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# Knowledge, Attitude, and Perception of Students Regarding Renewable Energies in Agriculture in Guilan, Iran

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**Abstract:** Transitioning from fossil to renewable energy is a global challenge, especially for countries with large fossil-fuel reserves and exports, such as Iran. This study analyses agricultural students' knowledge of, attitudes toward, and perceptions of renewable energies in the agriculture sector in Guilan Province in Iran. The research was based on a structured questionnaire comprising three sections: (i) respondents' socio-demographics; (ii) practicality and relevance of academic material and curriculum; and (iii) respondents' knowledge of and attitudes and perceptions toward renewable energies in agriculture. The results showed that students' attitudes regarding renewable energies ranked highest, and their perception was lowest. The results also showed a positive and significant relationship between the respondents' knowledge, marital status, age, and level of education. Moreover, respondents' age and educational level significantly impacted their attitudes. Cluster analysis divided students' behavior into three different clusters. These clusters were most affected by attitude. In clustering students' behavior towards using renewable energies, 38.5%, 33.5%, and 28% of respondents were positioned in the first, third, and second clusters, respectively. This is a pioneering study analyzing agricultural students' behavior regarding renewable energies in agriculture in Guilan Province, Iran. The results of this study can assist agricultural organizations, politicians in the field of energy, and local authorities in promoting sustainable energy in Guilan Province.

**Keywords:** renewable energy; students; agriculture; knowledge assessment; attitude; perception; Guilan; Iran

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## 1. Introduction

The modern agricultural production system is becoming more dependent on fossil fuels. It requires an energy input at every step of production, including direct energy use for farm equipment, water management, irrigation, cultivation, and harvesting, as well as indirect or sequestered energy inputs in the form of fertilizers, pesticides, and equipment manufacture. Globally, the food sector consumes 30% of the total energy supply, mainly fossil fuels [1]. The high energy supply derived from fossil fuels contributed to the significant improvements in food production observed since the 1960s and, hence, to achieving food security [2,3]. However, the agriculture energy nexus is challenged by two factors. Firstly, affordable energy sources seem to be becoming more limited, and energy markets look to be getting more volatile due mainly to geopolitical instabilities such as the ongoing Russia-Ukraine war [4], resulting in increased energy costs. In many developing countries, irrigation is primarily powered by thermal power facilities or biomass/diesel generators with high costs and low efficiency [5,6]. Meeting food production objectives may be hampered in the future by a scarcity of affordable fossil fuels [1].

Secondly, agriculture contributes directly and indirectly to 21% of the global GHG emissions resulting from conventional farming activities, deforestation, and direct use of fossil fuels in the agricultural process and livestock raising [7]. These emissions could substantially impede the world's efforts to combat climate change and maintain warming at a manageable level. Accordingly, lowering agriculture's carbon footprint is critical to preventing global warming and achieving the 2030 SDG goals [8,9]. Meanwhile, by decreasing deforestation, enhancing farming management, and developing renewable energy, the agricultural sector can significantly reduce overall emissions by 20–60% by 2030, thereby balancing the global carbon cycle. Further, climate change's effects on agriculture and its consequences on food security are already alarming [7,10]. Without immediate action to make agriculture more sustainable, productive, and resilient, climate change consequences will substantially jeopardize food production in already food-insecure countries and regions [7]. Accordingly, the type of energy used in the agro-food chain will significantly affect the food system's ability to satisfy future food security goals while supporting larger development goals in an environmentally sustainable way [1]. However, since significant social and economic burdens are involved with integrating renewable energy resources into national energy plans, public attitudes toward using renewable energy resources should be considered [11].

Transitioning from fossil to renewable energy sources is a major global challenge, particularly for countries with significant fossil-fuel reserves and exports, such as Iran [12,13]. Indeed, globally, Iran ranks second in natural gas reserves and fourth in proven crude oil reserves [14]. With a significant production of fossil fuels and rapid urbanization, Iran is the world's 7th largest emitter of greenhouse gases in 2019 [15]. With fossil fuels accounting for 97% of its energy mix, Iran's transition to renewable energy is critical for reducing greenhouse gases emissions [16,17]. Meanwhile, due to its advantageous geographic location, Iran has a wide range of renewable energy sources [18–21]. While the Iranian leadership recognizes climate change as an existential concern, combating it does not seem high on its priority list [22]. Indeed, analysts believe Iran's shift to a green economy is in jeopardy since lifting US sanctions is the central goal of its new government.

Meanwhile, Iran faces many environmental challenges as a highly vulnerable country to climate change's impact [23]. Undeniably, it will experience an increase of 2.6 $^{C}$ in mean temperatures and a 35% decline in precipitation in the following decades [24], resulting in an increased risk of droughts and threatening water and food security [25]. Furthermore, agriculture is regarded as one of the most important sectors of the Iranian economy. It accounts for around 11% of GDP, and almost 15 million people (19% of the population) work in this industry. It is critical to achieving self-sufficiency in the main basic food crops as well as ensuring food security for the country's growing population. Because of low subsided fuel costs in recent decades, the Iranian agricultural sector has been unable to improve its energy use efficiency [26]. In 2017, Iranian agriculture consumed 58.6 MBOE of natural gas, oil products, and electricity, accounting for 4.3% of total energy consumption [27]. Guilan Province lies along the Caspian Sea in Northern Iran. This province is one of the leading agricultural centers in Iran, especially for products such as rice and olive oil and agriculture employs a large number of people [28,29].

