

Article

Determination of Green Building Awareness: A Study in Turkey

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Abstract: The building sector is the world's most significant energy consumer. In addition to that, water consumption and increased waste are some of the most significant issues. Owing to the need to find a solution to this problem, the concept of green buildings has emerged. Green buildings are building types that consume less energy and are constructed with recyclable materials, in harmony with nature. The adoption of the concept of green building in societies is very important in this regard. This study aimed to understand the awareness level of people about green buildings. Its scope was to determine the level of awareness of people living in buildings with and without an energy identity certificate in Adana. The results were created in Microsoft Excel, and the survey questions were measured using SPSS. Data analysis was performed by the WEKA tool using the association rule mining method. According to the result, most of the participants did not have sufficient information about the subjects. The results show that nowadays, most people do not understand this building type and what it means to the next generation.

Keywords: green building; sustainability; construction management; WEKA; association rule extraction



Citation: Keleş, A.E.; Önen, E.; Górecki, J. Determination of Green Building Awareness: A Study in Turkey. *Sustainability* **2022**, *14*, 11943. <https://doi.org/10.3390/su141911943>

Academic Editors: Argaw Gurmu and Muhammad Nateque Mahmood

Received: 3 August 2022

Accepted: 19 September 2022

Published: 22 September 2022

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1. Introduction

Technological developments have been rapidly increasing in every sector in recent years. The construction sector is one of the sectors most affected by innovations brought about by these developments in the building production process. The construction production process, which includes many variables and reveals different collaborations, is construction management rather than random behavior, which results in the creation and maintenance of a planned and harmonious working environment. For this reason, especially in light of recent studies, it is emerging that the use of information technologies has an important place to systematically store the data produced in the construction sector and to ensure that it is used appropriately and effectively [1].

Nearly 40% total CO₂ emissions and over one-third of global energy consumption originate from the building and construction sectors. Energy demand continues to increase on a global scale owing to the increasing use of energy-consuming devices in developing countries and rapid growth in construction. In 2019, the Global Alliance for Buildings and Construction published its Global Status Report for Construction. Accordingly, the construction sector accounts for up to 36% of energy use [2]. These are 2018 data. It increases annually depending on the construction production rate. Currently, the concept of green building is popular because of its various benefits such as promoting long-term cost savings, optimizing energy consumption, and discussing global climate change [3]. In particular, a green building more emphasizes technologies for CO₂ reduction, air conditioning, and indoor environments. Green building techniques are affected by regulations, climatic conditions, building types, and costs. Some of these factors are internal while others are external. The fact that buildings produce large amounts of greenhouse gases throughout

their life cycle and consume a large amount of energy means that the construction industry has high energy consumption and imposes high environmental burdens [4].

To prevent escalating energy demand in the construction sector, some changes are required under environmental sustainability. Environmental sustainability is the sustainability of life using resources that are available in nature and can renew themselves. Although the concept of sustainability is common, it was not introduced until 1987. The sustainability concept was first used in this year with a report titled “Our Common Future,” published by the World Environment and Development Commission. Subsequently, sustainability began to be used as a keyword in the context of other concepts, including the construction industry [5].

Sustainable construction may mean using the recyclable materials of buildings or buildings that are able to produce their energy by themselves, causing minimal harm to nature. Simultaneously, the operation and maintenance phases should be in harmony with nature after construction [6]. A building that was constructed without threatening human health or the environment is called a ‘green’ building. However, green buildings are not only about them. Green buildings are environmentally sensitive buildings that have positive effects on human health. Its strengths include waste management, reduction in use, better water management, and improvement of indoor air quality. Building construction, as well as the operation and maintenance of buildings, contribute greatly to the increase in energy emissions of greenhouse gases in the EU [7].

Reducing greenhouse gas (GHG) emissions and the effects of climate change are among the main objectives of global climate policy. Increasing the use of renewable energy is central to achieving these aims. However, mitigating climate change through the increased use of renewable energy has no positive green/environmental impacts [8].

On the other hand, a related conference paper published in 2020 reveals that “green building is the practice of creating structures and using processes that are environmentally responsible and resource-effective throughout a building’s life-cycle from arrangement to design, construction, maintenance, operation, renovation, and deconstruction. Green buildings are also known as sustainable or high-performance construction buildings” [9].

