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A methodological framework to analyze stakeholder preferences and propose strategic pathways for a sustainable university

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Abstract Building sustainable universities calls for participative management and collaboration among stakeholders. Combining analytic hierarchy and network processes (AHP/ANP) with statistical analysis, this research proposes a framework that can be used in higher education institutions for integrating stakeholder preferences into strategic decisions. The proposed framework is applied to a private university in Turkey as a case study through a survey of 30 participants, representing key internal stakeholder groups. The present research extends the literature by adding a statistical analysis component involving a diverse sample of stakeholders, while previous applications of AHP/ANP in higher education involve a single or a few decision makers. The survey demonstrates stakeholder priorities with respect to sustainability performance indicators and a set of investment projects as well as how they change under low, medium and high financial constraints. The study finds that, while stakeholders have varying opinions regarding sustainable development, generally their highest priority is teaching, followed closely by research. Further, although stakeholders assign a high priority to environmental initiatives when the concern is service and social responsibility, they do not consider such investments profitable. Lastly, it appears that "high visibility" projects gain priority as the level of financial constraint increases.

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Introduction

In the eleventh and twelfth centuries, universities were established as teaching institutions. Modern research universities emerged in the nineteenth century as production of scientific knowledge gained significance and research became a core activity of universities. In the 1990s, increasing usage of scientific knowledge for economic benefit induced the entrepreneurial university approach (Slaughter and Leslie 1997; Etzkowitz 2004). Therefore, efficiency became a concern for universities, and various measurement systems focusing on teaching and research performance became prevalent (Ball and Halwachi 1987).

More recently, the sustainable university has been proposed as an alternative to entrepreneurial universities (Weenen 2000). In addition to the economic contribution, benefits of environmental and social responsibility practices such as improved reputation (Shriberg 2002) have gained recognition, and the entrepreneurial model based on economic interests has become inadequate (Yarime et al. 2012; Subotzky 1999). Velazquez et al. (2006) define a sustainable university as "a higher educational institution, as a whole or as a part, that addresses, involves and promotes, on a regional or a global level, the minimization of negative environmental, economic, societal, and health effects generated in the use of their resources in order to fulfill its functions of teaching, research, outreach and partnership, and stewardship in ways to help society make the transition to sustainable lifestyles."

Axelsson et al. (2008) and Filho (2011) point to the leadership role of universities in sustainable development. International declarations such as Talloires (1990), signed by world universities, support their view. Accordingly, researchers develop comprehensive performance measurement systems, taking into account environmental and social as well as teaching and research aspects (Madeira et al. 2011). Various studies address sustainability practices at universities using such systems. For instance, from the environmental perspective, Rauch and Newman (2009) analyze the institutional commitment to greenhouse gas reduction at Yale University. Similarly, from the social side, Wals and Jickling (2002) and Kurland (2014) emphasize cultural diversity, ethics and participative management as prerequisities for sustainability.

Although participation is necessary, it is a challenging task as sustainability is complex, and conflicts with the norms, values and objectives of stakeholders are accentuated in the process (Freeman 1984; Benneworth and Jongbloed 2010). While faculty members try to maintain academic standards, and students usually demand high-quality education, preferably without paying, management is charged with producing more by spending less, and the voice of other stakeholders such as the local community is typically missed. Toakley and Aroni (1998) and Geertshuis (2009) mention the growing need for comprehensive participation methods in higher education to deal with emerging problems related to nature, people and economies.

This research aims to contribute to the literature by proposing a framework to analyze stakeholder preferences and propose strategic pathways for a sustainable university. This framework provides an unbiased, formal tool to involve all relevant stakeholders in managerial decisions, thus increasing the quality and acceptance of strategic choices. Such an involvement is significant as it enables universities to become models for sustainable

development. The proposed framework involves two steps. First, the analytic hierarchy and network processes (AHP/ANP) are used to collect stakeholder perception data and to determine stakeholder priorities with respect to sustainability performance indicators and a set of alternative investment projects. Then, statistical analyses are performed to investigate differences in stakeholder perspectives. The output of the process can be used for conflict resolution among stakeholders and is also an input for resource allocation and investment planning to optimize the satisfaction levels of stakeholders.

This research also aims to contribute by yielding empirical information regarding the sustainability perception of stakeholders in higher education since the framework is applied to a private university in Turkey as a case study (Istanbul Kemerburgaz University 2014). A survey is conducted with representatives of internal stakeholders, including graduate and undergraduate students, faculty, administrative staff and management, and the results are analyzed by considering three research questions highlighted in the extant literature. Moore (2005) notes that university communities rarely discuss the meaning of universities' traditional activities, although such a dialogue is essential for sustainability. Hence, the first research question asks what the priorities among these activities and related sustainability indicators are when the objective is to develop a sustainable university model. Using these priorities, it further examines which projects improve the university's overall sustainability performance. On the other hand, the second research question compares the perspectives of stakeholder groups and investigates significant differences among them. Finally, the third research question examines how stakeholder priorities change under low, medium and high financial constraints, touching on the debate whether universities should be public, private-not-for-profit or private-for-profit (Carbone and Winston 2004).

The following section supplies a literature review. The methodology section explains the AHP/ANP methods and the statistical tests employed. The case study section involves model development, data collection, statistical analyses, managerial implications and implementation experience. The article concludes with a discussion of the limitations and future research directions.

