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Green Standard Model Using Machine Learning: Identifying Threats and Opportunities Facing the Implementation of Green Building in Iran

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Abstract

Residential buildings consume a major portion of energy resources and hence are seriously involved in environmental pollution. In Iran, the consumption of fossil fuels is on the rise, to the extent that it has grown by more than 400% from 1990 to 2018. One of the fundamental solutions for reducing fossil fuel consumption and creating a healthy environment inside and outside buildings is the implementation and development of green buildings. This study seeks to examine the obstacles and opportunities facing green building and proposes a localized green standard befitting the conditions of Iran with the aim of contributing to the development of green buildings. To this end, the requisite parameters were identified using the opinions of experts and Delphi method, and the opinions of 81 building experts including the employer, consultant and contractor were obtained using a three-part questionnaire. Based on the results obtained using the machine learning method, the score of the local green building in a total of five dimensions, namely site, water, energy, materials and quality of indoor environment was calculated to be 77.2, while the energy dimension was determined to be the most important green standard dimension with a significance coefficient of 0.548. In the ranking analysis of all parameters using Friedman test, the parameters of energy consumption management, use of renewable energy and thermal zoning attained the highest scores among other factors.

29 Furthermore, lack of awareness on green buildings (77%) and high potential for renewable energy
30 production (81%) were respectively identified as the biggest obstacle and opportunity facing the
31 implementation of green buildings in Iran.

32 **Keywords:** *Green standard, machine learning, energy consumption, environmental pollution, Iran*

Abbreviations

| | |
|---------|--|
| LEED | Leadership in Energy and Environmental Design |
| BREEAM | Building Research Establishment Environmental Assessment Method |
| CASBEE | Comprehensive Assessment System for Building Environmental Efficiency |
| ITACA | In English: Institute for Transparency of Contracts and Environmental Compatibility, Italy |
| DGNB | In English: German Sustainable Building Council |
| ASGB | Assessment Standard for Green Buildings |
| SB Tool | Sustainable Building Tool |
| GBL | Green Building Label |
| GM | Green Mark |
| GS | Green Star |

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35 **1. Introduction**

36 Climate change and the gradual process of global warming are among the serious threats and
37 challenges facing different societies that is directly related to the consumption of fossil fuels and
38 carbon dioxide production (Mirzaei and Bekri, 2017; Sarwar and Alsaggaf, 2020). The ever-
39 increasing demand for exploration and exploitation of natural resources in different countries has
40 resulted in devastating environmental impacts (Balaban and Oliveira, 2017). The complications of
41 increasing pollution and climate change have long been accounted by scientific evidence and various
42 studies, as approximately 20% of pollution and greenhouse gas emissions are attributed to residential
43 buildings, which are a significant part of carbon emissions in the environment (Zhang et al, 2018;
44 Cordero et al, 2019). Buildings often require special attention given their high energy consumption
45 and their role in creating environmental challenges, as they account for about 20 to 50% of global
46 energy consumption and more than 40% of solid waste production (Dwaikat and Ali, 2016;
47 MacNaughton et al, 2018; Kim et al, 2014). In China, about 60% of carbon dioxide emissions and in

48 the United States and the EU, 35 to 40% of carbon dioxide emissions are attributed to residential
49 buildings (Sinha et al, 2013; Li et al, 2014).

50 Energy consumption is reportedly excessive in Iran, which has resulted in threatening consequences
51 for various economic, political and environmental aspects (Taghvaei et al, 2017). Iran is a rich
52 country in oil and gas energy resources, holding 11% of world's oil reserves and 15.3% of the natural
53 gas reserves, where energy is mainly produced using fossil fuels. Unfortunately, the pattern of
54 energy consumption in Iran is highly inefficient and many factors such as low energy prices, energy
55 subsidies, high population rates, economic growth and poor resource management have also resulted
56 in a sharp increase in energy consumption, high carbon dioxide production as well as environmental
57 pollution (Moshiri et al, 2012; Hosseini et al, 2013). Energy consumption in Iran has increased by
58 415% from 1990 to 2018, that is from 53 to 273 TWh, while also the amount of carbon dioxide
59 emissions has increased by 238%, from 171 to about 580 million tons, During the same period (IEA,
60 2018; EIA, 2018) and is projected to increase with annual growth of 5% to about 985 million tons by
61 2025 (Mirzaei and Bekri, 2017).

62 Widespread concerns regarding high energy consumption, global warming, and depletion of non-
63 renewable energy sources have led to development of green building movement (Esa et al, 2011).
64 Green buildings have been proposed as one of the most efficient and ideal solutions for sustainable
65 and healthy buildings, optimal use of resources, increasing the recycling capacities of construction
66 materials, and hence has been proposed as an approach to alleviate environmental challenges
67 (Nguyen et al, 2017; Zuo et al, 2017). Green buildings greatly contribute to mitigation of the harmful
68 effects on the environment, economy and people (Neyestani, 2017), in which increased energy
69 efficiency and renewable energy are employed to significantly reduce the consumption of fossil fuels
70 (Eliasa and Lin, 2015). In recent years, the existence of some incentives or government subsidies in
71 some countries is one of the factors that has led many small contractors to build and develop green
72 buildings (Shan et al, 2020). Studies indicate that the significance of and the ensuing interest in green

73 buildings is rapidly growing in many countries around the globe, and some developed countries such
74 as the United States, the United Kingdom, Singapore, Hong Kong, Australia and Italy have taken
75 major strides in the development of green buildings, while developing countries such as Colombia,
76 Egypt and China have also sought to develop green building research (Darko and Chan, 2016). As
77 the understanding of the concept of green building development grows all around the world, the
78 notion of green construction has been widely expanding, and more attention is now being given to
79 the construction and development of green buildings worldwide (Qifa, 2013).

80 Huo and Yu (2017) examined the benefits of green buildings from 2007 to 2016 and reported that
81 green buildings are more environmentally-friendly, conserve energy, and provide better
82 performances in terms of thermal comfort, indoor air quality and noise pollution. Green buildings
83 have many positive environmental, social and economic consequences and contribute to national
84 economy and gross domestic product (GDP), effects of which gain more prominence over time (Zuo
85 and Zhao, 2014; Zhao et al, 2019). Although the initial costs of green buildings are higher than those
86 of conventional buildings, they hold a plethora of advantages, such as the use of renewable energy,
87 rainwater recycling, and environmentally friendly material, outweighing the costs (Khot et al, 2019;
88 Lee et al, 2013). MacNaughton et al. (2018) studied the benefits of implementing green buildings in
89 six countries, namely the United States, China, India, Brazil, Germany and Turkey, the results of
90 which revealed that implementing green buildings in the aforementioned countries has saved \$7.5
91 billion in energy consumption and has prevented 33 million tons of carbon dioxide emission into the
92 atmosphere. (Nangare et al, 2015) also revealed the implementation of green buildings has reduced
93 energy consumption by at least 25% in China. In Turkey, green buildings with platinum and gold
94 certification have respectively save 40% and 31% in energy consumption, respectively (Uğur and
95 Leblebici, 2018). Implementation of green buildings in Israel has reduced water and electricity
96 consumption respectively by 24% and 23% compared to those in conventional buildings (Meron and
97 Meir, 2017). Dwaikat and Ali (2018) reported that implementing green buildings in Malaysia has

98 reduced energy consumption by 28.9%, while Ebadati and Ehyaei (2018) been reported that
99 implementing green ceilings in Iran reduces energy consumption by 17%.

100 Despite the widespread benefits of green buildings, their implementation has been faced with many
101 challenges and obstacles in some countries. Darko and Chan (2017) reviewed the literature on green
102 buildings, and identified lack of information, high cost, lack of motivation, and lack of demand,
103 interest and regulations of green buildings as the most significant threats to the implementation of
104 green buildings. Esa et al. (2011) reported lack of education and lack of awareness regarding the
105 benefits of green buildings, and Samari et al. (2013) identified the lack of credit resources, high
106 investment risk, lack of demand and high costs as the greatest obstacles to the implementation of
107 green buildings. Based on the results Li et al. (2014), three factors of lack of awareness on the
108 stakeholder side, lack of research and non-favorable existing laws have been identified as the most
109 important threats to the development of green buildings in China (Li et al, 2014). In Thailand, lack of
110 motivation from landlords, high initial costs and financial and technical constraints (Shen et al,
111 2018), in Saudi Arabia, lack of government support and lack of skilled labor (Mosly, 2015), and in
112 Ghana, high costs, lack of government incentives, and lack of financial plans have been identified as
113 the biggest obstacles to implementation of green buildings (Chan et al, 2018).

