urban context.

Based on the existing literature, a one-stage normative model was developed, which served as the basis for the investigational objectives of this study (Bigerna *et al*., 2021). The conceptual framework (Fig. 1) shows the relationship between the independent and dependent variables and the intervening variables. The conceptual framework is made up of three independent factors, two dependent variables, and one mediating variable that give an overview of the essential interaction between nuclear energy, Fossil Fuels Energy (FFE), and renewable energy in terms of cost-effectiveness, sustainability, and energy security (Razmjoo *et al*., 2021). The Malaysian state of Sabah's cost-saving sustainability and energy security are covered by the study's dependent variable because they have grown to be a significant concern to address through environmental awareness (Surianshah, 2021). In the meantime, climate change mediates cost-saving sustainability (Aktan *et al*., 2023). In this study, the independent variables will be nuclear, fossil, and renewable energy sources (Voumik *et al*., 2023). The consistent literature is utilized to establish a connection between renewable and non-renewable energy resources to address the impact of climate change on cost-saving sustainability (CSS) and energy security (Voumik *et al*., 2023). The climate change Theory is relevant to the availability and abundance of fossil fuels on the earth and dominant primary energy sources since there is now broad agreement that human activity is what is causing the observed rise in atmospheric concentrations of carbon dioxide and other infrared-absorbing trace gases, which are warming the universe (Bandh *et al*., 2021; Holechek *et al*., 2022; Soeder *et al*., 2021). Although some academics contend that there is still a lack of evidence to support a causal relationship between conspiracy theory belief and behavior, others have claimed that conspiracy theories about climate change hamper pro-environment action (Biddlestone *et al*., 2022). Even though the most recent assessment from the Intergovernmental Panel on climate change (Khan, 2022) shows how human-caused climate change has already severely harmed societies all over the world (Pörtner *et al*., 2022). Conspiracy theories challenging the reality of climate change's occurrence, causes, and effects are still prevalent (Ibbetson, 2021). Recent findings addressing global warming, often known as anthropogenic global warming, support the hypothesis that the greenhouse effect, which humans have exacerbated, is what caused the globe to warm up, particularly since the Industrial Revolution (Letcher, 2022; Martinez, 2022; Mozaffari, 2022). Protection Motivation Theory provides a conservative framework to explain pro-environmental decisions by considering a wide range of predictors, such as the costs and rewards of both current (maladaptive) behaviour and anticipated adaptive behavior (Bockarjova and Steg, 2014). Therefore, the Protection Motivation Theory may improve the comprehension of the driving forces behind pro-environmental attitudes and behaviors, which may then be used to encourage pro-environmental choices to lower environmental hazards, particularly the use of fossil fuels in combating climate change (Singh and Vaibhav, 2020; Samimi and Shahriari Moghadam, 2018). Behavioral Reasoning Theory is best applied to mediating constructs, such as (i) reasons for adoption, (ii) reasons against adoption, and (iii) attitudes towards technology, to understand how consumers think about the adoption of renewable energy (RE) systems (Elahi *et al*., 2022; Fouad *et al*., 2022; Loaiza-Ramrez *et al*., 2022). A significant step towards less carbon-intensive and sustainable energy systems is consumer adoption of renewable energy sources (Ahmed *et al*., 2022; Claudy *et al*., 2013).

RESULTS AND DISCUSSION

Descriptive statistics and analysis for variables entering the analysis

Table 1 shows the geographic distribution of the (N = 80) individuals that were picked at random from across Sabah and Malaysia. Based on the above table, among the 80 participants, there were 45 male participants (56.25%) and 35 female participants (43.75%) in the study. Based on the above table, among the 80 participants, there were 45 male participants (56.25%) and 35 female participants (43.75%) in the study. The age groups of 25 to 34 years (21.3%) and 45 to 54 years (31.3%) generated the bulk of responses from the respondents. When it involved education, individuals who had completed at least a diploma or degree in postsecondary education fared better, scoring 32.5% and 28.7%, respectively. The public and private sectors responded with 27.5% and 26.3% in the profession or occupation category, followed by the unemployed, homemakers, and retirees with 21.3%. Geographically, the bulk of Sabah respondents were from the West Coast, where they made up 48.8%, and the East Coast, where they made up 17.5%. However, 15% of respondents were from West Malaysia.

