A Gap Model for Environmental Information Management in an African Higher Education Institution

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Abstract
The increase in awareness of social and environmental responsibilities has led Higher Education Institutions (HEIs) to invest in their role of developing inclusive communities. HEIs are increasing environmental sustainability awareness by monitoring and managing their environmental impact and involving communities in sustainability efforts and thus developing an inclusive community. The relatively low adoption of the concept of environmental sustainability in African HEIs is due to a number of factors such as problems with data access and quality of information. This paper investigates best practices for environmental information management and data centralisation in HEIs and analyses some of the AS-IS processes relating to environmental information management at a South African HEI. The paper proposes a model for addressing the gap between the existing AS-IS and the desired TO-BE environmental information processes in HEIs. The application of the model can improve environmental information management and reporting to the HEI community. This can in turn raise the environmental awareness of students, staff and external stakeholders of the institution and they can take action to reduce their contribution to the negative environmental impact of the institution.

Keywords
Environmental sustainability, inclusive communities.
Introduction

The topics of environmental sustainability and management of environmental information at Higher Education Institutions (HEIs) have gained increased interest internationally, particularly in Europe, the United States (U.S.), Asia, Australia, Canada and South America (Disterheft, da Silva Caeiro, Ramos and de Miranda Azeiteiro, 2012; Velazquez, Munguia, Platt and Taddei, 2006). However penetration into African institutions has been relatively low (Velazquez, et al., 2006). Despite this low penetration, there are some isolated incidents of environmental sustainability efforts at a number of South African HEIs which have strategic plans to be environmentally sustainable in the near future (Ducie, 2013; Rhodes, 2014; Scott, McGibbon and Mwalemba, 2012). However, environmental sustainability efforts in African HEIs lack proper coordination and this has prompted this research topic to receive increased attention in recent years. Sammalisto and Arvidsson (2005) argue that the lack of strong regulations placed on African HEIs by African governments or Non-Governmental Organisations (NGOs) might be the reason why HEIs in developing countries are lagging behind in terms of environmental sustainability efforts. Other possible reported factors could be the lack of data access, lack of communication and the lack of integrated and accurate information (Velazquez, Munguia and Sanchez, 2005). This is confirmed by the study of Bero, Doerry, Middleton and Meinhardt (2012) which reported that the management of environmental information is a key factor in achieving environmental sustainability at HEIs.

HEIs have followed the industry trend of developing environmental programs and systems (Bero, et al., 2012). However, HEIs have a unique set of challenges with regards to environmental information management and these are different to industrial contexts (Bero, et al., 2012; Kamal and Asmuss, 2013). The benefits of having environmental information readily available include the reduction in the environmental footprint of the institution, in terms of a reduction in water usage, an improvement in energy efficiency and a reduction in pollution (Jones, et al., 2011). Effective analysis of environmental information allows for top management to make well informed decisions that will result in the optimal use of resources such as energy and water.

The United States of America’s Environmental Protection Agency (EPA) highlighted that the environment has become everyone’s business and everyone now has a right to access high quality environmental information (EPA, 2009). One benefit of having environmental information readily available to the public is that it can raise the environmental awareness of the institution’s community (Jones, et al., 2011). The institution’s community includes students, staff members and external stakeholders. Making environmental information accessible to the public is a significant step in developing an inclusive community around an HEI. An inclusive community is defined as a welcoming environment that promotes the full participation of all faculty, staff, and students in the life of the institution (Christie, 2014). An inclusive community engages all its citizens in decision-making processes that affect their lives and gives them full access to resources (University of Kansas, 2013). Educating an institution’s community with regards to their environmental footprint promotes their involvement in decision-making and enables them to take action to reduce their contribution to the negative environmental impact of the institution. Effective environmental information management and reporting systems can support inclusive communities by supplying the relevant information to the stakeholders at the HEI, which facilitates...
improved and informed decision making with regards to environmental impact.