Literature review

Participative management is discussed in higher education literature in the context of shared governance. While shared governance is widely practiced, its interpretations vary among institutions (Heaney 2010). Researchers agree that shared governance is essential to the success of modern universities albeit in an updated form (Taylor 2013; Kurland 2014). University governance is a complex issue involving many challenges. Academic freedom, accountability, legitimacy, participation, environmental responsiveness and budgetary constraints are among the issues to be resolved. Heaney (2010) argues that universities today face a tension between the need to respond quickly and the need to increase involvement. Whereas centralized decisions enhance speed and flexibility, participative decisions ensure stability and legitimacy (Masten 2006). Luescher-Mamashela (2013) emphasizes the necessity of student involvement in university governance, while recognizing the difficulty of clearly defining their roles as political constituents, consumers/co-producers and community members. As Heaney (2010) points out, parties held accountable for decisions should also have the authority to make them, and even though all stakeholders may be involved in governance, different levels and types of decisions

demand different distributions of authority. Researchers seem to agree that revised, comprehensive and probably more complex forms of shared governance are needed. Nevertheless, the literature lacks specific recommendations on how to achieve such a model in practice. AHP and ANP as group decision support tools have the potential to solve some of the above-mentioned challenges.

The literature provides several applications of AHP/ANP in higher education. Saaty and Ramanujam (1983), Troutt and Tadisina (1992) and Liberatore and Nydick (1997) utilize AHP in decisions related to faculty promotion and article evaluation. Koksal and Egitman (1998), Raharjo et al. (2007) and Asif and Searcy (2014) use AHP in the context of education quality and excellence. Benjamin et al. (1992) and Begičević et al. (2007) benefit from AHP in infrastructure and facility layout planning. Canada et al. (1985) and Tadisina and Bhasin (1989) apply AHP for personal decisions such as career choice.

Similarly, Begičević et al. (2007) employ ANP to prioritize research projects. Asan and Soyer (2009) develop an ANP model to determine strategic concepts for their academic unit. Mahdavi-Mazdeh et al. (2013) use ANP to rank universities in terms of their entrepreneurship intensity, and Cortés-Aldana et al. (2009) utilize AHP/ANP to evaluate technology transfer mechanisms.

All these studies provide well-structured applications of AHP/ANP. However, they seem to be restricted in providing an actual participative environment since these studies involve a single or a few decision makers. In contrast to previous studies, the present research emphasizes participation and group decision, and it combines AHP/ANP with statistical analysis. Accordingly, the case study involves multiple representatives from different stakeholder groups, extending the literature not only methodologically, but also in scope.

From the perspective of stakeholder perceptions in higher education regarding sustainability, the literature also provides a limited number of examples. One of the pioneer researchers in this field, Wright (2010) investigates how university presidents conceptualize sustainability and the role of universities. She finds that the majority of presidents are dedicated to sustainable development, but they are less familiar with the sustainable university concept. She identifies the most significant barriers to sustainability as financial predicaments, lack of awareness and resistance to change.

Other researchers study the perspective of faculty. Reid and Petocz (2006) examine the relationship between teaching and sustainability. Shephard and Furnari (2013) detect significantly different viewpoints about education for sustainability among the faculty, ranging from advocacy to opposition. Wright and Horst (2013) explore what constitutes a sustainable university and conclude that universities should incorporate sustainability in the avenues of education, research and daily operations and that financial constraint is the major barrier.

Finally, some researchers analyze students' perception. While Kagawa (2007) finds that most students associate sustainability with environmental rather than economic and social aspects, Jones et al. (2013) identify that social networks and institutional trust are important factors for the implementation of environmental initiatives.

Even though these studies present interesting results, they have some limitations, involving the methodologies as well as content. First, most of these studies employ interviews and questionnaires without any formal tool for a fair and analytical integration of different perspectives into decision making. This research proposes a systematic framework that enables group decisions, allowing the aggregation of stakeholder priorities in an unbiased and analytical manner. Second, the content of these studies is somewhat limited such that they focus only on a single stakeholder group, without providing any

opportunity to compare different groups. In contrast, the present research is one of the first studies revealing the perception of each stakeholder group separately and comparing them from a statistical perspective. Finally, as mentioned previously, this research examines how stakeholder priorities change under low, medium and high financial constraints, providing insights into whether universities should be externally funded or funded by the income from their operations.

Methodology

The analytic hierarchy and network processes

The analytic hierarchy process (AHP) is a multi-criteria decision-making tool (Saaty 1995), enabling evaluation and prioritization of alternatives with respect to a goal and criteria set. It involves four stages:

Model development: For a given multi-criteria problem, a decision hierarchy is created by placing the goal at the top, alternatives at the bottom and decision criteria in between, without assuming any dependency or feedback mechanism among them.
Pairwise comparisons: The decision maker performs pairwise comparisons by assigning relative weights to the model entities—the goal, criteria set and alternatives—by considering the immediate upper level model entity. In these assignments, the fundamental scale of absolute numbers (Saaty 1995) is used to measure the intensity of importance. The numbers 1, 3, 5, 7 and 9 on the scale correspond to the verbal judgments of equal, moderate, strong, very strong and extreme importance, respectively (with 2, 4, 6 and 8 for compromise between two values). Applying redundant pairwise comparisons, the decision maker is forced to make consistent judgments, where a consistency ratio (CR) of 0.1 or lower is considered acceptable.
Priority calculation: The model is synthesized by summing up assigned weights throughout the hierarchy. An alternative's final priority represents its relative contribution to the goal compared to other alternatives with respect to the criteria set employed.
Sensitivity analysis: A sensitivity analysis may be performed to observe how the changes in pairwise comparisons affect the final priorities.