Reflective Measurement Model Results
Reliability Analysis

This additional reliability test was carried out based on the findings of earlier pilot research, which determined that when the sample size increased to N = 80, the data had an acceptable level of internal agreement between the statements assessing a given construct. Table 2 shows that using Cronbach's alpha, the outcome reacted with the sample size increasing to N = 80 from the initial pilot study at N = 50, indicating that the constructs have an acceptable level of agreement when the coefficient is more than 0.70. The findings establish that, aside from range, the variance and standard deviation of the data from the sample size or effect size had a significant impact on Cronbach's alpha's reliability. The growth in some areas demonstrates the stability of standard deviation and variance, which, other than range, exhibit an upward correlation with the Cronbach Alpha reliability coefficient (Amirrudin *et al*., 2021). Table 2 presents an explanation of how the measurement model converged. A greater value denotes a higher level of reliability, and the values of AVE and CR range from 0 to 1. The validity of convergence is confirmed when the AVE is greater than or equal to 0.5 (Shrestha, 2021). In the above case, the composite reliability is greater than 0.60, and all AVE values are higher than 0.50. Renewable energy (RE) has an AVE score of 0.511 and a fossil fuel energy value of 0.522, except for the nuclear energy (NE) record value of 0.472. Fornell and Larcker (1981) assert that the construct's convergent validity is still sufficient if AVE is less than 0.5 but composite reliability is higher than 0.6.

Construct Validity

Table 3 shows that fossil fuel energy (0.722) exceeds the other correlation values below it, which are presented in the fourth column. In other words, the square root of AVE for the construct fossil fuel

Table 1: Result of the respondent's profile

Demographic	Category	Frequency	Percent (%)
Gender	Male	45	56.3%
	Female	35	43.8%
Age	18 – 24 years	12	15.0%
	25 – 34 years	17	21.3%
	34 – 44 years	15	18.8%
	45 – 55 years	25	31.3%
	Above 55 years	11	13.8%
Highest Education Level	High School	19	23.8%
	Diploma	26	32.5%
	Degree	23	28.7%
	Master / PHD	12	15.0%
Income	RM0 – RM2,999	41	51.2%
	RM3,000 – RM5,999	15	18.8%
	RM6,000 – RM9,999	13	16.3%
	Above 10,000	11	13.8%
Profession / Occupation	Non-Government Organization (NGO)	7	8.8%
	Public Sector	22	27.5%
	Private Sector	21	26.3%
	Self-employed/ Business owners	9	11.3%
	Unemployed/ Homemakers/Retired	17	21.3%
	Political	4	50%
Region/Location	West Coast Sabah	39	48.8%
	East Coast Sabah	14	17.5%
	Northern Sabah	4	5.0%
	Southern Sabah	3	3.8%
	Interior Sabah	8	10.0%
	West Malaysia	12	15.0%

Table 2: Result of the reliability analysis

Construct	Measurement Items	Outer Loading	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
	RE1	0.659				
	RE2	0.835	0.756	0.810	0.833	0.511
Renewal Energy	RE3	0.418				
	RE4	0.760				
	RE5	0.819				
	FFE1	0.730				
	FFE2	0.692				
Fossil Fuel Energy	FFE3	0.516	0.762	0.777	0.842	0.522
	FFE4	0.818				
	FFE5	0.813				
	NE1	0.366				
	NE2	0.399	0.725	0.820	0.800	0.472
Nuclear Energy	NE3	0.751				
	NE4	0.872				
	NE5	0.863				
	CC1	0.854				
	CC2	0.661				
Climate Change	CC3	0.892	0.886	0.906	0.917	0.690
	CC4	0.878				
	CC5	0.846				
	CSS1	0.519				
	CSS2	0.802				
Cost-Saving Sustainability	CSS3	0.747	0.810	0.837	0.870	0.579
	CSS4	0.867				
	CSS5	0.820				
	ES1	0.382				
	ES2	0.807	0.810	0.873	0.872	0.592
Energy Security	ES3	0.740				
	ES4	0.921				
	ES5	0.876				

-*gnivas-tsoC =SSC ;egnahC etamilC=CC ;ygrenE raelcuN =EN ;ygrenE leuF lissoF =EFF ;ygrenE elbaweneR=ER
Sustainability; ES= Energy Security

