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Analytic Hierarchy Process: An Application in Green Building Market Research[1]

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ABSTRACT: Sustainability has become a necessity in the building industry. In recent years, as the general public is more informed and aware of sustainability related issues, they are becoming major players in the decision making process regarding their built environment. However, there are still challenges with how sustainability is communicated to occupants and owners of buildings. As the global economic crisis is continuing, the marketing of green buildings needs to be refined to communicate the lifetime benefits of sustainability. One of the ways to develop effective marketing strategies, is to understand what the occupants value the most among many aspects of green buildings thus develop focused marketing solutions. Authors present a conceptual methodology using Analytic Hierarchy Process toward identifying consumer ranking and weights of a major green building rating system's categories. Authors use sample non-representative data to illustrate the proposed methodology, while sharing preliminary qualitative data from the research in progress.

Keywords: LEED; Sustainable Buildings; Sustainability Marketing; Occupant Value; Criteria Weightings; AHP
JEL Classifications: C44; D81; M31

1. Introduction

Sustainability efforts are comprised of complex criteria and require complex methods for decision analysis and support (Omann, 2004). Decision making in sustainability related research and practice is an important aspect of achieving the ultimate goals of sustainability. One of the challenges of decision-making in sustainability is due to its interdisciplinary nature, thus the existence of multiple quantitative and qualitative criteria when making a decision. To further add to the complexity of the issue, there are multiple stakeholders, involved in sustainability decisions, who have different perspectives and goals. Multi-criteria decision models can aid in identifying these differing perspectives.

Sustainability as it applies to the building industry generally involves the evaluation of buildings' performance based on design, construction, and operation phases in relation to achieving the goals previously defined by sustainability research. These goals can turn into decision-making criteria to evaluate the public perception of sustainable buildings. Although decision makers in commercial/institutional sustainable design and architecture are rarely the occupants of those buildings, the public as well as the building occupants are the ones that are mostly impacted by the sustainability decisions within buildings. Assuming decision-makers within building projects are ultimately searching for occupant satisfaction, it is crucial to determine the occupant perspective on

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sustainable buildings in order to develop strong marketing strategies for sustainable buildings. Assuring the occupants about the high value of green buildings can be difficult, and developing marketing strategies that take occupants' preferences into consideration can be a step towards the solution (Celik and Attaran, 2011).

Developing marketing strategies for sustainable buildings involves understanding the occupant perception of these buildings. The term "green building" is widely used as a response to sustainability concerns in the building industry. However, it is rarely researched, how building occupants, and the general public perceive green buildings. One of the ways to do so is to introduce the positive aspects of these buildings to a chosen audience and research how those aspects are ranked by the subjects when evaluating green buildings. The determination of characteristics of green buildings that occupants value the most can ultimately allow for the development of more targeted marketing strategies for green buildings to a defined group of occupants or even decision makers. With the lack of consumer knowledge regarding sustainable products and practices becoming a barrier for the implementation of such practices, it is important for the industry to facilitate awareness for consumers. By determining the criteria that consumers find important, marketers are better able to communicate the benefits that consumers really care about, promote sustainable products more efficiently, and therefore implement sustainable practices. Such information can help to differentiate products so as to promote their consumption, protect consumer interests by sharing ways to improve consumer well-being, support informed consumer choice so consumers are aware of the benefits of such products and to stimulate behavior change such as demand for sustainable buildings (OECD, 2001).

It is evident that in a multi-criteria decision-making problem, such as evaluating green buildings from various aspects, it is also important to determine how those criteria are weighted in the evaluation of various attributes. This paper demonstrates a methodology to determine the occupant or public perception of green buildings. The Leadership in Energy and Environmental Design (LEED) system and its five major green building categories are utilized as an example in this paper.