However, Guilan Province is highly vulnerable to natural catastrophes as well as the possible implications of climate change. Climate factors such as precipitation and temperature fluctuation may impact paddy fields and pose a severe obstacle to agricultural development [30]. Further, the transition of this sector toward sustainability faces several challenges and constraints [31]. In general, increasing public awareness is crucial for renewable energy development [32]. Kardoni [33] believes that developing countries, including Iran, have several challenges in expanding renewable energy production, such as the lack of social acceptance and awareness.

This study aims to investigate agricultural students' knowledge, attitude, and perception regarding renewable energies in the agriculture sector in Guilan Province in Iran. The importance of this research derives from the need to understand better the role of education in increasing renewable energy awareness in the agriculture sector. Indeed, because of their significance in training and educating new professionals, Higher Education Institutions (HEI) play a critical role in the transition to renewable energies [34,35]. Further, universities throughout the globe increasingly recognize their responsibility to prepare students and society to actively contribute to climate change mitigation and adaptation [36]. Students must become sustainability change-makers to establish a more sustainable agricultural system and engage with problems connected to sustainability as outlined in the SDGs. As a result, they need to be prepared with the knowledge, skills, values, and attitudes necessary to contribute to sustainable development [34]. In line with this concern, Guilan Province, with its agricultural institutions and students studying agriculture-related areas, can move ahead with the education and training of a skilled generation in sustainable agricultural development. As more educated youth join the agricultural sector, they will apply what they have learned in the local agriculture sector. Indeed, graduated agricultural students must be familiar with the issues presented by climate change to properly advise the communities with whom they will be working [37]. Accordingly, it is necessary to study their attitude, knowledge, and perception regarding using these energies in agriculture.

Overall, research about students' knowledge, attitude, and perception toward renewable energy in Iran and the Middle East and North Africa (MENA) region is scarce, especially in the agriculture sector. The paucity of current research leaves a significant and worrying gap in the knowledge base needed to form effective policies. It would be, to our knowledge, the first study of its kind in Iran and the MENA region. Accordingly, the research has three main objectives:

1. Identify the main constraints that impact the perception and attitude of agricultural students in Guilan toward renewable energy.
2. Determine the key factors influencing the attitudes and perceptions of agricultural students in Guilan about renewable energy.
3. Provide recommendations on strengthening the link between academic curriculum and renewable energy and raising knowledge about renewable energy.

Figure 1, informed by Ashraf et al. [38] depicts the research structure that is used in this study.

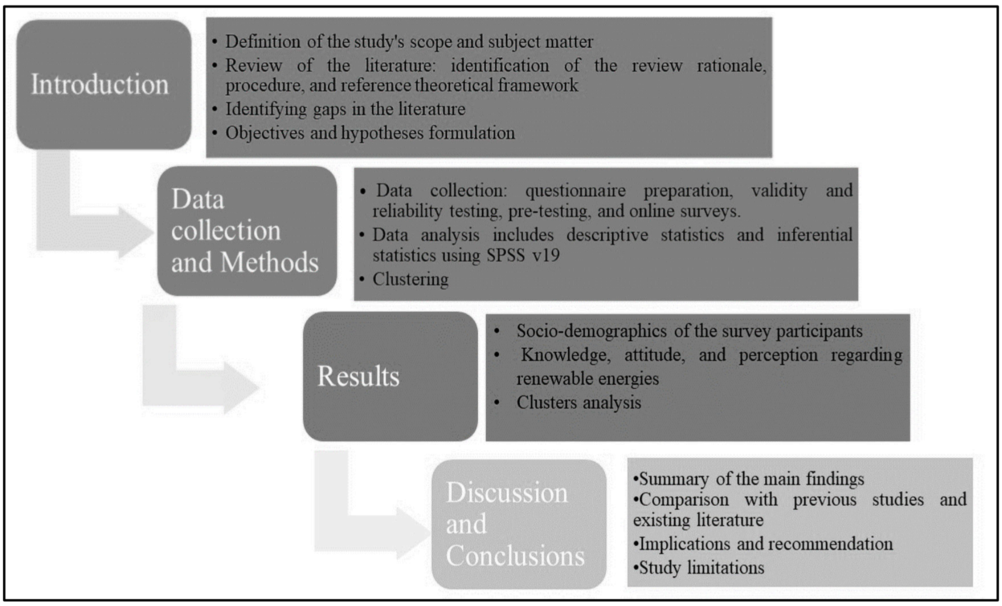


**Figure 1.** Research flowchart.

## 2. Theoretical Framework

Extensive evidence indicates that human actions and behaviors are at the foundation of many environmental challenges, including climate change. Accordingly, this research was inspired on Azjen's Theory of Planned Behavior (TPB). TPB is one of the classic theoretical models for studying individual behavior. It helps to predict people's behavior and explain how perceptions influence human behavior [39]. According to Spiegel [40], perceptions are thoughts about objects, events, or circumstances, whereas attitudes predispose us to accept or reject a specific thing, event, or situation. Perceptions often produce three main constructs: attitude toward the behavior, subjective norm, and perceived behavioral control [39]. According to the TPB, behavior is determined by an individual's intention to perform it. In turn, attitude, perceived behavioral control, and subjective norms are considered to influence behavioral intentions [41]. The TPB defines attitude as people's view of certain events [39]. It refers to the degree to which a person has a positive or negative opinion of behavior [41]. The apparent ease or difficulty of engaging in a behavior is referred to as perceived behavioral control. The perceived social pressure to execute or abstain from a behavior is referred to as a subjective norm [41].