Table 3: Discriminant Validity – Fornell – Larcker Criterion

	CC	CSS	ES	FFE	NE	RE
CC	0.830					
CSS	0.667	0.761				
ES	0.410	0.605	0.769			
FFE	0.721	0.584	0.480	0.722		
NE	0.741	0.669	0.501	0.672	0.687	
RE	0.504	0.458	0.617	0.527	0.458	0.715

-* CC = Climate Change; CSS = Cost-Saving Sustainability; ES = Energy Security; FFE= Fossil Fuel Energy; NE=Nuclear Energy; RE= Renewable Energy

energy (0.722) will be higher than its correlation with the other constructs in the study. Additionally, the fifth column showed that nuclear energy (0.687) is higher than the other correlation value underneath it. As for renewal energy (0.715), it is higher than the other correlation values, thus indicating that the discriminant validity of the study was present.

Cross - Loading Analysis

The cross-loading was evaluated to determine whether the assertions of a construct were loading towards other constructs. It is crucial since it allows us to examine whether or not the remarks focused more on the intended statistic or another construct. The statements that are affected by cross-loading should

Table 4: Cross – Loading Analysis

Constructs	CC	CSS	ES	FFE	NE	RE
CC1	0.854	0.520	0.326	0.603	0.609	0.397
CC2	0.661	0.391	0.275	0.413	0.348	0.327
CC3	0.892	0.564	0.215	0.645	0.624	0.500
CC4	0.878	0.568	0.409	0.676	0.692	0.397
CC5	0.846	0.677	0.447	0.617	0.720	0.459
CSS1	0.337	0.519	0.413	0.379	0.423	0.208
CSS2	0.513	0.802	0.480	0.387	0.483	0.343
CSS3	0.452	0.747	0.303	0.418	0.465	0.270
CSS4	0.609	0.867	0.495	0.524	0.602	0.453
CSS5	0.575	0.820	0.586	0.493	0.549	0.414
ES1	0.091	-0.022	0.382	0.155	0.047	0.266
ES2	0.225	0.430	0.807	0.310	0.310	0.468
ES3	0.338	0.472	0.740	0.365	0.443	0.451
ES4	0.400	0.604	0.921	0.458	0.520	0.512
ES5	0.415	0.600	0.876	0.466	0.446	0.610
FFE1	0.428	0.425	0.216	0.730	0.364	0.261
FFE2	0.515	0.451	0.413	0.692	0.514	0.570
FFE3	0.379	0.392	0.321	0.516	0.331	0.095
FFE4	0.629	0.422	0.276	0.818	0.659	0.339
FFE5	0.603	0.417	0.468	0.813	0.504	0.541
NE1	0.206	0.062	0.239	0.196	0.366	0.091
NE2	0.157	0.157	0.267	0.364	0.399	0.148
NE3	0.602	0.491	0.323	0.487	0.751	0.270
NE4	0.592	0.616	0.490	0.517	0.872	0.377
NE5	0.713	0.639	0.388	0.644	0.863	0.507
RE1	0.221	0.265	0.419	0.207	0.260	0.659
RE2	0.381	0.390	0.435	0.401	0.390	0.835
RE3	0.061	0.066	0.298	0.224	0.049	0.418
RE4	0.457	0.347	0.478	0.497	0.412	0.760
RE5	0.499	0.431	0.543	0.464	0.383	0.819

-* CC = Climate Change; CSS = Cost-Saving Sustainability; ES = Energy Security; FFE= Fossil Fuel Energy; NE=Nuclear Energy; RE= Renewable Energy

Table 5: VIF Values for the Structural Model

	CC	CSS	ES	FFE	NE	RE
CC	0.000	2.841	2.841	0.000	0.000	0.000
CSS	0.000	0.000	0.000	0.000	0.000	0.000
ES	0.000	0.000	0.000	0.000	0.000	0.000
FFE	2.050	2.428	2.428	0.000	0.000	0.000
NE	1.874	2.440	2.440	0.000	0.000	0.000
RE	1.422	1.456	1.456	0.000	0.000	0.000

be deleted in such a circumstance. Table 4 illustrates the evaluation of cross-loadings, commonly known as "item-level discriminant validity," as a different method for proving discriminant validity. In other words, for example, the indicator (factor loading) of the fossil fuel energy construct must be higher than the other indicator in another construct, i.e., renewal energy and nuclear energy. It demonstrates that the data utilized was discriminately valid.

