Multi-Dimensional Views for Sustainability: Ontological Approach

Full Papers

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Abstract

Sustainability has been assessed by measuring the environmental, social and economic performance. Such diverse measurements could include contrasting attributes in sustainability measures namely environmental, social, and economic attributes. Our research argues that it is necessary to use a multi-dimensional approach for sustainability knowledge improvements that consist of all sustainability dimensions. Ontology models the real world and is useful in understanding different dimensions of a phenomenon. The use of an appropriate ontology such as static, dynamic, social, and intentional ontologies help to better understand the sustainability dimensions - environmental, social, and economic. This research develops ontology-based multi-dimensional view to environmental management by focusing on sustainability. The research uses hypothetical situations to develop ontological views and maps the ontological knowledge onto the sustainability dimensions to develop knowledge. This approach integrates information systems and environmental research, while encouraging multi-dimensional approaches for improved knowledge.

Keywords

Sustainability, Ontology, Environmental management systems, Knowledge management, Information systems

Introduction

Increased need for natural environmental management can be reflected in increased legislation initiated by governments, increased environmental management standards by international organizations, significant natural environmental disasters, increased awareness of environmental issues, decreasing natural resources, and market competition (Carruthers and Tinning 2003; Cotton Australia 2013). During last two decades there were critical environmental management initiatives such as ISO14001 series and the Kyoto protocol which were accepted by over 165 countries (ISO 2012). There are many other regional, national and local environmental management programs such as European Environmental Management Audit Scheme (EMAS), Australian Land-Care Management system's MyEMS, Australia Victorian North East Catchment Management Authority's (eFarmer) and the New York Based "Rain forest alliance" (Carruthers 1999; Rainforest Alliance 2014; Roberts et al. 2009). The objective of all of these systems is to improve environmental performance, but the scope of these systems differs because of competing interests such as international, regional, local, industry specific or cross industry environmental management interests. Therefore the knowledge requirements in environmental management vary. Knowledge can be managed from different levels such as individual, communities of practice, and organizational.

The above issues create the necessity to categorize into knowledge into environmental management dimensions such as environmental, social and economic. Ontology has been viewed as an effective tool in decomposing the dimensions of a phenomenon (Wijesooriya and Xu 2008). Ontologies could be used to develop static, dynamic, social, and intentional views of the business context (Jurisca et al. 2004). The application of a static ontology improves understanding of the static nature of the phenomenon, developing unique knowledge. Similarly different ontologies could provide different ontology-based improved knowledge. Such different perspectives have been used in this research to reflect the environmental, social and economic context of the environmental management. Accordingly, this research presents how the ontology can be used in environmental management systems by improving environmental knowledge that leads to sustainability.

During the research development we use hypothetical cases using specific relevant ontologies that reflect unique knowledge views. Ontological examples are explained at depth, showing how these ontological views can be consolidated to provide collective knowledge in a knowledge management context. Ontological application can be performed as an iterative process resulting new knowledge development.

Findings from this research are conceptual. The research combines information systems research and environmental management research together to achieve the research objective. Such integration of different research domains simulates research ideas, encourages research expansion and continuation of the existing research. It is recommended that the ontological views should be implemented as part of environmental management systems development. Therefore, this research helps improve knowledge about environmental management and contributes to both academic and practice.

Background

Sustainability and Environmental Management Systems

Sustainability is defined as the effective use of resources without sacrificing the resources for the future use (McLennan 1996; OECD 2010). Sustainability has been measured using three dimensions, social and economic performance. Environmental performance is measured primarily by assessing how best the environmental management processes have been in used. For example, ISO14001 certification suggests that a process based environmental management approach is effective in achieving environmental performance (ISO 2012). The ISO14001 process has been the core component of many other environmental management systems (EMS) (ALM Group 2009; EMAS 2010).