TPB has been used to explain a broad range of environmental behavior. In fact, numerous environmentally relevant behaviors appeared to be adequately explained by the TPB [41] Since it offers an in-depth evaluation of the factors influencing behavioral intention, TPB could provide a valuable framework for investigating students' attitudes, knowledge, and perceptions about renewable energy in agriculture. Indeed, several studies have revealed that individuals' daily decisions and responses to climate change hazards are often influenced by their understanding and perception of the problem itself [42]. Further, Shi [43] highlights that public perception may affect policymakers' decisions. Furthermore, the importance of knowledge in addressing concerns about climate change and the importance of renewable energies has been debated in recent years. Several past studies have shown that different types of specific climate knowledge affect public concern about these topics and individuals' behavioral intentions to address global warming.

A large and growing body of literature has investigated the public's knowledge, attitude, and perception regarding renewable energies. Although the current research suggests that public opinion favors renewable energies, several factors influence the public's understanding of renewable energy sources and their readiness to adopt them, such as education, gender, income, age, etc. [44].

In Iran, Azadi et al. [45] demonstrated that favorable perceptions of renewable energy sources are predictors of increased readiness to use them. In New Zealand, an investigation of consumer attitudes toward renewable energies revealed a greater willingness to support renewable energy development despite having to pay somewhat higher power bills than for traditional fossil fuel energy products [46]. In the study of Kardooni et al. [47], in Malaysia, most respondents who were concerned about climate change knew about renewable energy technology, but just 40% had used them. The cost of these technologies also hindered their adoption. In Saudi Arabia, according to Almulhim [48], the majority of Saudis were moderately aware of renewable energy. According to the data, 79.2% of respondents said that people were concerned about the negative impacts of pollution and that alternative energy may be helpful. However, 97.2% of the respondents indicated that the high costs of renewable energy technologies made them useless.

Botelho et al. [49] studied Portuguese public opinion on renewable energy. Based on the citizen survey results, renewable energy resources were one of the most environmentally-friendly alternatives for power and electricity production with a higher degree of societal acceptability. However, the levels differed locally from one region to another. In Hungary, Szakály et al. [50] highlighted that a greater level of education, a higher income, an active white-collar career, and a health- and environment-conscious lifestyle are all advantages when it comes to awareness of renewable energy sources. Karytsas and Theodoropoulou [51] indicated that, in Greece, solar and wind were the best-known renewable energies. According to the study, gender, age, education, the head of the household's education level, environmentally friendly behavior, profession, environmental interest, and technical knowledge are statistically connected to renewable energy awareness. As a general observation, the degree of awareness and knowledge of various renewable energy sources varies by country and even by area within the same country [16]. Also, age and education are considered the main factors influencing knowledge and awareness regarding renewable energy.

A second group of research focused on youth and students' knowledge, attitude, and perception regarding renewable energies. Indeed, university students are an important demographic group to comprehend since experiences throughout life transitions have been demonstrated to have a long-term influence on behaviors [52] Several studies highlighted that younger individual are more likely to know about alternative energy sources [50] Yazdanpanah et al. [53] investigated Iranian youth's perceptions of renewable energy. They outlined that the usage of renewable energy was highly influenced by characteristics such as "perceived advantages" and "self-efficacy". Yakut Ipekoğlu et al. [54] investigated students' opinions about renewable energy at Süleyman Demirel University in Turkey. They highlighted that the level of maternal education and college enrolment also impacted students' views about renewable energy.

In Jordan, Zyadin et al. [55] investigated students' renewable energy knowledge, perceptions, and attitudes. The research found that students had little or no capacity to differentiate between renewable and non-renewable energy sources, even though many employed renewable energy sources such as the sun and wind. However, 87% see renewable energy as a future energy choice, and they have a positive attitude and a tendency to utilize renewable energy even at high rates. Female students have a better understanding of renewable energy than male students. Halder et al. [56] investigated youth people's knowledge and experience of bioenergy in Finland. According to the findings, respondents had limited knowledge of bio-energy. The results also revealed that the attitudes of urban people were more favorable than those living in rural areas. Qu et al. [57] studied Chinese university students' knowledge and attitudes toward forest bioenergy. Students were generally enthusiastic about renewable energy but less about forest bio-energy. In Greece, Liarakou et al. [58] revealed that, although instructors were aware of renewable energy sources, they lacked firm viewpoints on various topics, including wind and solar energy technologies and farms. The agricultural sector needs a range of knowledge and skills. As a result, educating students may assist them in achieving agricultural objectives and sustainable development.

## 3. Materials and Methods

This study was conducted at two major universities in Guilan Province, Iran: The University of Guilan and Islamic Azad University. The study addresses all students of agricultural universities of Guilan Province (N = 2000). Guilan University has 1200 students, and the three local branches of Islamic Azad University have 800 students at various levels (undergraduate and graduate). This study used the minimum sample size table of Bartlett et al. [59] to calculate the statistical sample size. Accordingly, a sample size of 200 individuals was deemed appropriate and representative. A stratified random sampling method was used to select the participants. Consequently, 120 students from Guilan University and 80 students from the three local branches of Islamic Azad University were selected to participate in the study. The survey was administered using the face-to-face interview method to the selected participants. At the beginning of the interview, all respondents were informed about the study objective and goals. They provided their written permission regarding privacy and information management standards.