Projects, reports, and studies on green buildings are critical for a more sustainable future. One of the significant sustainability studies was published by the European Union in 2012. The report’s main aim is to limit economic crisis and climate changes while reducing greenhouse gas emissions. Reaching 20% energy efficiency by EU countries, increasing renewable energy usage and renovating existing building stocks are some examples within the content of this directive [10]. As in the Czech Republic, some case studies in Europe determined the transformation of existing building stocks. Environmentally friendly exterior wall panels were constructed using the model. The results showed that energy loss was significantly avoided [11]. Another study examined the energy losses between pre-war buildings insulated with raw earth materials in Naples. The results show that the energy losses of constructions insulated with natural materials are reduced by almost 60% [12]. The other one examined why energy efficiency in construction is not popular in Norway. It was concluded that energy-efficient buildings are not in demand because of the economic concerns of individuals [13]. In another article, three researchers examined the marketability of energy-efficient constructions in the United Kingdom. A negative correlation has been observed between housing marketability and energy-efficiency [14]. As summarized above, there are important global-scale studies on the design of green buildings, their benefits, what they will provide to future generations, etc. Therefore, this study aimed to obtain data on the comprehension level of a subject in Turkey.

Another study aimed to determine the critical factors affecting the efficiency of green building construction projects, and the probability, impact, and criticality of the factors in comparison with traditional projects. The results showed that the experience of the workers, technology of the job, design changes, skill level of the workers, and planning of the job are the five most critical factors affecting the efficiency of green construction projects [15].

There have been some reports on CO₂ emissions and energy efficiency in the Turkish construction sector. The urbanization rate of Turkey, which is a rapidly developing country, was found to be quite high compared to that in many European countries. There were 39.1 million residences in Turkey at the end of the 2020 as specified by the National Address Database [16]. These data reveal that it is important to determine the awareness of the green building concept in a developing country such as Turkey, which has a high construction rate.

Adana was selected as the pilot area in this study. It is the 6th largest city with the highest population density in Turkey, boasting a population of 2,237,940 [17]. The authors have chosen this location for the case study—considering its urbanization and migration situation. In short, the manuscript intends to comprehend the concept of green buildings by evaluating the awareness levels on a local scale. This research supports the findings of further studies. It can be said that this awareness level measurement, which is unique to Turkey, is an important innovation in this area.

Energy efficiency has become a popular topic in Turkey, especially in recent years. The energy identity certificate, on the other hand, is now a legally mandatory document on issues such as energy efficiency, heat loss and the environmentally friendly construction of buildings. While this document is obligatory when new buildings are being built, the transformation period of old buildings will take time. In this respect, it is important to investigate the difference in consciousness between those residing in buildings with and without energy identity certificates, which is the subject of this study.

To summarize the contributions of this study to the literature:

- This study is the first of its kind in the research literature on the awareness of sustainable building in Turkey's construction industry.
- This research, which examines the determination of scientific awareness on this issue in the construction sector, is an original study.
- The fact that the study is the first in the construction industry to use data mining techniques to determine people's levels of awareness is another novel contribution to the field.
- It has been determined that Adana residents are not very aware of this issue in light of the data collected as a result of the study. These findings may serve as a starting point for future research.
- Within the scope of research findings, it has been clearly seen that there is a need to increase social-scale education activities on this issue in Turkey.

2. Materials and Methods

In this study, 252 surveys were applied to apartment residents living in energy-certified or non-certified buildings to measure the level of awareness of green buildings. The reason for choosing energy-certified buildings is that they are closer to the green building concept based on the scope of energy efficiency. The surveys were conducted face-to-face with residents. Residents were randomly selected on the basis of their relevance. Participants were selected for reasons such as living in densely populated areas and living in apartments. In addition, attention was paid to the heterogeneity of the educational status of the participants. It was preferred to obtain more reliable results and avoid prejudice about the survey. They were selected according to the stock densities of old and new buildings. Thus, we aimed to determine the differences between the consciousness levels of those residing in buildings with and without energy identity certificates. Care was taken to include all segments of society, such as engineers, architects, teachers, students, and housewives in the selection of these individuals. Simultaneously, we tried to reach a homogeneous number of participants from various districts of the province in the selection of those who participated in the survey. Thus, the data of this study were not concentrated in a single region.

2.1. Survey Design and Implementation

The study's data were obtained from face-to-face surveys with apartment residents. While creating the survey questions, a review of similar literature studies and the "Energy Performance Regulation in Buildings" items were scanned. As a result of the detailed literature review, a study on the sustainable awareness of construction and guiding this study was conducted in Malaysia (2012) and Taiwan (2018). The questions of this study concern green buildings [18].

