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Renewable Energy and Sustainable Development—Investigating Intention and Consumption among Low-Income Households in an Emerging Economy

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Abstract: To mitigate the harmful effects of climate change and progress toward achieving sustainable development goals, renewable energy sources should be available to low-income households. Households depend heavily on traditional energy sources. Therefore, this study aims to investigate the determinants that influence the intention and consumption of renewable energy among low-income households in Malaysia. Quantitative data was collected from 420 households through structured interviews. Analysis was conducted using SEM-PLS. The results revealed that perceived benefits and environmental concerns influence environmental attitudes. Motivation, skills, and knowledge affect subjective norms and perceived behavioral control, respectively. The study also found that attitude towards the environment and perceived behavioral control influence households' intention towards renewable energy consumption and renewable energy consumption behavior. The results provided a clear idea of households' intention in emerging economies towards renewable energy consumption to protect environmental damage from the harmful effects of the traditional use of energy sources. Therefore, policymakers in developing nations should focus on the feasibility of renewable energy projects and design group-agnostic campaigns for low-income households to ensure economic, social, and environmental sustainability through the mass adoption of renewable energy.

Keywords: low-income households; renewable energy; rural Malaysia; sustainable development; theory of planned behavior

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1. Introduction

Energy is the determining factor of well-being and sustainable development [1]. Global energy consumption depends on fossil fuels, such as natural gases, oil, and coal, contributing to global economic progress [1]. However, this situation has deteriorated human health, social well-being, and environmental sustainability, with issues such as air pollution, acid rain, and global climate change [2]. Consequently, sustainable development strategies have been widely followed around the world. Malaysia's fast-growing economy depends on fossil fuels for its growing energy needs [3]. In 2017, with 255.78 metric tonnes of carbon emissions, Malaysia occupied one of the top positions for greenhouse gas emitters in the Southeast Asia region [4]. Trends suggest that if neglected, Malaysia could be the global leader in carbon dioxide emissions by 2030 [3].

Undeniably, clean and renewable energy systems are needed without further delay [5]. Sustainable energy sources refer to traditional biomass, modern bioenergy, solar and wind energy, geothermal energy, and small hydroelectric plants. These could reduce the adverse effects on the environment, which will contribute to the social impacts (disparity of incomes, raw materials), economic (creation of jobs, profitability), and environmental (reduced air pollution, reduction of the emissions of greenhouse gases) [2]. Renewable energy covers approximately 15–20% of total world energy demand, which is expected to increase by more than 50% by the second half of the 21st century [6]. In Malaysia, the government implemented a five-fuel diversification strategy in 2000 to promote renewable resources that can be used to provide sustainable energy solutions, such as renewable electricity generation systems [3]. This strategy is a countermeasure for the limited reserves and the negative influence of fossil fuels [7]. One of the main reasons why Malaysia has opted for renewable energy is due to its severe carbon emissions [3].

Reducing dependence on fossil fuels is a global concern for governments, organizations, and consumers [5,8]. There is a growing interest in renewable energy coming from non-polluting, free, locally available, and continuous resources [3,9]. Policies are insufficient to allow the dissemination of clean energy to meet the challenges of consumer adoption of green practices [5]. As the green concept in Malaysia is developing [10], it is crucial to gain knowledge about the intention and adoption of green practices locally [3]. Lau, Choong, Ching, Wei, Sanadjki, Choong, and Seow [11] have pointed out that renewable energy projects in Malaysia are slow to materialize. However, Malaysia showed progress in installing renewable energy from 32 Mega Watts (MW) in 2012 to 1787 MW in 2021 [12], 2022). Malaysia also aims to attain 31% of its energy demands from renewable energy sources by 2025 by having 8.53 gigawatts of energy. It aims to achieve 40% of energy requirements from renewable energy sources by 2035 [12].

Although many studies have discussed sustainable energy in Malaysia, they focus on oil palm biomass, biogas, solar, and wind systems for sustainable electricity supply with a historical narrative of government entities, plans, strategies, and guidelines related to renewable energy in Malaysia [13]. The government's support for accepting renewable energy is well-established and mostly offered to corporations and business firms [11]. However, in line with Dudek et al. [14], this study argues that economic growth, as a result of innovative activities for society and the environment in hyperdynamic conditions, is accompanied by increased income inequality and population poverty, deterioration of environmental conditions, disproportionality of territorial development, unless compensated by increased inclusive social responsibility. This study argues that the performance of sustainable resources in Malaysia depends on the mass adoption of renewable energy as a reflection of such social responsibility.

Interestingly, this aspect of the renewable energy equation has not received sufficient attention in the past. According to Irfan et al. [8], limited research has been conducted to find out the intention of adopting renewable energy among consumer masses. Moreover, Masukujjaman et al. [15], citing the inadequacy of studies in a similar context, argued that rather than the urban people who have purchasing power to explore renewable energy, the focus needs to be moved to knowing the factors that could facilitate low-income to adopt renewable energy sources. In a more recent study, Mustafa et al. [1] noted that researchers have ignored the influence of environmental concern, knowledge, and other relevant factors, particularly missing the developing nations' perspective on renewable energy adoption. The current work, therefore, bridges the knowledge gap reflected above on renewable energy adoption by examining the factors affecting intention and behavior towards renewable energy among lower-income households, specifically those living in coastal Peninsular Malaysia. As we argue that the sustainable performance of renewable energy depends on mass adoption, we focus on low-income households who form a significant portion (bottom 40 percent) of the Malaysian population, mostly operating informal businesses and including workers in other trades catering to large communal groups, thereby playing a significant role in sustainable development [16].

Thus, this study builds on and extends existing studies, enriching the current literature on the adoption of renewable energy sources, particularly from an emerging economy perspective. Moreover, the paper extends the TPB model by integrating relevant variables into the original framework, expanding the lens of theory by examining adoption intention and behavior towards renewable energy sources within its scope. Furthermore, the paper contributes to the broader energy field and the SGD Goals 2030 by highlighting the enormous potential of renewable energy sources to meet current and future energy demands worldwide. As for practical implications, this study can benefit policymakers, socio-economic development organizations, governmental agencies, and academics through the insightful findings and recommendations presented in the following sections.

2. Literature Review

2.1. Renewable Energy and Sustainable Development

Sustainability and energy independence represent two major challenges in energy decision-making models [17]. Renewable energy, encompassing solar, wave, hydropower, wind, geothermal power, and waste energy, reflects one of the most effective and efficient solutions to environmental problems that we confront today, and hence the link between renewable energy and sustainable development is intimate [18,19]. Due to global economic uncertainty, renewable energy technologies with low carbon emissions (or that are carbon neutral) have become important for sustainability as environmental concerns rise, coupled with escalating labor and utility costs [18]. Unlike fossil-based technologies, the financial and operating costs of renewable energy-based technologies that are modular and flexible remain low. Empirically, Güney [20] found that renewable energy has a positive and statistically significant effect on sustainable development both in developed as well as developing nations. This means that as renewable energy adoption increases, the level of sustainable development increases. According to Bishoge et al. [19], renewable energy development is crucial for sustainable development goals (SDGs) and for realizing sustainable development globally. Specifically, D'Adamo et al. [17] showed how political (subsidies, tax deduction) as well as market (selling price, purchase price) conditions relate to the profitability of photovoltaic plants, wherein the share of self-consumption plays a key role in the development of a sustainable community. Furthermore, Güney [20] stressed that extensive adoption of renewable energy is highly important to progress toward achieving the 2030 Sustainable Development Goals. In particular, renewable energy and this paper relate to the 7th SGD Goal regarding access to reliable, affordable, modern, and sustainable energy. Based on the above, we argue that advancements toward self-consumption, sustainable communities, and broadly sustainable development depend on the adoption of renewable energy sources by the mass population. By stressing the improvement of the adoption rates of renewable energy sources in our everyday lives, this paper aspires to raise awareness regarding the 2030 agenda, particularly by revealing the significant determinants of renewable energy adoption by low-income households in emerging economies.

