ABSTRACT

Universities are isomorphic not because of the effectiveness of their processes but because of the legitimacy assigned by institutional logic. However, sustainable development discourses invoke a novel mission for producing knowledge and innovation for sustainable development. Accordingly, this research collected data from five types of internal stakeholders’ intellections of the four pillars of green university infrastructure. The analysis of data collected from 89 university stakeholders sufficient for a 90% confidence level with 5% relative tolerable error was organized as five groups in a contingency table for the chi-square test. The statistical analysis, that is, the chi-square value, indicates that all five stakeholders perceive in the same direction – that the four pillars of the green university soft infrastructure need to be reconfigured to produce green knowledge and innovation. Hence, the findings inspire the conventional universities and policymakers to transform their universities into sustainable institutions with four pillars of soft green infrastructure.

KEYWORDS

Contingency Tables, Green Knowledge and Innovation, Green University, Green University Infrastructure, Non-Linear Innovation Model, Non-Parametric Tests, Quintuple Helix Model, Sustainable Development

INTRODUCTION

Knowledge is what a knower knows with experiences, values, information in the context, and insights (Davenport & Prusak, 1998). It can be classified into two types: tacit knowledge and explicit knowledge. Tacit knowledge means the knowledge that is in the mind of the knower. In this study, the tacit knowledge of the universities’ internal stakeholders, viz., professors, senior lecturers, academic managers, non-academic managers, and students (hereafter referred to as internal stakeholders). Tacit knowledge is made of two components, cognitive knowledge and technically associated knowledge.
Cognitive knowledge relates to what is in the mind of the knower. It exists as a mental model of the knower. Because of the unstructured nature of cognitive knowledge, it cannot be used directly in an organized manner. On the other hand, explicit knowledge is structured and can be readily used.

The explicit and tacit knowledge of the university and the internal stakeholders are critical to organizational knowledge creation (Jennex, 2006). There are two views of organizational knowledge creation, the organizational learning view and the knowledge creation view.

According to the organizational learning view, members and the organization learn dynamics in the environment for acquisition, distribution, and sharing the knowledge. The organization’s future success depends on new knowledge created to meet new dynamics in the environment (Campanella et al., 2019). Organizational learning decodes the tacit knowledge of members of the organization (internal stakeholders) into organizational knowledge (Nonaka & von Krogh, 2009). In this process, universities and their internal stakeholders, as members of the organization, are active and purposive learners of new dynamics in the environment (Argyris & Schon, 1978). Nonaka et al. (2001) point out that active and purposive learning is confined to solving and improving existing problems.

The contemporary problem is why universities do not explicitly produce the knowledge needed for sustainable development in their mainstream knowledge production process. Sustainable development means knowledge that can address complex social problems codified as the 17 Sustainable Development Goals. A few of them are poverty, hunger, clean water, and global warming (hereafter referred to as green knowledge).

The underlying reason is that universities are isomorphic not because of the effectiveness of their processes but because their legitimacy is assigned by institutional logic. Namely, the conventional role of universities is to produce disciplinary knowledge in their discrete disciplines. As a result, the explicit knowledge produced at universities is increasingly inadequate for sustainable development.

However, the United Nations 2030 Agenda for 17 SDGs, the Paris Climate Agreement, and King IV: Code of Corporate Governance have conferred a new mandate. Accordingly, universities are supposed to produce green knowledge. It is interdisciplinary and multidisciplinary.

Despite the fact that the universities do not explicitly produce green knowledge in their mainstream knowledge production process, the internal stakeholders create green knowledge not in the mainstream but by sub-streams such as sustainability research, conference papers, guest lecturers, and renewable energy projects. It indicates that internal stakeholders’ tacit knowledge is green, but universities’ explicit knowledge is not green.

The gap mentioned above is inconsistent with the evolving higher education knowledge. The evolution can be noticed in two remarkable respects. One of them is the advocacy of Gibbons et al. (1994). They argue that the conventional production of knowledge with basic research labeled the Mode 1 innovation model is not adequate to resolve complex social problems in society. They propose producing interdisciplinary and transdisciplinary knowledge called the Mode 2 innovation model (Etzkowitz & Leydesdorff, 2000). One of the fundamental differences between the Mode 1 innovation model and the Mode 2 innovation model is the delay in applying the knowledge produced with the basic research.

On the other hand, basic research is conducted within discrete disciplines. Mode 2 research is interdisciplinary and transdisciplinary. It is critical to resolving complex social problems. Furthermore, the Mode 3 innovation model (Carayannis & Campbell, 2009) advocates pluralism and diversity of knowledge and innovation by coexistence and coevolution with different modes of knowledge and innovation.

Carayannis and Campbell (2010) introduced the other development, the Quintuple Helix innovation model. They argue that the university system needs to produce interdisciplinary and transdisciplinary knowledge with the government, industry, civil society, and the natural environment of society. Since knowledge is made with the natural environment, the corresponding knowledge is called green knowledge.
Nonetheless, the aforesaid evolution of knowledge cannot be used explicitly because of the traditional knowledge management system. For example, traditional university governance (leadership, structure, and strategy) cannot connect, communicate and transfer green knowledge effectively to knowledge users.

Nonaka (1994) articulates that knowledge is context-specific. Consequently, traditional universities produce linear knowledge and innovation with basic research because of conventional processes. In other words, universities’ traditional knowledge management processes, namely, governance, culture, and reporting processes, cannot create non-linear green knowledge (Liyanage, 2022). Jennex and Olfman (2006), in their KM success model, bridged the gap between the inadequate current knowledge management system of an organization and the prospective improved knowledge management system. In this regard, they devoted one of three constructs of their model to emphasize the importance of governance (leadership, strategy, and structure).

Accordingly, traditional governance, culture, and reporting processes are the underlying variables that inhibit the production of green knowledge. The gap reflects that the existing knowledge management system needs improvements to discover, capture, share, and apply (green) knowledge (Cacioppe, 2017). Hence, governance as a process can align knowledge management with organizational goals to achieve the benefits of knowledge management (Jennex, 2020). Organizational culture and knowledge management have a positive, strong relationship (Jennex, 2006). Furthermore, leadership rather than technology enables an organization to develop a culture of knowledge management (Jacks et al., 2012). The reporting process reflects the control structure to monitor knowledge and knowledge management use (Jennex, 2008) for organizational goals.