Similarly, other researchers wanted to measure students' awareness of green campus studies at a University (Portland State University). Surveys show that students who take the sustainability course or participate in the event have more knowledge than others [19]. There are thirty-one questions in the survey. The first 16 questions were related to the house where the residents lived. It includes questions such as the number of rooms in the house, its facades, and whether there is an energy identity document in the building. The second part contained questions about residents' awareness of sustainability, green buildings, and similar topics. In this section, it is measured whether people have an idea about the specified issues and if they have some information about where they learn the information.

The survey form was created by examining these studies in the literature. In addition, the authors of the study conducted questionnaires after obtaining the approval from the Ethics Committee of ATU (Date: 4 March 2019; No.: 76907350-659-E.465). The relevant board examined the questions from both technical and social perspectives. Ten questionnaires were piloted before they were administered. The participants were selected based on their demographic characteristics. Finally, questions in line with the purpose of the study were selected for analysis.

2.2. Analysis Methods

Microsoft Excel 2013, IBM® SPSS® Statistics 26, and WEKA 3.8.2 (Waikato Environment for Knowledge Analysis—New Zealand) programs were used for data analysis. A comprehensive literature review found that there is no awareness of energy-efficient and green building data analyzed using WEKA software. In this respect, this study is original and can be a pioneer for further research.

The answers were entered in the Excel program as 1, 2, 3, etc. and represent "Yes", "No", and "No Idea/Undecided", respectively. The measurement scale was determined to three-point as "1 = Yes", "2 = No", and "3 = Undecided/Have no idea". It was converted to *.arff (Attribute Relation File Format) and is available for analysis in the WEKA program.

The amount of data is increasing daily in every sector. The processing of these data is called data mining [20]. Data mining applications are used in many sectors including economics, engineering, textile, and medicine. Some of the applications mentioned are classification, regression, clustering, and association rules [21]. A similar study examined the energy consumption of Taiwanese markets using clustering, classification, and regression methods [22].

With association rules, the analysis was performed by explaining the relationships in two different datasets [23]. The *.arff is different for each data mining method [24]. Whereas some algorithms in WEKA work with numerical data, the others work with categorical data. Categorical data were analyzed in this study. Categorical data are required for the inference algorithms. The reason why the data obtained through the questionnaires in this study were designed as *.arff format categorically is that WEKA, the tool used to run the algorithms, works with *.arff files, and the association rule mining method is used.

In this study, KEEL software was used for the pre-processing stages and WEKA software was used for the classification stages. WEKA is a machine-learning software that works with .arff file format as previously explained. This file format was designed to perform the aforementioned operations. They were kept in the text structure. The @relation, @attribute, and @data are used to determine the file structure. The @relation statement specifies the general purpose or the name of the data stack. The @attribute statement is

used to specify the attribute names corresponding to the columns in the database in the data, whereas the @data statement refers to the row where the raw data starts [25].

KEEL is a software in Java. It is not rich in classical data mining algorithms, such as clustering. Instead, it includes many variants of fuzzy classifiers, artificial intelligence-based classification, and rule-based clustering algorithms. Because KEEL software offers advanced algorithms in the preprocessing parts compared to other software, it was used in the preprocessing phase of the data obtained from the surveys within the scope of this study; that is, the data preprocessing part, which constitutes the first four steps of the knowledge discovery process, was carried out with the help of KEEL software. From this preprocessing stage, the values that corrupt the data set, which are considered extreme values, were removed from the data set, a normalization process was performed, and the data were transformed into the relevant form (categorical) [25].

The SPSS program was utilized to measure the questionnaire's reliability. The Microsoft Excel program was utilized to obtain statistical data, and the WEKA program was utilized to analyze the survey. Using the association rule mining by WEKA, the data obtained were analyzed.

As it becomes difficult to obtain information owing to the increasing amount of data, many tools are being developed to reach information. At the beginning of these tools was the concept of producing usable information from large amounts of data, which is described as data mining. Computer software is required for data mining applications. Owing to the algorithms used by this software, the desired and intended information can be extracted from processed raw data [23].