Structural Model Results

Collinearity Assessment

A strategy for identifying common method bias is offered based on variance inflation factors produced by a comprehensive collinearity test. According to Li *et al*. (2023), the occurrence of a variance inflation factors greater than 3.3 is proposed as an indication of pathological collinearity and also as an indication that a model may be contaminated by common method bias. Table 5 shows that even with a model meeting the typical convergent and discriminant validity evaluation standards based on a confirmation factor analysis, the full collinearity test is useful in identifying common method bias. Following a thorough collinearity test, Table 5 displays the variance inflation factors produced for all of the latent variables. Therefore, all VIFs from a full collinearity test are equal to or less than 3.3. The model is deemed to be free of common method bias. It also reveals that the full collinearity test is effective in detecting common method bias with a model that, despite passing the usual convergent and discriminant validity evaluation standards based on a confirmation factor analysis, is nonetheless valid.

Path Coefficients

The use of bootstrapping was needed to test the path coefficient hypothesis. It made it easier to assess the statistical significance of the coefficients. Table 6 and Fig. 2 demonstrate how the structural equation model validates each of the hypotheses. On further assessment, the hypothesis was tested to ascertain the significance of the relationship. H1 evaluates whether there is a significant relationship between renewable energy and cost-saving sustainability in Sabah. The results revealed that renewable energy is insignificantly correlated with cost-saving sustainability in Sabah (B = 0.107, t = 0.870, p 0.05). Hence, H1 was not validated. Table 6 and Fig. 2 results indicated that to have a statistically significant p-value less than the specified alpha of 0.05, the very minimum for the 2-a tail test, the T-statistics value should be at least 1.96, which shows that most of the indicators in the latent variable have less than 1.96. The results are the least intriguing when it comes to statistical significance. The findings should specify the size of the effects of the treatment, not only whether or not they had any effect on the subjects (Clifford *et al*., 2021). However, the p-value does not allow for or is not meant to allow the researcher to determine how strong the correlations between the variables are. It is a good use for effect-size measures. While the number of papers and statistical estimates of impact sizes determined using parametric tests is continuously rising, reporting effect sizes with non-parametric testing is still uncommon (Misra *et al*., 2021). In null hypothesis testing, an effect size estimate is a measure that should be reported alongside the p-value. Poole *et al*., (2022) define a Type I error as rejecting the null hypothesis (H0) when it is true (also known as a “false positive” or “false alarm”). Researchers choose an adequately low alpha level in their analysis to minimize the possibility of discovering a difference that is not present in the data and to control for Type I errors. Contrarily, a Type II error (also known as a “false negative”) is when the null hypothesis (H0) is not rejected even though it is wrong and ought to be. In this case, increasing the sample size is an efficient strategy to lower the likelihood of obtaining a Type II error.

Table 6: Path Coefficients

Hypothesis	Path Coefficients (β)	Sample mean (M)	Standard Deviation (STDEV)	T statistics (|O/STDEV|)	P Values
RE -> CSS	0.107	0.131	0.123	0.870	0.384
FFE -> CSS	0.078	0.085	0.130	0.603	0.546
NE -> CSS	0.344	0.334	0.145	2.377	0.018
RE -> ES	0.487	0.451	0.183	2.662	0.008
FFE -> ES	0.130	0.122	0.128	1.015	0.310
NE -> ES	0.306	0.335	0.177	1.725	0.085
RE -> CC	0.108	0.133	0.116	0.933	0.351
FFE -> CC	0.364	0.353	0.101	3.598	0.000
NE -> CC	0.446	0.435	0.104	4.287	0.000
CC -> CSS	0.302	0.292	0.139	2.163	0.031
CC -> ES	-0.155	0.130	0.161	0.965	0.335
RE -> CC -> CSS	0.033	0.035	0.037	0.895	0.371
FFE -> CC -> CSS	0.110	0.105	0.064	1.709	0.088
NE -> CC -> CSS	0.135	0.129	0.071	1.896	0.058
RE -> CC -> ES	-0.017	-0.011	0.029	0.578	0.563
FFE -> CC -> ES	-0.057	-0.047	0.061	0.928	0.354
NE -> CC -> ES	-0.069	-0.063	0.076	0.915	0.360