Organizations use EMS for its benefits such as (but not limited to) efficiency in data collection, data processing, reporting, and information storage. There are many different environmental management approaches such as ISO14001 that suggests a process based approach which can be used across any industry at different levels of the organization. Another approach, Eco-Management and Audit Scheme (EMAS) recognizes the ISO14001 approach, but an additional reporting requirement is necessary (EMAS 2010). Rain forest alliance's EMS primarily focuses on large agricultural industries such as Tea, Coffee, and forestry where forest management is necessary (RainforestAlliance 2012). Others found that industry specific environmental management is effective. For example, Cotton Australia's best management practice (BMP) system and Wine Australian entWine system (Wijesooriya et al. 2010). Further the use of local environmental management approaches cannot be neglected. Examples of such systems are; Australian land care management system's MyEMS, and Australia's (Victoria) North East catchment management's eFarmer. In summary, many environmental management systems (EMS) have been effective in their own approaches. The scope of these systems differs from each other. For example, the scope of the EMS could be the farm, local catchment or the industry (Roberts et al. 2009). However, all of these systems increasingly use and depend on information systems in their approaches. Extent of the use of information technology can be reflected in the use of web based EMSs.

The internet helps organizations to collect and process data from a central location, disseminate information, and analyze information more effectively (Cotton Australia 2013). Further, information systems facilitate organizational processes to maintain consistency, to automate business processes, to integrate business processes, to develop relationships, and to improve knowledge in environmental management. Improving knowledge can be done with the help of multi-dimensional views. An ontological approach is effective in providing specific views resulting in better knowledge derived from the ontological perspective.

Ontology

Ontology is a formal representation of the real world. Ontology is defined as "*a specification of some conceptualization, which is an abstract simplified view of the world*" (Wang 1997). Ontologies have been used to categorized into static ontology, dynamic ontology, social ontology and intentional ontology. Ontologies have been used due to (Noy and McGuinness 2001):

- Share common understanding of the structure of information. (Helps to understand the structure of the environmental management issues)
- Make domain assumptions explicit. (Helps to have a clear and specific understanding of the environmental management issue)
- Analyse the domain knowledge. (Helps to analyse the environmental knowledge which leads to effective environmental management)

Categorization of environmental management issues has been used to present a static aspect of environmental management issues, thereby presenting the static ontology. The static ontology could improve the knowledge in a structural context (Massad and Beachboard 2008) of the environmental issues. The social aspect of the environmental management could be presented by explaining the dependencies within business process participants in environmental management. Contemporary environmental management process participants function within a highly dependent business networks. Therefore, the environmental management process participant's dependencies have been used to present the social ontology. The dynamic aspect of environmental management issues could be reflected by the development of business rules. Business rules help to direct, guide, and enforce the organizational processes focusing on business goals. Basic concepts of a dynamic ontology to be included reflect the dynamic ontological constructs of: state, state transition, and process. Finally the intentional ontology captures the motivations, intents, goals, beliefs, and choices (Jurisca et al. 2004). Intentional ontology enables alternatives and realities of the business environment. Such knowledge of the environmental issues helps organizations to assess the situations to make the best decisions. In summary, this study uses four ontological views, namely static, dynamic, social, and intentional. It is viewed that the use of several Ontologies (static: taxonomy, social: dependency, dynamic: business rules, intentional: question-option-criteria) as an effective way to increase the understanding of the phenomena (Wemmerlöv 1990).

Knowledge and Knowledge Management

From a philosophical stance, *knowledge has been defined as the justified true belief* (Gottschalk-Mazouz and Stuttgart 2007). In philosophy the study of *knowledge is viewed as epistemology* (Kuhle and Kuhle 2010). Epistemology is the knowledge science that addresses the issues such as the nature of the knowledge, what is knowledge, how the knowledge is acquired, what is the extent of the knowledge of the entity, and how do we know what we know (Gottschalk-Mazouz and Stuttgart 2007).