Data mining is the process of revealing undetermined relationships from large amounts of data using computer software together with statistical methods. The data mining method is used to efficiently correlate the mentioned amount of big data. Data mining is the process of obtaining valid, previously unknown applicable information from large and different data sources. With "data mining" methods, relationships between data can be revealed and predictions can be made about the future. The purpose of data mining is to transform raw data into meaningful, effective, and useful information. To achieve this goal, the use of software developed for data mining facilitates its processes. WEKA is an open source data mining software on the Java platform and is released under the GNU general public license. It provides access to SQL databases using Java database connectivity. It includes machine learning algorithms [26].

2.2.1. Processing Data

SPSS[®] offers advanced statistical analysis, text analysis functions, and integration with large datasets.

Microsoft Excel is a well-known application that creates and edits spreadsheets using automatic calculations.

WEKA allows for different data mining techniques. In this respect, it has been widely used today in the analysis of big data.

2.2.2. Association Rules

Association rules, developed by Agrawal and Srikant [27], are analytical methods that examine the realization status of other events [28]. In a more detailed and clear explanation, the association rules predict future work based on an analysis of existing data [29].

Association rules determine association relationships between large data sets. It is a frequently preferred and widely used algorithm today. It is a reliable and useful algorithm used to highlight general trends in the data set. Each rule obtained as a result of the operation of the "Apriori Algorithm" is expressed with support and confidence criteria. The support criterion expresses the frequency of association between items. The confidence criterion expresses the accuracy of the associations.

Class association rules (CAR) were used instead of general association rules in this study. This feature, which performs data mining by focusing on a special subset of associa-

tion rules called class association rules, is used for the integration of data. Class association rules were used in this study to select the most interesting rules from all possible sets of rules.

In the “Feature Selection Method” section of the Weka, first of all, which features are more effective among the number of team, age and experience were tested using the chi-square feature selection method. The chi-square feature selection method is widely used. Chi-square reveals the value of an attribute by calculating the statistical value according to the relevant class [30].

In this study, a data set for a question was created by considering the answers obtained from the survey questions. This question was chosen as the “class label”, and its relationship with the answers given to the others was investigated. This selected question concerned people’s “green building information”, as seen in Table 1. Thus, a class determined among the created data sets was kept as a label, and association rules were extracted.

Table 1. Results of WEKA analysis.

Rules No.	Association Rules			Reliability Value
	Properties of the Rules	⇒	Class Label Attribute	
1	Building sales ban = 2, Legislative sense = 2, Firm information = 2, Green building sensation from where = No place of sensation n, Green building association = 2	⇒	Green building information = 2	conf:(0.93)
2	Savings = 1, Legislative sense = 2, Firm information = 2, Green building sensation from where = No sensation place, Green building association = 2	⇒	Green building information = 2	conf:(0.92)
3	Saving = 1, Saving light bulb = 1, Legislative sense = 2, Firm information = 2, Green building sensation from where = No sensation place, Green building association = 2	⇒	Green building information = 2	conf:(0.92)
4	Savings = 1, Legislative sense = 2, Legislative sense from where = No sense location, Firm sense from where = No sense location, Green building sensation from where = No sense location, Green building association = 2, Association name = None	⇒	Green building information = 2	conf:(0.91)
5	Energy identity document from sensation = No sensation place, Building sales ban = 2, Firm information = 2, Green building sensation from where = No sensation place, Green building association = 2	⇒	Green building information = 2	conf:(0.91)

3. Results

In this section, the data are analyzed. In total, 252 surveys were administered to the residents of buildings with and without energy certificated buildings. In the questionnaire, to determine the building’s age, a four-point measurement scale was chosen for this question in which 1: younger than 1 year, 2: 2–10 years, 3: 11–20 years, and 4: older than 21 years. According to the questionnaire, there are 15 buildings younger than 1 year, 186 buildings 2–10 years old, 93 buildings 11–20 years old, and 148 buildings older than 21 years.

Statistical graphs, data analysis, and WEKA results are presented two ways. Cronbach’s alpha coefficient was used to determine the reliability of the data using SPSS 22.0. The findings were as follows.

3.1. Reliability Analysis Results on SPSS

Reliability analysis was performed using SPSS based on the questions in the survey form. Cronbach's alpha coefficient was 0.751. Since it is between 0.7 and 0.8, the survey questions and answers are quite reliable [31].