2.2. Underlying Theory

Although clean energy and its multiple benefits have received increasing support from governments and organizations worldwide, previous studies note that mass adoption is an essential consideration for the efficient deployment of renewable energy [5,21]. The current work examines the socio-psychological factors of the intention and behavior to adopt renewable energy. This study applies the theory of planned behavior (TPB), a well-established socio-psychological model [22]. This theory describes an individual's actual behavior as an observable response determined by behavioral intention, attitudes, subjective norms, and perceived behavioral control of the individual [3,22,23]. In TPB, an attitude refers to the extent of an individual's favorable or unfavorable assessment or appreciation of the outcome of a behavior. Subjective norms refer to perceived social pressure to initiate or avoid the behavior. Subsequently, perceived behavioral control refers to the degree to which an individual perceives that his behavior is difficult or easy to execute (under his voluntary control) [23]. Although TPB is a mature socio-psychological model, researchers have integrated other constructs to predict behavioral intent and improve the model's predictive power [24]. Ajzen [23] suggested that perceived benefits and environmental concerns, motivation, skills, and knowledge are determinants of attitude toward the environment, subjective norms, and perceived behavioral control, respectively.

2.3. Variables of Interest

Attitude towards Environment (ATE) is the first construct in the TPB framework. TPB predicts that individuals with optimistic attitudes toward the environment intend to buy or use green products [23,25]. Yazdanpanah et al. [24] established that attitude refers to a person who thinks that supporting renewable energy can encourage their will to use renewable resources. Wee et al. [10] pointed out that an individual's willingness to demonstrate behavior precedes their attitude towards a specific behavior. Zhang et al. [22] also confirmed this attitude as a salient determinant of consumers' ecological purchasing intentions. Mustafa et al. [1] confirmed that the attitude towards renewable energy investment is significantly associated with the intention to invest in renewable energy. To extend the framework of TPB, this study identified perceived benefit as a dimension of attitude towards the environment. A perceived benefit can be defined as an advantage obtained by individuals by adopting a behavior or the effectiveness of an action [26]. A lack of knowledge about the benefits of renewable energy can hinder the consumption of renewable energy [22]. Previous studies have pointed out that perceived environmental benefits can improve attitudes and intentions to consume renewable energy [25]. Abbas et al. [2] argued that cost benefits are essential determinants of using renewable energy. Yazdanpanah et al. [24] argued that deploying and implementing renewable energy sources can only be efficient and sustainable when the public is aware of their benefits. A high perceived benefit is likely to influence the environmental attitude and consumption of renewable energy [26].

Environmental concern, the other conceived dimension of attitude, is defined as the consumer's emotional involvement in various environmental problems [22]. Claudy et al. [25] noted that ecological concerns have become the reason for the growing demand for green products, and it is an attractive reflection of the choice of ecological life. Cheung, Lau, and Lam [27] mentioned that environmental concern is one of the factors that consumers consider when making green purchases. Maichum, Parichatnon, and Peng [28] pointed out that individual environmental concern facilitates the expression of positive attitudes towards the environment and, in turn, the intention and consumption of renewable energy. Zhang et al. [22] argued that environmental concerns could also determine consumers' attitudes. The current study hypothesizes that ATE influences the effect of perceived benefits and environmental concerns on intention towards renewable energy consumption (ITRE). Based on theory and literature [22,23], this study intended to test the indirect effect of perceived benefits and environmental concerns on ITRE.

TPB predicts that individuals who feel social pressure to adopt a green lifestyle are more likely to develop an intention to consume green products [3,23]. Wee et al. [10] noted that an individual's willingness to demonstrate behavior is linked to their SUN. Zhang et al. [22] confirmed that Subjective Norms (SUN) could determine consumers' green purchasing intentions. On the contrary, Yazdanpanah et al. [21] found that SUN does not influence the intention to consume renewable energy. This study conceptualized motivation as a determinant of SUN. TPB has suggested that the actual behavior of an individual in acting is guided by his motivation or plan [24]. From an organizational perspective, Malynovska et al. [29] proposed that for a fruitful focus on sustainable energy, a method for motivating employees is needed that allows the formation of diverse parameters of the optimal structure of fixed and commission remuneration payments for individuals to maximize their utility. Earlier, Hartmann and Apaolaza-Ibáñez [30] noted that motivation influencing concern for the well-being of others (altruism) could guide them to contribute to the common good by choosing green products rather than non-green alternatives or by consuming renewable energy rather than conventional alternatives. However, less attention has been paid to the motivational aspects of behavior change in TPB. Based on the literature, this study integrates motivation as an antecedent of the social norm. There is expected to be an indirect effect of motivation on ITRE through SUN. The present work argues the effect of motivation will affect SUN and have an indirect effect on ITRE. SUN is expected to mediate the effect of motivation on ITRE. Based on theory and literature [22,23,30], this study intended to test the indirect effect of motivation on ITRE.

Perceived Behavioral Control (PBC) represents the degree to which an individual feels that his behavioral performance is under voluntary control [31]. According to TPB, individuals with high behavioral control perceive that environmentally friendly adoption is easy, and they are likely to develop the intention to consume green products [3,23]. Wee et al. [10] stated that behavioral intentions were an indication of willingness to perform behavior based on PBC. PBC is characterized by an individual's beliefs about their ownership of resources and their chances of demonstrating behavior that influences decisions through behavioral intention [6]. This study extended that Skills and Knowledge are determinants of PBC. Insufficient technical knowledge and skills can lead to less adoption of green products, thus limiting renewable energy consumption [32]. Claudy et al. [25] indicated that the explanatory power of the pro-environmental determinants could decrease in situations where individuals have limited knowledge, financial resources, or ecological knowledge. A lack of public knowledge can weaken the usefulness of emerging technologies and innovation [21]. This study argues that individuals' skills and knowledge about renewable energy will affect their PBC, and PBC is expected to affect ITRE. It is expected that PBC mediates the relationship between skills and knowledge and ITRE. Based on the theory and literature [22,23], the study hypothesized that PBC mediates the relationship between skills and knowledge of ITRE.

TPB proposes that an individual's actual action is determined by his or her behavioral intention [23]. Then, intentions are directly related to an individual's subsequent behavior [25]. Behavioral intention is commonly used to predict actual behavior [6,33]. Yee et al. [3] further confirmed that the actual purchase behavior of green products was determined by the intention to purchase as an indication of individual readiness to perform green behavior. This study argues for the effect of ATE, SUN, and PBC on ITRE and the effect of ITRE on renewable energy consumption behavior (RECB). It is expected that ITRE mediates the relationship between ATE, SUN, PBC, and RECB.

3. Methodology

We utilized the theory of planned behavior (TPB) to explain the formation of intention and adoption of renewable energy among the study respondents. The current work also incorporates the perceived benefits and environmental concerns as factors that explain the attitude towards renewable energy. Motivation was used to elucidate subjective norms and the skills and knowledge fused to explain perceived behavioral control. Our work contributes towards extending the TPB and harnessing the explaining power of attitude, subjective norm, and perceived behavioral control. Aside from extending the TPB, we also examine the mediating effect of attitude, subjective norm, and perceived behavioral control with the extended factors on the intention towards consuming renewable energy. Lastly, the study utilized hybrid analysis techniques to confirm the findings and offer practical and theoretical implications. All variables of the study and associations among them that have been hypothesized and examined are presented in Figure 1. As observed, perceived benefits and environmental concerns have been integrated into the original TPB framework as antecedents of attitude towards the environment. Similarly, motivation is identified as a dimension of subjective norms. Finally, skills and knowledge are articulated as the determinants of perceived behavioral control.