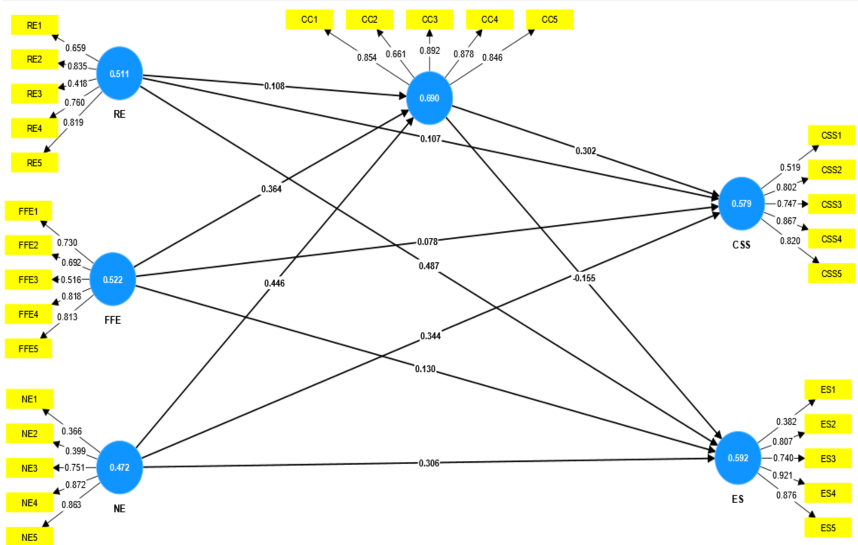

Fig. 2: The Structural Model – Path Coefficients

The findings are presented in Table 7, which demonstrates that the effect of mediation of climate change between energy resources (renewable energy, fossil fuels energy, nuclear energy) on the cost – saving sustainability (and energy security in Sabah, Malaysia. The result showed 40.0% choose to be neutral, while 32.5% and 7.5% strongly agree and agree respectively to pay for an additional utility cost and technology purchases. However, about 12.5% and 7.5% strongly disagree or disagree respectively on their readiness to pay more renewable energy sources of power. According to the research by Bai *et al.,* (2023); Azlina *et al*., (2018), price and household income play a major role in determining willingness to pay. Demand for renewable energy is inversely correlated with bid price, but positively correlated with income. Asif *et al.* (2023) and Mustafa *et al.* (2023) customers' intention to adopt renewable energy is positively correlated with their level of technical awareness. The findings showed that people are more likely to convert to renewable energy sources when the benefit-cost ratio is higher. Renewable energy installations may demand greater financial outlays than the minimum. Economic incentives are recommended by van Beesten *et al.* (2023) and Gao *et al.* (2020); Bamwesigye (2023) to lessen the users' financial burden. Studies on the willingness to pay for renewable energy (RE) as an alternative energy source have revealed negative feedback from users in Australia, the United Kingdom, Greece, and China (Dalton *et al.* 2008; Faiers and Neame 2006; Zografakis *et al.,* 2010). Nuclear energy (NE) relates to cost-saving sustainability. The information was sufficient to conclude that nuclear energy (NE) and cost-saving sustainability were positively influenced (β = 0.344, $p < 0.05$). The maximum beta values which indicate β = 0.344, which are acceptable and show a strong relationship between the latent variables. The information was sufficient to conclude that renewable energy (RE) and energy security were positively related (β = 0.487, $p < 0.05$). The findings are significant since they show that even the rise in the use of renewable energy (RE) has been much slower than expected because the new technology offers fewer comparative benefits than straightforward-to-use and manage energy alternatives. The highest Beta value, which is $\beta = 0.487$, indicates that the adoption of renewable energy grows at a pace of 48.7%. A strong correlation between the latent variables is this hypothesis indicated by the highest beta of 0.05 and 0.20. Therefore, the information was sufficient to conclude that fossil fuel energy and climate change were related (β = 0.364 $p < 0.05$). The strongest association between fossil fuel energy and climate change is the greatest Beta value (β = 0.364). A strong correlation between the latent variables is this hypothesis indicated by the highest beta of 0.05 and 0.20. There is a significant relationship between nuclear energy and climate change. The information was sufficient to conclude that nuclear energy and climate change were related (β = 0.446 $p < 0.05$). A Beta value β = 0.446, show a strong relationship between the latent variables.