The research was based on a self-developed questionnaire including three sections. The first section included questions on the social-demographic characteristics of the participants, such as age, gender, marital status, university of study, occupation, place of residence, etc. The second section provided an assessment of the practicality and relevance of academic material and curriculum (4 items) using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). In the third section, Students' knowledge (12 items), attitude (5 items), and perception (8 items) of renewable energy in agriculture were assessed. The items in this section were designed and measured using a five-point Likert scale.

The questionnaire was evaluated in two phases prior to distribution. Firstly, an expert panel comprised of university professors reviewed the content's quality to ensure its validity. Professional reviews led to removing irrelevant elements; the remaining items were updated to guarantee accuracy and clarity. Secondly, a pre-test with 20 participants was performed to assess the data's quality.

The reliability of the questionnaire was ascertained using Cronbach's alpha coefficient. All three factors were found to have acceptable reliability (knowledge 0.843; attitude 0.714 and perception 0.754). Descriptive statistics, including frequency, percentage, mean, and standard deviation, were used to analyze collected data from respondents. Mean scores were used to cluster the respondents' knowledge, attitude, and perception. Also, Pearson and Spearman correlation coefficients were employed to examine the relationship between respondents' characteristics with knowledge, attitude, and perception Chi-square test.

Moreover, a two-stage cluster analysis was used to determine the appropriate cluster number, followed by a K-mean cluster analysis for subjects' typology and clustering. This was due to the lack of a suitable number of clusters. Cluster analysis was done to group students based on their behavior (knowledge, attitude, and perception). Also, for analysis of variance, the Bonferroni post hoc test was used to compare the clusters for each variable. The cluster test examined each of the three variables of knowledge, attitude, and perception in pairs.

## 4. Results

We begin by introducing the survey participants' socio-demographic characteristics (Section 4.1), then examine students' knowledge, attitudes, and perceptions regarding renewable energies (Section 4.2), and finally, present the results of the cluster analysis (Section 4.3).

### 4.1. Socio-Demographic Characteristics of the Participants

As shown in Table 1, the socio-demographic characteristics of the participants indicate that 57% were male and 43% were women. In addition, 44% were 20–30 years old, 27.5% were between 30–40 years old, and the average age was 27 years. Regarding marital status, 54.5% of the students in this cohort were single, and 45.5% were married. Most respondents were full-time university students (52.5%), 45.5% were at bachelor's level, and 34.5% were at master's level. In addition, most of the respondents (81%) live in urban areas (Table 1).

**Table 1.** Socio-demographic characteristics of the survey participants ($n$ = 200).

| Characteristics | | Frequency | % |
|---|---|---|---|
| Gender | Male | 114 | 57 |
| | Female | 86 | 43 |
| Age (years) | 20 and Less | 46 | 23 |
| | 20–30 | 88 | 44 |
| | 30–40 | 55 | 27.5 |
| | 40 and above | 11 | 5.5 |
| Marital Status | Single | 109 | 54.5 |
| | Married | 91 | 45.5 |
| Education level | Bachelor | 91 | 45.5 |
| | Master | 69 | 34.5 |
| | Doctorate | 40 | 20 |

**Table 1.** *Cont.*

| Characteristics | | Frequency | % |
|---|---|---|---|
| University | Guilan | 120 | 60 |
| | Azad | 80 | 40 |
| Occupation | Student | 105 | 52.5 |
| | Employee | 71 | 35.5 |
| | Farmer | 24 | 12 |
| Residence ownership | Tenant | 94 | 47 |
| | Owner | 106 | 53 |
| Place of residence | Urban | 162 | 81 |
| | Rural | 38 | 19 |

### 4.2. Knowledge, Attitude, and Perception Regarding Renewable Energies

Regarding university syllabus relevance, the results show that 49% of the respondents believe that courses and academic resources in their universities are unrelated to renewable energy in agriculture. Meanwhile, 61.5% of the students think developing renewable energy training could be helpful for agricultural development in Guilan Province. Furthermore, 47.5% said that tackling the renewable energy issue is a top concern. However, most respondents (96%) stated that society's tendency to utilize renewable energy is average (Table 2).

**Table 2.** University syllabus relevance.

| Variables | None | Very Low | Low | High | Very High | Mean | SD |
|---|---|---|---|---|---|---|---|
| The relevance of academic resources and courses to renewable energies in agriculture | 0 | 18 | 49 | 30.5 | 2.5 | 3.17 | 0.75 |
| The usefulness of renewable energy training for the development of the Guilan province agricultural sector | 0 | 1 | 26.5 | 61.5 | 11 | 3.82 | 0.62 |
| The priority to address the issue of renewable energies | 0 | 1.5 | 40 | 47.5 | 11 | 3.68 | 0.68 |
| Variable | Very weak | Weak | moderate | Good | Very good | Mean | SD |
| The tendency of society to use these renewable energies | 0 | 4.5 | 48 | 43 | 4.5 | 3.47 | 0.66 |

Regarding students' awareness of renewable energy sources, the results showed that 80% of the respondents considered solar energy accessible and usable, and 87.5% considered this energy a renewable energy source. In addition, 66.5% considered nuclear energy accessible, and 84.5% thought this energy was a renewable energy source. Moreover, 88.5% of the respondents considered wind energy accessible, and 65% believed it is usable. In addition, 87.5% considered this energy a renewable energy source. Furthermore, 55% of the respondents viewed coal as accessible and 50% as usable, but 95% believed it is an unrenewable energy source. Wood waste from forest management is viewed by 83% as accessible, 62% usable, and 78% a renewable energy source. In addition, 96%, 83.5%, and 92.5% of the respondents, respectively, considered hydroelectric power as an accessible, usable, and renewable energy source.