For some real-life applications, AHP is inadequate as it only provides a hierarchical structure. To handle this, the analytic network process (ANP) has been developed (Saaty 2005). Although ANP has the same basis as AHP, it provides a network structure composed of subnetworks and submodels, allowing dependency and feedback mechanisms.

There are several criticisms of AHP/ANP, such as the large number of pairwise comparisons (Olson et al. 1995) and rank reversal (Gass 2005). Although the recent literature provides extensions of AHP/ANP to overcome some of these criticisms (e.g., Wang and Elhag 2006), the original forms of AHP/ANP are adopted in this research as they generate consistent results with relatively simple calculations, integrate both technical and psychological aspects of decisions, and allow aggregation of preferences impartially. In this aggregation process, the weighted geometric mean method (WGMM) is used since it is recommended that WGMM be used when the group acts together as a new individual or unit (Escobar and Moreno-Jiménez 2007).

Statistical analysis

Although WGMM is used for aggregating individual preferences, the statistical analyses are based on the arithmetic means of priorities since a particular stakeholder's priority for a model entity is considered a separate data point.

The analyses performed comprise both parametric (Maxwell and Delaney 2004) and nonparametric (Siegel and Castellan 1988) tests. It is considered that the independency assumption is satisfied as survey participants are sampled in a stratified random procedure. To compare multiple sample means, one-way analysis of variance (ANOVA) is used together with Tukey's HSD (honestly significant differences). If the normality assumption holds, and equal variance assumption does not hold, Welch's test is utilized together with the Games-Howell test. If neither normality nor equal variance assumptions hold, the Kruskal-Wallis test is employed together with the Mann-Whitney *U* test.

To compare two-sample means, the two-independent-sample pooled *t* test is used. If the normality assumption holds but the equal variance assumption does not hold, the two-independent-sample unpooled *t* test is utilized, and where the normality assumption does not hold, the Mann-Whitney *U* test is employed. In addition, when two dependent samples are compared, the paired *t* test is applied as long as differences between paired means are normally distributed. Finally, to check normality and equal variance assumptions, Kolmogorov-Smirnov and Levene's tests are adopted, respectively.

Case study

Istanbul Kemerburgaz University is a private university founded in 2011. At the time of data collection, it had seven schools: Arts and Sciences, Engineering and Architecture, Economics and Administrative Sciences, Fine Arts and Design, Law, Pharmacy and Foreign Languages.

Case studies are detailed analyses of real or hypothetical situations, and there are various approaches to such research (Bassey 1999). The present case is interesting as it pertains to a new institution, and the formal and informal procedures, roles, relational ties and power distribution among the members of organization have not yet calcified. This case also incorporates junior members of the university community, such as assistant professors, administrative staff and students, who are typically underrepresented or not represented at all in university governance in Turkey. Further, Turkish higher education institutions face intense competition today as the number of universities has increased from 52 (2 of them private) to 175 (71 of them private) within the last 20 years (Turkish Higher Education Council 2013).

The case study involves prioritization of five projects:

P1. Building a conference hall and a sports facility (Conference Hall)
P2. Establishing a career center (Career Center)
P3. Establishing labs and library system with state-of-the-art technology (Labs & Library)
P4. Investing in human resources, service quality and internationalization (HR & Intl)
P5. Minimizing the environmental impact of the campus (Envl Impact)

To minimize the number of pairwise comparisons, and hence the effort spent on data collection, a compact but comprehensive AHP/ANP model was needed. Thus, the research

team first generated a list of 25 projects and then reduced the number to 5 by grouping similar projects after discussions with other faculty members. For instance, projects such as material recycling, forestation, waste disposal management, low-emission transportation, and efficient use of energy, water and land were grouped under Envl Impact (P5). Second, to evaluate these projects with respect to their contribution to the university's sustainability, four main performance criteria were adopted: Teaching, Research and Development (R&D), Service and Social Responsibility (SSR) and Finance. Again, the research team created a long list of subcriteria for each main criterion and reduced the list through interviews with faculty, considering the current needs of the university, expectations of the Turkish Higher Education Council (2013), and the literature covering higher education studies, sustainability research and popular university rankings (e.g., Ruben 1999; Madeira et al. 2011; Times Higher Education 2013). Finally, a structured model was developed by connecting each subcriterion with the projects considered to have a direct impact on it. Thus, the selected subcriteria and the projects connected to them are as follows:

Teaching

Average Graduate Salary: Career Center (P2), Labs & Library (P3), HR & Intl (P4)
Faculty/Student Ratio: HR & Intl (P4)
Number of Students Following Graduate Study: Career Center (P2), Labs & Library (P3), HR & Intl (P4)
Overall Student Satisfaction: Conference Hall (P1), Career Center (P2), Labs & Library (P3), HR & Intl (P4), Envl Impact (P5)