114 The implementation of green rating systems for the evaluation of buildings is of paramount
115 importance increase awareness of sustainable development in the construction industry and help thus
116 reduce environmental pollution (Hedao and Khese, 2016; Cordero et al, 2019). Environmental
117 evaluation methods are one of the most prevailing and efficient instruments to enhance the
118 performance of buildings and in the last decade, a plethora of assessment standards have been
119 published or are under development around the world (Amos and Chan, 2016). Some of the green
120 building rating systems include LEED (US), BREEAM (UK), CASBEE (Japan), GS (Australia),
121 BEAM PLUS (Hong Kong), GM (Singapore), DGNB (Germany), GBL (China) and SB Tool are
122 multinational organizations established for different types of residential buildings (that is, detached

123 houses and apartments), schools, hospitals, office buildings, and industrial buildings among others
124 (Alyami and Rezgui, 2012; Zuo and Zhao, 2014 Gou and Xie, 2017). The BREEAM standard,
125 launched in 1990, is recognized as the world's first residential building rating assessment, followed
126 by the pilot version of the LEED standard in 1998 (Doan et al, 2017). Mattoni et al. (2018) compared
127 5 well-known standards of LEED, BREEAM, Green Star, CASBEE and ITACA, the result of which
128 reveal that, except for the CASBEE standard, in which comfort and safety are given the highest
129 importance, the highest ratings in other standards are attributed to energy consumption. Moreover,
130 Cordero et al. (2019) examined the application of different standards among EU countries and
131 reported that 65% of EU housing projects employ the UK BREEAM standard, 6.49% are based on
132 the German DGNB standard, 5.46% are based on the LEED standard, and the rest have employed
133 other standards.

134 Unfortunately, unlike many developed countries, Iran is yet to develop a green standard, and given
135 that the green standard of each country is developed tailored to the conditions and regulations of that
136 country, employing green standards of other countries is not recommended for Iran, and each country
137 should develop green building standards according to the laws, instructions and climatic conditions,
138 and only after identifying the existing opportunities and threat therein. Hence, based on the
139 aforementioned discussion, the purpose of the current study was to provide an overview on the
140 opportunities and obstacles of implementing green buildings in Iran based on different viewpoints
141 from employers, consultants and contractors, discusses the need to implement green buildings owing
142 to excessive consumption of fossil fuels and the high potential of using renewable energy, provide a
143 localized green standard model tailored to the conditions of the Iran using 6 widely used standards of
144 LEED, BREEAM, CASBEE, GS, BEAM PLUS and ASGB, and ultimately, seeks to predict total
145 score and rank the relevant items. Findings of this study can contribute to knowledge of green
146 building localization in Iran and can have implications for contractors, investors and decision makers
147 in the construction and energy sector with the aim of paving the way for development of green

148 buildings. It can also pose as a useful reference for international organizations seeking to develop
149 solutions to alleviate obstacles to and increase the potential of green buildings.

150 **2. Research method**

151 For the purposes of this study, 14 experts with postgraduate education in the fields of civil
152 engineering, architecture, electricity and mechanics who had the criteria of knowledge and
153 experience, sufficient opportunities and effective communication skills in the field of research
154 formed the Delphi research panel. In the first part of the research, 8 obstacles and 5
155 opportunities/necessities of implementing green building in Iran were identified by the panel, and in
156 the second part, 6 widely used green standards in the world, namely LEED, BREEAM, CASBEE,
157 GS, ASGB and BEAM PLUS, which had partial similarities with the conditions in Iran, were
158 examined to help identify national items for green building. After reviewing the items within the 6
159 standards, experts were able to comment, and hence delete, edit or add new items appropriate to the
160 conditions of Iran, and ultimately, 67 green standard parameters were identified in accordance with
161 the conditions of Iran in 5 dimensions of the site, water, energy, materials and the quality of the
162 indoor environment.

163 *2.1. Questionnaire*

164 A 3-part questionnaire with the issues of localized green standard items, obstacles and
165 opportunities/necessities of implementing green building in Iran was developed and the respondents
166 were asked to give their opinions and score the items using a 5-level Likert scale, ranging from zero
167 (insignificant) to 4 (with high importance). The questionnaires were proven to have proper validity
168 and reliability and Cronbach's alpha coefficient for national green standard items was 0.715, for
169 green building obstacles was 0.772, and for opportunities/necessities of implementing green building
170 was 0.778. In this study, 110 questionnaires were distributed among the statistical population of
171 contractors, employers and consultants, from which 81 questionnaires were completed and returned.
172 The characteristics of the respondents are presented in Table 1. The inclusion criteria were having an

173 education level of bachelor's degree to PhD in the fields of civil engineering, mechanics, electricity
 174 and architecture, working experience in the field of construction and high familiarity with
 175 construction industry projects. descriptive statistical method (central tendency and dispersion) was
 176 employed to rank the items of the inventory for obstacles and opportunities of implementing green
 177 building, while Friedman test in SPSS was used to rank items of green building standard.

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Table 1: Background information of the respondents

| Characteristics | Frequency | Percent | Years of Experience | | | | | | |
|---------------------------|-----------|------------|-----------------------|-----------|-----------|--------------|-----------------|-----------|-------------|
| | | | construction industry | | | | green buildings | | |
| | | | 1-5 | 6-10 | 10-20 | More than 20 | 1-2 | 3-5 | More than 5 |
| Field of education | | | | | | | | | |
| Civil | 39 | 48.2 | 2 | 9 | 18 | 10 | 23 | 11 | 5 |
| mechanical | 23 | 28.4 | 2 | 5 | 11 | 5 | 12 | 6 | 5 |
| electrical | 12 | 14.8 | 2 | 2 | 5 | 3 | 8 | 3 | 1 |
| Architectural | 7 | 8.6 | 3 | 1 | 3 | 0 | 4 | 3 | 0 |
| Subtotal | 81 | 100 | 9 | 17 | 37 | 18 | 47 | 23 | 11 |
| Job Type | | | | | | | | | |
| Employer | 26 | 32.1 | 6 | 5 | 10 | 5 | 15 | 7 | 4 |
| Consultant | 17 | 20.9 | 2 | 3 | 8 | 4 | 8 | 5 | 4 |
| Contractor | 38 | 47 | 1 | 9 | 19 | 9 | 24 | 11 | 3 |
| Subtotal | 81 | 100 | 9 | 17 | 37 | 18 | 47 | 23 | 11 |

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181 2.2. Machine Learning

182 Machine learning (ML) is a type of artificial intelligence (AI) which seeks to develop applications
 183 that can learn and progress without being explicitly programmed to do so. Machine learning is in fact
 184 consisted of various algorithms and statistical models used by computer systems instead of explicit
 185 instructions (Everitt and Hothorn, 2011). One of the most important branches of machine learning is
 186 multivariate analysis methods, in which several variables in the data set are reviewed and analyzed
 187 simultaneously. Two highly groundbreaking methods among multivariate analysis methods are
 188 exploratory factor analysis (EFA) and principal component analysis (PCA). In this research, PCA
 189 method and R software were used to predict or estimate the green building score.

190 3. Results

191 *3.1. Obstacles to the implementation of green buildings*

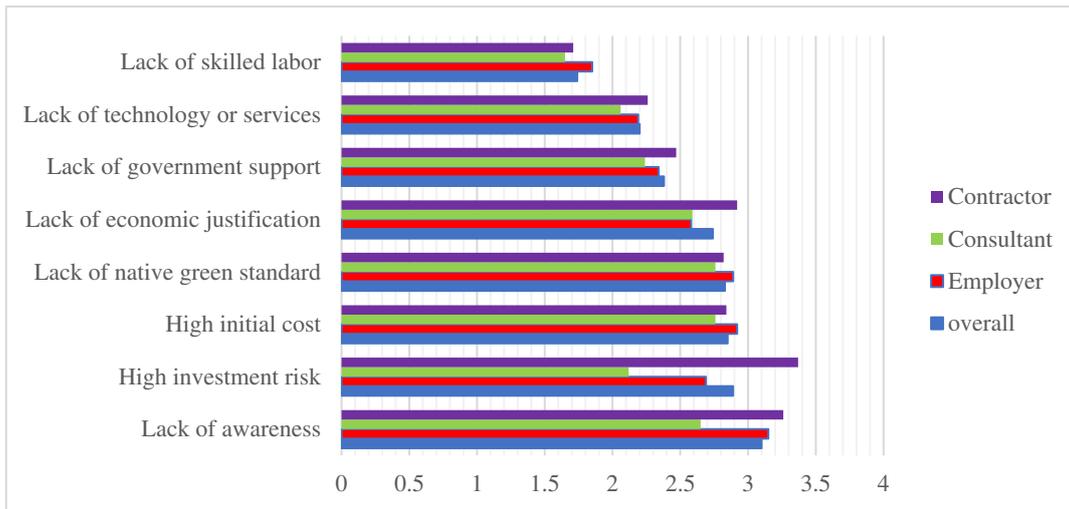
192 Eight major obstacles to the implementation of green buildings in Iran were identified by the expert
 193 panel and thus evaluated by the respondents using a 5-point Likert scale, the results of which are
 194 shown separately for employers, consultants and contractors in Table 2.