3.2. Graphical Analysis Results

In this section, statistical data obtained using Microsoft Excel are presented graphically. Three statistical results were selected because of their remarkable results. One question was, "A building that is built with energy-saving, environmentally friendly materials that can be recycled and do not harm human health is called a green building. Do you have any information about the defined building type? If yes, indicate where you have". This question aimed to determine whether the occupants know the green building concept. The results demonstrate that 34% of occupants say "yes," 55% of occupants, say "no" while 11% say "I was undecided." This graph is shown in Figure 1.

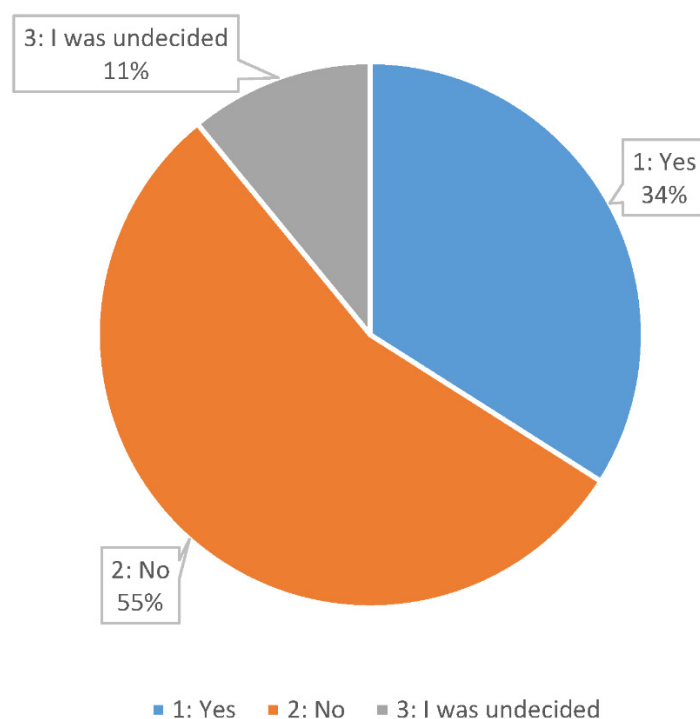


Figure 1. Awareness of the green building knowledge—results of the survey.

The second graph shows the results of the question "Do you know that the buildings defined as green buildings contribute to future generations because they emit less carbon dioxide to nature?" As stated in the graph, 47% of occupants say "yes", 40% of occupants say "no" while 13% of occupants say "I was undecided". This graph is shown in Figure 2.

The third graph shows the results of the question "Do you know that buildings defined as green buildings provide 25% to 50% less consumption of electricity, natural gas, and other energy sources than other buildings?". As stated in the graph, 39% of occupants say "yes", 48% of occupants say "no" while 13% of occupants say "I was undecided". This graph is shown in Figure 3.

3.3. WEKA Analysis Results

The Weka program, which includes various methods, was used in the analysis of the data obtained as a result of the survey study. The concept associated with whether a study is in a reliable range is called confidence. As this value approaches 1.00, the reliability rate of the study increases [31].

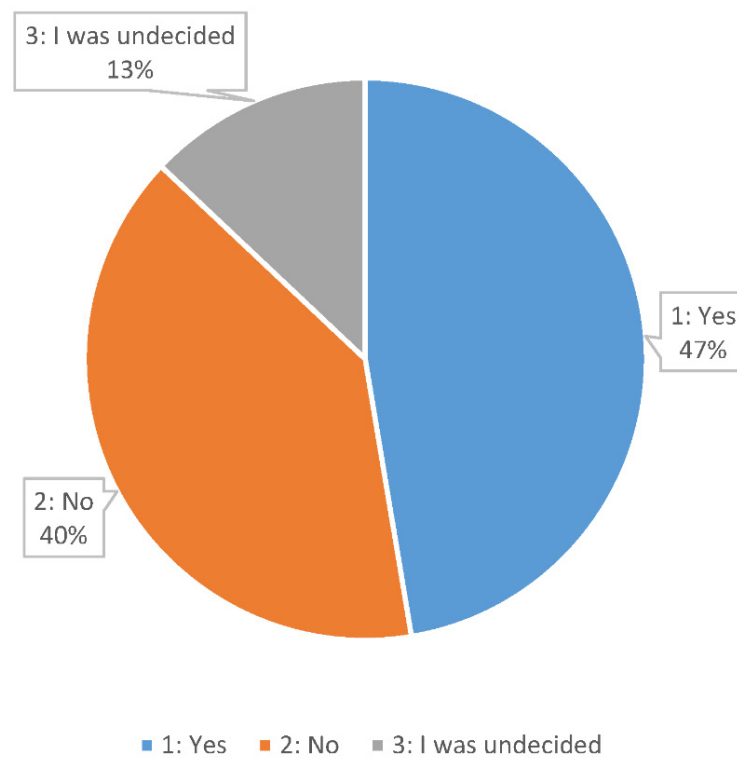


Figure 2. Awareness of the green buildings contributes to the next generation—result of the survey.