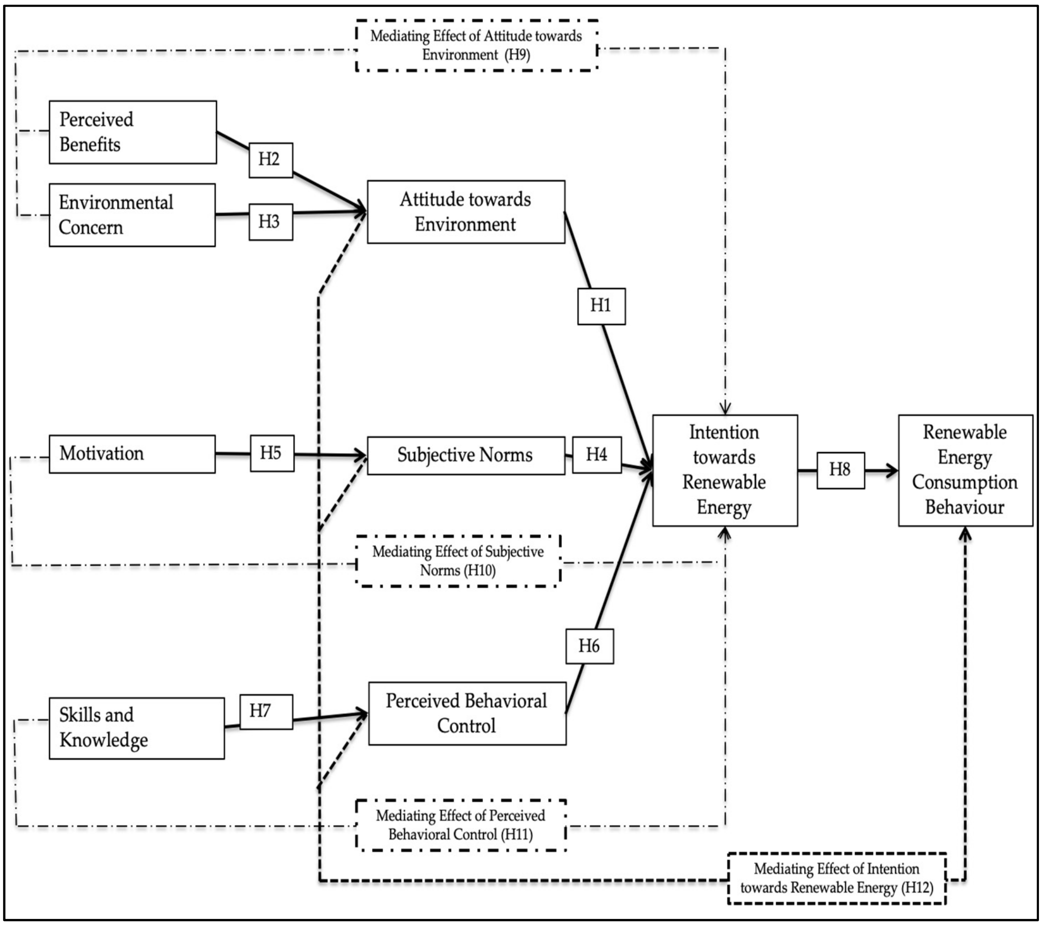

Figure 1. Research Model.

The research model shows that attitude towards the environment, subjective norms, and perceived behavior control affect intention towards renewable energy. On the other hand, intention towards renewable energy affects renewable energy consumption behavior. Figure 1 further depicts the mediating role of attitude towards the environment between perceived benefits, environmental concern, and intention towards renewable energy. Similarly, subjective norms are hypothesized to mediate the effect of motivation on intention towards renewable energy. Perceived behavioral control is hypothesized to mediate the effect of skills and knowledge on intention towards renewable energy. Finally, intention towards renewable energy is hypothesized to mediate the effect of attitude towards the environment, subjective norms, and perceived behavior control on renewable energy consumption behavior.

Low-income households with a net household income of less than RM 3471 (Department of Statistics Malaysia, 2017) who reside in rural Peninsular Malaysia are included in the study population. Four government agencies and development organizations in Malaysia (e.g., Majlis Amanah Rakyat, Majlis Agama Islam dan Adat Istiadat Melayu Kelantan, Amanah Ikhtiar Malaysia, and e-Kasih under the Implementation and Coordination Unit of the Prime Minister's Department) provided the study with a list of 3063 low-income households with specific information, including name, address, and contact information. This study randomly selected 500 low-income households from a list of 3063 low-income households. The respondents were contacted to explain the research's purpose, followed by appointments. However, only 420 of them agreed to participate in the interview. Data was collected through a structured interview from the respondents' preferred locations, including their residences and communal spaces, including local mosques and food courts.

3.1. Research Instrument

The research instrument was a survey questionnaire (see Appendix A). Researchers used simple words to design the research instruments to increase the readability of the respondents. The questionnaire consisted of three parts. The first part was a written informed consent for participation. The respondents who participated in the survey were asked to read the ethical statement posted at the top of the form. The second part collected demographic information from the respondents. The third part had items for the variables of the study. Questionnaire indicators for all variables of the study were adopted from previous relevant studies with slight modifications. Indicators were adopted for "environmental concern" from Cheung et al. [27] and Maichum et al. [28]. Perceived benefits were measured using six items adapted from Park and Ohm [34]. Moreover, seven items were used to measure motivation adopted by researchers [35,36]. Seven items were adopted from Liñán [37] and Miralles, Giones, and Riverola [38] to measure skills and knowledge. To measure Attitude towards Environment (ATE), items were adopted from Maichum et al. [28]. For Subjective Norms (SUN), the items were borrowed from Wu and Chen [39] and Maichum et al. [28]. Then, items that captured Perceived Behavioral Control (PBC) were adopted from Maichum et al. [28]. Eight items were used to measure Intention toward Renewable Energy Consumption (ITRE), which were adopted by Martins and Viegas [40], Chen and Deng [32], and Maichum et al. [28]. Next, six indicators were used to measure the Renewable Energy Consumption Behavior (RECB), adopted from Walton and Austin [41] and Osman, Isa, Othman, and Jaganathan [42].

3.2. Common Method Variance (CMV)

As recommended by Podsakoff, MacKenzie, Lee, and Podsakoff [43], findings of the single-factor test show that 31.51% of the variance is explained by one component below the maximum cutoff value of 50%. Moreover, the maximum correlation between constructs of this study is 0.763 (less than 0.9), which indicates that CMV is not a serious problem for this study [44]. Furthermore, this study evaluated the common method variance by following Kock's [45] recommendation to test the full collinearity of all the constructs. All the study constructs regressed on the common variable, and the variance inflation factor (VIF) values less than 3.3 (see Table 1) indicate the absence of bias from the single-source data.

Table 1. Full Collinearity Test.

PB	EC	MO	SK	ATE	SUN	PBC	ITRE	RECB
2.004	2.011	1.584	1.882	1.776	1.592	2.243	2.328	1.781

Note: PB—Perceived Benefits; EC—Environmental Concern; MO—Motivation; SK—Skills and Knowledge; ATE—Attitude towards Environment; SUN—Subjective Norms; PBC—Perceived Behavioral Control; ITRE—Intention towards Renewable Energy Consumption; and RECB—Renewable Energy Consumption Behavior.

3.3. Multivariate Normality

The *p*-value for Mardia's multivariate skewness and kurtosis coefficients was found to be lower than 0.05, and it could be confirmed that the dataset of this study has multivariate non-normality.

3.4. Analysis Strategy

Because of multivariate non-normality, this study used variance-based structural equation modeling (PLS-SEM) to test the associations. SmartPLS 3.0 maximizes the explained variance of the dependent latent constructs [46]. Moreover, artificial neural network analysis has been deployed for a model-free estimation using parallel, multilayer, and non-linear regression. According to standard practices of performing dual-stage analysis, PLS-SEM is first used to determine the important exogenous factors, which are subsequently used as the input neurons for ANN analysis to entirely appreciate the non-linearity among the endogenous and exogenous factors [47].