Knowledge management has been defined as the process of capturing, storing, sharing and using knowledge (Davenport & Prusak, 1998) and implies the use of information and communication technology (ICT). Contemporary organizations function in a complex network of processes. In a complex network of processes, knowledge management must take a collaborative and integrated approach to the creation, capture, organization, access, and use of an enterprise's intellectual assets (Grey 1996). Such business context reflects the necessity for knowledge management to adopt a multi-dimensional integrated system-based approach. Ontology provides a mechanism to develop and present contrasting views of a specific business context. Therefore ontology has been seen effective in developing a multi-dimensional integrated system-based approach in EMS. Accordingly we assess knowledge dimensions within an EMS context.

Research Development

Using ontological views we develop an approach to improve better understand the phenomena from several different dimensions. The research framework below describes how ontology provides a multi-dimensional view of the sustainability. For example, environmental knowledge can be informed through the combination of static, dynamic, intentional and social ontologies. Such ontological views could be mapped on to sustainable dimensions consisting environmental, social, and economic dimensions. The following figure-1 reflects this sustainable dimension using ontological views and its relation to the knowledge management at the start of the process.

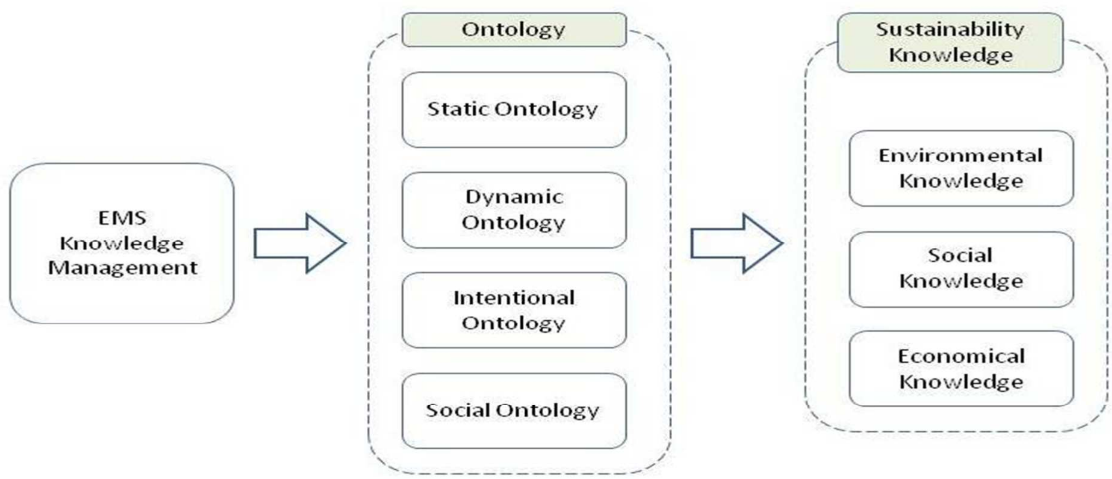

Figure-1: EMS Knowledge Management

Knowledge Scope

Knowledge is a continuously evolving property through the organizational processes (Nonaka 1994). Knowledge processes use external knowledge as well as internal knowledge in developing new knowledge. Knowledge can be explicit and it can be implicit. Implicit knowledge is known as tacit knowledge in organizational research. Accordingly knowledge has been viewed as primarily two types, namely tacit knowledge and explicit knowledge (Nonaka 1991). As shown in Table-1, tacit and explicit knowledge has been studied from individual, communities of practice (group), and organizational levels (Debowski 2006). Tacit knowledge is not clearly visible or transferable but the explicit knowledge can be transferred easily through documentation of instructions (Nonaka 1994). Individual knowledge is usually tacit. Tacit knowledge is deeply embedded within business actions and difficult to formalize and communicate (Nonaka 1994). However, such tacit knowledge could be extracted to some extent through observations and practice.