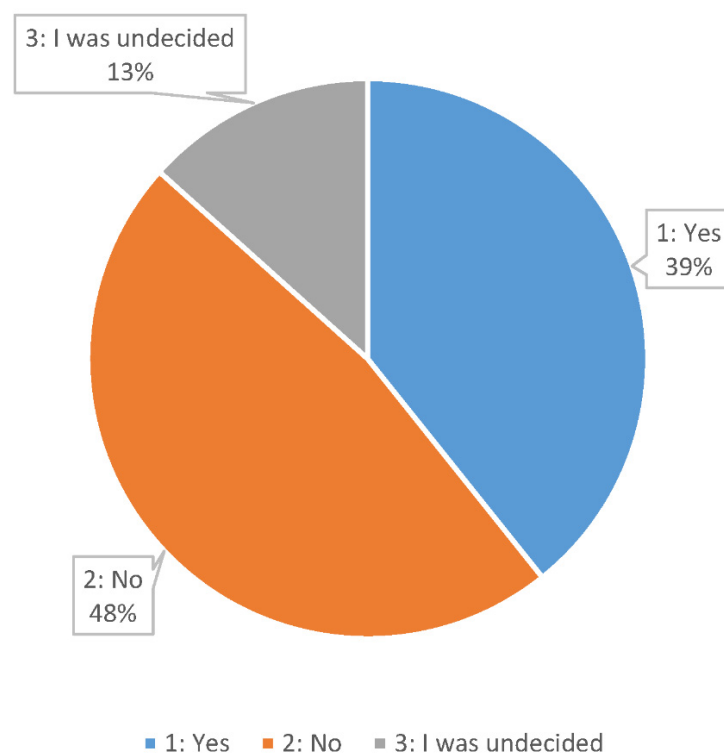


Figure 3. Awareness of the green buildings' consumption—results of survey.

In this scenario, the relevant question is selected according to the class label, and attempts are made to determine how often the answers to other questions appear together on this axis. Among the findings, the top five association rules are shared in Table 1. The comments on the association rules listed in Table 1 are explained in Table 2.

Table 2. Comments on WEKA analysis.

Rules No.	Association Rules	Reliability Value
1	It is stated that residents who do not know that there is a prohibition of sales without an energy identity document in the buildings have not heard about the energy legislation, do not know about the companies that help the structures with energy, do not hear about the green buildings and the associations working on the green buildings.	conf:(0.93)
2	Flat residents who prefer electrical economic products but have not heard about energy legislation, do not know about firms working on this subject, and do not know the green buildings and associations working on green buildings have stated that they do not know about green buildings.	conf:(0.92)
3	Flat residents who prefer electrical economic products and energy-saving bulbs but do not know the energy legislation, energy companies, green buildings, and associations working on green buildings have not heard of them.	conf:(0.92)
4	Individuals who prefer the economic ones in their electrical products but do not hear about the energy legislation, companies working on energy, green buildings, and associations working on green buildings have stated that they do not have information about green buildings.	conf:(0.91)
5	Those who have not heard about the energy identity certificate, energy companies, green buildings, and associations working on green buildings, and those who do not know that it is illegal to sell and rent apartments in energy-free buildings, also stated that they do not know green buildings concepts.	conf:(0.91)

In Table 2, it can be observed that each line has association rules. The first rule of this situation is that the residents who do not know that there is a prohibition of sales without energy identity documents in the buildings have not heard about the energy legislation, do not know about the firms that help the structures with energy, do not hear about green buildings and associations working on green buildings, and do not know about green buildings with 93% confidence intervals.

Similarly, the second rule states that residents who prefer electrical economic products but have not heard about the energy legislation do not know about the companies working on this subject, do not know the green buildings and associations working on green buildings, and are not aware of the green buildings at a rate of 92% confidence.