4. Results

4.1. Demographic Characteristics

To obtain a better feel of the data, this study collected demographic information from the respondents. The demographic analysis allowed us to address the issue of a representative sample in the context of the present study. Out of 420 respondents, most were females (56.9%), and most were married (85.2%). Moreover, 31.8% of respondents were aged between 41 and 50 years, 26.4% were between 31 and 40 years, 19.3% aged between 51 and 60 years, and 11.2% were aged between 20 and 30 years, while the rest of the respondents were aged below 20 or over 60. For education background, 59.8% of the respondents graduated secondary school, 2.5% had diploma certificates, 2.9% completed primary school, and 5.5% possessed undergraduate degrees. Only 0.5% of the respondents possessed a master's degree, while the remaining 1% were uneducated. To add, 349 respondents considered "business" as their main economic activity, while the rest considered "paid employment" as their main economic activity.

4.2. Reliability and Validity

Before assessing the structural model, the goodness of measure was examined by measuring the construct reliability and validity of the measurement model. Table 2 depicts the descriptive statistics of all the variables and the output of the relevant tests. Following Hair, Ringle, and Sarstedt [48], researchers assessed the reliability of each latent variable primarily through a composite reliability indicator. Table 2 shows that Cronbach's alpha estimates for all the latent variables were more than 0.85 (exceeding the cutoff value of 0.7), suggesting adequate reliability of all scales. Apart from Cronbach's alpha, researchers opted for an additional measure of internal consistency, known as 'composite reliability'. The composite reliability estimates for all the scales were more than 0.9 (above the cutoff value of 0.7), which indicated the unidimensionality of the items used to measure variables [46]. Moreover, Dillon-Goldstein's rho estimates for all the scales were more than 0.9, which confirmed internal consistency. The average variance extracted (AVE) values are more than 0.5, indicating the convergent validity of the items used. The VIF values for all variables were below 2.0, and no multicollinearity issue was reported [45].

Table 2. Validity and Reliability.

Variables	Items	Mean	Standard Deviation	Cronbach's Alpha	Dijkstra-Hensele's *rho*	Composite Reliability	Average Variance Extracted	Variance Inflation Factor
PB	6	4.226	0.573	0.893	0.907	0.918	0.651	1.945
EC	6	4.403	0.560	0.915	0.915	0.934	0.704	1.945
MO	7	3.374	0.743	0.937	0.941	0.949	0.727	1.000
SK	7	3.162	0.730	0.935	0.936	0.947	0.720	1.000
ATE	6	3.780	0.674	0.938	0.939	0.951	0.764	1.345
SUN	5	3.427	0.668	0.892	0.912	0.920	0.697	1.518
PBC	7	3.350	0.667	0.924	0.925	0.939	0.688	1.687
ITRE	8	3.297	0.666	0.933	0.934	0.945	0.683	1.000
REAB	6	3.790	1.075	0.960	0.961	0.968	0.834	-

Note: PB—Perceived Benefits; EC—Environmental Concern; MO—Motivation; SK—Skills and Knowledge; ATE—Attitude towards Environment; SUN—Subjective Norms; PBC—Perceived Behavioral Control; ITRE—Intention towards Renewable Energy Consumption; and RECB—Renewable Energy Consumption Behavior.

Discriminant validity was further investigated employing the Fornell-Larcker criterion, whereby the square root of AVE for each scale must exceed the corresponding construct's correlation with other constructs. As depicted in Table 3, all the variables met this criterion. Heterotrait-Monotrait Ratio (HTMT) values are below 0.9, and it could be translated that discriminant validity was established as recommended. Furthermore, all the indicator loadings were higher than the total cross-loadings to confirm discriminant validity (see Table 4).

Table 3. Discriminant Validity.

	PB	EC	MO	SK	ATE	SUN	PBC	ITRE	REAB
	Fornell-Larcker Criterion								
PB	0.807								
EC	0.697	0.839							
MO	0.221	0.189	0.852						
SK	0.219	0.175	0.535	0.849					
ATE	0.383	0.374	0.431	0.495	0.874				
SUN	0.316	0.325	0.331	0.388	0.391	0.835			
PBC	0.289	0.221	0.508	0.557	0.487	0.570	0.830		
ITRE	0.271	0.227	0.447	0.563	0.538	0.430	0.620	0.827	
REAB	0.173	0.179	0.362	0.465	0.462	0.399	0.484	0.623	0.913
	Heterotrait-Monotrait Ratio (HTMT)								
PB	-								
EC	0.763	-							
MO	0.246	0.206	-						
SK	0.238	0.189	0.572	-					
ATE	0.406	0.402	0.460	0.527	-				
SUN	0.353	0.359	0.349	0.413	0.426	-			
PBC	0.324	0.240	0.545	0.598	0.524	0.618	-		
ITRE	0.295	0.244	0.480	0.602	0.575	0.463	0.668	-	
REAB	0.188	0.188	0.383	0.491	0.487	0.431	0.515	0.658	-

Note: PB—Perceived Benefits; EC—Environmental Concern; MO—Motivation; SK—Skills and Knowledge; ATE—Attitude towards Environment; SUN—Subjective Norms; PBC—Perceived Behavioral Control; ITRE—Intention towards Renewable Energy Consumption; and RECB—Renewable Energy Consumption Behavior.

Table 4. Loadings and Cross-Loading.

	PB	EC	MO	PC	ATE	SUN	PBC	ITRE	REAB
PB—Item 1	*0.812*	0.594	0.178	0.214	0.395	0.200	0.211	0.246	0.153
PB—Item 2	*0.826*	0.565	0.164	0.153	0.313	0.254	0.204	0.216	0.105
PB—Item 3	*0.819*	0.586	0.145	0.152	0.299	0.261	0.181	0.176	0.083
PB—Item 4	*0.839*	0.598	0.139	0.123	0.268	0.288	0.217	0.167	0.141
PB—Item 5	*0.817*	0.587	0.212	0.201	0.300	0.320	0.306	0.253	0.193
PB—Item 6	*0.721*	0.413	0.244	0.213	0.233	0.225	0.307	0.253	0.169
EC—Item 1	0.547	*0.740*	0.187	0.185	0.330	0.264	0.276	0.240	0.189
EC—Item 2	0.625	*0.813*	0.183	0.121	0.310	0.272	0.244	0.186	0.172
EC—Item 3	0.591	*0.862*	0.162	0.110	0.311	0.291	0.180	0.173	0.154
EC—Item 4	0.579	*0.874*	0.136	0.141	0.291	0.267	0.119	0.161	0.112
EC—Item 5	0.587	*0.873*	0.137	0.157	0.325	0.261	0.140	0.187	0.134
EC—Item 6	0.571	*0.862*	0.141	0.163	0.305	0.277	0.142	0.187	0.131
MO—Item1	0.180	0.170	*0.765*	0.426	0.277	0.278	0.400	0.341	0.273
MO—Item 2	0.203	0.189	*0.784*	0.435	0.293	0.250	0.400	0.342	0.277
MO—Item 3	0.215	0.202	*0.830*	0.447	0.395	0.254	0.413	0.427	0.345
MO—Item 4	0.158	0.123	*0.896*	0.466	0.397	0.303	0.482	0.399	0.339
MO—Item 5	0.204	0.168	*0.902*	0.468	0.404	0.299	0.460	0.392	0.325
MO—Item 6	0.188	0.132	*0.894*	0.487	0.383	0.312	0.440	0.384	0.298
MO—Item 7	0.176	0.156	*0.886*	0.462	0.413	0.270	0.429	0.388	0.306
SK—Item 1	0.124	0.102	0.403	*0.779*	0.334	0.358	0.450	0.400	0.371
SK—Item 2	0.157	0.123	0.435	*0.829*	0.419	0.388	0.511	0.471	0.428
SK—Item 3	0.188	0.163	0.458	*0.849*	0.398	0.350	0.453	0.439	0.372
SK—Item 4	0.161	0.148	0.475	*0.872*	0.400	0.292	0.454	0.484	0.400
SK—Item 5	0.194	0.165	0.455	*0.898*	0.437	0.301	0.467	0.530	0.434
SK—Item 6	0.238	0.163	0.466	*0.865*	0.459	0.302	0.481	0.504	0.373