2. Literature Review

2.1 Consumer Decision Making for Sustainable Products

Consumers are exposed to information about products through multiple channels. This information is usually the basis for consumption decisions. Consumption choices involving sustainable products have more barriers than conventional products and can lead to more time spent in the decision making process. Consumer decision-making involves multiple steps. These steps include: need recognition, information search, evaluation of alternatives, and a final choice (Kotler and Keller, 2011). In order to complete this process, each stage involves a few prerequisites. First, consumers must be able to determine a need. If consumers do not know the value of green buildings, need creation may not be possible. Second, consumers search for information from previous experience with a product, brand loyalty, or price (Pickett-Baker and Ozaki, 2008). Since consumers often start with a low level of information about sustainable consumption (Pickett-Baker and Ozaki 2008), or a low brand recognition of LEED certification processes, then the internal search function may fail to supply enough information to make a decision. External search is then necessary. Picket-Baker and Ozaki (2008) found that consumers are unlikely to be exposed to communications about green consumer products and that better market communication will induce consumers to purchase green. Marketing green products is not easy as some research identifies that consumers are not engaged by pro-environmental product messages (Pickett-Baker and Ozaki, 2008). Pooley and O'Connor (2000) found that emotional appeals may be more successful as well as appealing to consumer values that drive consumer decision processes (WFA et al. 2002). Previous research indicates that consumers feel good about buying brands that are less damaging to the environment. Consumers want to be aware of the clear benefits (Alston and Prince Roberts, 1999) and how environmentally friendly products are. However, it is sometimes difficult for consumers to find this information and identify their options. Consumers may not be very aware of relevant or engaging marketing of green buildings, which could include information on the benefits of and improvements to their lives.

Green products are considered niche products so marketing influences from mass media are few (Charter et. al, 2002). Relatively few companies have the resources or product range to appeal to increasingly diverse lifestyles using mass media (Belz and Peattie, 2009). Therefore, consumers find it hard to move to the next step in the decision making process, the evaluation of alternatives. Awareness of product information and product alternatives is low and consumers lack the knowledge to evaluate alternatives based on importance of attributes or even decision rules.

Marketing sustainable products is challenging due to the complexity of the message that needs to be communicated. The message should increase the perceived net benefits of sustainable solutions as compared to conventional offerings by including such factors as the social and environmental attributes of a product and provide information about consumer benefits (Belz and Peattie, 2009). It is also helpful for marketers to mention the main buying criteria influencing the consumers' buying decision (Belz and Peattie, 2009). In order to make information retrieval easier for consumers a selection of the core information made of highly rated attributes can be transformed into simple advertising messages (Schrader, 2005). The key is to find what those important attributes are to consumers so that the message is crafted to precisely meet their needs and ultimately stimulate consumption decisions.

2.2. Decision Making in Sustainability Issues

Decision making in relation to sustainability involves various criteria including but not limited to social, economic, and environmental concerns. This generates decision-making problems with multi-criteria analysis that require particular methodologies to find solutions. For example, multi-Criteria Decision Making (MCDM) techniques are gaining popularity in sustainable energy management (Pohekar & Ramachandran, 2004). OECD Environmental Directorate Programme (OECD, 2001) discusses policy-making models in sustainable development. On a report based on an *Experts Workshop on Information and Consumer Decision-Making for Sustainable Consumption*, rational decision making is said to include two activities: knowing and evaluating (OECD, 2001). The report explores these two activities using subgroups: the identification of the possible alternatives; the selection of criteria by which to assess them; the assessment itself with respect to the criteria; the weighting of the criteria and; the aggregation of the partial assessment in an overall assessment (OECD, 2001). This procedure is similar to the methodology being used in this paper: Analytic Hierarchy Process (AHP).

AHP is a technique for analyzing complex decisions. Decisions are broken up into a hierarchy of sub-problems that can be analyzed by comparing them to one another two at a time. Since comparisons can be based on concrete data or human judgment, any issue related to the decision can be considered. Evaluations are then converted into numerical values with weights. Harker and Vargas (1987) explain the numerical evaluation process in their research on the theory of ratio scale estimation. Conversion to numerical weights allows diverse elements to be compared in a consistent and rational way, uncovering the marked advantage of using AHP over other decision-making techniques (Saaty, 2008).