The data, in particular, were sufficient to conclude that climate change and cost-saving sustainability were related (β = 0.302, $p < 0.05$). The highest beta value, β = 0.302, demonstrates that climate change and cost-saving sustainability are significantly related to the protection motivation theory. This theory uses predictors, such as the costs and rewards associated with pro-environmental attitudes and behavior, to

Table 7: Summary of discussion findings

No.	Hypothesis Testing	T statistics (|O/STDEV|)	P values	Decision
H1	There is a significant relationship between renewable energy (RE) relate to cost saving sustainability (CCS) in Sabah.	0.870	0.384	Not Supported
H2	There is a significant relationship between fossil fuel energy (FFE) relate to cost saving sustainability (CCS) in Sabah.	0.603	0.546	Not Supported
H3	There is a significant relationship between nuclear energy (NE) relate to cost saving sustainability (CCS) in Sabah.	2.377	0.018	Supported
H4	There is a significant relationship between renewable energy (RE) and energy security (ES) in Sabah.	2.662	0.008	Supported
H5	There is a significant relationship between fossil fuel energy (FFE) and energy security (ES) in Sabah.	1.015	0.310	Not Supported
H6	There is a significant relationship between nuclear energy (NE) and energy security (ES) in Sabah.	1.725	0.085	Not Supported
H7	There is a significant relationship between renewable energy (RE) and climate change (CC) in Sabah.	0.933	0.351	Not Supported
H8	There is a significant relationship between fossil fuel energy (FFE) and climate change (CC) in Sabah.	3.598	0.000	Supported
H9	There is a significant relationship between nuclear energy (NE) and climate change (CC) in Sabah.	4.287	0.000	Supported
H10	There is a significant relationship between climate change (CC) and cost saving sustainability (CSS) in Sabah.	2.163	0.031	Supported
H11	There is a significant relationship between climate change (CC) and energy security (ES) in Sabah.	0.965	0.335	Not Supported
H12	There is a significant relationship between renewable energy (RE) relates to climate change (CC) towards cost saving sustainability (CSS) in Sabah.	0.895	0.371	Not Supported
H13	There is a significant relationship between fossil fuel energy (FFE) relate to climate change (CC) towards cost saving sustainability (CSS) in Sabah.	1.709	0.088	Not Supported
H14	There is a significant relationship between nuclear energy (NE) relates to climate change (CC) towards cost saving sustainability (CSS) in Sabah.	1.896	0.058	Not Supported
H15	There is a significant relationship between renewable energy (RE) relate to climate change (CC) towards energy security (ES) in Sabah.	0.578	0.563	Not Supported
H16	There is a significant relationship between fossil fuel energy (FFE) relate to climate change (CC) towards energy security (ES) in Sabah?	0.928	0.354	Not Supported
H17	There is a significant relationship between nuclear energy (NE) relate to climate change (CC) towards energy security (ES) in Sabah?	0.915	0.360	Not Supported

explain pro-environmental decisions. It shows that Mahmood, (2020) claim that nuclear energy (NE) usage has surged by more than 40%, producing 12% of global power and meeting 5% of primary energy demands in 2018. According to research done in Malaysia by Dahlan *et al.,* (2014), generation mixes include nuclear power plants improve system dependability, produce less CO2, and have lower operating and investment costs. An empirical study by Ozcan and Ulucak, (2021) showed that more nuclear energy generation in the Indian energy system would be helpful for mitigating climate change because it immediately reduces environmental pollutants. However, most studies of the diffusion of renewable energy adopt a top-down strategy, concentrating solely on the policymakers and omitting the opinions of the general public (Çelikler, 2013: Moula *et al.,* 2013; Karatepe *et al.,* 2012). In Malaysia, air pollution has grown to be a significant environmental issue. In this nation, air pollution is brought on by the burning of coal, lignite, petroleum, natural gas, wood, and animal and agricultural waste. The substantial increase in primary energy use since the 1990s has increased CO2 emissions. Furthermore, the research suggests that environmental degradation occurs before economic growth.

H3: There is a significant relationship between nuclear energy relate to cost saving sustainability in Sabah.

H4: There is a significant relationship between renewable energy and energy security in Sabah.

H8: There is a significant relationship between fossil fuel energy and climate change in Sabah.