Table 4. *Cont.*

	PB	EC	MO	PC	ATE	SUN	PBC	ITRE	REAB
SK—Item 7	0.237	0.176	0.485	*0.844*	0.480	0.307	0.487	0.507	0.382
ATE—Item 1	0.265	0.285	0.413	0.442	*0.832*	0.303	0.411	0.480	0.429
ATE—Item 2	0.297	0.295	0.446	0.468	*0.841*	0.351	0.456	0.503	0.466
ATE—Item 3	0.326	0.341	0.377	0.402	*0.864*	0.349	0.419	0.451	0.388
ATE—Item 4	0.330	0.322	0.333	0.428	*0.896*	0.327	0.408	0.439	0.371
ATE—Item 5	0.397	0.359	0.333	0.426	*0.906*	0.352	0.415	0.471	0.381
ATE—Item 6	0.382	0.354	0.359	0.427	*0.900*	0.361	0.446	0.477	0.389
SUN—Item 1	0.188	0.196	0.213	0.261	0.274	*0.785*	0.405	0.286	0.322
SUN—Item 2	0.172	0.196	0.266	0.290	0.316	*0.830*	0.460	0.338	0.339
SUN—Item 3	0.327	0.378	0.170	0.245	0.353	*0.788*	0.373	0.337	0.329
SUN—Item 4	0.343	0.312	0.336	0.389	0.347	*0.894*	0.546	0.426	0.367
SUN—Item 5	0.273	0.275	0.352	0.393	0.340	*0.872*	0.551	0.384	0.315
PBC—Item 1	0.234	0.233	0.357	0.410	0.382	0.522	*0.742*	0.481	0.424
PBC—Item 2	0.255	0.249	0.390	0.460	0.407	0.559	*0.774*	0.538	0.471
PBC—Item 3	0.177	0.131	0.436	0.442	0.370	0.437	*0.828*	0.520	0.417
PBC—Item 4	0.240	0.205	0.440	0.475	0.432	0.437	*0.853*	0.504	0.370
PBC—Item 5	0.290	0.229	0.469	0.498	0.428	0.445	*0.855*	0.524	0.369
PBC—Item 6	0.243	0.120	0.434	0.479	0.415	0.455	*0.884*	0.524	0.404
PBC—Item 7	0.235	0.118	0.414	0.466	0.392	0.456	*0.862*	0.506	0.360
ITRE—Item 1	0.113	0.044	0.382	0.468	0.395	0.248	0.480	*0.767*	0.490
ITRE—Item 2	0.110	0.056	0.421	0.518	0.418	0.257	0.485	*0.785*	0.529
ITRE—Item 3	0.179	0.135	0.450	0.533	0.458	0.330	0.550	*0.852*	0.540
ITRE—Item 4	0.242	0.192	0.395	0.470	0.460	0.408	0.531	*0.864*	0.497
ITRE—Item 5	0.243	0.209	0.355	0.474	0.427	0.393	0.529	*0.871*	0.524
ITRE—Item 6	0.322	0.268	0.340	0.456	0.467	0.405	0.531	*0.834*	0.523
ITRE—Item 7	0.296	0.299	0.316	0.407	0.471	0.391	0.487	*0.818*	0.513
ITRE—Item 8	0.277	0.285	0.301	0.395	0.460	0.402	0.503	*0.816*	0.505
REAB—Item 1	0.121	0.079	0.356	0.445	0.403	0.346	0.441	0.544	*0.880*
REAB—Item 2	0.119	0.081	0.368	0.438	0.418	0.295	0.421	0.553	*0.910*
REAB—Item 3	0.146	0.143	0.309	0.425	0.442	0.371	0.451	0.575	*0.935*
REAB—Item 4	0.207	0.228	0.327	0.423	0.434	0.398	0.459	0.583	*0.945*
REAB—Item 5	0.182	0.225	0.305	0.406	0.409	0.370	0.421	0.560	*0.910*
REAB—Item 6	0.171	0.214	0.323	0.415	0.423	0.400	0.459	0.597	*0.898*

Note: (1) PB—Perceived Benefits; EC—Environmental Concern; MO—Motivation; SK—Skills and Knowledge; ATE—Attitude towards Environment; SUN—Subjective Norms; PBC—Perceived Behavioral Control; ITRE—Intention towards Renewable Energy Consumption; and RECB—Renewable Energy Consumption Behavior. (2) The italic values in the matrix above are the item loadings, and others are cross-loadings.

4.3. Path Analysis

The result shows that perceived benefits and environmental concerns positively and significantly affect ATE. The effect size of perceived benefit on ATE is small to medium (f^2 = 0.035), as shown in Table 5. The coefficient of determination (r^2) is 0.169, indicating that 16.9 percent of the variation in ATE could be explained by perceived benefit and environmental concern. In addition, the Q^2 value of 0.122 indicated that the level of perceived benefit and environmental concern has a small to medium predictive relevance for ATE. The findings show that motivation has a positive and significant effect on SUN. The coefficient of determination (r^2) is 0.110, which indicates that the level of motivation could explain 11 percent of the variation in the subjective norm. In contrast, motivation has a small predictive relevance on SUN (Q^2 = 0.069). The findings also show that skills and knowledge positively and significantly affect PBC. The coefficient of determination (r^2) is 0.311, which indicates that skills and knowledge could explain 31 percent of the variation in PBC, while skills and knowledge have medium to large predictive relevance on PBC (Q^2 = 0.205).

The results show that ATE, SUN, and PBC influence ITRE with β = 0.300; *p*-value <0.05; β = 0.063; *p*-value > 0.05 β = 0.438; and *p*-value < 0.05, respectively. The effect size of ATE, SUN, and PBC on ITRE is small to medium with f^2 = 0.124, zero with

f^2= 0.005, and moderate to large with f^2 = 0.211, respectively. The r^2 value of 0.460 shows that the ATE, SUN, and PBC levels could explain 46% of the variation in ITRE. The Q^2 value of 0.302 indicated that the ATE, SUN, and PBC levels had a medium to large predictive relevance for ITRE.

Finally, the path coefficient for the effect of ITRE on RECB is 0.623, with a p-value < 0.05. This result indicates that ITRE had a positive effect on RECB. The f^2 coefficient of 0.636 indicated a large effect of ITRE on RECB. Furthermore, the r^2 value of 0.389 implied that the level of ITRE could explain 38.9% of the variation in RECB. The Q^2 value of 0.312 indicated that the level of ITRE had a medium to large predictive relevance for RECB.

Table 5. Path Coefficients.