2.3. Defining and Assessing Green Buildings

Mariasiu (2013) states that human industrial activity has unfortunately not remained without consequences to the environment, health and social society. One of the major activities of humans is the creation of a built environment. Building green is a response to the environmental, economic, and social consequences of the construction activities. The United States Environmental Protection Agency (US EPA) defines green building as "the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle from siting to design, construction, operation, maintenance, renovation and deconstruction" (US EPA, 2012). As the green building industry is further tailoring its definitions and missions, one challenge is to assess how buildings meet these definitions and at which levels. In order to respond to this challenge many government and non-profit agencies and organizations from various countries have been developing green building assessment and rating systems. USGBC, for example, introduced LEED in 2000 as a green building rating system that allowed commercial buildings to achieve green building certification at "certified", "silver", "gold", and "platinum" levels. Since 2000, LEED has evolved through various versions and is currently circulating version 4 (LEED v.4) for comments and voting by its members.

In addition to LEED, other systems exist in various countries such as the United Kingdom, Canada, South Korea, Germany, Australia, and Japan. Building Research Establishment's (BRE) Environmental Assessment Method (BREEAM) in the UK, or the Comprehensive Assessment System for Building Environmental Efficiency (CASBEE) in Japan are just a few examples. Many of these systems work in a similar logic in which the building owners are required to prove that their building is designed and constructed in a sustainable way. These rating systems often have various categories with a set number of points available from each. If a building can collect a certain number of points, those points are used to certify the building as green. These categories generally focus on the green building aspects such as site, water, energy, resources, and indoor environmental quality. Each of these categories is assigned a total number of points and credits that building owners can qualify for in order to collect those points. One of the advantages of the point system is that it quantifies the sustainability efforts of buildings and makes it a much easier process to evaluate and compare different buildings while assessing their level of sustainability. However, a disadvantage of the point system is an often unintentional set of importance on different aspects of green buildings. In other words, if there are more points available from one category than the other, it naturally generates an assumption that one is more important than the other. For example, BRE states in its BREEAM 2011 for Non-Domestic Buildings Technical Manual that it "uses an explicit weighting system derived from a combination of consensus based weightings and ranking by a panel of experts. The outputs from this exercise are then used to determine the relative value of the environmental sections used in BREEAM and their contribution to the overall BREEAM score" (BRE, 2011). Table 1 displays the results of this methodology as the current category weightings of the BREEAM 2011. Based on Table 1, it is plausible to state that expert panel utilized by BRE perceives the energy performance of a building as more important than its water management performance.

Another example of determining the value of various green building aspects is USGBC's use of the National Institute of Standards and Technology (NIST) process to compare LEED credits to environmental impact categories defined by the "Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts" (TRACI) (US EPA, n.d.). This allows the LEED system to determine a number of credits for each of its categories based on their impact on the environment (Table 2). Thus it is plausible to state that LEED puts different values on each of its green building categories based completely on environmental criteria. However, USGBC states its mission is "to transform the way buildings and communities are designed, built and operated, enabling an environmentally and socially responsible, healthy, and prosperous environment that improves the quality of life" (USGBC, 2008). One may find it conflicting that the importance of LEED categories is set from an environmental perspective, when USGBC's mission integrates environmental responsibility as only one of the few criteria in the transformation of the buildings.

Table 1. BREEAM 2011 for Non Domestic Buildings Rating System Categories and Weightings

Category	Weighting
Management	12%
Health & Wellbeing	15%
Energy	19%
Transport	8%
Water	6%
Materials	12.50%
Waste	7.50%
Land Use & Ecology	10%
Pollution	10%
Total	100%
Innovation (additional)	10%

Table 2. LEED v.3 for New Construction and Major Renovation Rating System Categories and Weightings

Category	Weighting
Sustainable Sites (SS)	26%
Water Efficiency (WE)	10%
Energy and Atmosphere (EA)	35%
Materials and Resources (MR)	14%
Indoor Environmental Quality (IEQ)	15%
Total	100%
Innovation in Design (ID) (Additional)	6.00%
Regional Priority (RP) (Additional)	4.00%

It is also critical to note that an important change from the most recent LEED rating system version 3 (LEED v.3), to a new upcoming LEED v.4, is that USGBC has been working on changing how they determine category weights. They also are changing the criteria they use in the process. This means that the weight of each LEED category on the final score of a building will not be determined only by the TRACI criteria. In the new LEED v.4 system, USGBC has developed a set of impact categories as the new criteria that more closely aligns with their mission and vision for ongoing LEED development (USGBC, 2011). The new criteria, or impact categories as USGBC refers to them, are listed below (USGBC, 2011):

- Reduce contribution to global climate change
- Enhance individual human health, well-being, and vitality
- Protect and restore water resources
- Protect, enhance, and restore biodiversity and ecosystem services
- Promote sustainable and regenerative material resource cycles
- Build a greener economy
- Enhance community: social equity, environmental justice, and quality of life.