195 *Table 2: Ranking the obstacles to the implementation of green buildings*

| Items | Overall | | | Employer | | | Consultant | | | Contractor | | |
|---------------------------------|---------|-------|----|----------|-------|----|------------|-------|----|------------|-------|----|
| | M. | SD | R. | M. | SD | R. | M. | SD | R. | M. | SD | R. |
| Lack of awareness | 3.1 | .889 | 1 | 3.23 | 0.815 | 1 | 2.94 | 0.966 | 2 | 3.08 | 0.912 | 1 |
| High investment risk | 2.89 | 1.024 | 2 | 3.04 | 0.999 | 2 | 3.12 | 0.693 | 1 | 2.68 | 1.141 | 3 |
| Lack of economic justification | 2.74 | .946 | 3 | 2.38 | 0.941 | 3 | 2.94 | 0.899 | 3 | 2.89 | 0.924 | 2 |
| Lack of national green standard | 2.4 | 1.08 | 4 | 2.15 | 1.19 | 4 | 2.59 | 0.939 | 5 | 2.47 | 1.059 | 5 |
| Lack of government support | 2.38 | 1.056 | 5 | 2.04 | 1.183 | 6 | 2.65 | 0.931 | 4 | 2.5 | 0.98 | 4 |
| Lack of skilled labor | 2.25 | .929 | 6 | 2.11 | 0.952 | 5 | 2.29 | 0.849 | 8 | 2.32 | 0.962 | 8 |
| High initial cost | 2.22 | 1.084 | 7 | 1.92 | 1.129 | 7 | 2.41 | 0.939 | 6 | 2.34 | 1.097 | 7 |
| Lack of technology or services | 2.2 | 1.123 | 8 | 1.81 | 1.2 | 8 | 2.41 | 0.939 | 7 | 2.37 | 1.1 | 6 |
| Average | 2.52 | - | - | 2.34 | - | - | 2.67 | - | - | 2.58 | - | - |

196 Note: M.= mean; R.= rank; SD= standard deviation; Cronbach's Alpha=0.772

197 As can be seen from Table 2 and Figure 1, the item with the highest rank according to the
 198 respondents was the lack of awareness with a mean 3.1, which is consistent with the findings of
 199 many different studies in the world (Darko and Chan, 2017; Esa et al, 2011, Li et al, 2014). Items
 200 with the second and third highest ranks according to the respondents were respectively high
 201 investment risk and lack of economic justification with respective means of 2.89 and 2.74. The
 202 opinion of respondents from the 3 job groups (namely employer, consultant and contractor) slightly
 203 diverges in ranking the evaluation indicators. All items on obstacles to green building have relatively
 204 high scores with a minimum of 2.2, indicating that the implementation of green buildings in Iran is
 205 met with serious challenges and obstacles.



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207 *Figure 1: Obstacles to the implementation of green buildings in Iran*

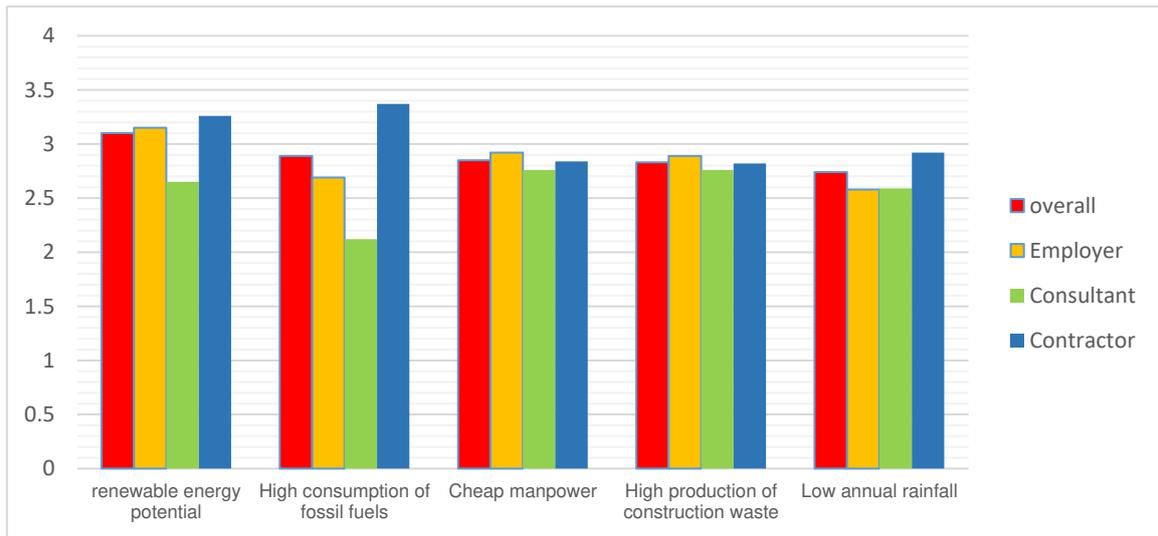
208 *3.2. Opportunities or necessities of implementing green buildings in Iran*

209 Respondents were asked about various indices for assessing the opportunities or necessities of
210 implementing green building in Iran, the results of which are shown in Table 3.

211 *Table 3: Ranking opportunities or necessities of green building implementation*

| Items | Overall | | | Employer | | | Consultant | | | Contractor | | |
|---------------------------------------|---------|-------|----|----------|-------|----|------------|-------|----|------------|-------|----|
| | M. | SD | R. | M. | SD | R. | M. | SD | R. | M. | SD | R. |
| Renewable energy potential | 3.25 | 0.874 | 1 | 3.08 | 1.055 | 2 | 3.35 | 0.786 | 1 | 3.32 | 0.775 | 1 |
| High consumption of fossil fuels | 3.15 | 0.95 | 2 | 3.12 | 0.993 | 1 | 3.24 | 0.903 | 2 | 3.13 | 0.963 | 4 |
| Cheap manpower | 3.07 | 0.946 | 3 | 2.92 | 0.935 | 3 | 3.06 | 1.144 | 4 | 3.18 | 0.865 | 3 |
| High production of construction waste | 3.07 | 1.093 | 4 | 2.85 | 1.287 | 4 | 3.12 | 1.111 | 3 | 3.21 | 0.935 | 2 |
| Low annual rainfall | 2.88 | 1.279 | 5 | 2.65 | 1.355 | 5 | 3.06 | 1.088 | 5 | 2.95 | 1.314 | 5 |
| Average | 3.08 | - | - | 2.92 | - | - | 3.17 | - | - | 3.16 | - | - |

212 Note: M.= mean; R.= rank; SD= standard deviation; Cronbach's Alpha=0.778



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Figure 2: Opportunities or necessities of implementing green buildings in Iran

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Based on the results obtained from Table 3 and Figure 2, the potential of renewable energy production in Iran was ranked first with a score of 3.25, followed by the the high consumption of fossil fuels, which was ranked second with a score of 3.15 among other factors. The average score obtained is significant and equal to 3.08, except for one item, the score of other items is higher or approximately equal to the average of the results. Based on the obtained results, evaluation indicators in all 3 occupational groups are of paramount significance, and hence a brief description is provided for each item.

3.2.1. Renewable energies

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Iran offers highly favorable conditions for the production of renewable solar and wind energy, as about 60% of the land is desert which can receive maximum solar radiation. There are areas in Iran where sunny hours are significant, that is, 1050 hours in summer, 700 hours in spring, 830 hours in autumn and 500 hours in winter. Also, the presence of various tropical wind currents results in an abundance of windy areas and fortunately Iran's wind sites have attained the highest-ranking classes by the US Department of Energy (Ghorashi and Rahimi, 2011). Although the production of renewable energy and especially solar energy in Iran has increased in size in recent years, that is,

230 more than 8 times from 2016 to 2019, this amount of energy in 2019 still stands at a very small value
231 of about 367 MW, accounting for only 2% of the total energy produced in Iran (IRENA, 2019).

232 *3.2.2. High consumption of energy and fossil fuels*

233 Iran is one of the top ten producers of carbon dioxide in the world, while it has the most natural gas
234 reserves and the fourth most oil reserves in the world (Mousavi et al, 2017). Energy consumption in
235 Iran is increasing rapidly and most of the energy production is supplied by fossil fuels, to the extent
236 that in 2018, about 96% of energy in Iran is supplied from non-renewable sources such as oil and
237 natural gas (IEA, 2018). Energy consumption in Iran is 15 times that of Japan, 10 times that of the
238 European Union and 2.5 times that of other countries of Middle East, and with a growth rate of 3.2%,
239 the construction industry has one highest annual energy growth, only second to the manufacturing
240 industry (EIA, 2018). The implementation of green buildings can provide a significant reduction in
241 fossil fuel consumption and hence carbon dioxide emissions.

242 *3.2.3. Cheap manpower*

243 Manpower is one of the most significant issues in the economic development of any country and the
244 optimal use of physical capital heavily relies on the human resources of that country (Sameei, 2012).
245 Due to the high initial cost of green buildings (Chen et al, 2011; Hwang and Tan, 2012), the cheap
246 manpower of the country offers a good potential for the implementation of green buildings. High
247 unemployment, high youth population, and abundance of foreign immigrants, who work mainly as
248 construction workers, have led to reduced construction wages.