Hypo		**Beta**	**CI—Min**	**CI—Max**	***t***	***p***	r^2	f^2	Q^2	**Decision**
	Factors Affecting Attitude towards Environment									
H_1	PB → ATE	0.238	0.144	0.344	4.056	0.000		0.035		Accept
H_2	EC → ATE	0.208	0.117	0.304	3.656	0.000	0.169	0.027	0.122	Accept
	Factors Affecting Subjective Norms									
H_3	MO → SUN	0.331	0.246	0.420	6.653	0.000	0.110	0.123	0.069	Accept
	Factors Affecting Perceived Behavioral Control									
H_4	SK→ PBC	0.557	0.489	0.623	13.798	0.000	0.311	0.451	0.205	Accept
	Factors Affecting Intention towards Renewable Energy									
H_5	ATE → ITRE	0.300	0.227	0.374	6.702	0.000		0.124		Accept
H_6	SUN → ITRE	0.063	−0.007	0.137	1.422	0.078	0.460	0.005	0.302	Reject
H_7	PBC → ITRE	0.438	0.356	0.512	9.266	0.000		0.211		Accept
	Factors Affecting Renewable Energy Adoption Behavior									
H_8	ITRE→REAB	0.623	0.570	0.678	18.543	0.000	0.389	0.636	0.312	Accept
	Mediation Analysis									
	Mediating Effect of Attitude towards Environment				Beta	CI—Min	CI—Max	*t*	*p*	Decision
H_{1M}	PB → ATE → ITRE				0.071	0.041	0.106	3.601	0.000	Mediation
H_{2M}	EC → ATE → ITRE				0.063	0.031	0.102	2.977	0.002	Mediation
	Mediating Effect of Subjective Norms									
H_{3M}	MO → SUN → ITRE				0.021	−0.002	0.048	1.339	0.091	No Mediation
	Mediating Effect of Perceived Behavioral Control									
H_{4M}	SK → PBC→ ITRE				0.244	0.190	0.298	7.388	0.000	Mediation
	Mediating Effect of Intention towards Renewable Energy									
H_{5M}	ATE → ITRE → REAB				0.187	0.139	0.241	5.905	0.000	Mediation
H_{6M}	SUN → ITRE → REAB				0.039	−0.004	0.086	1.406	0.080	No Mediation
H_{7M}	PBC→ ITRE → REAB				0.273	0.217	0.330	8.256	0.000	Mediation

Note: PB—Perceived Benefits; EC—Environmental Concern; MO—Motivation; SK—Skills and Knowledge; ATE—Attitude towards Environment; SUN—Subjective Norms; PBC—Perceived Behavioral Control; ITRE—Intention towards Renewable Energy Consumption; and RECB—Renewable Energy Consumption Behavior.

4.4. Mediation

The results revealed that perceived benefit had a significant indirect effect (p-value < 0.05) on ITRE. That means ATE mediates the relationship between perceived benefit and ITRE. Similarly, environmental concern is found to have a positive indirect effect on ITRE (p-values < 0.05). As for the mediating effect of SUN, the finding revealed that motivation did not have a significant indirect effect on ITRE (p-values > 0.05). Moreover, the finding for skills and knowledge revealed a positive indirect effect on ITRE (p-values < 0.05). This proved that PBC mediated the relationship between skills and knowledge and ITRE.

The results also show that ATE had a positive indirect effect on RECB (p-values < 0.05). In other words, the ITRE mediated the relationship between the ATE and RECB. The results also revealed that SUN had no significant indirect effect on the RECB (p-values > 0.05). Finally, PBC had a positive indirect effect on the RECB (values of p < 0.05). This proved that the ITRE mediated the relationship between PBC and the RECB.

4.5. Importance Performance Matrix

Researchers conducted a post-hoc importance-performance matrix analysis (IPMA) by adopting ITRE and RECB as the main constructs (see Table 6). The results revealed that PBC was the most influential factor of ITRE, followed by ATE, skills and knowledge, perceived benefits, environmental concerns, SUN, and motivation. For RECB, the most influential factor was ITRE, followed by PBC, ATE, skills and knowledge, perceived benefit, environmental concern, SUN, and motivation.

Table 6. Performance and Total Effects.

Target Construct	Intention towards Renewable Energy		Renewable Energy Adoption Behavior	
Variables	**Total Effect**	**Performance**	**Total Effect**	**Performance**
PB	0.083	74.573	0.084	74.573
EC	0.074	81.158	0.075	81.158
MO	0.019	49.805	0.019	49.805
SK	0.223	54.078	0.226	54.078
ATE	0.295	59.301	0.298	59.301
SUN	0.062	60.528	0.063	60.528
PBC	0.436	58.763	0.441	58.763
ITRE	-	-	1.000	54.819

Note: PB—Perceived Benefits; EC—Environmental Concern; MO—Motivation; SK—Skills and Knowledge; ATE—Attitude towards Environment; SUN—Subjective Norms; PBC—Perceived Behavioral Control; ITRE—Intention towards Renewable Energy Consumption; and RECB—Renewable Energy Consumption Behavior. Source: Author's data analysis.

4.6. Artificial Neural Network Analysis

ANN is a robust and adaptable model that does not need multivariate assumptions (such as homoscedasticity, normality, multicollinearity, and linearity) to be satisfied, unlike other linear approaches [49]. Thus, ANN models are considered to be reliably more accurate and precise than linear models [50]. This section of the analysis focused on predictive accuracy, estimated with the data part in training and testing the data. Root mean square of error (RMSE) values for training and testing (presented in Table 7) of the data described the relative accuracy of the prediction. A multi-layer perception (MLP) was utilized, having three layers: input, output, and hidden [50]. Feed-forward-back propagation (FFBP) MLP engaged for the study. For handling the overestimation issue tenfold, the ANN model was employed. 70% of the data was utilized for training and 30% for testing, as suggested by Liébana-Cabanillas et al. [49]. The difference in values of RMSE between training and testing within the range 0.064–0.000 for Model A and 0.077–0.002 for Model B indicates close values with high accuracy and strong predictive power of the study models [49]. Model A was able to predict intention towards renewable energy consumption by 96.5% through the goodness of fit. For Model B, the goodness of fit accounted for 94.8% of renewable energy consumption behaviour [50].

Table 7. RMSE Values.

Network	Sample Size (Training)	Sample Size (Testing)	RMSE (Training—Testing)	Sample Size (Training)	Sample Size (Testing)	RMSE (Training—Testing)
Model A: Intention towards Renewable Energy Consumption				Model B: Renewable Energy Consumption Behaviour		
1	300	120	0.037	300	120	0.047
2	285	135	0.000	302	118	0.002
3	276	144	0.022	280	140	0.014
4	294	126	0.062	299	121	0.027
5	291	129	0.064	305	115	0.033
6	296	124	0.009	308	112	0.014
7	281	139	0.025	298	122	0.003
8	291	129	0.027	294	126	0.072
9	283	137	0.032	287	133	0.077
10	297	123	0.024	292	128	0.008
		Mean	0.030		Mean	0.030
	Standard Deviation		0.020	Standard Deviation		0.028

Sensitivity analysis evaluates the contribution of exogenous predictors for all endogenous constructs. Findings presented in Table 8 confirmed that the most influential variable to predict ITRE is PBC, followed by skills and knowledge and ATE. As for the RECB, the most influential variable is ITRE, followed by SUN and ATE and skills and knowledge, respectively.

Table 8. Sensitivity Analysis.

Network	PB	EC	MO	SK	ATE	SUN	PBC	ITRE
Model A: Intention towards Renewable Energy Consumption								
1	0.068	0.057	0.035	0.273	0.105	0.044	0.418	
2	0.045	0.054	0.096	0.269	0.155	0.047	0.334	
3	0.045	0.101	0.047	0.229	0.144	0.116	0.318	
4	0.030	0.045	0.128	0.187	0.210	0.103	0.297	
5	0.088	0.092	0.062	0.224	0.201	0.059	0.274	
6	0.050	0.075	0.089	0.241	0.172	0.053	0.319	
7	0.075	0.090	0.133	0.116	0.282	0.042	0.262	
8	0.069	0.071	0.093	0.185	0.262	0.053	0.266	
9	0.079	0.026	0.047	0.312	0.184	0.025	0.327	
10	0.045	0.038	0.050	0.187	0.238	0.085	0.358	
Mean Importance	0.059	0.065	0.078	0.222	0.195	0.063	0.317	
Model B: Renewable Energy Consumption Behavior								
1	0.075	0.072	0.041	0.077	0.136	0.154	0.052	0.393
2	0.064	0.047	0.029	0.167	0.126	0.130	0.089	0.346
3	0.058	0.151	0.075	0.113	0.108	0.120	0.083	0.293
4	0.080	0.046	0.036	0.119	0.051	0.205	0.055	0.408
5	0.060	0.148	0.097	0.070	0.081	0.104	0.097	0.342
6	0.084	0.075	0.065	0.086	0.113	0.102	0.048	0.427
7	0.061	0.081	0.052	0.024	0.147	0.114	0.075	0.446
8	0.039	0.094	0.092	0.125	0.078	0.145	0.095	0.332
9	0.080	0.133	0.032	0.204	0.120	0.034	0.201	0.197
10	0.070	0.117	0.095	0.104	0.112	0.080	0.110	0.311
Mean Importance	0.067	0.096	0.061	0.109	0.107	0.119	0.091	0.350

Note: PB—Perceived Benefits; EC—Environmental Concern; MO—Motivation; SK—Skills and Knowledge; ATE—Attitude towards Environment; SUN—Subjective Norms; PBC—Perceived Behavioral Control; ITRE—Intention towards Renewable Energy Consumption.