This study acknowledges that the value of different aspects of green buildings, such as the ones used in LEED certification, can be perceived in many different ways depending on the perspective of the evaluating groups or individuals. As building owners, designers, and builders may have a difficult time communicating the value of green buildings in order to justify their often relatively higher initial costs, it is critical to identify methodologies that can be used to develop marketing strategies targeted to specific groups or individuals based on their unique perceptions of green buildings.

3. Conceptualization

This paper presents a demonstration of AHP methodology as it applies to ranking different LEED categories. The methodology behind AHP as it applies to LEED categories is illustrated in Figure 1. (SS: Sustainable Sites, EA: Energy and Atmosphere, WE: Water Efficiency, IEQ: Indoor Environmental Quality, MR: Materials and Resources).

The methodology in this paper aims to resolve the following challenges of multi-criteria decision making in green building marketing:

Step 1. Determine alternatives of different aspects of green buildings

Step 2. Select criteria that the occupants utilize when choosing between alternative green building aspects found in Step 1.

Step 3. Determine the weight of each criterion identified in Step 2.

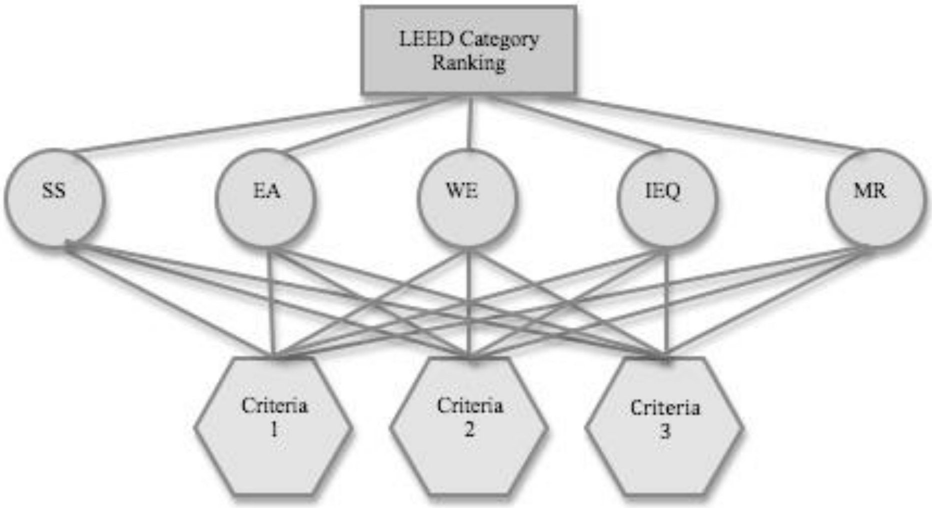
Step 4. Assess alternative aspects of green buildings (identified in Step 1), with respect to the criteria (identified in Step 2)

Step 5. Normalize and rank the alternative aspects of green buildings (identified in Step 1 and compared in Step 4), based on criteria (identified in Step 2), and the criteria weights (identified in Step 3) to calculate the importance of each alternative for each subject.

Step 6. Combine the final importance rates (identified in Step 5) for each subject to perform statistical analysis of a group's perceptions.

Each step in the proposed methodology is described in more detailed in the upcoming sections.

Figure 1. AHP methodology as it applies to ranking of LEED categories.



3.1. Determining Decision Alternatives from Different Aspects in Green Buildings

As discussed in the literature review section of this paper, determining aspects of green buildings is the initial step of the proposed methodology. These aspects are the basis of what defines a "green building". The demonstration of AHP methodology introduced in this paper uses five of the LEED v.3 categories as an example (See Table 2). This can be justified with the fact that LEED has become a significant assessment system in the US for certifying green buildings. Researchers or practitioners following the methodology introduced in this paper may choose to redefine these categories based on the specifics of their research. Determining decision alternatives from different aspects of green buildings can include using categories from different green building rating systems, or conducting survey analyses of specific populations in order to extract which aspects of green buildings could be analyzed. Following the steps introduced in this paper will help researchers rank these categories based on a set of criteria obtained from a specific group or individual to determine which attribute to emphasize in a certified green building marketing plan.