Moreover, according to the participants' responses, 94% and 88% of them perceived fossil fuels as accessible and valuable energy sources, respectively, whereas 92.5% viewed this energy as unrenewable. While 53% and 67.5% considered geothermal an inaccessible and unsuitable energy source, 89.5% said it was renewable energy. Regarding agricultural and animal waste, 62% and 85.5%, respectively, saw it as a usable renewable energy source, while 62.5% said it was unsuitable. While 62.5% and 90% thought waves and tides were inaccessible and useless energy sources, respectively, 90.5% thought they were renewable (Table 3).

**Table 3.** Energy sources.

| Energy Source | Accessibility | | Useable | | Renewable | | |
|---|---|---|---|---|---|---|---|
| | No | Yes | No | Yes | No | Yes | Not sure |
| Solar | 19.5 | 80.5 | 20 | 80 | 0.5 | 87.5 | 12 |
| Nuclear | 33.5 | 66.5 | 49.5 | 50.5 | 0 | 84.5 | 15.5 |
| Wind | 11.5 | 88.5 | 35 | 65 | 0.5 | 87.5 | 12 |
| Coal | 45 | 55 | 50 | 50 | 95 | 0 | 5 |
| Wood waste | 17 | 83 | 38 | 62 | 9.5 | 78 | 12.5 |
| Hydroelectric | 4 | 96 | 16.5 | 83.5 | 4.5 | 92.5 | 3 |
| Fossil fuels | 6 | 94 | 12 | 88 | 94.5 | 5 | 0.5 |
| Geothermal | 53 | 47 | 67.5 | 32.5 | 1.5 | 89.5 | 9 |
| Food waste | 56 | 44 | 62.5 | 37.5 | 3.0 | 85.5 | 11.5 |
| Agricultural and livestock waste | 29.5 | 70.5 | 44.5 | 55.5 | 3.0 | 83.5 | 13.5 |
| Waves and tides | 88.0 | 12 | 90 | 10 | 0 | 90.5 | 9.5 |

Regarding students' knowledge of renewable energy sources, Table 4 shows that the knowledge indicators with the highest average are "Climate change due to GHG emissions from fossil fuel consumption" (M = 4.42), "Wind turbines to generate electricity from wind energy" (4.37), and "Solar cells to generate electricity from solar energy" (M = 4.36). In addition, the indicator "Energy extraction techniques from firewood in developing countries" (M = 3.55), has the lowest mean. Based on the average knowledge items, it can be concluded that the students have a strong understanding and good knowledge of renewable energy.

**Table 4.** Respondent's knowledge of renewable energy sources.

| Knowledge Items | Mean | SD | Rank |
|---|---|---|---|
| Climate change due to GHGs emissions from fossil fuel consumption | 4.42 | 0.58 | 1 |
| Wind turbines to generate electricity from wind energy | 4.37 | 0.64 | 2 |
| Solar cells to generate electricity from solar energy | 4.36 | 0.63 | 3 |
| Photovoltaic (sunlight conversion technology) | 4.30 | 0.65 | 4 |
| Biodiesel (fuel from natural oils) | 4.25 | 0.68 | 5 |
| Hot springs | 4.24 | 0.68 | 6 |
| Biogas production from municipal wastewater | 4.23 | 0.71 | 7 |
| Solar water heater | 4.23 | 0.66 | 8 |
| Global plans and policies to reduce future energy demand | 3.91 | 0.90 | 9 |
| Bioethanol (biomass fermentation) | 3.91 | 0.74 | 10 |
| Geothermal energy (Earth's thermal energy) | 3.90 | 0.76 | 11 |
| Energy extraction techniques from firewood in developing countries | 3.55 | 0.95 | 12 |

The students' need for better training in renewable energy (M = 4.58) was connected to respondents' attitudes towards renewable energy sources (M = 4.58). The indicator "More training to develop abilities to utilize renewable energy" (M = 3.12) is also in the bottom position, with the lowest mean. There is a strong correlation between mean scores and students' attitudes regarding renewable energy usage indicators (Table 5).

**Table 5.** Respondents' attitudes on renewable energy sources.

| Attitude Indicators | Mean | SD | Rank |
|---|---|---|---|
| I need better training tools in the field of renewable energy | 4.58 | 0.51 | 1 |
| I need to connect to experts who have enough information on renewable energy | 4.56 | 0.53 | 2 |
| I would like to learn more about renewable energy | | | |
| I feel I have enough knowledge to utilize renewable energy in agriculture | 4.38 | 0.56 | 3 |
| I need more training to develop my abilities to utilize aspects of renewable energy in agriculture | 4.14 | 0.66 | 4 |

According to Table 6, the indicators "Development of renewable energy sources in Iran will result in long-term energy independence" (M = 4.44), "Growth in the renewable energy sector will lead to economic growth" (M = 4.35), and "The lack of native specialists is a major obstacle to the development of the renewable energy sector" (M = 3.82) were ranked first through third, respectively. In addition, the indicators "Production of biofuels from agricultural products may pose a food threat in developing countries" (M = 3.15) and "The future of energy production in Iran depends on the discovery of new oil resources" (M = 2.72) were ranked lowest. According to the mean scores, most respondents had an average perception of renewable energies.