R&D

External Research Grants and Awards: Career Center (P2), Labs & Library (P3), HR & Intl (P4)
Number of Graduate Programs: Labs & Library (P3), HR & Intl (P4)
Number of Refereed Publications: Labs & Library (P3), HR & Intl (P4)
Qualification of Graduate Students: Career Center (P2), Labs & Library (P3), HR & Intl (P4)

SSR

Employee Satisfaction: Conference Hall (P1), Labs & Library (P3), HR & Intl (P4), Envl Impact (P5)
Environmental Footprint: Envl Impact (P5)
Local Community Collaboration: Conference Hall (P1), Career Center (P2), HR & Intl (P4), Envl Impact (P5)

Finance

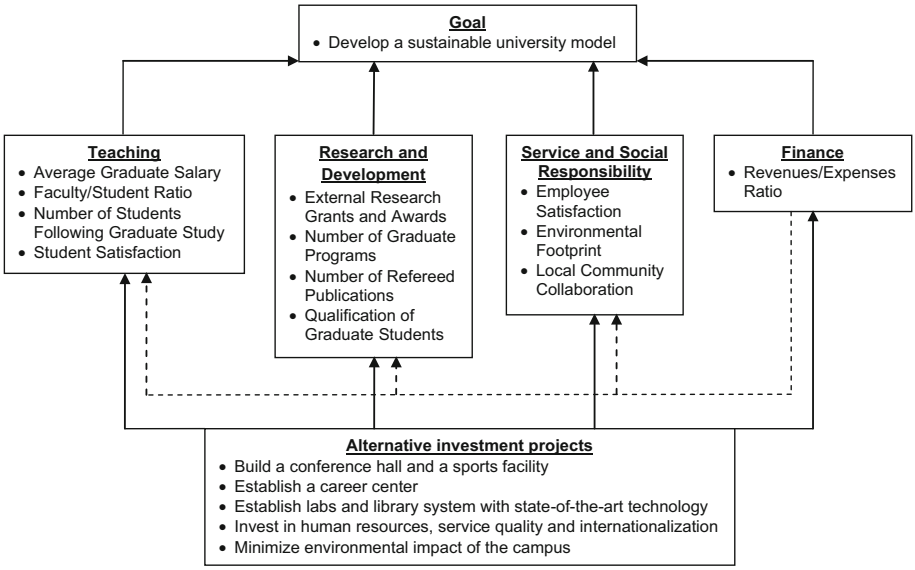

Fig. 1 The AHP/ANP model

Table 1 Survey participants

Stakeholders	Size	Female	Male	Age	ADMIN	SAS	SEA	SEAS	SFAD	SL	SP	SFL
Undergraduate	6	3	3	20.0		x	x	x	x		x	
Graduate	5	2	3	29.2			x	x		x		
Faculty	7	4	3	34.1		x	x	x	x	x	x	x
Management	6	2	4	53.0			x	x			x	x
Administrative staff	6	3	3	33.5	x							
Aggregate	30	14	16	34.1	x	x	x	x	x	x	x	x

ADMIN Administrative staff, *SAS* School of Arts and Sciences, *SEA* School of Engineering and Architecture, *SEAS* School of Economics and Administrative Sciences, *SFAD* School of Fine Arts and Design, *SL* School of Law, *SP* School of Pharmacy, *SFL* School of Foreign Languages

Revenues/Expenses Ratio: Conference Hall (P1), Career Center (P2), Labs & Library (P3), HR & Intl (P4), Envl Impact (P5)

Figure 1 shows the AHP/ANP model developed. The model also involves a dependency mechanism from the Finance criterion to the other three main performance criteria (dashed lines) to represent the potential impact of financial predicaments on sustainability performance, as identified by Wright (2010) and Wright and Horst (2013).

The study involves a diverse group of stakeholders. As seen in Table 1, each group was represented by 5 to 7 participants, leading to a sample size of 30, while at the time of data collection, the numbers of employees and students were about 150 and 1500, respectively. To determine how participants prioritize alternative projects and criteria with respect to the goal without any bias or misinterpretation, a document explaining the five projects and the overall sustainability objective of the university was e-mailed to the participants in

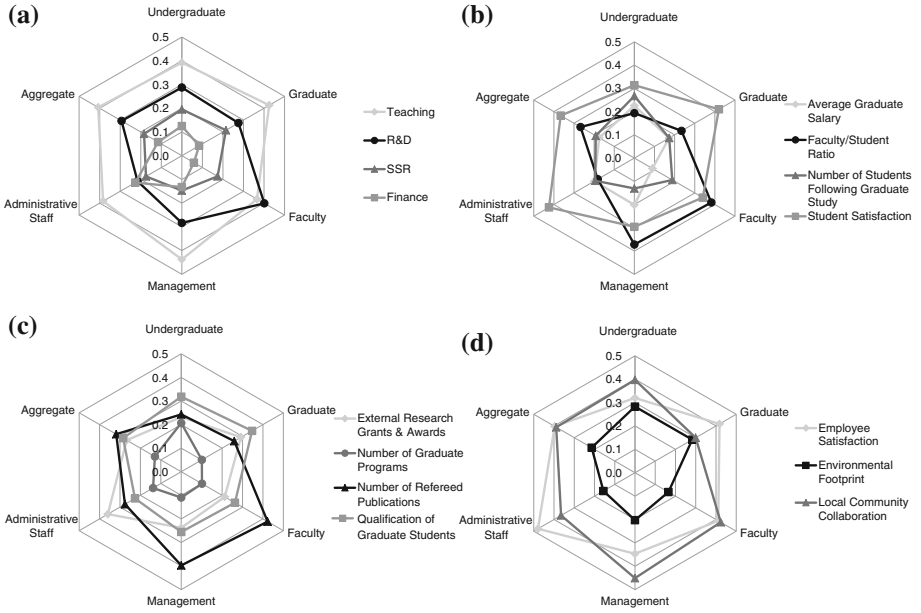

Fig. 2 Criteria priorities. **a** Main criteria; **b** Teaching subcriteria; **c** R&D subcriteria; **d** SSR subcriteria