3.2. Selecting Criteria the Occupants Utilize When Ranking the Importance of LEED Categories

This step of the methodology requires researchers to identify the criteria that subjects utilize when making their choices between different categories of green buildings. For example, if an occupant believes that conserving water resources is more important than sustainable planning of a building's site management, there has to be one or more criteria while making that decision. This methodology offers two ways to execute this step:

- Utilize an existing criteria list
- Develop a survey with open ended questions to obtain criteria

Utilizing an existing criteria list can be achieved by conducting a literature review. Researchers can review existing literature to find information on what criteria is generally used in evaluation of green buildings. An example for this is USGBC's approach to criteria development for LEED ratings systems prior to version 2012. Before determining the importance of each category, LEED utilizes a TRACI model for the evaluation of categories. The Environmental Protection Agency (EPA) developed the TRACI model and some of the criteria described in the model are listed below (US EPA, n.d):

- Global Warming
- Cancer

- Fossil fuel use
- Land use
- Water use

It is also common for researchers to collect criteria from different resources to create a complete list of criteria that satisfies the needs of the specific decision making dilemma.

Developing a survey with open-ended questions is another way of creating a list of decision criteria. This method is more time consuming and requires a level of expertise in qualitative research. It would involve asking subjects which category of green buildings they value the most without providing any specific criteria to base their decision on. This would be followed by an open-ended question asking the subject the reasoning behind their decision. Authors administered multiple surveys with college students in order to explore the possibilities of using answers to open-ended questions as a means of developing criteria (Celik and Attaran, 2012). Example comments from subjects are given in Table 3 along with a potential criterion that can be extracted from each of these examples. Qualitative analysis software programs such as NVivo can be utilized by the researchers to code and analyze data similar to the ones given in Table 3 especially when the number of open-ended questions and responses increase. It is important to note that the subjects used in Table 3 were provided extensive information about the intent of LEED categories and were then asked to rank the importance of each category prior to being given open ended questions asking the reasons behind their ranking selections.

Table 3. Example comments from previous research with open-ended answers to ranking the importance of different green building categories

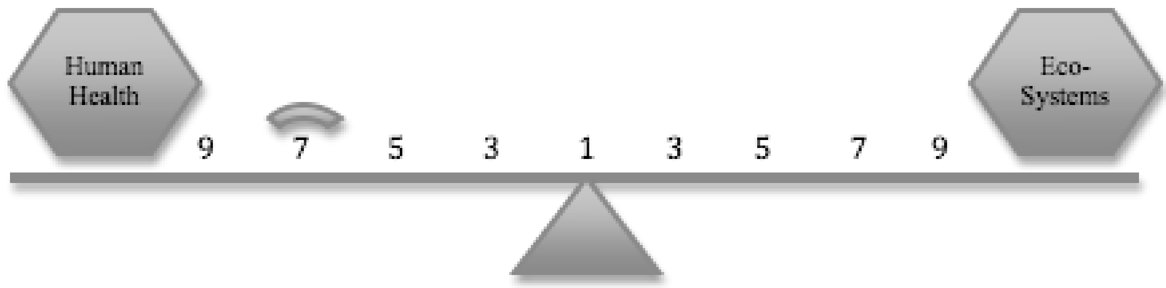
User Comment	**Potential Criteria (Concern)**
"*I would want to know that the buildings I am in do not harm my health in any way, shape, or form*"	Human health
"Buildings are contributing to harming the ozone layer for not only my generation but for future generations"	Future Generations
"I believe that part of my tuition goes to the school's social responsibility and its image to the outside world"	Public image
"Landfills are a major issue as they are sources of pollution that can have detrimental impacts upon the surrounding area"	Environment

3.3. *Determining the Weight of Each Criteria*

This step of the methodology requires the criteria identified in Step 2 to be weighted against one another. In an AHP model, researchers can assume that although there might be multiple criteria when making a decision, not all the criteria may have the same impact on the final decision. It is then the task in this step to determine the criteria weights as perceived by the building occupants.