Hence, an inquisitiveness emerges as to how internal stakeholders’ mental models conceive the reconfiguration of processes, green corporate governance, green corporate culture, the three pillars of sustainability, and green reporting. These four knowledge management processes create a strong platform on which green knowledge can be created. Nissen and Jennex (2007) justify the separation of multiple dimensions of knowledge management to prevent the risk of stagnation of the knowledge management system.

Accordingly, the study’s objective is to ascertain how the internal stakeholders of universities conceive the necessity for reconfiguring four knowledge management processes. The findings are significant for uncovering the tacit knowledge of internal stakeholders. The tacit knowledge of members of the organization is the basis for creating organizational knowledge (Nonaka & Takeuchi, 1995). Furthermore, the insights from their mental models can be used to improve the current knowledge management system to produce green knowledge in the mainstream. Consequently, the following hypotheses are framed.

The null hypothesis \( H_0 \) is that:

\[
H_0: \text{There is no significant difference in mental models among university stakeholders regarding the reconfiguration of knowledge management processes, green corporate governance, green corporate culture, the three pillars of sustainability, and green reporting.}
\]

In other words, different university stakeholders perceive in the same direction that the knowledge management processes, Green corporate governance, Green corporate culture, Three pillars of sustainability, and Green reporting need reconfiguration to be a green university.

Consequently, the alternative hypothesis \( H_a \) is that:

\[
H_a: \text{There is a significant difference in mental models among university stakeholders regarding the reconfiguration of knowledge management processes, green corporate governance, green corporate culture, three pillars of sustainability, and green reporting.}
\]
In other words, different stakeholders of universities do not perceive in the same direction that the knowledge management processes, Green corporate governance, Green corporate culture, Three pillars of sustainability, and Green reporting need reconfiguration to be a green university.

A green university is meant in this study as a university that produces green knowledge in its mainstream knowledge production process. This paper is structured, beyond this introduction, to include a literature review, methodology, data analysis & findings, discussion, and conclusion sections.

LITERATURE REVIEW

Triple Helix innovation model (Etzkowitz & Leydesdorff, 1995), Quadruple Helix innovation model (Carayannis & Campbell, 2009), and Quintuple Helix innovation model (Carayannis & Campbell, 2010) are called Helix Innovation Models. They are non-linear innovation models. Gibbons et al. (1994) demonstrate that the non-linear innovation model enables universities to produce i. problem-focused knowledge in the context of application, ii. Transdisciplinary knowledge, iii. Heterogeneous knowledge with organizational diversity, iv. Socially accountable knowledge with reflexivity, and v. Quality knowledge beyond peer review.

As a non-linear innovation model, the Quintuple Helix model recommends reconstructing national knowledge structures with five helices: university, industry, government, society, and nature. These five knowledge sub-systems blend with each other, focusing on the natural environment as a central sub-system. It is an alternative to Schumpeter’s innovation model (1912, 1934, 1939) because Schumpeter’s creative destruction created negative impacts on living standards and economic development over time. For example, overconsumption of nonrenewable resources, global warming, imminent encroachment of ecological boundaries (Daniels et al., 2015), and unequal income distribution have caused an unsustainable world. Carayannis et al. (2019) explain that several critical factors have weakened Schumpeter’s creative destruction innovation model based on free and open international trade. They substantiate their argument by giving critical factors, such as espousing rising populist social movements, mercantilism, protectionism, and economic nationalism.

Consequently, the Quintuple Helix innovation model enables universities to produce green knowledge. It is superior to the triple helix innovation model and quadruple helix innovation model because of the natural environment of society and coopetition (Ferasso & Grenier, 2019; Liyanage, 2022). It shelters different knowledge systems such as the Mode 1 innovation model, Mode 2 innovation model, Mode 3 innovation model, Triple Helix innovation model, and Quadruple Helix innovation model.

However, the dynamics for a win-win situation depend on each sub-system’s internal knowledge structure (Ode & Ayavoo, 2020), in this study, the university system. Van Lancker et al. (2015) point out that an organizational innovation system, i.e., a microlevel innovation system, improves innovation performance not only at the organizational level but also at higher system levels, such as the sectoral, regional, and national levels (Walshok et al., 2014).

Structural changes (Senge, 1990) with four infrastructural knowledge management processes are critical for universities to create deep knowledge and higher-level learning. Sparrow (1998) demonstrates that the constituent parts of a phenomenon (green knowledge) can be integrated to configure a coherent system. These learning processes build an infrastructural environment needed to create knowledge under the views of organizational learning and knowledge creation.

The structure of the knowledge management system is not necessarily restricted to a document management system (Jennex, 2009). It can be in any form if the knowledge management system can accomplish its goals (Churchman, 1979). For example, the green governance directs and controls by vision, mission, goals, and objectives provide for green information processing system. Green culture recognizes green values and beliefs. The information system espouses with the necessary reconciliation of three pillars of sustainability. The green reporting process ensures the measuring and control system for the information processing system. The overall objective of reconfiguration
is to align four processes as an information processing system. The system’s role is to encode, store, retrieve, and use green knowledge. Consequently, it develops (green) cognitive knowledge of internal stakeholders and the university in their mainstream knowledge creation process.

System thinking (Senge, 1990) enables a knowledge management system to develop higher-level learning against lower-level learning. There are fundamental differences between these two levels. Higher-level learning creates deep knowledge, whereas lower-level learning creates learning adequate for survival or short-term learning (Senge, 1990). Argyris and Schon (1978) developed another distinction called single- and double-loop learning models. Accordingly, lower-level learning creates a single-loop learning model. It engages with a single feedback loop. It detects the errors and fixes them, but there is no focus on the theories of action. Learning organizations with higher levels detect errors and strategies, but the learning process goes beyond fixing the errors. It relates the errors with the theories of action. In other words, the norms that contribute to the organization’s functioning are also fixed.