According to Velazquez et al. (2006), a HEI is considered to be a sustainable institution if the institution addresses, involves and promotes the minimisation of negative environmental, economic, social and health impact of daily activities involved in the functioning of the institution. Sustainable universities have influence to the extent that they help regional or global societies to transition to a sustainable livelihood. Whilst the importance of environmental sustainability and the relevant role of environmental information management and reporting in higher education has been emphasised in HEIs, Africa is lagging behind (Fonseca, Macdonald, Dandy and Valenti, 2011). Studies of environmental sustainability and the role of information management in African HEIs are limited.

The aim of this paper is to propose a gap model for Environmental Information Management (EIM) in African HEIs. A gap model describes the transition process from the current state (AS-IS state) to the desired state (TO-BE state) (Harmon, 2007). This model will therefore propose approaches for HEIs to move from their current AS-IS state to a desired TO-BE state for environmental information management which will assist in their environmental sustainability efforts. This paper also highlights the critical role that EIM plays in environmental sustainability efforts at HEIs. There is a lack of formal guidance for migrating from existing AS-IS to the desired TO-BE environmental information processes in HEIs. An EIM framework which can assist with designing the gap model is proposed. The proposed framework is then applied at a South African HEI in order to analyse the current AS-IS processes and to design the desired TO-BE processes for the case study. Several conclusions can be made based on the literature review, the design and application of the EIM framework for HEIs and the gap model for NMMU.

The next section provides a concise description of the research objectives and the methodology that was employed in this study. This is followed by a rigorous literature review that highlights that EIM is pivotal to any environmental sustainability efforts. Then an investigation into the current AS-IS processes and proposed TO-BE processes of the case study are analysed. The South African HEI: Nelson Mandela Metropolitan University (NMMU) was used as the case study. Several conclusions and recommendations are then made based on the literature review and the design of the EMIS for HEIs.

**Research Objectives and Methodology**

EIM has been identified as a key factor to achieving environmental sustainability in HEIs. HEIs should play a leading role as the world faces increasing environmental issues and they need to take action and be pioneers in driving environmental sustainability into the community (Watson, et al., 2010). However, there is limited formal guidance or frameworks for HEIs that wish to adopt environmental sustainability practices, particularly for the management of environmental information (Bero, et al., 2012). Therefore, the main research objective of this paper is: “To design a gap model that supports the efficient management of environmental information at a HEI.”

In order to derive this model, three secondary objectives must be achieved:

1. Describe the “As-Is” processes, structure and information stores at NMMU which

are related to Environmental Information Management.
2. Propose the “To-Be” processes for the management of environmental information at NMMU.
3. Identify the elements of the gap model for Environmental Information Management in HEIs.

This research followed a case study approach in which NMMU was the HEI that was used as the case study. A careful rigorous investigation into literature, previous research and extant systems were done in order to gain an understanding of the research domain. This allowed for the identification of some of the key elements of the gap model. In an attempt to understand and describe the current processes that are involved in the management of environmental information at NMMU, a two phased approach was followed. The first phase was to conduct a short survey aimed at determining the various administrative and non-administrative projects that affect or influence the university’s environmental indicators. The second phase was to conduct interviews with selected individuals, in projects or administrative service units, responsible for the alignment and reporting of the major environmental indicators at NMMU. The first survey was sent out as an email to all the university students and staff members. A list of projects and the contact people involved was generated from the survey. Each of the contacts was then interviewed. These interviews allowed the researcher to gain a deeper insight into the processes involved in the management of environmental information. Furthermore, document studies were done in an attempt to uncover underlying problems that interviewees were not willing to point out.

Environmental Information Management

Environmental sustainability is multifaceted; however most aspects of it, if not all, are tightly dependent on the availability and accessibility of correct and current environmental information (Frysinger, 2001). Hence, environmental sustainability requires correct environmental information management. Organisation stakeholders need access to environmental information to evaluate and assess the environmental dimension of organisational decisions, both at a managerial level and at a strategic level (El-Gayar and Fritz, 2006).

The most predominant initiative to enhance environmental sustainability in HEIs is the implementation of Environmental Management Systems (EMS) at these institutions (Disterheft, et al., 2012; Jones, et al., 2011). The ISO 14001 standard, specified by the International Standardisation Organisation (ISO), defines an EMS as a part of a management system that consists of planning activities, processes, procedures and resources for developing and maintaining of environmental policies within an organisation (ISO, 2004). An EMS is not a computer system but rather a set of management tools and principles designed to aid an organisation to incorporate environmental concerns in their daily business activities (Speshock, 2010).