249 *3.2.4. High production of construction waste*

250 Production of construction waste has rapidly increased in many countries with the increased trend of
251 urbanization, and has thus been acknowledged as one of the most serious environmental challenges
252 (Ding et al, 2018). The construction industry in Iran is considered as one of the largest waste
253 production industries of the country (Eghbali et al, 2019), to the extent that only in Tehran from 2013

254 to 2014, about 23 million tons of construction waste was produced, a small part of which was
 255 recycled and the rest to were transferred to landfills (Nikmehr et al, 2015). Implementation of green
 256 buildings can lead to the use of renewable materials, recycling of construction waste and reducing
 257 the consumption of natural materials, all of which can contribute to the reduction of carbon dioxide
 258 emissions and hence environmental pollution.

259 3.2.5. Low mean annual rainfall

260 Iran is located in one of the semi-arid regions of the world which has low rainfall as well as unequal
 261 distribution of rainfall in different regions (Khozaymehnezhad and Tahroudi, 2019). Intermittent
 262 droughts in recent years have led to serious challenges for drinking water supply in some cities, and
 263 green buildings can provide ground optimal use of water, rainwater recycling and gray water
 264 treatment.

265 3.3. Ranking of different items of green standard

266 For the localized green standard in Iran, 67 indicators were identified in a total of 5 dimensions,
 267 namely site, water, energy, materials and quality of indoor environment. After obtaining the results
 268 from the questionnaires, each dimension was ranked based on Friedman ranking test (Soleymani and
 269 Nik Nafs, 2017), the results of which is presented in Table 4.

270 *Table 4: Suggested list of green standard parameters in Iran*

| code | F. | R. | Activity description |
|-------------|-------|----|--|
| Site | | | |
| S2 | 12.24 | 1 | At least 10 different services such as bank, store, school, university, etc should be provided within a maximum distance of 500 meters from the site |
| S13 | 10.48 | 15 | The project is located in areas where residents can walk inside or outside the project |
| S10 | 10.13 | 13 | The building is designed in accordance with the rules and preserves the historical landscape of the area |
| S3 | 10.04 | 16 | At least 2 different recreational or sports facilities are provided within the site for the use of residents |
| S5 | 9.79 | 14 | Provide places for parking bicycles and electric motorcycles |
| S11 | 9.67 | 2 | Design green space on the roof that covers at least 50% of the roof area |
| S9 | 9 | 3 | Build the building in areas that do not need to occupy new land |
| S7 | 8.9 | 4 | The building is designed according to local laws for the physically disabled |
| S6 | 8.64 | 5 | In the parking lot, there are places for parking cars for the disabled |
| S15 | 8.29 | 6 | Build the building in areas where the risk of flooding is low and there is a possibility of rapid discharge of runoff (mandatory) |

| | | | |
|------------------|------|----|---|
| S1 | 7.77 | 7 | The maximum distance of the building from one of the public transport networks is 500 meters |
| S8 | 7.1 | 8 | Avoid selecting sites in agricultural areas or areas endangered by animal and plant species |
| S14 | 6.81 | 9 | Landscaping and planting of suitable plants in the site has been done |
| S4 | 5.85 | 11 | In the house there is a work room with convenient services such as internet, printer, desk, chair, etc. |
| S12 | 5.72 | 10 | Protect the ecological features of the land and prevent the destruction of existing trees during construction |
| S16 | 5.63 | 12 | In order to reduce the volume of runoff, various plans have been taken to direct or absorb surface water |
| Water | | | |
| W1 | 7.56 | 1 | Drinking water consumption should be managed so that the average water consumption in a one-year period is at least 25% less than the normal consumption of the city or region under study |
| W5 | 6.78 | 2 | There is the necessary equipment to collect and recycle rainwater in the project |
| W9 | 6.51 | 6 | Use leak detection systems that are able to detect major water leaks |
| W7 | 6.46 | 3 | At least 50% of wastewater is treated and used for non-drinking purposes |
| W3 | 6.19 | 4 | All faucets are equipped with water saving facilities |
| W10 | 5.99 | 5 | Water consumption monitors have been installed for bathrooms, kitchens, and toilets |
| W2 | 5.01 | 7 | In the building, sanitary components and drinking needs are separated from non-drinking needs |
| W4 | 4.07 | 8 | Installation of efficient valves and devices in water that have a grade A or B efficiency label design |
| W6 | 3.98 | 9 | The quality of drinking water in the building is good and has the necessary standards |
| W8 | 2.44 | 10 | Drip irrigation has been used to irrigate the yard and green space |
| Energy | | | |
| E1 | 7.81 | 1 | The location of the building, the dimensions of the windows, the thermal insulation and in general the energy design of the building should be done in such a way that the estimated energy consumption of the building using simulation is at least 20% lower than the energy consumption of similar non-green buildings |
| E6 | 7.31 | 2 | Use green and renewable energy to provide at least 5% of total energy |
| E2 | 6.23 | 3 | In order to encourage consumption reduction, the average electricity consumption of a building over a one-year period should be at least 25% less than the normal consumption of the city or area under study |
| E4 | 6.19 | 7 | In the building, energy consumption display systems have been used in different parts of the building |
| E10 | 6.17 | 4 | In order to encourage consumption reduction, the average gas consumption of the building in the period of one year has been studied and should be at least 25% less than the normal consumption of the city or region under study |
| E5 | 5.76 | 9 | If the equipment is not optimally operated, alarm systems have been used to users |
| E9 | 5.21 | 5 | The outer shell of the building, including the walls, ceiling and floor, is made of suitable thermal insulation |
| E8 | 4.65 | 6 | Intelligent disconnection and connection system has been used in heating and cooling systems of the building |
| E7 | 3.51 | 8 | At least 80% of energy devices and equipment must have energy consumption categories A and B. |
| E3 | 2.14 | 10 | Insulation of cooling and heating distribution systems such as water pipes and canals has been done. |
| Materials | | | |
| M6 | 8.75 | 1 | Use at least 50% of construction waste to the production process and reuse them in the building |
| M12 | 7.98 | 2 | Use materials that have the least environmental impact (LCA) |
| M8 | 7.88 | 3 | At least 5% of non-structural building materials are recycled materials |
| M4 | 7.23 | 4 | The building is designed so that at least 30% of the building skeleton can be reused |
| M7 | 7.15 | 5 | At least 5% of structural concrete is made from recycled materials or green items, rubber scraps, slag, etc |
| M5 | 6.77 | 6 | At least 5% of the total cost of materials from renewable materials such as bamboo, fiber, chipboard, straw cardboard, etc. has been used |
| M10 | 6.69 | 7 | At least 20% of the prefabricated elements of the building are produced off-site and in a separate workshop |
| M1 | 6.33 | 8 | At least 50% of the building materials are procured at a maximum distance of 800 km |
| M2 | 6.15 | 9 | Building materials are prepared based on modeling different parts of the building and have a valid standard |
| M9 | 5.1 | 10 | At least 50% of the wood materials used in the building are sustainable and licensed forest products |

| | | | |
|-----------------------|-------|----|--|
| M3 | 4.1 | 11 | In the design of the building, a false roof and a duct have been used to pass the installation pipes |
| M11 | 3.88 | 12 | Provide plans that allow the development or change of the architectural layout of the building in the futur |
| Indoor Quality | | | |
| I17 | 14.64 | 1 | Hot and cold thermal zoning is designed and implemented for all parts of the building |
| I16 | 13.19 | 2 | There is adequate heating equipment to achieve the desired temperature of residents in summer and winter |
| I8 | 12.35 | 3 | Lighting control by different areas as a remote control or automatic control system |
| I4 | 12.41 | 4 | All parts of the building have adequate daylight |
| I15 | 12.31 | 6 | For proper ventilation, the window open space is designed for at least one-eighth of the room space |
| I6 | 11.69 | 7 | At least 60% of the interior of the building has a direct and unmediated view to the outside |
| I19 | 11.63 | 5 | Telephone and internet connections and access to fiber optic network are available in each room |
| I13 | 11.14 | 8 | Natural or mechanical ventilation design is done for all residential spaces (mandatory) |
| I14 | 10.9 | 9 | Selected from the air conditioning system to reduce the vertical distribution of temperature and air velocity in the room |
| I2 | 10.48 | 10 | The building is equipped with carbon dioxide warning devices inside the building |
| I11 | 10.32 | 11 | Suitable materials have been used to create sound and heat insulation in the walls and floors |
| I3 | 10.23 | 12 | The building is located away from noise-sensitive areas and is at least 800 meters away |
| I10 | 9.48 | 13 | Air inlets are located away from pollution sources and away from sewage outlets |
| I18 | 8.67 | 14 | Appropriate security measures such as installing CCTV cameras are designed for the building |
| I12 | 6.86 | 15 | All areas of the building are equipped with fire alarm and extinguishing system (mandatory) |
| I9 | 6.75 | 17 | Intelligent or sensor lighting has been used for the common areas of the building |
| I1 | 6.62 | 16 | Interior paints, adhesives and sealants comply with the standard for volatile organic compounds |
| I7 | 6.03 | 18 | Facade lighting from the top to the bottom of the building is minimized and all external lighting (except safety and security lighting) is automatically turned off between 11pm and 7am |
| I5 | 4.33 | 19 | Sunlight is controlled by conventional curtains or in the advanced type by automatic curtains |

Note: F.= Friedman test; R.= rank; Cronbach's Alpha=0.715

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Based on the results from the Friedman test for each dimension, facility access items (S2) for the site dimension, water consumption management (W1) for the water dimension, energy consumption management (E1) for the energy dimension, construction waste recycling (M6) for the material dimension and thermal zoning (I17) for the indoor quality dimension have obtained the highest scores in their respective dimensions. In the second stage, in order, Friedman test was re-formed based on a total of 67 evaluation indicators to identify and assess the significance of each item in the whole green standard, the results of which determined that the parameters of energy management (E1) with a score of 53.48, renewable energy (E6) with a score of 50.72, thermal zoning (M6) with a score of 48.44 and the proximity of the building to the service centers with a score of 48.25 have achieved the highest overall scores among all the parameters of the local green standard. The results for the top 10 parameters are shown in Figure 3.