<table>
<tr><th>Knowledge Scope</th><th>Knowledge Dimension and notes</th><th>References</th><th>Ontological Dimension</th><th>Sustainability Knowledge</th></tr>
<tr><td>Individual/ organizational Knowledge</td><td>Tacit, Explicit
(Example: Documents, cognitive ability)</td><td>(Nonaka 1991)</td><td>Static, Social, intentional</td><td rowspan="3">Environmental

Social,

Economical</td></tr>
<tr><td>Group Knowledge (communities of practice)</td><td>Tacit, Explicit
(Example: Chat Rooms, Online social groups, intranets)</td><td>(Alavi and Leidner 2001; Jurisca et al. 2004)</td><td>Static, Social, Dynamic</td></tr>
<tr><td>Organizational Knowledge</td><td>Tacit, Explicit
(Example: Intranet, Library, Information Systems, Enterprise Applications, Ecommerce, Archives, Knowledge culture, Learning organization)</td><td>(Alavi and Leidner 2001; Nonaka 1991)</td><td>Static, Social, Dynamic</td></tr>
</table>

Table-1 Knowledge Scope

As noted above, the scope of the application of the EMSs varies (Table-1). For example, an EMS can be used to manage a farm, catchment, a state, or a country, and further categorized into a specific industry such as Cotton Australia's BMP, or be functionally specific as with eFarmer (North East Victoria Catchment Management Authority, Australia). Such different scopes reflect the knowledge management activities from an individual level, communities of practice level, and organizational level. Organizational level knowledge management could vary from a small family owned farm to large organizations.

Knowledge Dimensions

Static Ontology in EMS

In our research the structure/categorization of an environmental management indicator has been used to present the static aspect of the environmental management issues. Static ontology can explain the static attributes of the world such as what things exist, their hierarchy, their attributes and their relationships (Jurisca et al. 2004). Further, static ontology can be presented with the taxonomies. Accordingly the following figure-2 has been prepared to reflect the hypothetical situation of an environmental management indicator, its dimensions and its attributes. Each dimension is explained by its own attributes or measures. Hierarchy or the structure of the taxonomy together with its levels is shown in the figure-2 below.

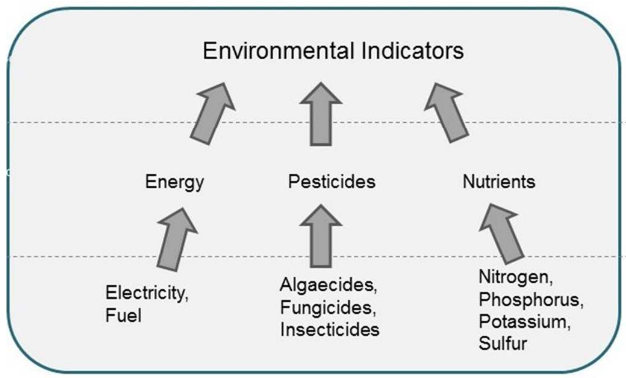

Figure-2: Taxonomy Dimension

Dynamic Ontology in EMS

Contemporary organizations function in a dynamic business environment. The business processes change frequently to meet market demands. Therefore it is necessary to develop knowledge in changing aspect of the business environments by specifically changing the natural environmental state. Dynamic ontology can be used to explain the changing state of environmental issues, specifically the state, state transition, and the process (Dardenne et al. 1993; Jurisca et al. 2004). The following Figure-3 is a reflection of dynamic ontology in environmental management.

Business Rules implemented through the Environmental Management System	Reflection of Basic Dynamic ontology functionality

PROCEDURE: Determine Soil Moisture level(HydroMeterData)
CHECK HydroMeter (HydroMeterData)
IF Insufficient (HydroMeterData) AND NOException() THEN
Read (Location, Area, WaterSupplyStatus)
DOWHILE Insufficient (HydroMeterData)=FALSE
Supply (Location, Area, WaterSupplyStatus)
Read (Location, Area, WaterSupplyStatus)
ENDDO
SupplyEnd (Location, Area, WaterSupplyStatus)
UPDATE (Location, Area, WaterSupplyStatus)
REPORT (Location, Area, WaterSupplyStatus)
ENDIF
END PROCEDURE
	State: Insufficient Water status
	State Transition: Supply water based on the meter location
	Process: Determine soil moisture level and supply water as needed.
	The process can be broken into small activities as necessary.