In order to accomplish this step, researchers can use the AHP methodology along with a survey in which occupants can complete pair-wise comparison of all identified criteria. Subjects are given a scale and asked to choose a certain point on the scale based on which criteria they weigh more heavily. Figure 2 illustrates an example of a scale that is commonly used in AHP.

Figure 2: Example scale to be used in criteria comparison surveys



By completing the pair-wise comparison of all criteria, researchers can build a matrix similar to the one given in Figure 3 for each unique subject. Microsoft Office Excel (MS Excel) or similar spreadsheet programs can be utilized for AHP calculations. Although there are commercial software available for AHP calculations these programs can be expensive and may have many limitations such as a maximum number of subjects or data entry. The advantage of MS Excel is its flexibility in data entry and its wide availability for faculty, student, or industry researchers. One disadvantage of MS Excel is the requirement to complete the AHP calculations individually for every single subject. Once the criteria matrix is created on a spreadsheet the researcher can enter the comparison data received from each subject as illustrated in the example given in Figure 3. Assuming the data illustrated in Figure 3 is actual data, when "Human Health" criterion receives a score of 7, "Preserving Ecosystems" criterion would automatically receive the reciprocal, 1/7. The number of comparisons that each subject needs to complete can be calculated as:

$$\frac{1}{2}n(n-1) \tag{1}$$

Here n represents the number of criteria evaluated.

Figure 3. Pair-wise comparison of criteria

	G	H	I	J	K
1	SUBJECT #1 Input	Future Generations	Environment	Health & Comfort	Public Image
2	Future Generations	1.00	0.14	0.20	2.00
3	Environment	7.00	1.00	0.14	7.00
4	Health and Comfort	5.00	7.00	1.00	9.00
5	Public Image	0.50	0.14	0.11	1.00
6	SUM	13.50	8.29	1.45	19.00

Figure 4. Normalized and final criteria weights using MS Excel formulas

	G	H	I	J	K	L
1	SUBJECT #1 Input	Future Generations	Environment	Health & Comfort	Public Image	
2	Future Generations	1	=1/H3	=1/H4	2	
3	Environment	7	1	=1/I4	7	
4	Health and Comfort	5	7	1	9	
5	Public Image	=1/K2	=1/K3	=1/K4	1	*Number of*
6	SUM	=SUM(H2:H5)	=SUM(I2:I5)	=SUM(J2:J5)	=SUM(K2:K5)	*Criteria*
7						
8	SUBJECT #1 Normalized	Future Generations	Environment	Health & Comfort	Public Image	WEIGHTS
9	Future Generations	=H2/H$6	=I2/I$6	=J2/J$6	=K2/K$6	=SUM(H9:K9)/4
10	Environment	=H3/$H$6	=I3/I$6	=J3/J$6	=K3/K$6	=SUM(H10:K10)/4
11	Health and Comfort	=H4/$H$6	=I4/I$6	=J4/J$6	=K4/K$6	=SUM(H11:K11)/4
12	Public Image	=H5/$H$6	=I5/I$6	=J5/J$6	=K5/K$6	=SUM(H12:K12)/4
13	SUM	=SUM(H9:H12)	=SUM(I9:I12)	=SUM(J9:J12)	=SUM(K9:K12)	=SUM(L9:L12)
14						
15	**ECOSYSTEMS**	**=L10/(L10+L11)**				
16	**HEALTH**	**=L11/(L10+L11)**				

Once all comparisons are completed for the subject, values given to each criterion are normalized and converted into a percentage criteria weight. Normalizing each cell is achievable if the cell is divided by the sum of the entire column. The formulas for normalization and the overall results of the sample data are shown in Figure 4. In this case, researchers can choose to eliminate the criteria that have considerably small values. For instance, looking at Figure 5 reveals that the criteria weight for "Future Generations" and "Improved Public Image" is considerably less than "Preservation of

Ecosystems" and "Human Health". If the researchers want to eliminate the two low weighted criteria from the research, they can do so by normalizing values of the criteria with higher weights.