**Table 6.** Respondents 'perception of renewable energy sources.

| Perception Indicators | Mean | SD | Rank |
|---|---|---|---|
| The development of renewable energy sources in Iran will result in long-term energy independence | 4.44 | 0.59 | 1 |
| Growth in the renewable energy sector will lead to economic growth | 4.35 | 0.58 | 2 |
| The lack of native specialists is a major obstacle to the development of the renewable energy sector | 3.82 | 0.78 | 3 |
| Currently, utilizing renewable energy in Iran is a costly strategy | 3.81 | 0.82 | 4 |
| In some developed countries, part of the commercial energy is generated from the burning of environmentally friendly forest biomass | 3.67 | 0.79 | 5 |
| Nuclear energy is seen as a sustainable option in the coming years | 3.19 | 0.95 | 6 |
| Production of biofuels from agricultural products may pose a food threat in developing countries | 3.15 | 0.81 | 7 |
| The future of energy production in Iran depends on the discovery of new oil resources | 2.72 | 1.04 | 8 |

To rank the three items of knowledge, attitudes, and perceptions, the indicators for each item were merged, and the mean score generated was considered the score of each item. As a result, students' attitudes were placed first, with the highest average (4.16). Knowledge (4.13) and perception (3.65) came in second and third place, respectively (Table 7).

**Table 7.** Ranking of Behaviour Indicators.

| Variables | Mean | SD | Rank |
|---|---|---|---|
| Attitude | 4.16 | 0.37 | 1 |
| Knowledge | 4.13 | 0.44 | 2 |
| Perception | 3.65 | 0.29 | 3 |

The association between renewable energy knowledge, attitudes, and perceptions and several socio-demographic variables was investigated (Table 8). The findings show a strong correlation between knowledge and marital status ($p < 0.05$), age ($p < 0.01$), and educational level ($p < 0.01$). The findings also revealed that attitudes toward renewable energy are substantially related to age ($p < 0.05$) and educational level ($p < 0.01$). Finally, no significant association was found between perceptions and socio-demographic variables.

**Table 8.** Socio-demographic effects on knowledge, attitude, and perceptions. about renewable energy.

| Variables | Test | Knowledge | Correlation Coefficient | |
|---|---|---|---|---|
| | | | **Attitude** | **Perception** |
| Gender | Chi-square | 25.06 | 9.11 | 9.22 |
| Marital Status | Chi-square | 0.82 * | 9.88 | 14.96 |
| Age | Pearson | 0.551 ** | 0.158 * | 0.095 |
| Education level | Spearman | 0.799 ** | 0.237 ** | 0.064 |
| University | Chi-square | 30.97 | 8.00 | 11.67 |
| Occupation | Chi-square | 58.10 | 0.97 | 28.19 |
| Residence ownership | Chi-square | 23.23 | 8.03 | 7.89 |

* $p < 0.05$. ** $p < 0.01$.

### 4.3. The Clusters Analysis

A two-stage cluster analysis approach was used in this study to assess the homogeneity of indices for each knowledge, attitude, and perception indicator. Based on the three indices of knowledge, attitude, and perception, the findings revealed that the student's behavior was classified into three clusters, with the quality of clustering ranging between zero and 0.5 (the average degree of this type of clustering) (Figure 2).

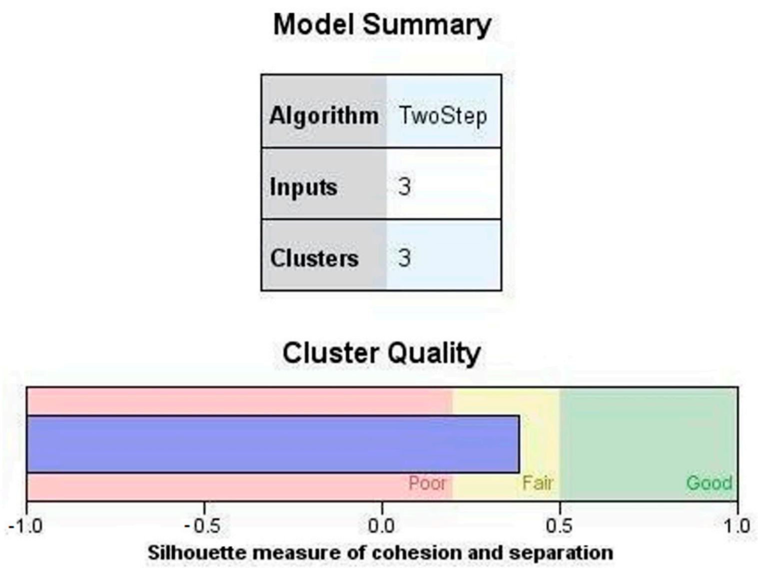


**Figure 2.** Cluster Analysis Model Summary.

Figure 3 illustrates that attitude had a more significant impact on the three clusters. As a result, knowledge and perception have each had an impact on cluster formation. Furthermore, the k-mean cluster analysis classified the research participants into three clusters based on three variables (knowledge, attitude, and perception). The resulting cluster centers are given for the three variables in Table 9 and Figure 3. Knowledge had the most significant impact in the first and third clusters, whereas attitude had the most significant influence in the second.