Since the creation of green knowledge is a new phenomenon, higher-level learning is warranted for deep knowledge. Deep/broad knowledge focuses not on how things can be fixed for errors but on why it happens or the cause-and-effect relationship (Kim, 1993). For example, the green reporting system detects errors and fixes them with necessary changes in the theory of action, the master program for green knowledge. Accordingly, the infrastructural processes system enables organizational learning to create deep knowledge with a double-loop learning model. Since green knowledge is a new phenomenon, double-loop learning is critically important. It involves substantial and transformative environmental dynamics. As a result, the theory of action can be recreated to create knowledge (DiBella et al., 1996).

In brief, these reconfigured four-processes system improve existing knowledge and develop internal stakeholders’ (green) cognition. Ultimately, internal stakeholders apply their tacit knowledge to explicit knowledge by externalization (Jennex, 2005; Nonaka et al., 2000). In other words, they apply their tacit knowledge while teaching, research, internal operations, and community outreach.

**METHODOLOGY**

Quantitative research aims to uncover the tacit knowledge of internal stakeholders if their mental models advocate transforming universities’ conventional knowledge management systems to produce green knowledge and innovation. Internal stakeholders’ mental models are unstructured. They are difficult to explain in numeric terms, but they can be ranked. Consequently, the Likert scale instrument collected ordinal data for four constructs: Green corporate governance, Green corporate culture, Three pillars of sustainability, and Green reporting. Each construct represented three Likert items totaling 12 Likert items for four constructs (Appendix 1). These four processes reflect organizational knowledge creation from the organizational learning view.

However, the same Likert scale instrument collected ordinal data for four more processes: green education, green research, green internal operations, and green community outreach. These four processes reflect organizational knowledge creation from a knowledge creation view. They are not within the scope of this research.

After a pilot run, some modifications were made to improve the readability and answerability of the questionnaire. Some demographic questions were dropped, and the ten-point Likert scale was reduced to five. The five points are Strongly disagree, Disagree, Undecided, Agree, and Strongly agree. They were assigned numerical values of 1, 2, 3, 4, and 5, respectively. Furthermore, perceptions were collected from five types of stakeholders. Hence, nonparametric statistics are more appropriate than parametric statistics. Accordingly, contingency tables with chi-squared tests were carried out to test the hypothesis.

This study collected 94 observations, of which five observations were removed while cleaning. Participants in the survey were met at four conferences in two countries in 2019 and 2020. The themes
of the conferences were related to sustainability. The sample size was determined as prescribed by Park and Jung (2009), who point out that 65 observations are sufficient when the number of Likert items is three, the confidence level is 90%, the relative tolerable error is 5%, and the pairwise coefficient correlation is 0.5. The authors further prescribe that 257 observations are needed for 95% confidence level, which could not be met due to the COVID-19 pandemic environment. Hence, 89 observations were available for data analysis.

Cronbach’s alpha was calculated for each of the four constructs. Each construct consists of three Likert items. Accordingly, Cronbach’s alpha is 0.624 for green corporate governance, 0.660 for green corporate culture, 0.650 for the three pillars of sustainability, and 0.403 for green reporting. These Cronbach’s alpha values are sufficient to satisfy the internal consistency even though higher values are preferred over lower values. In support, Cronbach (1951) asserts that even though higher alpha values are preferred over lower values, the most crucial point is that the values are interpretable. Adding one Likert item for each construct adds eight Likert items and makes the readability and answerability of the instrument difficult. Cronbach (1951) further indicates that even though Cronbach’s alpha value can be increased by adding more questions, additional questions may be redundant if they add little information. Correspondingly, three Likert items for each construct provide sufficient information to test the hypothesis.

DATA ANALYSIS AND FINDINGS

Wu (2007) asserts that the Likert Scale (Likert, 1932) is a vital device to measure constructs that refer to abstract concepts difficult to explain in numeric terms, such as opinions, attitudes, and images. In this study, there are four constructs: Green corporate governance, Green corporate culture, Three pillars of sustainability, and Green reporting. Perceptions were ranked from strongly disagree = 1 to strongly agree = 5.

Three Likert items for each concept totaling 12 Likert items were used to collect ordinal data. They were analysed with contingency tables and Pearson’s chi-squared test ($\chi^2$) (Table 1 to Table 4). Each contingency table consists of two rows and five columns ($2 \times 5$) table of frequencies.

The five columns display five groups of internal stakeholders. The first column represents 15 professors as group one. The second, third, fourth, and fifth columns represent 24 senior lecturers, 16 academic managers, 13 non-academic managers, and 21 students. Two rows are used to demonstrate the five points summarized into two. The first row denotes ‘Agreed,’ consisting of two points, ‘Agree =4’ and ‘Strongly Agree = 5’. The second-row displays ‘Strongly disagree,’ ‘disagree,’ and ‘Undecided.’ The second row included ‘undecided’ to prevent small values of expected counts. The collapsing ‘undecided’ into the second row does not reverse the trend that appears in the data set. Consequently, there is no danger of misleading the results by collapsing Simpson’s paradox, also known as Yule’s paradox. In other words, collapsing does not affect the hypothesis.

Findings: the chi-square statistic of 5.56 is less than the critical value of 7.78. It indicates that $H_0$ cannot be rejected. In other words, there is no significant difference in perceptions among the stakeholders at $\alpha$ at the 0.1 level of significance.

Findings: the chi-square statistic of 4.671 is less than the critical value of 7.78. It indicates that $H_0$ cannot be rejected. In other words, there are no significant differences among the stakeholders at $\alpha$ at the 0.1 level of significance.

Finding: the chi-square statistic of 2.827 is less than the critical value of 7.78. It indicates that $H_0$ cannot be rejected. In other words, there are no significant differences among the stakeholders at $\alpha$ at the 0.1 level of significance.