An Environmental Management Information System (EMIS) can be defined as a class of Information Systems (IS) that is focused on the automation of environmental information (ISESS, 2000). Watson, Boudreau and Chen (2010) discuss how an EMIS can take the central role in supporting environmentally sustainable practices. An EMIS is identified as
the backbone or a precondition to environmental management efforts by supporting the organisation’s EMS and by meeting the reporting needs of stakeholders (El-Gayar and Fritz, 2006; Stuart, 2000). Hence, EMIS and EMS are closely linked and complimentary to one another. The planning phase of the EMS helps to implement an effective EMIS and to allocate resources (Speshock, 2010). The planning phase of an EMS is where the institution’s stakeholder’s such as top management and the Information Technology (IT) department establish policies and objectives of their EMS (UNECE, 2014). The elements included in this phase are, namely:

1. **Environmental policy:** An environmental policy is a commitment that an organisation makes. The commitment stipulates the organisation’s stance towards the environment (UNECE, 2014). Environmental policies may be established by an organ of the government or by a Non-Government Organisation.

2. **Environmental aspects/indicators:** The team identifies the environmental impacts of all activities for which the institution has influence on. The institution can choose which environmental aspects/indicators to prioritise on (for example, water or energy).

3. **Legal and other requirements:** The institution can choose to comply with some regulations. However, due to the legal requirements enforced on institutions in the United States of America or Europe this might be compulsory as compared to institutions in Africa, and

4. **Objectives and goals:** The team establishes objectives and goals which will allow for assessment and improvement measurement.

Once the planning stage of an EMS has been completed, the environmental information architecture must be determined (Speshock, 2010). Muntean, Sabau, Bologa, Surcel and Florea (2010) proposed an architectural framework for a Performance Management System (PMS) for HEIs. A PMS can be identified as the process of quantifying action which leads to organisational efficiency, competitiveness and growth (Ohemeng, 2011). The PMS uses data warehousing technology to manage data from various pools of data and displays meaningful information by means of a performance dashboard. A performance dashboard is an application that allows stakeholders to measure, monitor and manage organisation performance more effectively (Muntean, et al., 2010).

The PMS framework uses data warehousing technology to Extract, Transform and Load (ETL) the data in the ETL layer. The ETL processes will then allow for data aggregation, normalisation and integration. Data is extracted from various sources and is stored in the database of the data warehouse which is in the data layer. The reporting layer allows users to access and query data. In addition, the reporting layer allows for ad-hoc querying and standard report generating from the university portal and is valuable for managerial decision making (Muntean, et al., 2010). The analytical layer is a useful tool for management in decision making and strategising. This layer allows for advanced functionality such as data mining, Online Analytical Processing (OLAP), forecasting, decision support and data visualisation (Lih Ong, Hwa Siew and Fan Wong, 2011). The monitoring layer is for performance monitoring. Tools that are available in this layer include dashboards and scorecards (Muntean, et al., 2010). The university portal which is also a presentation layer is the hub of all the university IT applications and services needed by students, administrators, faculty and staff.
The PMS framework can be applied to the domain of environmental sustainability performance management and environmental information management. The framework can also be extended to incorporate the iterative planning and review elements recommended by the ISO 14001 (2004) for environmental impact management. The resulting extended framework is an EIM Framework for HEIs (Figure 1) and is iterative in nature, similar to ISO14001. Planning is the first stage in the framework and this is where environmental policy is determined and indicators are identified and prioritised. The design of an architecture for EIM is the second stage and here reports can be generated for the stakeholders so that they can check progress and to see if they have or will achieve their goals. This phase can therefore provide guidance for designing the desired “TO-BE” information stores and processes for EIM and reporting in an HEI. In the last phase of the proposed EIM framework for HEIs, the stakeholders will have a chance to do a management review in order to assess their performance, improve their goals, set new ones and even add or remove environmental indicators and the cycle can begin again.