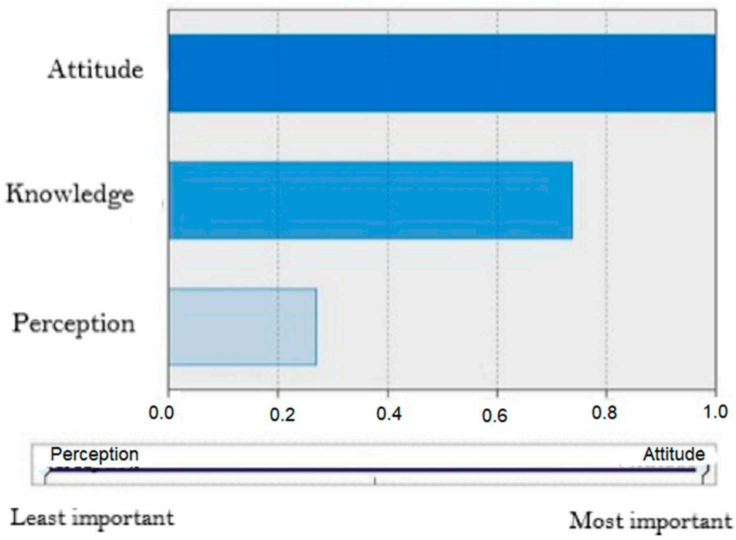


**Figure 3.** Predictor importance.

**Table 9.** Final cluster centers.

| Variables | Cluster 1 | Cluster 2 | Cluster 3 |
|---|---|---|---|
| Knowledge | 4.54 | 3.72 | 3.99 |
| Attitude | 4.36 | 4.34 | 3.77 |
| Perception | 3.64 | 3.58 | 3.72 |

Respondents were classified into three groups based on their behavior toward renewable energy use in agriculture, reflecting behavioral levels based on each indicator's measurement. As a result, 77 people were assigned to the first cluster, 56 to the second, and 67 to the third (Table 10).

**Table 10.** Frequency distribution of clusters.

| Clusters | Frequency | Percentage |
|---|---|---|
| Cluster 1 | 77 | 38.5 |
| Cluster 2 | 56 | 28.0 |
| Cluster 3 | 67 | 33.5 |
| Total | 200 | 100 |

As a result of the ANOVA test, we concluded that these three clusters were not identical and differed in terms of the mean (Table 11).

**Table 11.** ANOVA Analysis.

| Variables | Mean | F | *p*-Value |
|---|---|---|---|
| Knowledge | 11.602 | 155.95 ** | **0.000** |
| Attitude | 7.43 | 113.52 ** | **0.000** |
| Perception | **0.345** | **4.15 *** | **0.017** |

* $p < 0.05$, ** $p < 0.01$.

The Bonferroni test revealed that the participants' knowledge in each cluster differed from that of the other clusters (Table 12). Individuals in the first and third clusters and the second and third clusters showed significantly different attitudes, indicating that those in the third cluster had a different attitude than those in the first and second groups. However, there was no statistically significant difference in the attitudes of people in the first and second clusters. There was only a considerable variation in perception between the first and second clusters, showing a difference in their perspective of the use of renewable energy in agriculture. However, perception did not vary between the first and third clusters nor between the second and third clusters.

**Table 12.** Bonferroni post hoc test.

| Variables | Clusters (I) | Clusters (J) | Mean Difference | Std. Error | $p$-Value |
|---|---|---|---|---|---|
| Knowledge | 1 | 2 | 0.812 * | 0.047 | 0.00 |
| | | 3 | 0.543 * | 0.045 | 0.00 |
| | 2 | 1 | −0.812 * | 0.048 | 0.00 |
| | | 3 | −0.269 * | 0.049 | 0.00 |
| | 3 | 1 | −0.543 * | 0.045 | 0.00 |
| | | 2 | 0.269 * | 0.049 | 0.00 |
| Attitude | 1 | 2 | 0.019 | 0.045 | 1.00 |
| | | 3 | 0.585 * | 0.042 | 0.00 |
| | 2 | 1 | 0.19 | 0.045 | 1.00 |
| | | 3 | 0.566 * | 0.046 | 0.00 |
| | 3 | 1 | −0.585 * | 0.043 | 0.00 |
| | | 2 | 0.566 * | 0.046 | 0.00 |
| Perception | 1 | 2 | 0.144 * | 0.051 | 0.014 |
| | | 3 | 0.079 | 0.048 | 0.310 |
| | 2 | 1 | −0.144 * | 0.051 | 0.014 |
| | | 3 | −0.065 | 0.052 | 0.632 |
| | 3 | 1 | −0.079 | 0.048 | 0.310 |
| | | 2 | 0.065 | 0.052 | 0.632 |

* $p < 0.05$.

## 5. Discussion and Implications

This research examined agricultural students' knowledge, attitudes, and perceptions of renewable energy in the agriculture sector in the Iranian province of Guilan. The findings revealed several aspects of their knowledge, attitude, and perception.