Finding: the chi-square statistic of 0.997 is less than the critical value of 7.78. It indicates that $H_0$ cannot be rejected. In other words, there is no significant difference in perceptions among the stakeholders at $\alpha$ at the 0.1 level of significance.
The institutional logic of universities is evolving from the production of disciplinary knowledge to the production of green knowledge. The underlying philosophy is the third mission, universities’

Table 1. Contingency Table: Perceptions of Green corporate governance

| Green Corporate Governance     | Group 01 | Group 02 | Group 03 | Group 04 | Group 05 |
|--------------------------------|----------|----------|----------|----------|----------|
| Agreed                         | 40       | 61       | 42       | 28       | 53       | 224 |
| Expected                       | 38.09    | 60.94    | 40.63    | 33.01    | 53.33    | 226 |
| Disagreed & Undec              | 8        | 10       | 6        | 10       | 7        | 41  |
| Expected                       | 6.91     | 11.06    | 7.37     | 5.99     | 9.67     | 41  |
| Sigma(O/E)^2/E                 | 0.031    | 0.018    | 0.046    | 0.487    | 0.134    | 0.717|
|                                | 0.172    | 0.101    | 0.255    | 2.687    | 0.739    | 3.954|
| Chi-Square Statistics          |          |          |          |          |          | 4.671|
| D/F = 4 and at 10% significance level |          |          |          |          |          | 7.78|

Table 2. Contingency Table: Perceptions of the green corporate culture

| Green Corporate Culture        | Group 01 | Group 02 | Group 03 | Group 04 | Group 05 |
|--------------------------------|----------|----------|----------|----------|----------|
| Agreed                         | 40       | 65       | 40       | 33       | 58       | 236 |
| Expected                       | 39.78    | 63.64    | 42.43    | 34.47    | 55.69    | 236 |
| Disagreed & Undec              | 5        | 7        | 8        | 6        | 5        | 31  |
| Expected                       | 5.22     | 8.36     | 5.57     | 4.53     | 7.31     | 31  |
| Sigma(O/E)^2/E                 | 0.001    | 0.029    | 0.139    | 0.063    | 0.096    | 0.328|
|                                | 0.010    | 0.221    | 1.057    | 0.478    | 0.732    | 2.499|
| Chi-Square Statistics          |          |          |          |          |          | 2.827|
| D/F = 4 and at 10% significance level |          |          |          |          |          | 7.78|

Table 3. Contingency Table: Perceptions of Three pillars of sustainability

| Three Pillars of Sustainability | Group 01 | Group 02 | Group 03 | Group 04 | Group 05 |
|----------------------------------|----------|----------|----------|----------|----------|
| Agreed                           | 40       | 65       | 40       | 33       | 58       | 236 |
| Expected                         | 39.78    | 63.64    | 42.43    | 34.47    | 55.69    | 236 |
| Disagreed & Undec                | 5        | 7        | 8        | 6        | 5        | 31  |
| Expected                         | 5.22     | 8.36     | 5.57     | 4.53     | 7.31     | 31  |
| Sigma(O/E)^2/E                   | 0.001    | 0.029    | 0.139    | 0.063    | 0.096    | 0.328|
|                                 | 0.010    | 0.221    | 1.057    | 0.478    | 0.732    | 2.499|
| Chi-Square Statistics            |          |          |          |          |          | 2.827|
| D/F = 4 and at 10% significance level |          |          |          |          |          | 7.78|

**DISCUSSION**

The institutional logic of universities is evolving from the production of disciplinary knowledge to the production of green knowledge. The underlying philosophy is the third mission, universities’
contribution to economic development (Miotto et al., 2018). In this mission, the Quintuple Helix innovation model intends to align national-level knowledge structures to produce green knowledge. However, innovation cannot be achieved without organizational change at the micro-level of universities. The change is imperative because learners have to learn complex social and ecological issues to act as problem solvers and change agents of sustainable development (Burns, 2013).

Correspondingly, Areed et al. (2020) articulate that the organizational learning and knowledge creation processes drive organizational innovation and competitive advantage in the modern world. Liyanage and Netswera (2021) introduced a Green University System model and suggested reconfiguring eight knowledge management processes. Four of them relate to the organizational learning view to develop the tacit knowledge of internal stakeholders. They are green corporate governance, green corporate culture, three pillars of sustainability, and green reporting. These processes create a knowledge management system for information processing by encoding, storing, retrieving, and using (green) knowledge (Akbar, 2022).

Green corporate governance: universities’ current governance structure is not conducive to green knowledge management. A fundamentally different structure is required to produce green knowledge and innovation (Dale & Newman, 2005; Farley & Smith, 2014; Weisser, 2017). Galpin et al. (2015) point out that the organization’s multiple governance processes, vision, mission, values, strategies, goals and objectives, and human resource value chain should be aligned for sustainability as a competitive strategy. Jennex (2019) expressed that the functionality of the structure, strategy, and leadership under governance is not restricted to making information processing effective for achieving the organization’s goals. They can be used to align knowledge management to organizational competitive strategy.

Hence, Likert item 01 is designed to ascertain the tacit knowledge of internal stakeholders if “a system of governance consists of rules, regulations, procedures, processes, and practices to strategize for greening a university is an essential aspect in greening a university.” Apart from the structure and strategy, another important aspect of green governance is leadership. Hence, items 2 and 3 were focused on leadership. Ghosh et al. (2022) demonstrate that knowledge leaders are facilitators and integrators of knowledge management. They are a product of both transformational and transactional leadership. Jennex et al. (2012) explain the two-way positive causal relationship between knowledge leadership and knowledge management. They point out that the knowledge leader can successfully implement a knowledge management system needed for innovation. On the other hand, leadership fortifies successful knowledge management (Jennex, 2019). The finding of data analysis reflects that internal stakeholders’ mental models are not different from each other.