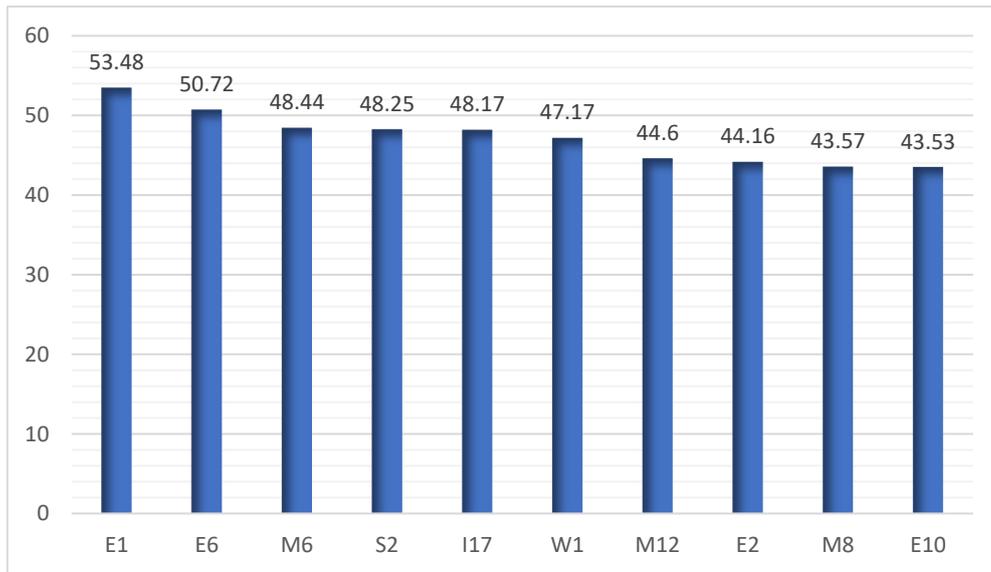


Figure 3: The most important items of national green standard in Iran

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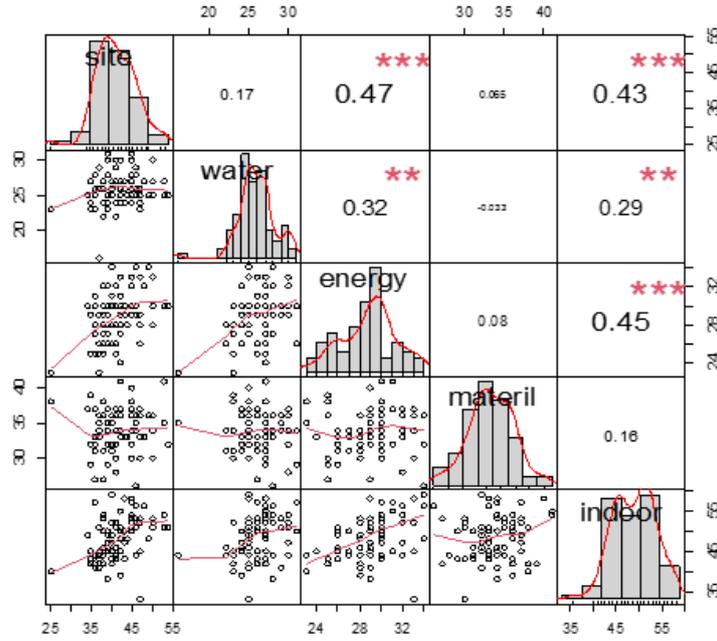
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286 4. Numerical results

287 4.1. Principal Component Analysis

288 The principal component method is an orthogonal linear transform that transfers data to a new
 289 coordinate system, such that the greatest variance of the data is formed on the first coordinate axis
 290 and the second variance of the data on the second coordinate axis. Correlation of variables is the
 291 prerequisite to this method which has been met in this study, and the numbers in Figure 4 indicate
 292 the amount and type of correlation, while plotted histograms illustrates how the variables are
 293 distributed. The highest correlation value pertains to the two variables of energy and site with 0.47,
 294 followed by energy and indoor quality with 0.45



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Figure 4: Histogram charts and distribution of variables in 5 standard green chapters

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298 Due to the existence of a latent variable, that is, the projected green building score, only the first
 299 component (PC1), which has the highest amount of variance and variability, has been used in the
 300 calculations, the equation of which is as follows:

301
$$pc1 = a_1 Site + a_2 Water + a_3 Energy + a_4 Material + a_5 Indoor Quality \quad (1)$$

302
$$\mathbf{a} = (a_1, a_2, a_3, a_4, a_5)^T. \quad s. t. \quad \mathbf{a}^T \mathbf{a} = 1 \quad (2)$$

303 Where a_j ($j = 1, \dots, 5$) are the coefficients of each dimension of green standard, and based on the
 304 first component, the standard deviation is 1.4535 and the variance ratio is 0.42. In other words, about
 305 42% of the total changes can be explained by the first component. To calculate the values of a_j , first
 306 the data correlation matrix is formed and then the eigenvalues, eigenvectors and finally a_i are
 307 calculated using R software. The highest and lowest significance coefficients respectively pertain to
 308 the energy and materials dimensions, the supplementary results of which are shown in Figure 5.

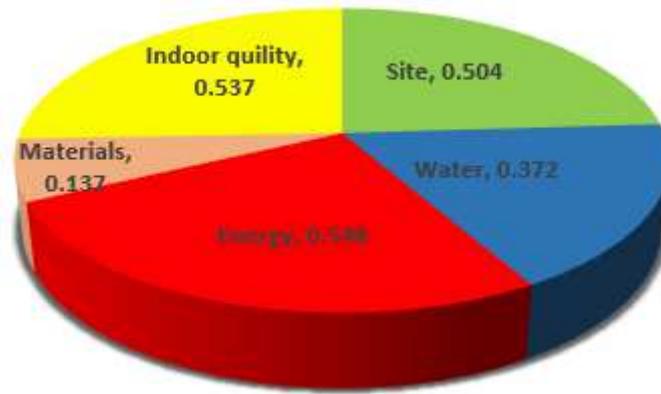


Figure 5: Significance coefficients of 5 Green Standard dimensions

4.2. Biplot graph

Biplot is another tool to examine the significance of each green standard dimension. The numbers on the graph indicate the number of the person responding to the questionnaire, in which the horizontal axis represents the first component (PC1) and the vertical axis represents the second component (PC2). Owing to the existence of only one dummy variable, the first component is the focal point of the study, and variables that are parallel to the first component are hence considered more important. According to Figure 6, the energy dimension has the highest importance, followed by the dimensions of quality of indoor environment, site, water and finally, the least importance dimension, materials.

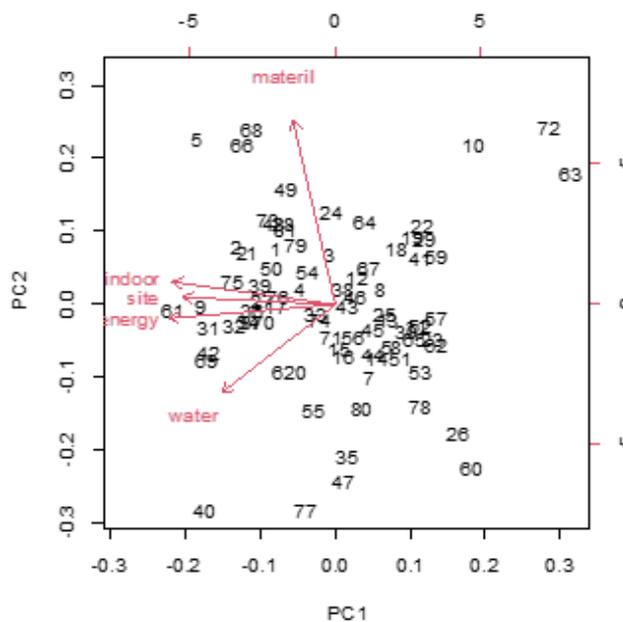


Figure 6: Significance of each of the standard green seasons based on the Biplot graph

322

323 4.3. Predict the national green building score

324 After estimating the a_j s, it is necessary to calculate the scores of the first component, which the
325 general equation is as follows:

$$326 \widehat{pc1} = \Lambda^{-1} A^T x_i \quad (3)$$

327 Where Λ is a matrix with diagonal elements of eigenvalues, A^T is the transposition of the matrix A ,
328 Λ^{-1} is the inverse of Λ and $\widehat{pc1}$ is the projected score of the first component per x_i .