Analysis of literature shows that the architecture of an EMIS is similar to that of the PMS (Gunther, Marx Gomez and Rautenstrauch, 2004; Yang, Li and Wang, 2012). An EMIS is typically implemented in a large organisation where there are several data sources which are characteristically in different physical locations and diverse implementations (El-Gayar and Fritz, 2006). These organisations already have other information systems in place to automate aspects of the organisation, for example Enterprise Resource Planning (ERP) systems. An EMIS can also be used as a tool to support and compliment environmental management efforts (Moore and Bordeleau, 2001). An analysis of several studies (Alshuwaikhat and Abubakar, 2008; Disterheft, et al., 2012; El-Gayar and Fritz, 2006; Fryinger, 2001; ISESS, 2000) of EMIS reveal four commonly identified features of an EMIS, namely:

- Data collection,
- Centralised data storage and access,
- Data processing, and
- Reporting.

Data collection within an EMIS includes the integration of legacy and heterogeneous systems and the data collection mechanisms vary depending on the legacy systems or the lack of legacy systems. Data collection includes the mechanisms that are used for data acquisition and data pre-processing which includes data cleaning, validation, integration and normalisation. After the retrieval of the data from the various data sources, data can be stored and processed to produce meaningful information (Athanasiadis, 2006). Some EMIS are also developed to cater for document management. In environmental efforts documents such as environmental policies need to be stored in a safe and secure environment.
The Green Reporting Initiative (GRI) is a popular standard for establishing environmental indicators in industry (GRI, 2013). Non-institutional organisations usually have a main focus which determines their environmental indicators, for example pharmaceutical companies would have their environmental indicators focused on hazardous waste. HEIs have a broad set of institutional activities and facilities including offices, laboratories, operating machinery, classrooms, dining halls, dormitories, and maintenance, hence environmental indicators associated with HEI are diverse. The Sustainability Tracking, Assessment and Rating System (STARS) is a voluntary, self-reporting framework for recognising and gauging sustainability performances for a HEI (AASHE, 2012).

Organisations need to process environmental data into useful information which can be used to draw meaningful conclusions (Speshock, 2010). Advanced EMIS offer the capability to analyse environmental information, simulate and provide decision support. These capabilities are useful and make an EMIS valuable to the top management of any institution. Data processing further involves complex algorithms that provide aggregation, ad-hoc querying and modelling of environmental data and processes (El-Gayar and Fritz, 2006). Reporting of sustainability information can foster public participation, social responsibility and promotion of sustainability in teaching and research (Alshuwaikhat and Abubakar, 2008). The Adaptive Intelligent Service Layer for Environmental information management (AISLE) is one such service-oriented EMIS that mediates between environmental data providers and actual end user applications that require pre-processed environmental information (Athanasiadis, 2006). An example of a web-based EMIS that
Determining the Gap Model for the NMMU Case Study

Water management is crucial in developing communities (Jonker, 2007). Ferguson and Maxwell (2010) highlight that developing countries in particular need to manage their water resources carefully. Podmore, Larsen, Louie and Waldron (2011) argue that the scarcity of electricity in developing communities such as those in sub-Saharan Africa is a major problem since 75% of households do not have access to basic lighting. Developing countries need to use resources such as water and energy sparingly and efficiently as these resources are limited (Von Bormann & Gulati, 2014). South African HEIs therefore need to address these two areas of sustainability as a top priority. However a lack of co-ordinated effort and poor decision making with regards to achieving environmental sustainability at these institutions in Africa has been reported (Jones, et al., 2011). This poor decision making can be attributed to the lack of efficient processes, structures and information systems which support centralised environmental data sources and eliminate information silos in different departments, faculties and campuses (Bero, et al., 2012; Jones, et al., 2011; Velazquez, et al., 2005).

In South Africa, the Nelson Mandela Metropolitan University (NMMU) has identified sustainability as a key strategy in its Vision 2020 (NMMU, 2010). This is in alignment with the South African National Development Plan (NDP) which aims to develop inclusive communities by 2030 (National Planning Commission, 2012). NMMU has undertaken several Green Campus Initiatives in an attempt to implement this strategy. These initiatives require an integrated database which facilitates decision making regarding the strategic focus of the institution on the reduction of environmental impact based on several key indicators such as resource usage (water and electricity), transportation and waste management. The application of the EIM framework to the NMMU case study took part in two phases, the planning phase and the design phase.