Figure-3: Dynamic Ontology

Social Ontology in EMS

Social ontology reflects the integration and inter-action between business and business processes. Social ontology can explain the social setting, networks of alliances, and inter-dependencies (Jurisca et al. 2004). In our research, individuals (farmer, EMS consultant (EMSC), groups (Industry groups, catchment management authority (CMA)) and organizations (government (GOVT), CMA, Internet service provider (ISP)) have been used to reflect the social ontological dependencies. The Figure-4 below is a simple reflection social setting of a farm operation presenting networks and inter-dependencies. It is not to present fully functional comprehensive social setting diagram because the figre-3 shows only a selected area of the environmental management process.

Farm depends on the internet service provider for stable internet access

Farm depends on the EMSC (Environmental Management Systems Consultant) for advice

Farm depends on the EMSC to provide the system

Farm depends on the EMSC to achieve environmental performance

Farm depends on the government to provide regulatory framework

EMSC depends on the internet service provider for stable internet access

EMSC depends on the government to provide regulatory framework

EMSC depends on the FARM for its reputation

EMSC depends on the government to provide regulatory framework

GOVT depends on the FARM to environmental reporting

GOVT depends on the FARM to achieve environmental performance

Following diagram reflects the above social ontology dependencies within four main actors FARM, ISP, EMSC and the government.

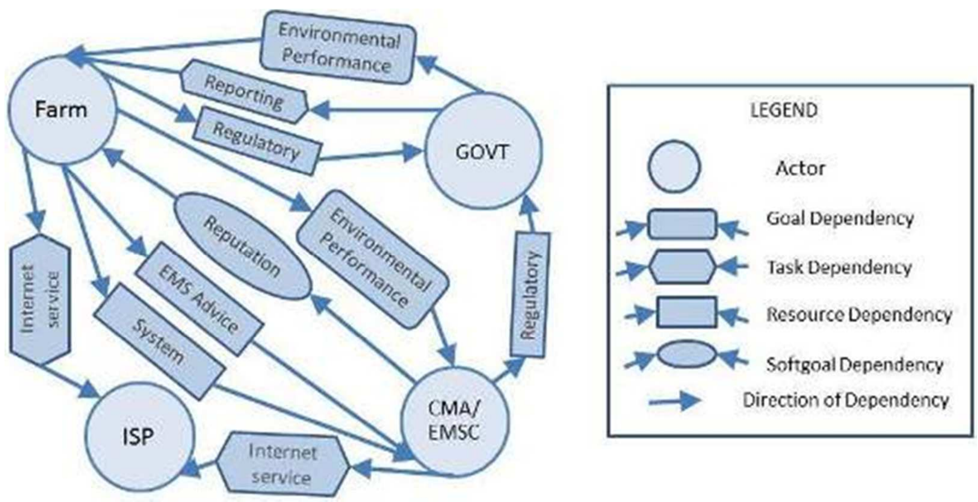

Figure-4: Social Ontology through Dependencies

Intentional Ontology in EMS

Intentional ontology, Figure-5 below, illustrates an environmental question, the options, and criteria reflecting motivations, intents, goals, beliefs, and choices (Jurisca et al. 2004). Intentional ontology presents alternatives and realities of the business environment facilitating decision making options. Consider a farm management situation that reflects the intentional ontology. It is a hypothetical situation is where a farmer intends to maintain the water requirement in the farm. The farmer must check the current state of the water requirement to the farm and make a decision whether to activate an automated or a manual water supply.

Intentional ontology is presented consisting questions (Q1, Q2), options (O11, O12, O13, O21, O22) and criteria (C11, C12, C21).

Q1: What are the water supply options available for the FARM?