advance. AHP/ANP sessions were held separately with each participant not only to avoid friction or influence, but also to provide a sufficient explanation about the methodology, projects, criteria and sustainability. With assurance of confidentiality, the participants were asked to complete a computer-based questionnaire using SuperDecisions (2013) (see Tables 3, 4, 5 in "Appendix" for calculation details), having 67 pairwise comparisons. If the respondent exceeded the 0.1 CR level, he/she was asked to review his/her responses. The time spent for each session was 60 min on average, and data collection lasted from November 2012 to June 2013.

Results

Figure 2 shows the priorities for main performance criteria and corresponding subcriteria.

Figure 3 presents the project priorities with respect to Teaching, R&D, SSR and Finance criteria as well as the overall sustainability goal.

Figure 4 demonstrates the changes in aggregate project priorities under financial constraint.

The statistical analysis of results was performed using IBM-SPSS software (2014), assuming a 0.05 significance level. Although different approaches to statistical testing can be adopted, first multiple sample tests were used together with corresponding post hoc tests. In the cases where no significance was found, criteria, projects or stakeholders having similar priorities were grouped, and then two sample tests were utilized. Table 2 provides the significant findings for aggregate groups as well as the significant differences among stakeholder priorities. Table 2 also reveals the impact of financial constraint on stakeholder preferences (see Table 6 in "Appendix" for deriving the priorities of the main performance criteria under financial constraint).

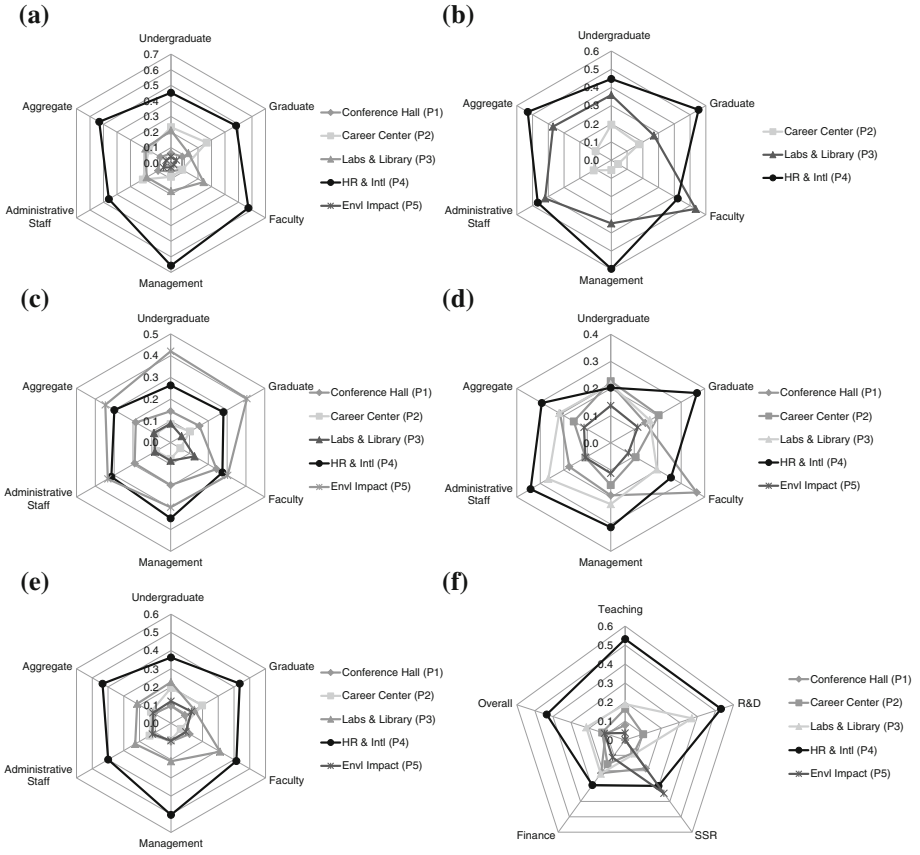

Fig. 3 Project priorities with respect to different criteria. **a** Teaching criteria; **b** R&D criteria; **c** SSR criteria; **d** Finance criterion; **e** overall sustainability goal; **f** summary of priorities

Managerial implications

Stakeholders generally find the Teaching criterion and HR & Intl (P4) project as the most important for sustainability, implying a perspective close to the education for sustainable development philosophy (developing knowledge and skills for a sustainable future as well as creating changes in people's values and behaviors) (UNESCO 2014). Stakeholders assign second priority to R&D, indicating that high-quality teaching should be supplemented with high-quality research. They further believe that the Labs & Library (P3) project is critical for success, especially in R&D. On the SSR side, social sustainability appears more important than environmental. The responses also indicate that collaboration is key to successful implementation of environmental initiatives. Although stakeholders assign the highest priority to Envl Impact (P5) for SSR, they believe it is the least profitable project, disregarding the savings it can provide through recycling, reusage, energy efficiency, etc. This perception partially matches the findings of Wright (2010) and Wright and Horst (2013).