Green corporate culture: Jennex (2007) clarifies that knowledge management does not necessarily mean only an information system and its components. Still, governance and the organizational culture

|                | Group-1 | Group-2 | Group-3 | Group-4 | Group-5 |
|----------------|---------|---------|---------|---------|---------|
| Agreed         | 41      | 63      | 43      | 33      | 55      | 235 |
| Expected       | 39.61   | 63.37   | 42.25   | 34.33   | 55.45   | 225 |
| Disagreed & Undec | 4      | 9       | 5       | 6       | 8       | 32  |
| Expected       | 5.39    | 8.63    | 5.75    | 4.67    | 7.55    | 32  |
| Sigma(O/E)'2/E | 0.049   | 0.002   | 0.013   | 0.051   | 0.004   | 0.119 |
|                | 0.360   | 0.016   | 0.099   | 0.376   | 0.027   | 0.877 |
| Chi-Square Statistics | 0.997 |         |         |         |         |      |
| D/F = 4 and at 10% significance level | 7.78 |         |         |         |         |      |

Table 4. Contingency Table: Perceptions of Green Reporting
are also imperative to make an effective knowledge management system. Schein (2004:17) defines organizational culture as “the patterns of shared basic assumptions learned by the organization as it solves its problems of external adaptations and internal integration that has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think, and feel concerning those problems.” According to Schein (2004), people in the organization resolve the problems and develop values and beliefs over time when they have resolved issues successfully. Hence, Jennex (2009; Jennex & Olfman, 2005) identifies culture as a critical success factor that needs to be aligned with the organization’s structure, strategy, and leadership.

Accordingly, organizational culture plays an instrumental role in achieving the goals and objectives of the organization. Correspondingly, the first Likert question was framed to ascertain stakeholders’ tacit knowledge about green values and beliefs. However, communication of culture among members of the organization to create institutional behaviour is a challenge (Martin & Murray, 2011). Galpin et al. (2015) discuss a holistic view of how an organization’s existing culture could be transformed into a green culture. Accordingly, they require aligning and communicating green values and beliefs through multi-processes of an organization. They are vision, mission, values, strategies, goals and objectives, and the human resource value chain with the sustainability culture. Hence, the second Likert item ascertained whether the communication of the values and beliefs of sustainability culture through vision and the mission are necessary for greening a university’s culture. Further, the third Likert item intended to know if the green values and beliefs of sustainability should be embedded with multiple processes of the university. The finding of data analysis reflects that internal stakeholders’ mental models are not different from each other.

Three pillars of sustainability: This process is a newer knowledge management process introduced in this study. The Brundtland Commission (1987) advocated sustainable development focusing on the three pillars of sustainability, economic growth, environmental protection, and social equity. Accordingly, another dimension that needs to be considered in reconfiguring a knowledge management system for green knowledge management is the three pillars of sustainability. Hence, the first Likert item investigated whether the internal stakeholders perceive all three pillars are essential in greening universities.

Murphy (2012) points out that the social pillar’s meanings and objectives are vague compared to the other two pillars. Conner et al. (2018) point out that the university under study is more robust in environmental and social pillars, while the economic pillar is the weakest. Panatsa and Malandrakis (2018) argue that even though education for sustainable development relates to all three pillars of sustainability, social and economic sustainability are usually ignored. The metaphors of the three pillars are interrelated, and therefore, a trade-off among these three pillars (SDG 17) is inherent (Mischen et al., 2019; Weisser, 2017). Hence, the second Likert item investigated the mental model of internal stakeholders concerning the necessity of reconciliation of three pillars.

Universities can contribute to sustainable development at the national, regional, (North, 2005; Vekic et al., 2020), and global levels of sustainability (Cartwright & Craig, 2006). Gallardo-Vazquez and Folgado-Fernández (2020) point out that the university’s role is to provide quality teaching and research while reconciling the three pillars of sustainability to improve the quality of life. Hence, the third Likert item ascertained if the internal stakeholders believe that the focus on local, national, and global perspectives is necessary. The finding of data analysis reflects that internal stakeholders’ mental models are not different from each other.

Green reporting: Sustainability practices in a green knowledge management system contribute to organizational knowledge creation. These practices create green knowledge with teaching, research, internal operations, and university community outreach. However, assessing sustainability practices remains a complex process because of the infancy level of sustainability reporting (Sassen & Azizi, 2018). Hence, the first Likert item examined how internal stakeholders perceive the importance of sustainability reporting.
However, universities’ sustainability reporting tools are still in the early stages because of the voluntary nature of disclosure in all territories (Lopatta & Jaeschke, 2014). These tools have their strengths and weaknesses. However, measuring the progress is essential (Lozano, 2006). As well said, “What gets measured, gets managed.” Hence, the second Likert item probed how the internal stakeholders perceive measuring the progress of sustainability practices of a green university. The third Likert question tested the tacit knowledge of internal stakeholders about measuring and reporting green culture. The finding of data analysis reflects that internal stakeholders’ mental models are not different from each other.

CONCLUSION

Universities are expected to contribute to the national economy under the third mission of universities. In response to this appeal, several innovation models have been developed. This study advocates the Quintuple Helix innovation model. It is superior to other Helix models because the natural environment of society as a helix enables universities to produce green knowledge.

The Helix models intend to make national-level structural changes for knowledge production. However, national-level structural changes cannot be achieved without micro-level knowledge management changes. It reflects that the universities do not explicitly produce green knowledge in their mainstream knowledge production process. In contrast, internal stakeholders are actively creating green knowledge in sub-streams such as published research papers, academic books, research conferences, and guest speakers. Hence, it is necessary to improve existing knowledge management processes at universities. A change in the knowledge management system facilitates the users to adopt it (Jennex, 2008; Veeravalli & Vijayalakshmi, 2021).

On this premise, the null hypothesis was set to ascertain if the different stakeholders of universities perceive in the same direction that the knowledge management processes, *Green corporate governance*, *Green corporate culture*, *Three pillars of sustainability*, and *Green reporting* need reconfirmation to be a greening a university. The results demonstrate that all five types of internal stakeholders of universities have the same mental models that the above knowledge management processes need reconfiguration into a green knowledge management system.

The findings encourage policymakers to rethink of restructuring of conventional knowledge management processes to produce green knowledge platform in the mainstream knowledge production process. However, this study did not include stakeholders, such as parents of the students, employers, sponsors, and public educational authorities. Their mental models are also essential to complete the full picture of their tacit knowledge. Furthermore, this research paper did not focus on green curriculum, green research, green internal operations, and green community outreach (Liyanage, 2022). They can also be studied under the knowledge creation view. Hence, further research are needed in these areas.

CONFLICT OF INTEREST

The authors of this publication declare there is no conflict of interest.