329 Given the existence of a principal component $A_5 = a$ and also we have:

$$330 x_i = ((site)_i. (water)_i. (energy)_i. (material)_i. (Indoor Quality)_i)^T. i = 1. \dots .81 \quad (4)$$

331 To predict the green building score, there are many options for central criteria and scatter, such as
332 median, mode, variance, standard deviation, minimum, etc., but given that the central indicators are
333 numbers that are usually located around the center of many curves, so the most appropriate The
334 option for this is to use the mean (or expected value) of the central index, which is used in this study
335 according to the following formula:

$$336 \widehat{pc1} = \Lambda^{-1} \Lambda^T \bar{x} \quad (5)$$

337 \bar{x} is calculated using Equation 6, in which \overline{site} is the average for the site variable, \overline{water} is the
338 average for the water variable, \overline{energy} is the average of the energy variable, $\overline{material}$ is the
339 average for the material variable and $\overline{Indoor Quality}$ is the average of the indoor quality variable.

$$340 \bar{x} = (\overline{site}. \overline{water}. \overline{energy}. \overline{material}. \overline{Indoor Quality})^T \quad (6)$$

341 Finally, $\widehat{pc1}$ is the estimated score for the national green building standard based on the average of
342 the variables, which is calculated to be 77.2088 using R software with an error of 0.2387.

343 4.4. National Green building ranking

344 The basis of the rating for the proposed green standard was on the US LEED standard rating pattern,
345 such that in the local standard, a building with a green score of 30 to 38 (40 to 49%) receives a
346 certification, 39 to 45 (50 to 59%) would result in a silver certification, green buildings with scores
347 of 46 to 61 points (60 to 79%) are awarded the gold certificate, while those with scores of 62 to 77
348 (80 to 100%) are awarded the platinum certificate.

349 5. Conclusion

350 The development of green buildings has garnered a high level of global attention in recent years,
351 mainly owing to limited resources and high energy consumption and, as such, various standards have
352 been developed to this end. Nevertheless, Iran is yet to develop a local green standard, and despite
353 high fossil fuel consumption within the country, green buildings are still highly neglected. The
354 current study sought to identify the parameters of the national green standard, as well as the obstacles
355 and opportunities for the implementation of green buildings, with the aim of contributing to the
356 development of green buildings. The study was performed by obtaining comments through
357 questionnaires from 81 construction industry experts, the results of which showed that items with the
358 topics of access to public services for the site dimension, water consumption management for the
359 water dimension, energy consumption management for the energy dimension, construction waste
360 recycling for the materials dimension, and thermal zoning for indoor quality dimension achieved the
361 highest scores in each dimension. Also, lack of awareness on green buildings and renewable energy
362 potential obtained the highest scores respectively among the obstacles and opportunities for green
363 buildings. Using the machine learning method and multivariate analysis, the total score of the local
364 green building standard was predicted and calculated to be 77.2, on which the energy dimension had
365 the most and the materials dimension had the least impact among the five dimensions of the local
366 green standard. A building with a score of at least 40% is considered green in this standard, and,

367 silver, gold and platinum certifications are handed out based on the scores obtained in different
368 categories.

369 Findings of this study can contribute to knowledge of green building localization in Iran and can
370 have implications for contractors, investors and decision makers in the construction and energy
371 sector with the aim of paving the way for development of green buildings. It can also pose as a useful
372 reference for international organizations seeking to develop solutions to alleviate obstacles to and
373 increase the potential of green buildings.

374 Although research objectives were mostly achieved, but this study has remarkable limitations and
375 weaknesses. First, although the size of samples was sufficient for statistical analysis, increasing the
376 number of samples for future studies can enhance the quality of findings. Secondly, since in this
377 article, only the parameters and scores of the national green standard have been examined, as future
378 research avenue in Iran and other countries with similar climatic conditions, case studies of green
379 buildings can be conducted using the proposed green standard.

380 **Declarations**

381 **Ethics Approval:** Not Applicable

382 **Consent to Participate:** Not applicable

383 **Consent to Publish:** Not applicable

384 **Authors' Contributions: Conceptualization:** [Mohamad Rajabi, Javad Majrouhi Sardroud];

385 **Methodology:** [Mohamad Rajabi, Javad Majrouhi Sardroud];

386 **Writing -original draft preparation:** [Mohamad Rajabi, Ali Kheyroddin];

387 **Writing -review and editing:** [Javad Majrouhi Sardroud];

388 **Resources:** [Mohamad Rajabi];

389 **Supervision:** [Javad Majrouhi Sardroud; Ali Kheyroddin].

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391 **Competing Interests:** The authors declare that they have no competing interests

392 **Availability of data and materials:** Data can be made available on request

393 **References**

394 Alyami SH, Rezgui Y, (2012) Sustainable building assessment tool development approach,
395 Sustainable Cities and Society, 5, 52–62

396 Babahaji Meibodi A, (2015), On-site concrete waste minimisation in Iran, *ethos.bl.uk*

397 Balaban O, Oliveira JAP, (2017), Sustainable Buildings for Healthier Cities: Assessing the
398 Cobenefits of Green Buildings in Japan, *Journal of Cleaner Production*, 163, S68-S78

399 Chan APC, Darko A, Olanipekun AO, Ernest Effah Ameyaw, (2018), Critical barriers to green
400 building technologies adoption in developing countries: The case of Ghana, *Journal of*
401 *Cleaner Production*, 172, 1067-1079

402 Chen M, Chen JG, Cheng XX, (2011), Life Cycle Incremental Cost-Benefit Analysis of Green
403 Building, *Applied Mechanics and Materials*, 71, 4645-4651

404 Darko A, Chan APC, (2016), Critical analysis of green building research trend in construction,
405 *Habitat International*, 57, 53–63

406 Darko A, Chan APC, (2017), Review of Barriers to Green Building Adoption, *Sustainable*
407 *Development*, 25, 167-179

408 Ding Z, Zhu M, Tam VWY, Yi G, Tran CNN, (2018), A system dynamics-based environmental
409 benefit assessment model of construction waste reduction management at the design and
410 construction stages, *Journal of Cleaner Production*, 176, 676-692

411 Doan DT, Ghaffarian hoseini A, Naismith N, Zhang T, Ghaffarian hoseini A, Tookey J, (2017), A
412 critical comparison of green building rating systems, *Building and Environment*, 123, 243-
413 260

414 Dwaikat LN, Ali KN, (2016), Green Building Cost Premium: A Review of Empirical Evidence,
415 Energy and Building, 110, 396-403

416 Dwaikat LN, Ali KN, (2018), Green Buildings Life Cycle Cost Analysis and Life Cycle Budget
417 Development: Practical Applications, Journal of Building Engineering, 18, 303-311

418 Ebadati M, Ehyaei MA, (2018), Reduction of energy consumption in residential buildings with green
419 roofs in three different climates of Iran, Advances in Building Energy Research, 14, 66-93

420 Eghbali SR, Azizzadeh Araee R, Mofrad Boushehri A, (2019), Construction Waste Generation in the
421 Iranian Building Industry, Civil Engineering Infrastructures Journal, 52, 1-10

422 Eliasa EM, Lin CK, (2015), The Empirical Study of Green Buildings (Residential) Implementation:
423 Perspective of House Developers, Procedia Environmental Sciences, 28, 708-716

424 Energy Information Administration (EIA) website (www.eia.doe.gov/iea)

425 Esa bin MR, Marhani MA, Yaman R, Noor, Adnan H, (2011), Obstacles in Implementing Green
426 Building Projects in Malaysia, Australian Journal of Basic and Applied Sciences, 5(12),
427 1806-1812

428 Everitt B, Hothorn T, (2011), An Introduction to Applied Multivariate Analysis with
429 R. Springer, New York Dordrecht, Heidelberg, London

430 Ghorashi AH, Rahimi A, (2011), Renewable and non-renewable energy status in Iran: Artofknow-
431 howand technology-gaps, Renewable and Sustainable Energy Reviews, 15, 729-736

432 Gou Z, Xie X, (2017), Evolving green building: triple bottom line or regenerative design?, Journal of
433 Cleaner Production, 153, 600-607

434 Hedao MN, Khese SR, (2016), A Comparative Analysis of Rating Systems in Green Building,
435 International Research Journal of Engineering and Technology, 03, 1393-1399

436 Hosseini SE, Andwari AM, Wahid MA, Bagheri G, (2013), A review on green energy potentials in
437 Iran, Renewable and Sustainable Energy Reviews, 27, 533-545

438 Huo X, Yu ATW, (2017), Analytical Review of Green Building Development Studies, Journal of
439 Green Building, 2(12), 130-148