H9: There is a significant relationship between nuclear energy and climate change in Sabah.

H10: There is a significant relationship between climate change and cost saving sustainability in Sabah.

The data was insufficient to conclude that renewable energy and cost-saving sustainability were not related ($\beta = 0.107$, $p > 0.05$). The results revealed no relationship between renewable energy relates to cost-saving sustainability. The standardized coefficient shows how significant or insignificant the independent variables are in clarifying the correlation between renewable energy and cost-saving sustainability. A lesser beta of 0.05 and 0.20 indicates a weaker connection between the latent variables. The lowest Beta value, which is $\beta = 0.107$, indicates that renewable energy is an insignificant factor in cost–saving sustainability. The lesser the value of a technology is to consumers, the lower its adoption rate and the higher its cost. The lack of perceived value addition among customers is impeding the adoption of small-scale renewable energy. Therefore, the hypothesis H1 is not accepted. The information concluded that fossil fuel energy and cost-saving sustainability were insignificantly related ($\beta = 0.078$, $p > 0.05$). The findings showed that the energy from fossil fuels has no bearing on cost-saving sustainability. When examining the relationship between fossil fuel energy and economically viable sustainability, the Beta's (standardized coefficient) demonstrate that the independent variables are less significant or insignificant than the others. The use of fossil fuels may be less influenced by cost-saving measures. The lowest Beta value, which is $\beta = 0.078$, indicates that fossil fuel energy is an insignificant factor in cost–saving sustainability. Therefore, the H2 is not accepted. There is an insignificant relationship between fossil fuel energy and energy security ($\beta = 0.130$, $p > 0.05$). The results demonstrated that energy security is unaffected by fossil fuel energy. A lesser beta of 0.05 and 0.20 indicates a weaker connection between the latent variables. The lowest Beta value, which is $\beta = 0.130$, indicates that the fossil fuels grow lower at a pace of 13.0%. In this instance, this relationship related to the environment has undergone a dramatic transition, and the scarcity of fossil fuels is no longer the concern claimed by Blondeel, Bradshaw, Bridge, and Kuzemko (2021). The H5 is not accepted. Nuclear energy and energy security has a negligible relationship. ($\beta = 0.306$, $p > 0.05$). Nuclear energy does not affect energy security (ES), according to the findings. Despite having a strong Beta value of = 0.306, the p-value score needed to be accepted in the hypothesis analysis, and there is sufficient to infer that nuclear energy (NE) and energy security (ES) are not associated. This relationship related to the energy environment and nuclear energy (NE) has negative consequences on people, animals, the environment, and ecological systems (Liang, 2021). The H6 is not accepted.

H1: There is an insignificant relationship between renewable energy relate to cost saving sustainability in Sabah.

H2: There is an insignificant relationship between fossil fuel energy relate to cost saving sustainability in Sabah.

H5: There is an insignificant relationship between fossil fuel energy and energy security in Sabah.

H6: There is an insignificant relationship between nuclear energy and energy security in Sabah.

CONCLUSION

The energy industry will also be able to fully capitalize on possibilities brought about by the energy transition attributable to the DTN's driven Low Carbon Nation Aspiration. The energy industry will need to align with domestic developments and be well-positioned to support the Wawasan Kemakmuran Bersama 2030 (WKB 2030) and Twelfth Malaysia Plan, 2021–2025.