FUNDING AGENCY

The publisher has waived the Open Access Processing fee for this article.
REFERENCES

Akbar, H. (2022). Integrating Divergent Epistemologies of the Two Influential Views on Organizational Knowledge Creation. *International Journal of Knowledge Management, 18*(1), 1–17. doi:10.4018/IJKM.290327

Aareed, S., Salloum, S. A., & Shaalan, K. (2020). The Role of Knowledge Management Processes for Enhancing and Supporting Innovative Organizations: A Systematic Review. In M. Al-Emran, K. Shaalan, & A. Hassanien (Eds.), *Recent Advances in Intelligent Systems and Smart Applications. Studies in Systems, Decision and Control* (pp. 143–161). Springer. doi:10.1007/978-3-030-47411-9_8

Argyris, C., & Schon, D. (1978). *Organizational learning*. Addison-Wesley.

Brundtland Commission. (1987). *Our Common Future: Report of the World Commission on Environment and Development*. http://www.un-documents.net/ocf-ov.htm

Burns, H. (2013). Meaningful Sustainability Learning: A Study of Sustainability Pedagogy in Two University Courses. *International Journal of Teaching and Learning in Higher Education, 25*(2), 166-175. [https://www.isetl.org/ijtlhe/](https://www.isetl.org/ijtlhe/)

Cacioppe, R. L. (2017). Integral mindflow. *The Learning Organization, 24*(6), 408–417. doi:10.1108/TLO-06-2017-0063

Campanella, F., Derhy, A., & Gangi, F. (2019). Knowledge management and value creation in the post-crisis banking system. *Journal of Knowledge Management, 23*(2), 263–278. doi:10.1108/JKM-11-2017-0506

Carayannis, E. G., Acikdilli, G., & Ziemnowicz, C. (2019). Creative Destruction in International Trade: Insights from the Quadruple and Quintuple Innovation Helix Models. *Journal of the Knowledge Economy, 11*(4), 1489–1508. doi:10.1007/s13132-019-00599-z

Carayannis, E. G., & Campbell, D. F. J. (2009). ‘Mode 3’ and ‘Quadruple Helix’: Toward a 21st-century fractal innovation ecosystem. *International Journal of Technology Management, 46*(3/4), 201–234. doi:10.1504/IJTM.2009.023374

Carayannis, E. G., & Campbell, D. F. J. (2010). Triple Helix, Quadruple Helix, and Quintuple Helix and How Do Knowledge, Innovation, and the Environment Relate To Each Other? *International Journal of Social Ecology and Sustainable Development, 1*(1), 41–69. doi:10.4018/jiesd.2010010105

Cartwright, W., & Craig, J. L. (2006). Sustainability: Aligning corporate governance, strategy and operations with the planet. *Business Process Management Journal, 12*(6), 741–750. doi:10.1108/146371506106710909

Churchman, C. W. (1979). *The systems approach*. Dell Publishing.

Conner, D., Falkner, A., Lantieri, N., McGavisk, B., & Mcshea, B. (2018). Stakeholder Perceptions of Campus Sustainability Efforts: Lessons from Vermont. *Sustainability, 10*(11), 3849. Advance online publication. doi:10.3390/su10113849

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika, 16*(3), 297–334. doi:10.1007/BF02310555

Dale, A., & Newman, L. (2005). Sustainable development, education, and literacy. *International Journal of Sustainability in Higher Education, 6*(4), 351–362. doi:10.1108/14676370510623847

Daniels, J. D., Radebaugh, L. H., & Sullivan, D. P. (2015). *International Business: Environments and Operations* (15th ed.). Addison-Wesley.

Davenport, T. H., & Prusak, L. (1998). *Working knowledge*. Harvard Business School Press.

DiBella, A. J., Nevis, E. C., & Gould, J. M. (1996). Understanding organizational learning capability. *Journal of Management Studies, 33*(3), 361–379. doi:10.1111/j.1467-6486.1996.tb00806.x

Etzkowitz, H., & Leydesdorff, L. (1995). The Triple Helix — University-Industry-Government Relations: A Laboratory for Knowledge Based Economic Development. *EASST Review, 14*, 14–19.
Etzkowitz, H., & Leydesdorff, L. (2000). The Dynamics of Innovation: From National Systems and “Mode 2” to a Triple Helix of University–Industry–Government Relations. Research Policy, 29(2), 109–123. doi:10.1016/S0048-7333(99)00055-4

Farley, H. M., & Smith, Z. A. (2014). Sustainability: If It’s It is Everything, Is It Nothing? Routledge.

Ferasso, M., & Grenier, C. (2019, July). Fostering SME’s co-development of innovative projects in Biotech clusters: extending the enablers’ set for the knowledge creation process [Conference Paper]. XLIII Encontro da ANPAD 2019, São Paulo.

Gallardo-Vázquez, D., & Folgado-Fernández, J. A. (2020). Regional economic sustainability: Universities’ role in their territories. Land (Basel), 9(4), 1–21. doi:10.3390/land9040102

Galpin, T., Whittington, J. L., & Bell, G. (2015). Is your sustainability strategy sustainable? Creating a culture of sustainability. Corporate Governance (Bingley), 15(1), 1–17. doi:10.1108/CG-01-2013-0004

Ghosh, V., Kabra, G., & Mukerjee, H. S. (2022). Influence of Knowledge Leadership on IT Project Performance and Quality Practices: Examining the Role of Leader Risk-Mitigation Efforts. International Journal of Knowledge Management, 18(1), 1–20. doi:10.4018/IJKM.290024

Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P., & Trow, M. (1994). The new production of knowledge: The dynamics of science and research in contemporary societies. Sage (Atlanta, Ga.).

Jacks, T., Wallace, S., & Nemati, H. (2012). Impact of Culture on Knowledge Management: A Meta-Analysis and Framework. Journal of Global Information Technology Management, 15(4), 8–42. doi:10.1080/109719 8X.2012.10845622

Jennex, M. E. (2005). What is KM? International Journal of Knowledge Management, 1(4), 1–4.