Figure 5. Final criteria weights after normalization and elimination

	G	H	I	J	K	L
8	SUBJECT #1 Normalized	Future Generations	Environment	Health & Comfort	Public Image	WEIGHTS
9	Future Generations	0.07	0.02	0.14	0.11	8%
10	Environment	0.52	0.12	0.10	0.37	28%
11	Health and Comfort	0.37	0.84	0.69	0.47	59%
12	Public Image	0.04	0.02	0.08	0.05	5%
13	SUM	1.00	1.00	1.00	1.00	100%
14						
15	**ECOSYSTEMS**	**32%**				
16	**HEALTH**	**68%**				

3.4. Assessing Alternative Aspects of Green Buildings with Respect to the Criteria

This step of the methodology is very similar to the previous one in terms of mathematical calculations. In this step, subjects do a pair-wise comparison between green building aspect alternatives. However, unlike the survey example mentioned in the second step, subjects are given selected criteria to consider while making their choices. Referring to Figure 2, instead of having two different criteria on the sides of the scale, LEED categories will be on each side, along with a criterion in mind. For example, subjects will choose which LEED category they favor more when it comes to "Preserving Ecosystems". They will then be asked the same question for "Human Health" criterion.

As discussed earlier, it is very important to inform the subjects of all characteristics and intent of each LEED category prior to the pair-wise comparison. On the other hand, alternative future research should explore the correlation between rankings of LEED categories based on prior knowledge about the green building industry. In that case, it is acceptable to choose different subject groups with different levels of green building education to prove a correlation among ranking patterns.

Figure 6 illustrates an example of the pair-wise comparison as well as the normalized and final importance values for each LEED category.

3.5. Finalizing the Ranking of Alternative Aspects of Green Buildings

In this final step of the methodology, weighting of each green building aspect (LEED categories) is combined for a final weighting and ranking. The final results from the example data, as can be seen in Figure 7, show that Indoor Environmental Quality is the most important criteria based on the example data, with a score of 39.9%. This step exposes the occupant perspective (or any other specific population in other studies) on different LEED categories. The significance of achieving this and its contribution to the researchers' on-going research project toward determining marketing strategies for green buildings will be discussed in the conclusion section of this paper.

3.6. Combine the Final Importance Rates for Each Subject to Assess a Group's Perceptions

Once the importance rates of each alternative (LEED categories) are determined for each subject, results from each subject are combined to perform various statistical analyses. This allows researchers to bring data from each subject using AHP into a more conventional statistical setting. Eventually the researcher may be able to make conclusions regarding a larger group. However, it is critical to note that this process can be lengthy, as the steps illustrated in this paper have to be completed for every single subject in a specific sample. Although there are various software programs commercially available for this person, as mentioned previously in this paper, these programs may require extensive training, financial commitment, and most of the time a maximum amount of subjects that can be included in the calculations. MS Excel, as a widely available software program along with basic AHP calculations can offer full control over data and in some cases the only opportunity to complete analyses such as the ones covered in this study.

Figure 6. Normalized and final LEED category weights based on various criteria

	G	H	I	J	K	L	M
28	IMPORTANCE OF LEED CATEGORIES BASED ON ENVIRONMENTAL CRITERIA						
29	SUBJECT #1 Input	EA	WE	SS	IEQ	MR	
30	EA	1.00	0.33	5.00	9.00	5.00	
31	WE	3.00	1.00	3.00	9.00	0.33	
32	SS	0.20	0.33	1.00	9.00	3.00	
33	IEQ	0.11	0.11	0.11	1.00	0.11	
34	MR	0.20	3.00	0.33	9.00	1.00	
35	SUM	4.51	4.78	9.44	37.00	9.44	
36							
37	SUBJECT #1 Normalized	EA	WE	SS	IEQ	MR	WEIGHT
38	EA	0.22	0.07	0.53	0.24	0.53	32%
39	WE	0.67	0.21	0.32	0.24	0.04	29%
40	SS	0.04	0.07	0.11	0.24	0.32	16%
41	IEQ	0.02	0.02	0.01	0.03	0.01	2%
42	MR	0.04	0.63	0.04	0.24	0.11	21%
43	SUM	1.00	1.00	1.00	1.00	1.00	1.00
51							
52	IMPORTANCE OF LEED CATEGORIES BASED ON HEALTH CRITERIA						
53	SUBJECT #1 Input	EA	WE	SS	IEQ	MR	
54	EA	1.00	3.00	5.00	0.14	7.00	
55	WE	0.33	1.00	3.00	0.14	7.00	
56	SS	0.20	0.33	1.00	0.11	5.00	
57	IEQ	7.00	7.00	9.00	1.00	9.00	
58	MR	0.14	0.14	0.20	0.11	1.00	
59	SUM	8.68	11.48	18.20	1.51	29.00	
60							
61	SUBJECT #1 Normalized	EA	WE	SS	IEQ	MR	WEIGHT
62	EA	0.12	0.26	0.27	0.09	0.24	20%
63	WE	0.04	0.09	0.16	0.09	0.24	13%
64	SS	0.02	0.03	0.05	0.07	0.17	7%
65	IEQ	0.81	0.61	0.49	0.66	0.31	58%
66	MR	0.02	0.01	0.01	0.07	0.03	3%
67	SUM	1.00	1.00	1.00	1.00	1.00	1.00