The proposed EIM framework for HEIs (Figure 1) was applied to the NMMU. The first phase of this framework is the planning phase. During the planning phase of the framework, several priorities and objectives for environmental sustainability at NMMU were identified. The following is the list of the main objectives and high priorities areas regarding environmental sustainability at NMMU (NMMU, 2009):

- Energy efficiency and conservation;
- Energy management, monitoring and reporting system;
- The use of renewable energy;
- Water conservation and management;
- Protecting the environment; and
- Vehicle Fleet Management.

The STARS framework was used at NMMU to identify the environmental indicators for the selected high priority areas. Moreover, several studies, interviews and document studies revealed the common environmental indicators actually implemented at NMMU which can also be linked to the STARS system and indicators (Table 1). The scope of this paper is limited to energy management monitoring and reporting and water conservation and
management, since they have been given top priority at NMMU.

<table>
<thead>
<tr>
<th>STAR indicator name</th>
<th>NMMU Indicator</th>
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<tr>
<td>STAR energy and water interventions</td>
<td>Utilities usage</td>
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<tr>
<td>Building energy consumption</td>
<td>Electricity usage</td>
</tr>
<tr>
<td>Clean and renewable energy</td>
<td>Renewable electricity generation (Solar)</td>
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<tr>
<td>Water consumption</td>
<td>Potable water usage (municipal water)</td>
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<tr>
<td>Storm water management</td>
<td>Non-potent water usage (reclaimed water, borehole water, rain harvested water)</td>
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<tr>
<td>Transportation interventions</td>
<td>Transportation and commuting</td>
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<tr>
<td>Student and employee commute model</td>
<td>Faculty, staff and student commuting</td>
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<tr>
<td>Campus fleet</td>
<td>NMMU campus service and utility vehicles</td>
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<td></td>
<td>Shuttle/bus ridership</td>
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<td></td>
<td>Air travel (NMMU official business)</td>
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<tr>
<td>Waste interventions</td>
<td>Waste generation</td>
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<td>Waste reduction and diversion</td>
<td>Solid waste</td>
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<td>Hazardous waste management</td>
<td>Hazardous waste</td>
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<td>Greenhouse gas emissions inventory</td>
<td>Air emissions</td>
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<tr>
<td>and reduction</td>
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<tr>
<td>Electronic waste recycling programme</td>
<td>Electronic waste, recycling, composting, landscaping wastes</td>
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<tr>
<td>Education and Research</td>
<td>Educational Programs</td>
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<tr>
<td>Curriculum Interventions</td>
<td>Environmental study programs</td>
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<tr>
<td>Co-curricular education interventions</td>
<td>Student organisations (Green Campus Initiative)</td>
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<td></td>
<td>On-campus programs and outreach programs</td>
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<tr>
<td>Research interventions</td>
<td>Related research projects</td>
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<tr>
<td>Grounds interventions</td>
<td>Grounds/natural heritage</td>
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<tr>
<td>Integrated pest management</td>
<td>Pesticide/herbicide, fertilizer use</td>
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<tr>
<td>Dining services and purchasing</td>
<td>Purchasing/food services</td>
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<td>purchasing interventions</td>
<td>Dinning services</td>
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<tr>
<td>Food and beverage purchasing</td>
<td>Janitorial products</td>
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<td>Cleaning products purchasing</td>
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<td>Computer purchasing</td>
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<td>Office paper purchasing</td>
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<td>Vendor code of conduct</td>
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Table 1: List of environmental indicators at NMMU.

The second phase of the EIM framework is the design and implementation of an EMIS. In order to design such an EMIS, the first step is to analyse the existing environmental data sources/stores and the related processes that are involved in the management of environmental information. Interviews were therefore conducted at NMMU and the AS-IS
processes for electricity and water were analysed and documented (Figure 2). Electricity and water are two of the main priorities of NMMU’s environmental sustainability objectives. The existing data collection process for electricity at NMMU consists of two main sub-processes; the manual electricity reading process and the smart reader process. This is because the institution has been gradually installing Johnson Control Building Management System (JCBMS) smart meters and replacing the old meters with smart meters. Hence some buildings are monitored by the JCBMS smart meters and others still have the old manual meters. At the time of this study there were no smart readers for water readings installed at NMMU. A similar process that is used to acquire electricity readings from manual meters is used to acquire the water readings from manual water meters.