4. Discussion

At the beginning of these analyses, Cronbach's alpha coefficient was found, and the reliability of the study was questioned. As a result of the value found, statistical data containing the answers to the demographic questions in the survey, graphics, and data analysis results obtained using WEKA and SPSS programs were divided into subgroups.

The results are expected to contribute to the literature and the construction sector. The reasons for this are as follows:

- Although many researchers are working in this field in the construction sector [3,4,7,9,13,24,25], there are still few studies in the Turkish construction sector. There are no studies on sustainable construction awareness in the construction sector in Turkey (except for a study by the authors) [31].
- In the construction sector, where production is conducted with limited resources, issues such as building efficiency, energy saving, sustainability and efficient working are very important.
- Few studies have been conducted on green buildings in the construction sector. However, there is no study specific to the determination of the level of awareness of the users of buildings regarding the concept of green buildings. In this study, answers were sought to determine whether there was awareness of this issue and to what extent there is awareness of scientific facts. This study is unique in this respect.

- The following two studies supported this topic and its results. Prada et al. give the opinion that the concept of sustainable energy conservation can only be promoted if it is accepted by a sufficiently large segment of society. All segments play a role in creating a culture in terms of energy conservation. It states that national accordance is essential for promoting energy savings [32]. The authors, based on the importance of education on this subject, aimed to promote the education process at the Romanian level in the field of energy saving, especially in the construction sector. The results of the study show that consciousness of the concept of sustainable development and energy saving can only be achieved if it is accepted by a large part of society. In this study, the importance of education on this issue is discussed [32]. In another study, to achieve EU energy targets, they studied trends in energy consumption at Oradea University in Romania. They have achieved results, such as the use of waste energy, increasing the use of renewable energy systems, and the establishment of green energy production systems. They also emphasized that effective energy-efficiency awareness should be created in these matters [33].
- It has been determined that people living in Adana have low levels of consciousness in this regard. This finding can be used as a pioneer for future studies. It is also clear that there is a need to increase social-scale educational activities in Turkey.
- The mentioned studies show that education is among the priority issues for awareness of energy efficiency. This situation also supports the results of this study.

Within the scope of all these, the strengths of this study are: it is the first study on “green building awareness” in Turkey, its originality, emphasizing that education is the main factor in this regard, and stating that awareness can be created with the participation of all relevant people/institutions (not just citizens). The weaknesses are that the study was carried out only in Adana province and the number of buildings with energy identity certificates is less than the others. In future studies, it can be said that it would be beneficial to carry out a wider study on the whole of Turkey and on a global scale.

5. Conclusions

This study aims to determine the awareness of residents of Adana/Turkey regarding green buildings. As mentioned previously, the surveys were conducted face-to-face with people residing in houses with and without energy identity certificates. It is important to measure the level of consciousness of the residents of these two building types and to determine the significant differences between them. It can be assumed that this study’s results will be carried out on a larger scale, for example, throughout the entire country, which will lead to further studies. Since this study has not been conducted before in Turkey, it is thought that the results of this study will provide an important example for other future studies. From this perspective, this study makes a significant contribution to the literature.

When the graphical analysis results were examined (Figures 1–3), it was observed that most participants did not have much knowledge about “green buildings”. It is an important finding that more than half of the participants were unaware of a concept that had to be legally enforced in apartments in Turkey, and their awareness level was low. As a result, it was concluded that the level of awareness in Adana/Turkey was insufficient. It is thought that it is important to organize education for all the public on the subject to raise the level of consciousness.

The results obtained from WEKA are examined, and many residents do not know about the features of their buildings, including insulation. Similarly, this situation indicated a lack of awareness of the subject. To summarize the survey results, it is clear that most people do not know about green buildings or what includes green buildings. The importance of providing more education on the subject is obvious. In this regard, it is important to disseminate the results of these and similar studies.

Presenting the original results of this study to the community and the construction sector employees is of critical importance in terms of raising awareness on this issue. In this

respect, it is considered important that all stakeholders including especially universities, other educational institutions and public institutions cooperate.

Author Contributions: A.E.K. and E.Ö. conceived the main idea of the paper. E.Ö. conducted face-to-face surveys. A.E.K. conducted the analysis. A.E.K., E.Ö. and J.G. wrote the manuscript, and all authors contributed to improving the paper. All authors have read and agreed to the published version of the manuscript.

Funding: This article/material has been supported by the Polish National Agency for Academic Exchange under Grant No. PPI/APM/2019/1/00003.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data are available on request from the authors.

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

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