5. Discussions

The depleting reserves and fluctuating oil and gas prices have seriously impacted human, social, and environmental well-being, increasing the significance of the transition to low-cost and sustainable energy sources. Public perceptions, awareness, and adoption of renewable energy sources are considered for developing, implementing, and deploying sustainable energy systems [5,24]. With the premise of the TPB, we investigated the impact of possible factors on the intention and consumption of renewable energy to address the underachievement of renewable resources in Malaysia. Results portrayed a positive influence of perceived benefit on the ATE and an indirect effect of perceived benefit on ITRE. It was consistent with the findings of Claudy et al. [25], indicating that the advantage obtained by individuals develops their favorable or unfavorable assessment of adopting renewable energy in the Malaysian context. The finding also showed a positive influence of environmental concern on ATE and an indirect effect on ITRE. Wee et al. [10] argued that persons concerned about our environment do not necessarily behave pro-environmentally. However, previous studies [22,25] affirmed that environmental concern is likely to enhance positive attitudes to the environment, increasing the intention and consumption of renewable energy. These findings substantiated integrating perceived benefits and environmental concerns into the TPB framework. Motivation positively affects the SUN, but no effect is found on the ITRE. This means that a reason must exist to feel social pressure to adopt a green lifestyle across the dataset of the present study. However, such a reason does not necessarily develop an intention to adopt renewable energy in the Malaysian context. In addition, skills and knowledge have been shown to affect ITRE indirectly. Skills and knowledge have been incorporated as a determinant of PBC and ITRE. Undoubtedly, skills and knowledge are resources that enable individuals to cultivate pro-environmental behavior to the extent of their abilities and reinforce the ITRE.

The results also revealed a positive effect and an indirect influence of the ATE on ITRE as well as RECB, respectively. These results supported the TPB and the literature [23–25] associated with pro-environmental behavior, which provokes the ITRE. The finding suggests that a positive attitude is necessary for advantages obtained by individuals, along with their emotional involvement in various environmental problems, to affect their intention to adopt renewable energy, which consecutively results in renewable energy consumption behavior. In the case of SUN, no significant effect of SUN has been reported on ITRE. Although this result is not consistent with a few studies [22], we agreed with Yazdanpanah et al. [21], who stressed that SUN might not influence an individual's will or observable response towards renewable energy consumption. Among Malaysian low-income households, SUN did not significantly influence ITRE, unlike Denmark and Ireland (where renewable energy sources are abundant). Renewable sources are not familiar in Malaysia, which could explain why the apprehension of renewable sources is lacking among Malaysian social groups. PBC showed a positive impact on the ITRE and an indirect positive effect on the RECB. Although this conclusion is not consistent with Zhang et al. [22], findings in line with TPB [23] and Yazdanpanah et al. [24] indicated that the PBC could enhance environmental protection, behavior under voluntary control, which facilitates their preparation and the consumption of renewable energy. Last but not least, there was a positive effect of ITRE on RECB. This finding confirmed TPB and previous studies [10,33], which indicated that the desire to use renewable energy could predict the real adoption of renewable energy. As a result, PBC was the strongest predictor of ITRE; in turn, it was the strongest predictor of RECB.

6. Implications

Theoretically, this paper enriches the literature on the adoption of renewable energy sources, particularly from an emerging economy's perspective. Specifically, the paper extends the TPB model by integrating relevant variables into the original framework. The lens of TPB is further extended by examining adoption intention and behavior towards renewable energy sources within its scope. This paper also contributes to the broader energy field and the SGD Goals 2030 by highlighting the enormous potential of renewable energy sources to meet current and future energy demands worldwide due to their potential to reduce greenhouse gas emissions, improve energy security, and drive economic growth. Moreover, this paper could potentially raise awareness of investment, innovation, and adaption to renewable energy sources that represent a critical aspect of the global transition towards clean energy.

Regarding the practical implications, this study can benefit policymakers, socio-economic development organizations, governmental agencies, and academics who wish to improve the adoption of renewable energy. This study generally allows decision-makers to formulate long-term energy policies for realizing the 12th Malaysian plan (2021–2025) through greater use of renewable energy in the energy sector. In particular, our results can help the Malaysian Ministry of Energy, Green Technology and Water, the Special Commission on Renewable Energy (SCORE), Tenaga Nasional Berhad (TNB), and the Sustainable Energy Development Agency strengthen political mechanisms to facilitate wider dissemination and create stable markets for renewable energy systems in Malaysia [12]. In Malaysia, where renewable energy sources are expensive options compared to other conventional energy sources, which are heavily subsidized, the importance of such support policies cannot be compromised for the massive adoption of renewable energy.

Based on the results, the underlying organizations should increase public awareness of the benefits of renewable energy and the environmental issues associated with conventional fuels to induce positive attitudes towards renewable energy that encourage adoption. Furthermore, the subjective norm towards renewable energy is weak and requires attention. The Malaysian aim to have 9 gigawatts of solar energy capacity by 2050 may only be possible when all governmental agencies and the general public collectively think positively about renewable energy resources [12]. In addition, the skills and knowledge of low-income households can be improved through group agnostic campaigns on renewable energy resources, including hydroelectricity, solar, wind, and biomass. It will improve their PBC to facilitate the RECB. In particular, we highlighted the importance of public acceptance of a pro-environmental lifestyle. Malaysian policymakers should consider the interests of low-income segment laws and strategies such as the 1979 national energy policy, feed-in tariff (FiT) regime, small renewable energy program, and integrated projects, including the application of photovoltaic technologies and the national Green Technologies Policy project. One of the suggested measures may be to initiate lease programs to achieve the 4% renewable energy target by 2040 set by the Malaysian National Energy Policy (2022–2040). It helps to offer an incentive to harness the renewable energy market in Malaysia [12]. For Malaysians, messages are created to remind the public of energy issues, encouraging lifestyle changes that will stimulate renewable energy consumption. However, reflecting on the demographic profiling of the current study, we add that married females could better appreciate the positive policy implications of renewable energy. Moreover, mature adults (41 to 50 years) who have at least graduated secondary school should be prioritized for policies to extend the adoption of renewable energy sources. Finally, as most low-income households are found to be engaged in small business as their main economic activity, it could be fruitful for policymakers, developmental organizations, and renewable energy advocates to focus more on micro-enterprises for the mass adoption of renewable energy sources.

7. Conclusions

This paper aims to support the 7th SGD Goal 2030, which portrays everyone's concerns regarding access to reliable, affordable, modern, and sustainable energy. Stressing on improving adoption rates of renewable energies in our everyday lives, this paper aspires to raise awareness regarding the 2030 agenda, particularly by revealing the significant determinants of renewable energy adoption by low-income households in emerging economies. Conventional energy sources based on fossil fuels harm the environment and human life [8]. There is enormous potential for renewable energy sources to meet current and future energy demands worldwide [3]. According to Sala et al. [51], renewable energy sources, such as wind, solar, and hydropower, are increasingly emerging as viable alternatives to traditional fossil fuels due to their potential to reduce greenhouse gas emissions, improve energy security, and drive economic growth, wherein investment, innovation, and adaption to renewable energy sources represent a critical aspect of the global transition towards clean energy. However, based on the existing literature, it is clear that despite considerable efforts, government strategies, and research, the adoption of renewable energy is underperforming [11]. Therefore, public acceptance and its socio-psychological determinants are the missing links that require further investigation. To remedy this limitation, this study examined how the socio-psychological factors influenced the intention and the behavior of adopting renewable energy within the framework of the TPB.