440 Hwang BG, Tan JS, (2012), Green Building Project Management: Obstacles and Solutions for
441 Sustainable Development, Sustainable Development, 20, 335-349

442 International Energy Agency (IEA) website ([www.iea.org/ Data and Statistics](http://www.iea.org/Data%20and%20Statistics))

443 International Renewable Energy Agency (IRENA) website (www.irena.org/Statistics)

444 Khot Prof. Sainand, Raut R, Choudhari D, Shubhangi P, Amit J, (2019), Comparison Study between
445 Conventional Building and Sustainable Green Building, International Journal for Research in
446 Applied Science and Engineering Technology, 7, 3622-3623

447 Khozaymehnezhad H, Tahroudi MN, (2019), Annual and seasonal distribution pattern of rainfall in
448 Iran and neighboring regions, Arabian Journal of Geosciences, 271, 1-11

449 Kim JL, Greene M, Kim S, (2014), Cost Comparative Analysis of a New Green Building Code for
450 Residential Project Development, Journal of Construction Engineering and Management,
451 140, (140021-2) - (140021-10)

452 Lee S, Lee B, Kim J, Kim J, (2013), A Financing Model to Solve Financial Barriers for
453 Implementing Green Building Projects, the Scientific World Journal, 1-10

454 Li Y, He B, Zhao D, (2014), Green building in China: Needs great promotion, Sustainable Cities and
455 Society, 11, 1-6

456 MacNaughton P, Cao X, Buonocore J, Cedeno-Laurent J, Spengler J, Bernstein A, Allen J, (2018),
457 Energy savings, emission reductions, and health co-benefits of the green building movement,
458 Journal of Exposure Science & Environmental Epidemiology, 28(4), 307-318

459 Mattoni B, Guattari C, Evangelisti L, Bisegna F, Gori P, Asdrubali F, (2018), Critical review and
460 methodological approach to evaluate the differences among international green building
461 rating tools, Renewable and Sustainable Energy Reviews, 82, 950-960

462 Meron N, Meir IA, (2017), Building green schools in Israel costs, economic benefits and teacher
463 satisfaction, *Energy and Building*, 154, 12-18

464 Mirzaei M, Bekri M, (2017), Energy consumption and CO2 emissions in Iran, 2025, *Environmental*
465 *Research*, 154, 345-351

466 Moshiri S, Atabi F, Panjehshahi MH, Lechtenböhmer S, (2012), Long run energy demand in Iran: a
467 scenario analysis, *International Journal of Energy Sector Management*, 6, 120-144

468 Mosly I, (2015), Barriers to the Diffusion and Adoption of Green Buildings in Saudi Arabia, *Journal*
469 *of Management and Sustainability*, 5(4), 104

470 Mousavi B, Lopez NSA, Biona JBM, Chiu ASF, Blesl M, (2017), Driving forces of Iran's CO2
471 emissions from energy consumption: an LMDI decomposition approach, *Applied Energy*,
472 206, 804-814

473 Najafpoor AA, Zarei A, Jamali F, Vahedian M, Zarei A, (2014), A Study Identifying Causes of
474 Construction Waste Production and Applying Safety Management on Construction Site,
475 *Iranian Journal of Health Sciences*, 2(3), 49-54

476 Nangare PP, Chandrakant PG, Warudkar A.A, (2015), Evaluation of Green Building with Resources
477 and Cost Aspects, *International Journal On Recent and Innovation Tends in Computing and*
478 *Communication*, 3, 127-130

479 Neyestani B, (2017), A Review on Sustainable Building (Green Building), *SSRN*, 1-9

480 Nguyen HT, Skitmore M, Gray M, Zhang X, Ayokunle Olubunmi Olanipekuna, (2017), Will green
481 building development take off? An exploratory study of barriers to green building in
482 Vietnam, *Resources Conservation and Recycling*, 127, 8-20

483 Nikmehr B, Hosseini MR, Oraee M, Chileshe N, (2015), Major Factors Affecting Waste Generation
484 on Construction Sites in Iran, *International Conference on Engineering, Project, and*
485 *Production Management*, 528-536

486 Qifa J, (2013), Economic Analysis on Chinese Green Building in the Context of Life Cycle Costing,
487 6th International Conference on Information Management, Innovation Management and
488 Industrial Engineering

489 Samari M, Godrati N, Esmaeilifar R, Olfat P, Shafiei MWM, (2013), The Investigation of the
490 Barriers in Developing Green Building in Malaysia, Modern Applied Science, 7, 1-10

491 Sameei G, (2012), An Investigation of the Unemployment of Higher Educated Manpower in Iran,
492 International Journal of Human Resource Studies, 2, 142-154

493 Sánchez Cordero A, Gómez Melgar S, Manuel Andújar Márquez J, (2019), Green Building Rating
494 Systems and the New Framework Level(s): A Critical Review of Sustainability Certification
495 within Europe, Energies, 13, 66

496 Sarwar S, Alsaggaf MI, (2020), The willingness and perception of people regarding green roofs
497 installation, Environmental Science and Pollution Research, 27, 25703-25714

498 Shan M, Liu WQ, Hwang BG, Lye JM (2020), Critical success factors for small contractors to
499 conduct green building construction projects in Singapore: identification and comparison
500 with large contractors, Environmental Science and Pollution Research, 27, 8310-8322

501 Shen W, Tang W, Siripanan A, Lei Z, Duffield CF, Hui FKP, (2018), Understanding the Green
502 Technical Capabilities and Barriers to Green Buildings in Developing Countries: A Case
503 Study of Thailand, sustainability, 10(10), 3585

504 Sinha A, Gupta R, Kutnar A, (2013), Sustainable Development and Green Buildings, Drvna
505 Industrija, 64(1), 45-53

506 Soleymani B, Nik Nafs J, (2017), Evaluate and Prioritize the Factors Affecting the Project Cost
507 Construction and Friedman Test Using a Special Vector, International Research Journal of
508 Applied and Basic Sciences, 11(1), 87-94

509 Taghvaei VM, Mavuka C, Shirazi JK, (2017), Economic growth and energy consumption in Iran: an
510 ARDL approach including renewable and non-renewable energies, *Environment,*
511 *Development and Sustainability*, 19, 2405-2420

512 Uğur LO, Leblebici N, (2018), An examination of the LEED green building certification system in
513 terms of construction costs, *Renewable and Sustainable Energy Review*,1476-1483

514 Zhang L, Wu J, Liu H, (2018), Turning green into gold: A review on the economics of green
515 buildings, *Journal of Cleaner Production*,172, 2234-2245

516 Zhang Y, Wang J, Hu F, Wang Y, (2017), Comparison of evaluation standards for green building in
517 China, Britain, United States, *Renewable and sustainable energy*,68, 262-271

518 Zhao X, Zuo J, Wu G, Huang C, (2019), A bibliometric review of green building research 2000–
519 2016, *Architectural Science Review*, 62, 74-88

520 Zuo J, Pullen S, Rameezdeen R, Bennetts H, Wang Y, Mao G, Zhou Z, Du H, Duan H, (2017),
521 Green building evaluation from a life-cycle perspective in Australia: A critical review,
522 *Renewable and Sustainable Energy Reviews*, 70, 358-368

523 Zuo J, Zhao ZY, (2014), Green building research–current status and future agenda: A review,
524 *Renewable and Sustainable Energy Reviews*, 30, 271-281