Even though there is convergence to certain criteria, subcriteria and projects at the aggregate level, stakeholder groups also present distinctive characteristics. Management

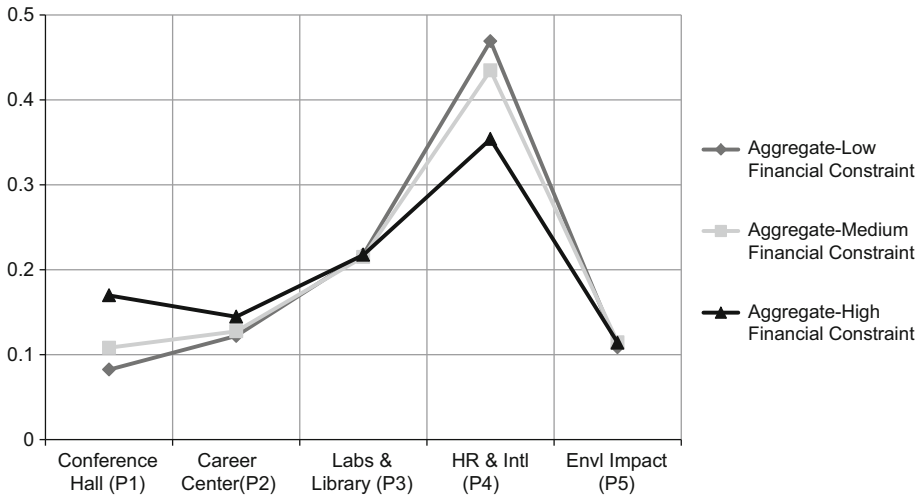

Fig. 4 Changes in aggregate project priorities under financial constraint

assigns the highest priority to the Teaching criterion and HR & Intl (P4) project. On the other hand, faculty seems more research oriented, assigning the highest priority to the R&D criterion and Labs & Library (P3) project for a superior R&D performance. Faculty also thinks differently from other groups with respect to Finance and assign a significantly lower priority to Finance, directly opposing administrative staff.

Students take the environment into consideration more than employees and assign higher priorities to the Environmental Footprint subcriterion and Envl Impact (P5) project. This finding supports the results of other research noting students' association of sustainability with its environmental aspect more than the economic and social (Kagawa 2007). Students also assign a relatively higher priority to the Career Center (P2), revealing their need for career guidance. However, undergraduate students do not differentiate projects based on profitability, possibly because they are less familiar with financial concepts such as return on investment.

Finally, when financial constraints are considered, the priorities of Conference Hall (P1) and Career Center (P2) increase while the priority of HR & Intl (P4) decreases, suggesting that projects with "high visibility" become more preferred as the level of financial constraint increases.

Validation and implementation

Although the AHP/ANP model was based on the literature and current needs, for face validation it was also evaluated by the president and vice-president before data collection. The only member of the board of trustees involved in the study was the president. Hence, the results obtained were first presented at a meeting with the president and the chairman of the board of trustees. They both mentioned that the framework and results would be very helpful for strategic decisions and suggested repeating the process each year to keep track of stakeholders' opinions and build collaborative relationships with them.

The results were also shared with the university community through an academic seminar. Some listeners commented that although they had been previously exposed to