Jennex, M. E. (2006). Culture, context, and knowledge management. International Journal of Knowledge Management, 2(2), 1–4. doi:10.4018/ijkm.2014040101

Jennex, M. E. (Ed.). (2007). Knowledge Management in Modern Organizations. IGI Global., doi:10.4018/978-1-59904-261-9

Jennex, M. E. (2008). Exploring System Use as a Measure of Knowledge Management Success. Journal of Organizational and End User Computing, 20(1), 50–63. doi:10.4018/joeuc.2008010104

Jennex, M. E. (2009). Knowledge Management in Support of Education. Journal of Administration and Development Mahasarakham University, 1(2).

Jennex, M. E. (2019). Towards understanding and implementing knowledge management strategy. Information Institute Conferences, 1-12.

Jennex, M. E. (2020). A Re-Examination and Re-Specification of the Jennex Olfman Knowledge Management Success Model. In M. Jennex (Ed.), Current Issues and Trends in Knowledge Management, Discovery, and Transfer (pp. 1–29). IGI Global., doi:10.4018/978-1-7998-2189-2.ch001

Jennex, M. E., & Olfman, L. (2006). A Model of Knowledge Management Success. International Journal of Knowledge Management, 2(3), 51–68. doi:10.4018/jkm.2006070104

Jennex, M. E., Smolnik, S., & Croasdell, D. (2012). Towards a Consensus Knowledge Management Success Definition. In Organizational Learning and Knowledge: Concepts, Methodologies, Tools and Applications (pp. 403–415). IGI Global. doi:10.4018/978-1-60960-783-8.ch201

Kim, D. H. (1993). The link between individual and organizational learning. Sloan Management Review, 35(1), 37–50.

Likert, R. (1932). A technique for the measurement of attitudes. Archives de Psychologie, 22(140), 1–55.

Liyanage, S. I. H. (2022). Producing Green Knowledge and Innovation: A framework For Greening Universities. Innovation, Technology, and Knowledge Management. Springer. doi:10.1007/978-3-030-97850-1

Liyanage, S. I. H., & Netswera, F. G. (2021). Greening Universities with Mode 3 and Quintuple Helix Model of Innovation–Production of Knowledge and Innovation in Knowledge-Based Economy, Botswana. Journal of the Knowledge Economy. Advance online publication. doi:10.1007/s13132-021-00769-y
Lopatta, K., & Jaeschke, R. (2014). Sustainability reporting at German and Austrian universities. *International Journal of Education Economics and Development, 5*(1), 66–90. doi:10.1504/IEJED.2014.059868

Lozano, R. (2006). Incorporation and institutionalization of SD into universities: Breaking through barriers to change. *Journal of Cleaner Production, 14*(9-11), 787–796. doi:10.1016/j.jclepro.2005.12.010

Martin, S., & Murray, P. (2011). The role of wicked problems: Values in personal and organisational change. *Learning and Teaching in Higher Education, 5*, 163–169.

Miotto, G., Alicia, B. G., & Cristina, D. C. F. (2018). Social Responsibility: A Tool for Legitimation in Spanish Universities’ Strategic Plans. *Tripodos, 42*, 59–79.

Mischen, P. A., Homsy, G. C., Lipo, C. P., Holahan, R., Imbruce, V., Pape, A., Zhu, W., Graney, J., Zhang, Z., Holmes, L. M., & Reina, M. (2019). A Foundation for Measuring Community Sustainability. *Sustainability, 11*(7), 1903. Advance online publication. doi:10.3390/su11071903

Murphy, K. (2012). The social pillar of sustainable development: A literature review and framework for policy analysis. *Sustainability: Science, Practice, and Policy, 8*(1), 15–29. doi:10.1080/15487733.2012.11908081

Nissen, M., & Jennex, M. E. (2007). Toward the Multidimensional Conceptualization of Knowledge. In M. Jennex (Ed.), *Knowledge Management in Modern Organizations* (pp. 278–284). IGI Global. doi:10.4018/978-1-59904-261-9.ch015

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science, 5*(1), 14–37. doi:10.1287/orsc.5.1.14

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company—How Japanese companies create the dynamics of innovation*. Oxford University Press.

Nonaka, I., Toyama, R., & Byosiere, P. (2001). A theory of organizational knowledge creation: Understanding the dynamic process of creating knowledge. In M. Dierkes, A. B. Antal, J. Child, & I. Nonaka (Eds.), *Handbook of organizational learning and knowledge* (pp. 491–517). Oxford University Press.

Nonaka, I., Toyama, R., & Konno, N. (2000). SECI, Ba, and leadership: A unified model of dynamic knowledge creation. *Long Range Planning, 33*(1), 5–34. doi:10.1016/S0024-6301(99)00115-6

Nonaka, I., & von Krogh, G. (2009). Tacit knowledge and knowledge conversion: Controversy and advancement in organizational knowledge creation theory. *Organization Science, 20*(3), 635–652. doi:10.1287/orsc.1080.0412

North, D. C. (2005). *Understanding the process of economic change*. Princeton University Press. doi:10.1515/9781400829484

Ode, E., & Ayavoo, R. (2020). The mediating role of knowledge application in the relationship between knowledge management practices and firm innovation. *Journal of Innovation & Knowledge, 5*(3), 209–217. doi:10.1016/j.jik.2019.08.002

Panatsa, V., & Malandrakis, G. (2018). Student teachers’ perceptions about the social pillar of urban sustainability. *International Journal of Sustainability in Higher Education, 19*(5), 998–1018. doi:10.1108/IJSHE-09-2017-0162

Park, J., & Jung, M. (2009). A Note on Determination of Sample Size for a Likert Scale. *Communications for Statistical Applications and Methods, 16*(4), 669–673. doi:10.5351/CKSS.2009.16.4.669

Sassen, R., & Azizi, L. (2018). Assessing sustainability reports of US universities. *International Journal of Sustainability in Higher Education, 19*(7), 1158–1184. doi:10.1108/IJSHE-06-2016-0114

Schein, E. H. (2004). *Organizational culture and leadership* (3rd ed.). Jossey-Bass.

Schumpeter, J. (1912). *The theory of economic development*. Oxford University Press.

Schumpeter, J. (1939). *Business cycles: A theoretical, historical and statistical analysis of capitalist process*. McGraw-Hill.