Figures

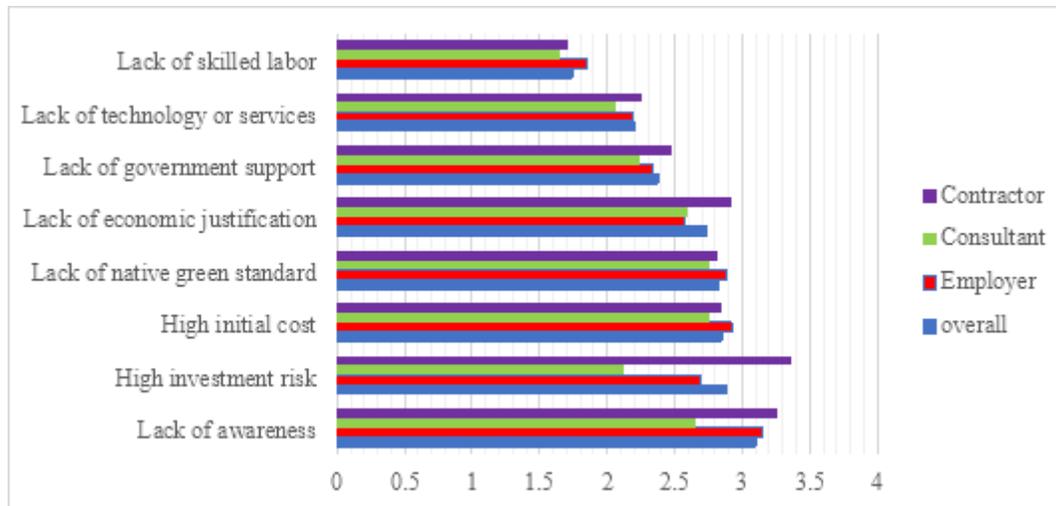


Figure 1

Obstacles to the implementation of green buildings in Iran

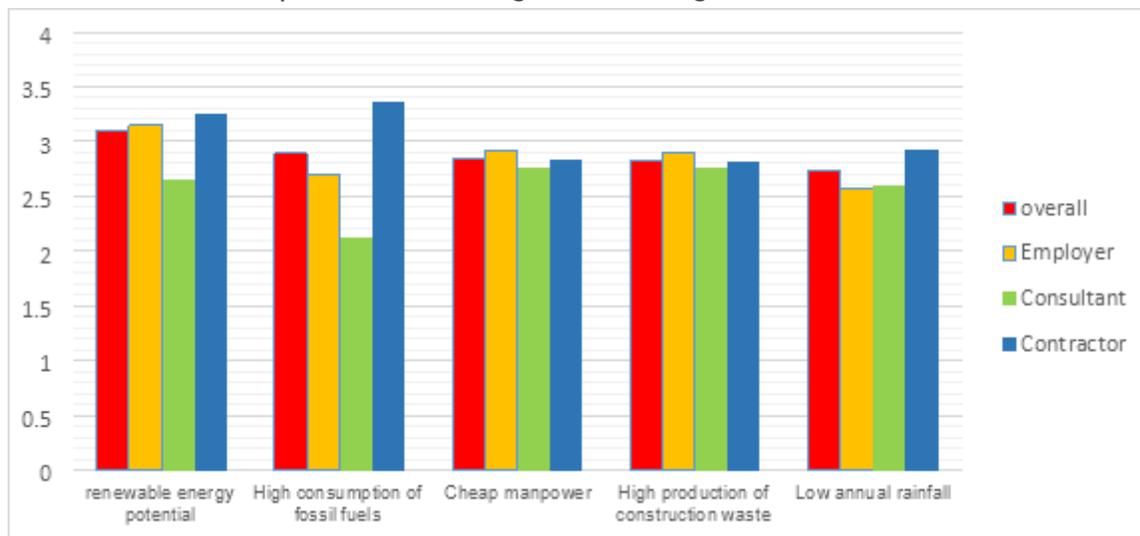


Figure 2

Opportunities or necessities of implementing green buildings in Iran

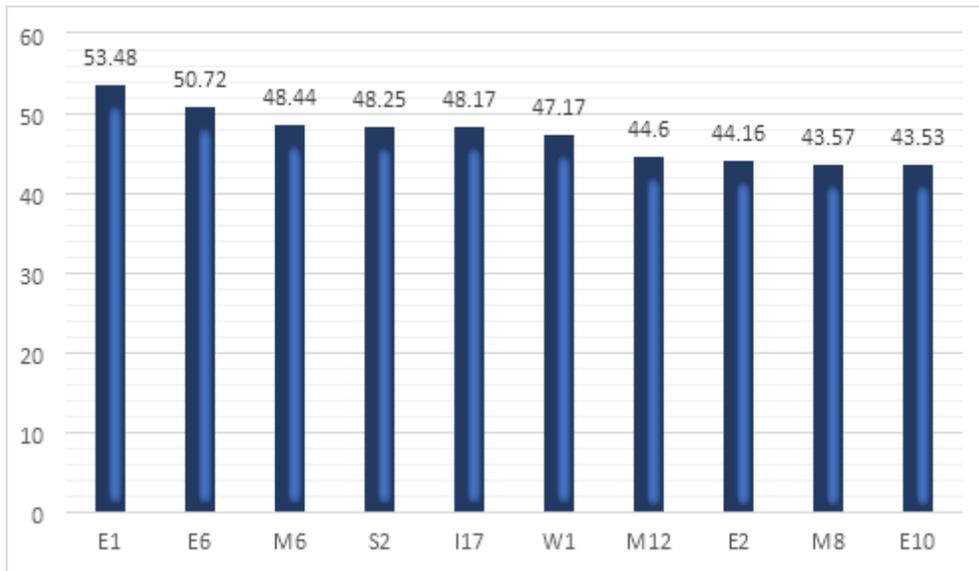


Figure 3

The most important items of national green standard in Iran

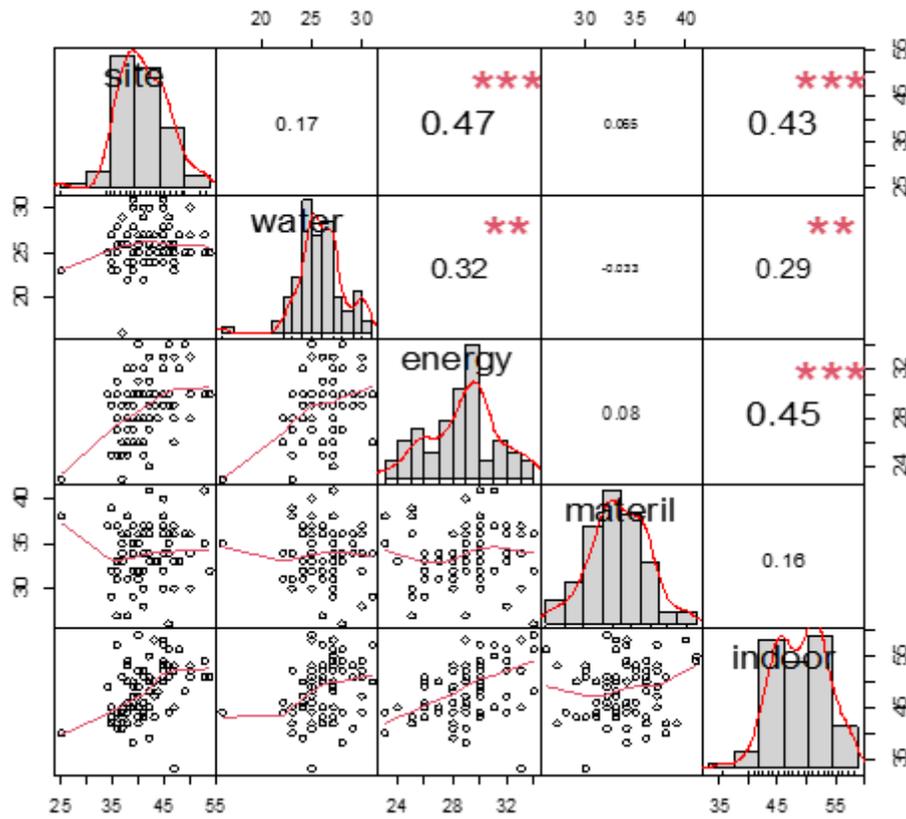


Figure 4

Histogram charts and distribution of variables in 5 standard green chapters

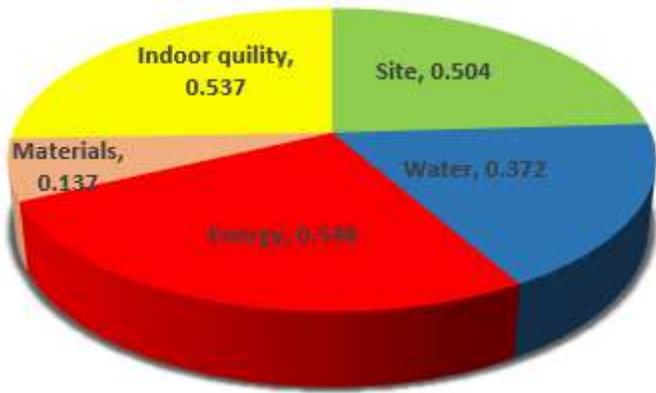


Figure 5

Significance coefficients of 5 Green Standard dimensions

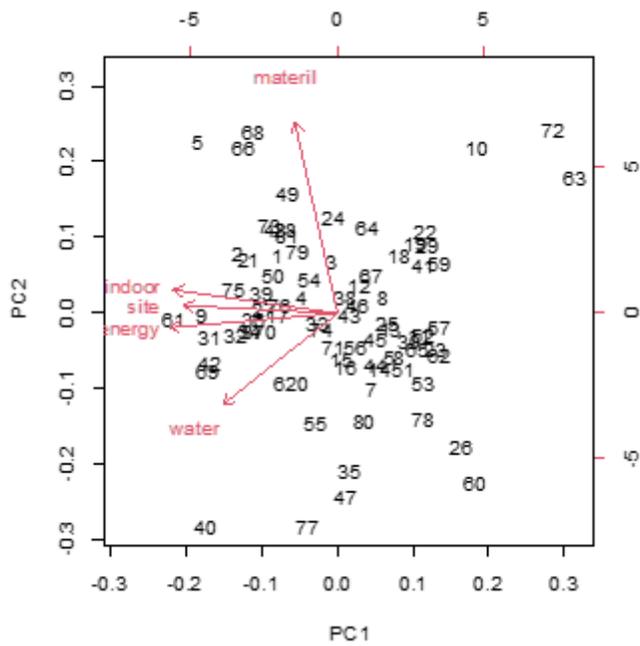


Figure 6

Significance of each of the standard green seasons based on the Biplot graph