**The manual electricity reading process:** An electrician goes around the various campuses reading data from each meter and records it into a handwritten document which is filed at the technical services department. The data manager at the technical services department then captures a summary of the usage into an Excel file, which is used for reporting or reconciling bill payment purposes.

**The electricity smart reader process:** Data from the smart readers are automatically stored in the JCBMS database and can be extracted from the smart meter at the user’s request for reporting or bill payment purposes. However, currently only summarised data is available.

From the analysis of the processes it can be deduced that the manual process is cumbersome, time consuming and inefficient. Moreover, there is a lot of human
intervention which is unnecessary as it increases the chances of errors.

To design the gap model for a HEI, the guidelines for the design and implementation of an EMIS from the study by Bero et al. (2012) were used. These best practice guidelines are:

1. Support for automated, sensor-based collection of data;
2. Improve processes relating to inefficient manual entry of environmental data;
3. Provide support for allocating resource usage to buildings, and campus facilities such as sports grounds; and
4. Support public awareness and outreach by allowing access to simplified aggregated data summaries of system data for access by community.

The processes at NMMU can therefore be improved by applying these four guidelines in order to derive the proposed, desired TO-BE processes for EIM at NMMU (Figure 3). The processes allow for realistic and comprehensive data gathering as it caters for manual systems. NMMU is in the process of upgrading to smart meters (electricity meters only) and this process began in 2009 and will take several years to be fully implemented.

*Figure 3: The proposed TO-BE processes for NMMU.*

The desired processes allow for the automated collection of data from smart meters, but improve the data collection processes for data from manual meters by the implementation of a Mobile Meter Reader app. This Mobile Meter Reader app allows the automated collection of data from manual meters, thereby eliminating any manual entry of environmental data. The data is saved on the mobile device and with the push of the button the data can be submitted to a central EIM database.

The gap model proposed for EIM in HEIs (Figure 4) highlights the importance of providing access for stakeholders to environmental information through the university portal. The access to information is important for inclusive communities and stakeholders, with direct interests in the HEIs and thus provides the required institutional sustainability information. The institution’s community can therefore have access to the environmental data via the public view to the university portal. The stakeholders include the entire community, for example staff, management, board, sponsors, students and future students. The university portal can therefore increase sustainability awareness by educating internal and external society of their environmental impact and involve them in sustainability efforts. Making environmental information public between departments can foster healthy competition in which departments become more environmental in their daily operations in an attempt to get credit for improvements or cost saving/avoidance and celebrate accomplishments.
Conclusions and recommendations

This paper proposed a framework which can assist HEIs to move from their AS-IS processes towards a desired TO-BE situation and therefore create a gap model. The framework facilitates for the involvement of the HEI community. The framework was successfully applied at NMMU and several improvements to the data collection processes were made. Application of the framework exposed the ever increasing complexity in campus infrastructure and showed the varying quality of datasets and the differences in the data collection procedures. This calls for the implementation of a robust and
comprehensive EMIS that can accommodate automated and manual data collection. An improvement in EIM can facilitate on improvement in decision making, environmental awareness and community involvement.

This study forms part of a larger research study which aims to design and develop a university-wide environmental information data warehouse. The development of the data warehouse is focused on making environmental data accessible for querying and to end user applications. This will allow for the development of innovative end user applications to serve as the portal for which stakeholders can access the environmental information and view it in a meaningful way. This research is to serve as proof-of-concept in a hope to drive senior management to support and drive towards creating an environmentally sustainable institution and an inclusive community.

The development of the fully analytical tools to support senior management in decision management is important. Future research can also be done in the field of Environmental Performance Dashboards (EPD) that will allow for the communication of the environmental data from different perspectives and present the information in a way that the community can understand. HEIs are generally publically funded, hence transparency and community involvement and uplifting are of utmost importance.

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