Table 2 Significant findings

Fig.	Finding	Test employed (p value)
3a	Priority of Teaching is higher than those of other performance criteria	ANOVA (0.000), Tukey's HSD (all <0.05)
3a	Priority of R&D is higher than priorities of SSR and Finance	ANOVA (0.000), Tukey's HSD (both <0.05)
3a	Priority assigned by faculty to Finance is less than that assigned by administrative staff	Welch's (0.000), Games-Howell (0.046)
3b	Priority of Student Satisfaction is higher than priorities of Average Graduate Salary and Number of Students Following Graduate Study	ANOVA (0.000), Tukey's HSD (both 0.000)
3b	Priority assigned by management and faculty to Faculty/Student Ratio is higher than that assigned by other groups	Mann-Whitney U (0.004)
3c	Priority of Number of Graduate Programs is less than those of other R&D criteria	Welch's (0.000), Games-Howell (all 0.000)
3c	Priority assigned by management and faculty to Number of Refereed Publications is higher than that assigned by other groups	Mann-Whitney U (0.031)
3c	Priority assigned by undergraduate students to Number of Graduate Programs is higher than that assigned by other groups	Mann-Whitney U (0.025)
3d	Priority of Environmental Footprint is less than those of other SSR criteria	Welch's (0.000), Games-Howell (all 0.000)
3d	Priority assigned by students to Environmental Footprint is higher than that assigned by employees	Mann-Whitney U (0.016)
4a	With respect to Teaching criteria, priority of HR & Intl (P4) is higher than those of other projects	Welch (0.000), Games-Howell (all 0.000)
4a	With respect to Teaching criteria, priorities of Career Center (P2) and Labs & Library (P3) are higher than priorities of Conference Hall (P1) and Envl Impact (P5)	Welch (0.000), Games-Howell (all 0.000)
4a	With respect to Teaching criteria, priority assigned by students and administrative staff to Career Center (P2) is higher than that assigned by other groups	Two-independent-sample unpooled t test (0.000)
4b	With respect to R&D criteria, priority of Career Center (P2) is less than those of other projects	ANOVA (0.000), Tukey's HSD (both 0.000)
4b	With respect to R&D criteria, priority assigned by students to Career Center (P2) is higher than that assigned by employees	Two-independent-sample unpooled t test (0.002)
4c	With respect to SSR criteria, priorities of HR & Intl (P4) and Envl Impact (P5) are higher than those of other projects	Welch's (0.000), Games-Howell (all 0.000)
4c	With respect to SSR criteria, priority of Conference Hall (P1) is higher than priorities of Career Center (P2) and Labs & Library (P3)	Welch's (0.000), Games-Howell (both 0.000)
4d	With respect to Finance criterion, priority of Envl Impact (P5) is less than priorities of Conference Hall (P1), Labs & Library (P3) and HR & Intl (P4)	Welch's (0.000), Games-Howell (all 0.000)
4e	Priority of HR & Intl (P4) is higher than those of other projects	Kruskal-Wallis (0.000), Mann-Whitney U (all 0.000)
4e	Priority of Labs & Library (P3) is higher than priorities of Conference Hall (P1), Career Center (P2) and Envl Impact (P5)	Kruskal-Wallis (0.000), Mann-Whitney U (all 0.000)
4e	Priority assigned by faculty to Labs & Library (P3) is higher than that assigned by graduate students	ANOVA (0.037), Tukey's HSD (0.021)
4e	Priority assigned by students to Career Center (P2) is higher than that assigned by employees	Mann-Whitney U (0.004)

Table 2 continued

Fig.	Finding	Test employed (p value)
4f	Priorities of HR & Intl (P4) with respect to Teaching and R&D criteria are higher than its priorities with respect to SSR and Finance criteria	ANOVA (0.000), Tukey's HSD (all 0.000)
4f	Priority of Envl Impact (P5) with respect to SSR criteria is higher than its priorities with respect to Teaching and Finance criteria	Kruskal-Wallis (0.000), Mann-Whitney U (both 0.000)
4f	Priority of Labs & Library (P3) with respect to R&D criteria is higher than those with respect to other criteria	Welch's (0.000), Games-Howell (all 0.000)
5	Priority of Conference Hall (P1) under high financial constraint is higher than that under low financial constraint	Paired samples t test (0.015)
5	Priority of HR & Intl (P4) under high financial constraint is less than that under low financial constraint	Paired samples t test (0.014)

sustainability concepts, they never had the had opportunity to discuss them, especially in the university context. They also found the framework very useful for not only discovering others' perspectives, but also for conveying their wishes and expectations to the management.

Even though the results imply an investment portfolio of projects, the main objective is not to put a strict plan in place, but to provide insights. The full implementation of projects requires further analysis involving their scope and budget. Nevertheless, providing a communication environment, inclusion of different stakeholders in the study and dissemination of results can be considered partial implementation efforts, fostering a sustainability culture throughout the university.

Limitations

One major drawback of AHP/ANP is the large number of pairwise comparisons. To deal with this, a compact but comprehensive model was developed. However, providing a structured model to the participants may cause some bias in the results and can be considered a limitation of the case study, without impacting the general theoretical construction of methodological framework.

Ideal participation may integrate all stakeholders into strategic decisions; but, for several reasons, a relatively small sample involving only internal stakeholders was taken. First, the stakeholders' lack of familiarity with AHP/ANP required individual assisted sessions, generating a logistical cost that limits the number and diversity of participants. Second, for a new university, it may be more reasonable to listen to the internal stakeholders first and the external ones afterwards. Technically, a 30-participant sample is a limitation, especially as it provides a comparatively low representation of students when the number of students is considered; nevertheless, it meets the minimum criteria for statistical analysis and is a representative sample when the number of employees is considered.

Additionally, if the study is repeated at a later time, it is possible to obtain different results because of changes in conditions and participants' experience. However, providing absolute results is not an objective; instead, this study can be considered an experiment that investigates stakeholder preferences and how they change under competing objectives and certain conditions, providing a snapshot of the university.

Finally, since this research concentrates on a single case, generalization of results is difficult. Yet, the majority of issues are common in most universities, particularly for new and private ones. Therefore, the results obtained can provide insights for decision makers in higher education, encouraging them to adopt sustainability practices at their institutions.

Conclusion and future research directions

Improving the sustainability performance of universities requires participation. Combining AHP/ANP with statistical analysis, this research proposes a methodological framework for decision makers in higher education to integrate stakeholder priorities into strategic decisions in an unbiased and analytical manner, and it provides an application of the framework to a university in Turkey as a case study. Different from the previous studies that involve a single or a few decision makers, this study includes a sample of participants enabling statistical analysis and hence extends the literature both methodologically and in scope. The study also makes a contribution by yielding empirical information about the sustainability perception of stakeholders in higher education.

