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Abstract

Information Systems scholars have played a limited role in addressing the problem of environmental sustainability, resulting in calls for our community to become more actively involved in tackling this critical problem. One of the most significant hurdles standing in the way of progress is measurement. Sustainability measurement represents a complex issue requiring the expertise of many different fields. We propose that sustainability measurement principles, which represent adopted rules or methods for conducting measurement in practice, provide an important mechanism for building the necessary linkages between disciplines, while at the same time moving us forward in protecting our global environment. In this paper we outline eight essential measurement principles and provide illustrative examples of how IS can support and embody these principles. We conclude the paper with research directions in relation to the potential role of IS in sustainability measurement.

Keywords: Environmental sustainability, measurement, information systems, climate change, green

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DEFINING THE ROLE FOR INFORMATION SYSTEMS IN ENVIRONMENTAL SUSTAINABILITY MEASUREMENT

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ABSTRACT

Information Systems scholars have played a limited role in addressing the problem of environmental sustainability, resulting in calls for our community to become more actively involved in tackling this critical problem. One of the most significant hurdles standing in the way of progress is measurement. Sustainability measurement represents a complex issue requiring the expertise of many different fields. We propose that sustainability measurement principles, which represent adopted rules or methods for conducting measurement in practice, provide an important mechanism for building the necessary linkages between disciplines, while at the same time moving us forward in protecting our global environment. In this paper we outline eight essential measurement principles and provide illustrative examples of how IS can support and embody these principles. We conclude the paper with research directions in relation to the potential role of IS in sustainability measurement.

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DEFINING THE ROLE FOR INFORMATION SYSTEMS IN ENVIRONMENTAL SUSTAINABILITY MEASUREMENT

Information Systems scholars have played a limited role in addressing the problem of environmental sustainability, resulting in calls for our community to become more actively involved in tackling this critical problem (Piotrowicz & Cuthbertson 2009; Watson, Boudreau & Chen 2010). One of the most significant hurdles standing in the way of progress in this area is measurement (Connection Research 2010). In practical terms, measurement is necessary to reduce the uncertainty and risks associated with decision-making (Hubbard 2010). Successful measurement of environmental impacts provides the necessary visibility into the effects of our actions on the planet, enabling us to make better decisions in line with our vision for the future.

Still, sustainability measurement represents a complex issue (Henri & Journeault 2010) requiring the expertise of many different fields. As a result, no single discipline can have full responsibility for environmental reporting (Clarke & O'Neill 2005) and collaborative efforts across different disciplines with diverse levels of expertise are necessary (Corbett et al. 2010; Piotrowicz & Cuthbertson 2009). Getting in the way of productive cooperation is the fact that a common language does not exist to bridge communication between these fields (Frenkel 2009). We propose that sustainability measurement principles, which represent adopted rules or methods for conducting measurement in practice, provide an important mechanism for building the necessary linkages between disciplines, while at the same time moving us forward in protecting our global environment. Although arguably, it may be beyond the expertise or responsibility of IS academics to define the essential measurement principles for environmental sustainability, it is our belief that IS has an essential part to play in implementing and enforcing these measurement principles, which in turn will contribute to better environmental decision-making at all levels of our society.

In this short paper, we articulate a set of measurement principles in relation to the role of IS in sustainable development and then present an illustrative example of how these measurement principles can be incorporated into Green IS and outline areas for future research. Through this work, we hope to inspire researchers to investigate how IS can enable environmental sustainability through the application of well-founded measurement principles.

ENVIRONMENTAL SUSTAINABILITY MEASUREMENT

At a high level, sustainability is most often thought to encompass the triple bottom line of economic, social, and environmental factors. While we recognize the importance of economic and social factors to global sustainability, we limit our focus in this paper to environmental considerations. Drawing on various perspectives on the definition of measurement (e.g., Finkelstein 2005; Hubbard 2010), we view environmental sustainability measurement as the identification of relationships between inputs, processes, and outputs related to the natural environment to be used in such a way by organizations, individuals and society to make decisions regarding their actions.

Each disciplinary area has unique strengths in addressing measurement. For example, accountants focus on control tools, standard reporting procedures, and external verification. Economists and political scientists consider the market effects and mechanisms such as the pricing of externalities and the impact on consumer surplus. Finance may examine the effects of environmental actions on firm performance, and strategic management investigates the competitive implications for organizations. Environmental scientists and engineers provide insight into the anticipated effects on the natural environment and help to determine the maximum permissible levels of emissions or other pollutants for individuals and organizations. Complementing these disciplines, IS brings important strengths to this process. IS contributes to inputs by focusing on the design of sensor networks for data collection, data base design, interface design, and digital data generation (Piccoli & Watson 2008). Processes are supported by software development, business process modeling, and data exchange technology (e.g., XML). Outputs include the necessary systems to provide intelligence for decision-making, knowledge-sharing, and environmental reporting.

To take advantage of existing technologies, systems, and IS expertise, any environmental measurement system must be based on robust and relevant measurement principles. Measurement provides the common ground for communication and represents an important opportunity for IS to support environmental sustainability (Zapico, Brandt & Turpeinen 2010).