Schumpeter, J. A. (1934). *The Theory of Economic Development: An Inquiry into Profits, Capital, Credit, Interest, and the Business Cycle*. Transaction Publishers.

Senge, P. M. (1990). *The fifth discipline*. Doubleday.
Sparrow, J. (1998). *Knowledge in organizations: Access to thinking at work*. Sage Publications.

van Lancker, J., Mondelaers, K., Wauters, E., & Huylenbroeck, G. V. (2015). The Organizational Innovation System: A systemic framework for radical innovation at the organizational level. *Technovation, 52*, 40–50.

Veeravalli, S., & Vijayalakshmi, V. (2021). Revisiting Knowledge Management System Use: Unravelling Interventions that Nurture Knowledge Seeking. *International Journal of Knowledge Management, 18*(1), 1–25. doi:10.4018/IJKM.291707

Vekic, A., Djakovic, V., Borocki, J., Sroka, W., Popp, J., & Oláh, J. (2020). The Importance of Academic New Ventures for Sustainable Regional Development. *Amfiteatru Economic, 22*(54), 533–550. doi:10.24818/EA/2020/54/533

Walshok, M., Shapiro, J., & Owens, N. (2014). Transnational innovation networks aren’t all created equal: Towards a classification system. *The Journal of Technology Transfer, 39*(3), 345–357. doi:10.1007/s10961-012-9293-4

Weisser, C. R. (2017). Defining sustainability in higher education: A rhetorical analysis. *International Journal of Sustainability in Higher Education, 18*(7), 1076–1089. doi:10.1108/IJSHE-12-2015-0215

Wu, C. H. (2007). An empirical study on the transformation of Likert-scale data to numerical scores. *Applied Mathematical Sciences, 1*(58), 2851–2862.
APPENDIX A - A FRAMEWORK FOR GREENING OF UNIVERSITIES IN SOUTHERN AFRICAN COUNTRIES

We asked you to complete this survey to help us develop a framework for the greening of universities in South African countries so that the universities in South African countries would be able to transform their universities into sustainable universities.

THIS SURVEY DOES NOT HAVE YOUR NAME ON IT, SO YOUR COMMENTS AND INPUTS ARE CONFIDENTIAL, which means that no one will know how you answer these questions. Please make sure you read each question carefully and select the response that best suits you. Mark your answers by placing a tick mark in the appropriate answer, 1, 2, 3, 4, or 5 (1 denotes strongly disagree to 5 denotes strongly agree).

The questionnaire begins to be completed by those who are passionate about sustainable/green universities in Southern African Countries.

A Framework for Greening of Universities in Southern African Countries.
We kindly request that you take a few minutes of your time to answer the following questions. This will help us develop a framework for greening a university in South African countries.

a) Are you aware of greening universities in South African countries? Yes No

b) In which country is your university located?

For each of the statements below, please rate how much you agree or disagree as follows.

1 2 3 4 5

Strongly Disagree Disagree Undecided Agree Strongly Agree

Thank you very much for completing the Research Questionnaire!

Table 5. Questionnaire questions

| Green Corporate Governance | | | | | |
|----------------------------|---|---|---|---|
| GG01 A system of governance consisting of rules, regulations, procedures, processes, and practices for greening a university is an important aspect of greening a university. | Strongly Disagree | 1 | 2 | 3 | 4 | 5 | Strongly Agree |
| GG02 For greening a university, a top-down approach rather than a bottom-up approach is required | Strongly Disagree | 1 | 2 | 3 | 4 | 5 | Strongly Agree |
| GG03 A member of the board of directors/governing council is required for accountability of the greening of the university to the rest of the board or governing council of the university | Strongly Disagree | 1 | 2 | 3 | 4 | 5 | Strongly Agree |

| Green Culture | | | | | |
|-----------------|---|---|---|---|
| GC01 A sustainability culture with necessary values and beliefs is also another important aspect of greening a university | Strongly Disagree | 1 | 2 | 3 | 4 | 5 | Strongly Agree |
| GC02 The communication of values and beliefs for sustainability culture to the stakeholders by way of policy documents such as vision, mission, etc., are required for greening university | Strongly Disagree | 1 | 2 | 3 | 4 | 5 | Strongly Agree |
| GC03 The values and beliefs for sustainability culture embedded in multi processes of the university, such as human resource, marketing, financing, etc. is required for greening the university | Strongly Disagree | 1 | 2 | 3 | 4 | 5 | Strongly Agree |

| Triple Bottom Line | | | | | |
|-------------------|---|---|---|---|
| GT01 The three pillars of sustainability (environmental, social, and economic sustainability) is also an important aspect of greening a university | Strongly Disagree | 1 | 2 | 3 | 4 | 5 | Strongly Agree |
| GT02 When designing sustainable practices needed for greening a university, a reconciliation of three pillars, environmental, social, and economic sustainability, is required | Strongly Disagree | 1 | 2 | 3 | 4 | 5 | Strongly Agree |
| GT03 The local, regional and global context of the three pillars of sustainability(environmental, social, and economic sustainability) is required to be taken into consideration in sustainability practices to be adopted in greening | Strongly Disagree | 1 | 2 | 3 | 4 | 5 | Strongly Agree |

continued on following page
### Table 5. Continued

| Green Corporate Governance                                                                 | Strongly Disagree | 1 | 2 | 3 | 4 | 5 | Strongly Agree |
|-------------------------------------------------------------------------------------------|-------------------|---|---|---|---|---|----------------|
| GA01 Sustainability reporting is another important aspect of greening a university         | Strongly Disagree | 1 | 2 | 3 | 4 | 5 | Strongly Agree |
| GA02 Measuring and reporting of sustainability is able to understand the progress of     | Strongly Disagree | 1 | 2 | 3 | 4 | 5 | Strongly Agree |
| sustainability practices of the green university                                          |                   |   |   |   |   |   |                |
| GA03 Measuring and reporting of sustainability is able to understand the green culture of | Strongly Disagree | 1 | 2 | 3 | 4 | 5 | Strongly Agree |
| the green university                                                                      |                   |   |   |   |   |   |                |