Firstly, most students stressed the absence of links between their academic curriculum and renewable energy. This study shows that students have a greater need for knowledge and awareness in this area and are more receptive to learning. They saw the training as valuable in strengthening Guilan province's agricultural sector and addressing the issue of renewable energy in agriculture. The majority of respondents are willing to utilize renewable energy regularly.

Second, many energy sources, including hydropower, fossil fuel, wind, wood waste, solar, geothermal, and others, were identified as accessible and feasible in the Guilan province agriculture sector. Respondents are familiar with these energy sources since they are essential to the province's energy supply. Respondents said that although fossil fuels are a readily available and usable energy source, they are not renewable. Their responses revealed that they are aware of the environmental consequences of fossil fuel consumption and the need to replace it with renewable energy. According to most responders, wood waste is not a renewable energy source but a conveniently available and usable energy source. Because wood waste is a by-product of tree cutting, they were most likely concerned that it might affect forest resources.

Furthermore, respondents were aware of climate change and its connection to GHG emissions. These results suggest they acknowledge the need to shift away from polluting fuels and toward greener and more sustainable ones. To accomplish this transition, they are aware of specific alternative energy sources, such as solar and wind. On the other hand, respondents reported that they are unfamiliar with bioethanol, geothermal energy, and wood waste.

These results emphasize the limitations of the educational system in this area. Similarly, respondents responded that they need more educational materials, connections with professionals and experts, and a greater understanding of renewable energy in general. Consequently, educational institutions may influence students' awareness of and attitudes toward renewable energy. According to respondents' perspectives, expanding renewable energy sources in Iran would have several economic and environmental benefits. These results confirm those of Zyadin et al. [55] in Jordan and Halder et al. [56] in Finland.

However, the lack of local knowledge significantly hinders expanding the renewable energy sector. Consequently, to make significant progress toward economic growth and development, we recommend improving local knowledge infrastructure and then sharing their experience and information in institutions [60].

These results confirm the observations of Atabi [60]. Indeed, she highlighted a lack of infrastructure, capital, and knowledge about renewable energy potential in Iran. Also, she indicated a lack of training, maintenance, and capacity to purchase the technology.

The relationship between renewable energy knowledge, attitude, and perception and some research characteristics indicated that as students' ages rise, so do their knowledge and attitude toward using renewable energies in agriculture. According to the data, increasing students' educational levels improves their comprehension and attitude toward renewable energy. However, there is no relationship between perception and research parameters.

Based on the cluster analysis results, students' behavior was divided into three categories, with attitudes playing the most critical role in this grouping. Respondents' opinions about renewable energy are divided into three groups. Most respondents fell into the first group with the best knowledge, attitude, and perception. This finding suggests that most respondents are involved in high-level renewable energy activities. Because exemplary behavior (knowledge, attitude, and perception) may increase the use of this energy in agriculture, good knowledge, attitude, and perception on this issue will be critical to sustainable development and agriculture. Consequently, universities and academic institutions should focus more on expanding students' knowledge, attitude, and perception of renewable energy to the level required. Universities should improve and develop current renewable energy programs.

Our findings made some contributions to the TPB. Firstly, the TPB model of Ajzen [39] proposes behavior as a function of intention to perform a behavior. However, it is sometimes difficult to discern between actual behavior and behavioral intention in surveys. Secondly, the basic TPB model addresses the link between attitudes and behavioral intention, ignoring external factors that impact an individual's attitude and behavior. It also ignores the effects of socio-demographic characteristics on behavioral intentions [61]. However, our research (along several others [41,61]) demonstrated that these factors are significant.

## 6. Conclusions

The research findings provided more evidence of the significance of education for the shift toward the use of renewable energy. Indeed, over the last ten years, there has been a global increase in the number of young people interested in tackling climate change in the workplace. As a result, the need for training in renewable energy sources is being driven by both the working population and students. Consequently, renewable energy policy is a relatively new and ever-changing topic. Even the most prestigious educational institutions are falling behind in updating their curriculum to include new information under these new challenges. Accordingly, it is necessary to educate both newly minted students who will work on these topics as well as seasoned professionals for an economy based on renewable resources [62].

## 7. Limitations and Future Research Opportunities

The survey technique and instrument have certain limitations restricting the sample's representativeness. Firstly, the main limitation of this research was the sample bias. The survey participants were solely students chosen at random, hired voluntarily, and not rewarded. As a result, the questionnaire was self-administered and completed strictly by those interested in the topic. Consequently, our sample does not accurately represent the general Iranian or student population. For instance, male were overrepresented in our sample. Because of this bias, it is not easy to generalize the survey results to the whole Iranian population. Secondly, immediacy bias could affect how students perceive their knowledge, attitude, and perception regarding renewable energies. Indeed, since individuals are conscious of and sensitive to societal expectations regarding climate change and renewable energies, this could have affected this research's results. This bias is typical in studies dealing with environmental issues [63]. In the future, researchers may consider broadening their inquiry to include additional universities as well as disciplines such as engineering. Another way is to look at how keen Iranian farmers are to incorporate renewable energy sources into their activities. In fact, in many developing nations, such as Iran, the primary source of electricity for irrigation is either thermal power facilities or biomass/diesel generators, which have both high prices and poor efficiencies [5,6]. Therefore, it is essential to investigate the factors that might either support or impede farmers' transition toward using renewable energy in Iran.

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