Figure 7. Normalized and final LEED category rankings (formulas on left)

	G	H	I	J	K
76	SUBJECT #1 FINAL RANKINGS OF LEED CATEGORIES				
77			CRITERIA		COMBINED SCORES
78			ENVIRONMENT	HEALTH	
79		Crit. Weight	=H15	=H16	
80	LEED CATEGORIES	EA	=M38	=M62	=I80*$I$79+J80*$J$79
81		WE	=M39	=M63	=I81*$I$79+J81*$J$79
82		SS	=M40	=M64	=I82*$I$79+J82*$J$79
83		IEQ	=M41	=M65	=I83*$I$79+J83*$J$79
84		MR	=M42	=M66	=I84*$I$79+J84*$J$79

	G	H	I	J	K
76	SUBJECT #1 FINAL RANKINGS OF LEED CATEGORIES				
77			CRITERIA		COMBINED SCORES
78			ENVIRONMENT	HEALTH	
79		Crit. Weight	32%	68%	
80	LEED CATEGORIES	EA	32%	20%	23.6%
81		WE	29%	13%	17.9%
82		SS	16%	7%	9.8%
83		IEQ	2%	58%	40.0%
84		MR	21%	3%	8.7%

4. Conclusion

It has been a challenge for many green building rating systems such as LEED to determine which aspect of a building's sustainability is more or less important. Most rating systems utilize the environmental impact of each aspect of a building or interview a panel of experts to determine importance levels for those aspects. As many developers are still struggling with perceptions that green buildings have higher initial costs, it becomes critical to identify what aspects of these buildings are considered more important, especially by the people who will be buying it or living in it. In this paper, an AHP methodology is described in detail as it can be applied in green building market research. The graphics shown regarding the AHP method are developed based on non-representative sample data. The goal of the paper is to illustrate the proposed methodology rather than present rankings of LEED categories. Based on a review of the literature, there are limited results of similar investigations in the building industry.

Understanding the client and the occupants is the first step in the development of responsible, efficient, healthy, and functional projects. LEED-certified buildings create less waste; use less energy, water and natural resources; and are overall healthier and more comfortable for occupants. Some of the benefits of a LEED building include lower utility bills, reduced impact on the environment, and less exposure to indoor toxins such as mold (USGBC). In order to further persuade consumers to try sustainable products, consumers must learn these benefits of sustainability through the use of promotional strategies such as product literature or production demonstrations (Belz and Peattie, 2009). This can help lower perceived risk associated with purchases of high cost products such as investing in a green home. This study is significant, as it will help develop more effective marketing strategies for green buildings. Using this methodology, architecture and construction companies will be able to provide insightful implications when promoting sustainable practices.

It is important for future studies to focus on new methodologies that offer speed and accuracy in determining perceptions of building owners and occupants. It is also critical to create tools such as software programs that are more accessible, easier to use, and accurate to make the assessment process smoother and decrease the number of potential mistakes throughout the mathematical calculations. It is important for future studies to expand similar approaches to different populations, thus fill potential gaps of information in the building industry regarding occupant satisfaction.

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