Energy transition describes a fundamental change in energy systems in favor of greener energy sources. This transition entails a change from a consumption pattern dominated by fossil fuels with high carbon emission intensity to one with a higher rate of renewable energy utilization and lower carbon emission intensity. Rapid technology advancement and aggressive climate change legislation are projected to accelerate the present energy transition. To ensure that all Malaysians have a decent standard of living through development for all, address wealth and income disparities, and create a united, prosperous, and dignified Malaysia, WKB 2030 serves as the primary reference point for the country's progressive national socioeconomic goals development and growth priorities. The energy sector is impacted by five Key Economic Growth Activities (KEGAs), including the green economy, renewable energy (RE), and sustainable mobility. Improving the resilience of the nation's fiscal and economic situation by fostering new energy-related industries would also help achieve the goal of decreasing reliance on petroleum-based revenue and commodity trade. By utilizing the nation's abundant energy resource resources, equitable regional development will be supported by prioritizing the distribution of energy-related costs and benefits across income groups, ethnicities, regions, and supply chains. The "Dasar Tenaga Negara" (DTN) includes oil, natural gas, coal, hydropower, solar, photovoltaic, bioenergy, and other cutting-edge energy sources within its wide range of non-renewable and renewable energy sources. The final use of energy in every sphere of the economy, including transportation, industry, housing, and commerce, is likewise covered by "Dasar Tenaga Negara" (DTN). The country will reap significant benefits from the prompt and efficient execution of the "Dasar Tenaga Negara" (DTN) programs. This includes improve social outcomes for Malaysians by fostering balanced regional development and securing future-proof jobs for workers. Protecting low-income households' access to affordable energy and advancing rural electrification will be priorities. Greater domestic energy indepen-dence and fuel diversification will promote a more robust energy industry and enable improved control over energy as a major strategic resource for the nation. Energy affordability has advantages such as improved energy access and reliability. In terms of the energy sector's environmental sustainability, significant gains are expected in the future. These advantages will be distributed equally to all parties involved, including the rakyat, industry, and government. The "Dasar Tenaga Negara" (DTN) includes oil, natural gas, coal, hydropower, solar, photovoltaic, bioenergy, and other cutting-edge energy sources within its wide range of non-renewable and renewable energy sources. The final use of energy in every sphere of the economy, including transportation, industry, housing, and commerce, is likewise covered by "Dasar Tenaga Negara" (DTN). The country will reap significant benefits from the prompt and efficient execution of the "Dasar Tenaga Negara" (DTN) programs. This includes improve social outcomes for Malaysians by fostering balanced regional development and securing future-proof jobs for workers. Protecting low-income households' access to affordable energy and advancing rural electrification will be priorities. Greater domestic energy independence and fuel diversification will promote a more robust energy industry and enable improved control over energy as a major strategic resource for the nation. Energy affordability has advantages such as improved energy access and reliability. In terms of the energy sector's environmental sustainability, significant gains are expected in the future. These advantages will be distributed equally to all parties involved, including the rakyat, industry, and government.

AUTHOR CONTRIBUTIONS

J.S. Dionysius performed the literature review, experimental design, analyzed and interpreted the data, H.L. Vasudevan prepared the manuscript text, and manuscript edition. J.S. Dionysius and H.L. Vasudevan performed the experiments and literature review, compiled the data and manuscript preparation. J.S. Dionysius performed in the data analysis and findings while H.L. Vasudevan compiled the data analysis and findings for the manuscript edition.

ACKNOWLEDGEMENT

The authors would like to take this opportunity to express their heartfelt gratitude for the opportunity to publish their manuscript in this journal. The authors appreciate the committee members' efforts and time spent on the peer-review process.

CONFLICT OF INTEREST

The authors declare that no potential conflicts of interest in publishing this work. Furthermore, the authors have witnessed ethical issues such as plagiarism, informed consent, misconduct, data fabrication, double publication or submission, and redundancy.

PUBLISHER'S NOTE

IJHCUM Publisher remains neutral with regard to jurisdictional claims in published maps and institutional afflictions.

ABBREVIATIONS

$\bar{Y}\bar{Y}$	Average of observed data
$R^2{}_{adj}$	Adjusted coefficient of determination
$\bar{y}\bar{y}$	Average of observed data
AVE	Average variance extracted
R^2R^2	Coefficient of determination
CC	Climate Change
CSS	Cost-saving Sustainability
DTN	Dasar Tenaga Negara
FFE	Fossil Fuel Energy
HP	Hypothesis
KEGA	Key Economic Growth Activities
$\propto$	Level of significance
NE	Nuclear Energy
p-value	Probability value
r	Pearson correlation coefficient
R-value	Pearson correlation coefficient
RE	Renewal Energy
SSE	Sum of Squared Errors
WKB	Wawasan Kemakmuran Bersama

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HOW TO CITE THIS ARTICLE

Dionysius, J.S.; Vasudevan, H.L., (2023). The mediating effect of climate change on the relationship between energy resources and cost-saving sustainability and energy security in urban context. Int. J. Hum. Capital Urban Manage.,8(4): 499-514.

DOI: 10.22034/IJHCUM.2023.04.05

URL: https://www.ijhcum.net/article_705621.html