In the future, the case study can be extended by collecting additional data from external stakeholders, as well as internal. Such an extension will increase the power and scope of statistical tests and improve the quality and acceptance of strategic decisions that will be made. Further, in the aggregation process, different weights can be assigned to stakeholder priorities to allow the distribution of authority over only the relevant groups. In addition, since stakeholder preferences might change over time, data can be collected periodically to track the changes. In this process, AHP/ANP sessions can be performed through the Internet after providing necessary training to the participants to minimize the effort spent for periodic data collection. For such purposes, researchers have recently worked on developing web-based ANP solvers (Kirytopoulos and Rokou 2013) and big data analytics.

Similar studies can also be conducted at other private or public higher education institutions to compare and verify the perceptions of different stakeholder groups as the framework presented is a formal procedure for both engaging stakeholders and integrating their preferences into strategic decisions. In these applications, offering an unbiased, easily accessible, interactive approach to reliably share, aggregate and report different preferences, the framework also has potential as a conflict resolution mechanism to initiate communication and facilitate discussion about strategic issues among stakeholders.

Strategic decisions are complex problems involving not only the satisfaction of multiple stakeholders, but also many and interdependent input and output variables, making modeling such problems highly challenging. However, AHP/ANP provide a realistic and flexible modeling environment, and the results of AHP/ANP can effectively be used to optimize the satisfaction levels of stakeholders. Since stakeholder preferences typically have a dynamic nature, this may require the consideration of uncertainty, and such an uncertainty can be handled by employing sensitivity analysis, dynamic AHP/ANP (Saaty 2007) or various optimization techniques (Turan and Needy 2013).

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Appendix

Calculating AHP/ANP priorities and consistency ratio (CR)

AHP/ANP priorities and CR can also be calculated without software (Saaty 1995). For a random participant, Table 3 provides the initial pairwise comparisons of the four main performance criteria. The numbers shown represent how much more important the row criterion is compared to the column criterion with respect to the sustainability goal. For instance, as R&D is two times more important than Teaching, Teaching must be only 1/2 as important as R&D. The priorities for these criteria are calculated by dividing each number by its column sum (i.e., normalizing columns) and taking the row averages, also presented in Table 3.

In AHP/ANP, model entities are always compared with respect to the parent entity. Therefore, for a multilevel hierarchical model, the priority of an alternative is found by summing up the assigned priorities throughout the hierarchy. In the case study, for example, to calculate the priority of HR & Intl (P4) with respect to Teaching, first the priority of the Teaching criterion with respect to the sustainability goal is multiplied with the priorities of the Teaching subcriteria with respect to the Teaching criterion, then summing up all these values after multiplying each of them by the priority of HR & Intl (P4) with respect to the corresponding Teaching subcriterion.

The procedure to find CR follows a similar process, including four steps. First, each column of Table 3 is multiplied by the priority of the related criterion. As an example, the first column of Table 3 is multiplied by 0.354. Then, the row sums are taken as provided in Table 4. In the second step, these row sums are divided by the priority of the related criterion, and the average of the resulting ratios is taken as shown in Table 4.

Table 3 Deriving priorities for the main performance criteria

	Initial pairwise comparisons				Normalizing columns and taking row averages				
	Teaching	R&D	SSR	Finance	Teaching	R&D	SSR	Finance	Averages
Teaching	1	1/2	4	5	0.290	0.240	0.471	0.417	0.354
R&D	2	1	3	4	0.580	0.480	0.353	0.333	0.436
SSR	1/4	1/3	1	2	0.072	0.160	0.118	0.167	0.129
Finance	1/5	1/4	1/2	1	0.058	0.120	0.059	0.083	0.080

Table 4 First and second steps of the CR calculation

	Multiplying columns with priorities and taking the row sums					Dividing the row sums to priorities and taking the average	
	Teaching	R&D	SSR	Finance	Sums	Averages	Ratio (sums/averages)
Teaching	0.354	0.218	0.517	0.400	1.489	0.354	4.204
R&D	0.709	0.436	0.388	0.320	1.853	0.436	4.245
SSR	0.089	0.145	0.129	0.160	0.523	0.129	4.051
Finance	0.071	0.109	0.065	0.080	0.325	0.080	4.056
						Average	4.139

Table 5 Random indices for consistency (Saaty 1995)

N	2	3	4	5	6	7	8	9	10
Random index	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Table 6 Aggregate priorities for main performance criteria under financial constraint

Performance criteria	Low	Medium	High
Teaching	0.466	0.407	0.216
R&D	0.341	0.293	0.156
SSR	0.193	0.184	0.098
Finance	0.000	0.116	0.530

The third step involves the calculation of the consistency index (CI) using the following formula, where n is the number of rows in the table investigated:

$$\mathrm{CI} = \frac{\text{Average ratio from step 2} - n}{n-1} = \frac{4.139 - 4}{4 - 1} = 0.046 \quad (1)$$

Finally, the CR is calculated by dividing the CI by the appropriate value in Table 5. Therefore, the CR for the pairwise comparisons shown in Table 3 is calculated as 0.046/0.90 = 0.051.

Deriving priorities for the main performance criteria under financial constraint

Table 6 shows the aggregate priorities for the main performance criteria when there is financial constraint. These priorities were derived from the responses of participants after running the model under three different scenarios: low (the model does not have a Finance criterion), medium (the model has a Finance criterion) and high (there is a dependency from the Finance criterion to the other three main performance criteria) financial constraints.

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