Measurement Principles

At a broad level, measurement principles represent the collection of adopted rules or methods for conducting measurement in practice. Historically, measurement principles arose in the 'hard' sciences and focused on such issues as simplicity and consistency (e.g., Byerly & Vincent 1973). Measurement principles have been extended to the 'soft' sciences, such as economics and psychology (Finkelstein et al. 2005) and only recently have researchers started to examine these soft measurement principles as they relate to sustainability (e.g., Fisher 2009). We contend that quicker progress can be made toward sustainability by strengthening the symbiotic connection between IS and these measurement principles. Table 1 (see below) summarizes the principles relevant to practice-oriented measures, with an illustrative real-world example.

GREEN IS EXAMPLE: UPS TELEMATICS[1]

Not all companies will want to wait for a nifty application to help them reduce their environmental impacts. Indeed, some have developed, from the ground up, sophisticated information systems that allow them to become better corporate citizens while improving their competitiveness. This is the situation at UPS, with the company's use of telematics to improve the environmental impact of its delivery trucks (Watson, Boudreau & Li 2010). In brief, UPS developed proprietary firmware to collect and record the state of its vehicles, and now has access to more than 200 vehicle-related elements (e.g., RPMs, oil pressure, seatbelt use, accelerations, idling time, etc.) from its trucks. UPS captures these time-stamped data constantly throughout the day, such that between 2,000 to 5,000 readings, per truck and per day, must be transmitted to UPS's main data center. Five years of data collected via the above sensors led to a massive data repository, with which UPS can perform the necessary data analysis to identify patterns, and where necessary, proceed to

[1] Due to length limits, we only present one example in this short paper. Additional illustrations are available from the authors on request.

interpretation and recommendation. Overall, the environmental benefits associated with UPS's telematics project were multiple, among which significant reduction in mileage, in fuel consumption, and even in replacement parts (Watson, Boudreau & Li 2010).

In this example, the main measurement principles that are supported are *accuracy*, *integrability*, and *granularity*. Accuracy is improved: although truck drivers could previously provide some assessment on the many elements that are now measured, such data would only be approximations and thus rather meaningless once aggregated. With the firmware installed on the vehicles, the accuracy of the data is ensured, and thus its analysis improved. Concerning integrability, UPS captures data from both its trucks and the driver's tablet for recording deliveries and pickups. Because data from both streams are time stamped, UPS can integrate the two streams using this common element. The integration of all data within a central repository, along with the data mining application that can leverage them, thus allow for the discovery of new insights. Finally, this system also illustrates the importance of granularity: disaggregated and visually appropriate information enables UPS drivers to determine how they can reduce their environmental impacts. UPS drivers learn from the precise breakdown of their daily routes: they learn, for example, where and when they reverse or idle their trucks.

DISCUSSIONS AND CONCLUSIONS

In this paper, we outlined a set of measurement principles related to environmental sustainability and then provided examples to illustrate how IS can support and embody these principles. Because science and management cannot progress without measurement, we argue that we need to apply our expertise to incorporate principles of measurement for environmental sustainability that are applicable across multiple IS domains and environmental issues. We do not purport to have all the answers to the environmental sustainability measurement challenge. In fact, we believe this discussion raises further questions that should inspire and motivate IS researchers to collaborate with colleagues across disciplines and explore these issues in more detail. Specifically, we see three particularly fruitful areas for further research.

- Quantifying the intangibles of environmental sustainability.
- Extending measurement theory for sustainability.
- Addressing the practical urgency for change.

IT has been identified as a growing culprit in environmental degradation. Rather than talk theoretically about the value of Green IS, researchers should work with practice in a multi-disciplinary fashion to identify and quantify concrete "wedges" (Pacala & Socolow 2004) that will lower GHG emissions. Our contributions as IS scholars are to ensure that our systems deliver appropriate, reliable, and actionable information to the full range of decision makers who will shape tomorrow's environment and determine the sustainability of our society.

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Table 1: Measurement Principles for Environmental Sustainability

Information Systems Examples

Issue	**Description**	***GreenStar Network***	***Digital Meadowlands***	***Earthster and GoodGuide***	***UPS Telematics***
Uniformity	The measure is based on consistent reference standards (Fisher 2009)	X			
Transferability	A sample-based measure can be generalized to the population (Finkelstein 2009)			X	
Integrability	The measure is based on input incorporated from multiple stakeholders (Bellini et al. 2008, Fisher 2009)		X		X
Accuracy	The measure captures what it is supposed to measure (Fisher 2009, Ghiselli 1981)				X
Transparency	The measure is based on open standards (Fisher 2009, Mari 2005)	X		X	
Granularity	Measures are divisible and additive (Fisher 2009) and should reflect the necessary level of detail relevant to their particular purpose		X		X
Scope: Range	The measure has clearly defined boundaries and ensures that assumptions related to underlying measures have not been overlooked (Mari 2005)	X			
Scope: Inclusion	The measure captures all aspects of the phenomenon of concern		X		

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