The disadvantaged community groups on the Malaysian coast form a significant community exposed to both climate change and socio-economic vulnerability. Malaysia was a hub for studying renewable energy due to its rich renewable sources such as oil palm biomass, biogas, and other preferred strategies [3]. Malaysia, a rapidly growing country, is highly dependent on its depleted fossil reserves with fluctuating prices, resulting in high carbon emissions and increasing social, economic, and environmental problems [13]. In this case, Malaysia serves as an appropriate data source to examine the intention and consumption of renewable energy, although it is not a popular choice of country.

Second, the results depict a positive influence of perceived benefits and environmental concerns on environmental attitudes. A positive impact of motivation on SUN, followed by a positive effect of skills and knowledge on PBC, a positive influence of ATE and PBC on ITRE, and a positive effect of the ITRE on RECB is observed. Concerning theoretical contributions, we have addressed limited studies on the public acceptance of renewable energy. As Malaysia is an underdeveloped developing country, the results validated the applicability of the TPB model to predict the intention and consumption of renewable energy. TPB has been integrated with perceived benefits, environmental concerns, skills, and knowledge.

Regarding limitations, not all socio-psychological factors were considered in the model. In addition, our focus on the low-income group could have limited the generalization of the results. It is encouraged that future studies consider a diverse demographic population and relevant construction to improve our understanding of the adoption of renewable energy. It could also be worthwhile for future researchers to explore how different income groups could access the required skills and knowledge for the successful adoption of renewable energies. Moreover, future studies could further study the feasibility of supplying subsidized renewable energy technologies to mass consumers and the role of large corporations in reducing environmental degradation and supporting pro-environmental initiatives. Such future endeavors can explore effective ways to reduce dependence on fossil fuels, which mitigate the impact of climate change and sustainable development.

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Informed Consent Statement: The local ethics committee of Universiti Malaysia Kelantan, Malaysia ruled that no formal ethics approval was required for this paper because (a) the data is completely anonymous with no personal information being collected; (b) the data is not considered to be sensitive or confidential; (c) the issues being researched are not likely to upset or disturb participants; (d) vulnerable or dependent groups are not included; and (e) there is no risk of possible disclosures or reporting obligations. This study has been performed in accordance with the Declaration of Helsinki. Written informed consent for participation was obtained from respondents who participated in the survey. The respondents who participated in the survey were asked to read the ethical statement posted at the top of the form ("There is no compensation for responding, nor is there any known risk. To ensure that all information will remain confidential, please do not include your name. Participation is strictly voluntary, and you may refuse to participate at any time") and proceeded only if they agreed. No data were collected from anyone under the age of 18.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A Research Instrument

Item Code	Questions
PB—Item 1	An environmentally friendly lifestyle may lead to new and better ways to clean up the environmental hazards
PB—Item 2	An environmentally friendly lifestyle may help us to innovate sustainable and eco-friendly ways to deal with environmental issues
PB—Item 3	An environmentally friendly lifestyle may lead to new and better ways to treat and solve social problems
PB—Item 4	An environmentally friendly lifestyle is safe for everyone and everything around us
PB—Item 5	An environmentally friendly lifestyle does not harm our society, including animals and plants
PB—Item 6	There are no significant risks associated with an environmentally friendly lifestyle
EC—Item 1	You are very concerned about the state of global environmental issues
EC—Item 2	You believe major social changes are necessary to protect the natural environment
EC—Item 3	You believe humans must live in harmony with nature in order to survive
EC—Item 4	You think environmental problems are very important to address
EC—Item 5	You think environmental problems cannot be ignored
EC—Item 6	You think we should care more about environmental problems
MO—Item1	You are motivated to practice an environmentally friendly lifestyle
MO—Item 2	Your personal philosophy is to do anything to practice an environmentally friendly lifestyle
MO—Item 3	You want to promote an environmentally friendly lifestyle, among others
MO—Item 4	You are able to use your past experience and training to practice an environmentally friendly lifestyle
MO—Item 5	You want to prove that you can practice an environmentally friendly lifestyle
MO—Item 6	You want to contribute to the world by practicing an environmentally friendly lifestyle
MO—Item 7	You want to have a career focused on solving environmental issues
SK—Item 1	You can easily identify environmentally friendly income-generating opportunities
SK—Item 2	You possess sufficient skills to start an environmentally friendly business
SK—Item 3	You have the problem-solving skills to be a green entrepreneur
SK—Item 4	You have the leadership and communication skills required to become a green entrepreneur
SK—Item 5	You can transfer the skills that were learned to promote your business
SK—Item 6	Because of your previous work experience, you know how to start an environmentally friendly business
SK—Item 7	You are satisfied with your knowledge about how green business works
ATE—Item 1	Environmental protection is important to you when making a purchase decision
ATE—Item 2	Between environmentally friendly and conventional products, you prefer the environmentally friendly ones
ATE—Item 3	Practicing an environmentally friendly lifestyle is necessary to mitigate global warming
ATE—Item 4	You think an environmentally friendly lifestyle is crucial for the future of our existence
ATE—Item 5	You think that an environmentally friendly business is a good idea
ATE—Item 6	You think that environmentally friendly consumption is safe
SUN—Item 1	You feel under social pressure to practice an environmentally friendly lifestyle
SUN—Item 2	You feel bad if you choose to buy conventional products instead of environmentally friendly products.
SUN—Item 3	Everyone has a responsibility to contribute to environmental preservation by purchasing environmentally friendly products
SUN—Item 4	Everyone has a responsibility to promote environmentally friendly behavior, among others
SUN—Item 5	Most people who are important to you would wish you to practice an environmentally friendly lifestyle
PBC—Item 1	You are confident that you can practice an environmentally friendly lifestyle
PBC—Item 2	You see yourself as capable of practicing an environmentally friendly lifestyle
PBC—Item 3	You have resources to practice an environmentally friendly lifestyle
PBC—Item 4	You have time to search and practice an environmentally friendly lifestyle
PBC—Item 5	You have the willingness to practice an environmentally friendly lifestyle
PBC—Item 6	There are likely to be plenty of opportunities for you to practice an environmentally friendly lifestyle
PBC—Item 7	Being environmentally friendly would be entirely within your control.
ITRE—Item 1	You would use renewable energy even if the supply is uncertain
ITRE—Item 2	The probability that you will start using green energy is very high
ITRE—Item 3	You plan to use more renewable energy rather than non-renewable energy
ITRE—Item 4	You will consider the use of renewable energy for ecological reasons
ITRE—Item 5	Comparing with non-renewable energy, you are more willing to use renewable energy.
ITRE—Item 6	You intend to use renewable energy
ITRE—Item 7	If you have an opportunity, you will consider using renewable energy because they are less polluting
ITRE—Item 8	If you had a choice, you would choose to switch to renewable energy
REAB—Item 1	You intentionally avoid the use of non-renewable energy
REAB—Item 2	You intentionally use technologies that utilize renewable energy
REAB—Item 3	You intentionally purchase products manufactured or grown in a renewable energy environment
REAB—Item 4	You buy appliances that use renewable energy
REAB—Item 5	You talk to people using non-renewable energy in an effort to persuade them to use renewable energy.
REAB—Item 6	You set a positive environmental example by using renewable energy for your friends to follow.

Note: PB—Perceived Benefits; EC—Environmental Concern; MO—Motivation; SK—Skills and Knowledge; ATE—Attitude towards Environment; SUN—Subjective Norms; PBC—Perceived Behavioral Control; ITRE—Intention towards Renewable Energy; and REAB—Renewable Energy Adoption Behavior.

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