O11: Tank Water

C11: Automate water supply

C12: Manual water supply

O12: Rain Water

Q2: What is the weather forecast (... *to make a decision based on weather*)

O21: No Rain

C21: Manual water supply

O22: Rain

O13: Water not required

Following diagram reflects the intentional ontology for the above logical flow of questions, options and criteria.

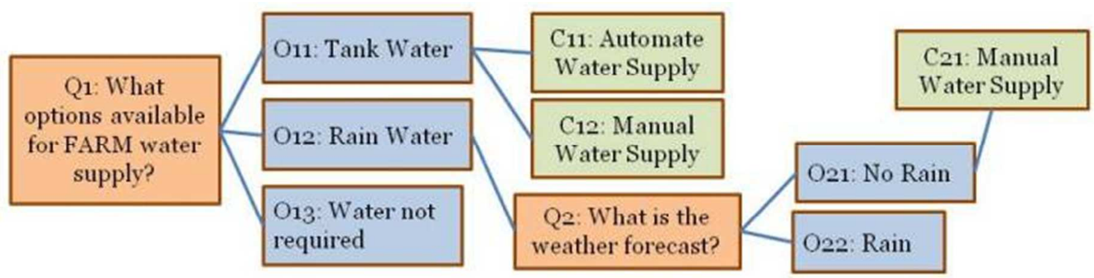

Figure-5: Intentional Ontology through questions, options and criteria Developed based on (Jurisca et al. 2004)

Incorporating Ontology in EMS

Organizations use EMS to achieve environmental performance as well as to achieve organizational sustainability. Sustainability of an organization has been assessed based on the ecological, social and economic performance (Malhotra et al. 2013). In this study, ontology is used to reflect the ecological (structural, dynamic), social (social, intentional) and economical (social, intention) context of the EMS. The structural aspect of the environmental indicators is been used in eFarmer's spatial mapping system to record and report information about: soil test results, soil carbon levels, rainfall measurements, and other monitoring information (eFarmer 2011). The use of such information through spatial mapping is an example of using structural aspects of the environmental management, therefore reflects static ontology. The creation of spatial mapping involves adhering to government legislation, and working together with local CMA and industry groups. This relies on developing and maintaining relationships among stakeholders to achieve a common goal in environmental management resulting in organizational sustainability. These relationships must include process relationships as well as business relationships, reflecting the social ontology. Thus ontologies are effective in improving explicit knowledge of sustainability dimensions. (Knowledge is viewed as tacit and explicit knowledge) (Nonaka 1991).

Developers can incorporate ontological views of the environmental management in the design and development of EMS applications. For example, an EMS application that uses spatial mapping could incorporate geographical environmental data into a spatial map. Dynamic ontology can be incorporated by introducing environmental management business rules into the EMS applications. Social ontology can be incorporated by developing stakeholder relationships in environmental processes in EMS applications. Intentional ontology can be incorporated through the issues in environmental management, options and the criteria for a solution. Intentional ontology can be implemented dynamically as an ongoing development, using past experiences of the organizations and the industry. This research plans to develop the above stated ontologies in an EMS. Then the knowledge obtained through such system is to be evaluated to its usage and implications.

Knowledge Management Process and Ontology

Knowledge management is the process of capturing, storing, sharing and using knowledge (Davenport & Prusak, 1998). Accordingly, the following process has been developed for ontology-based knowledge management approach. Knowledge acquisition is the process of capturing information for organizational requirements. Knowledge identification is where organizations identify knowledge requirements for organizational decision making. Knowledge identification could lead to development of data warehousing and data mining processes. Data mining involves making sense of data by extracting meaningful information. Ontology can make data meaningful by providing ontological views. For example, ontology can be used to present the structural and dynamic nature of the data. Similarly we present sustainability knowledge by using multi-dimensional ontological views. Such multi-dimensional views lead to ontology based new knowledge. This scenario is presented in the figure-6 below and further discussion about the ontology based knowledge management process and the implementation is explained in another section.

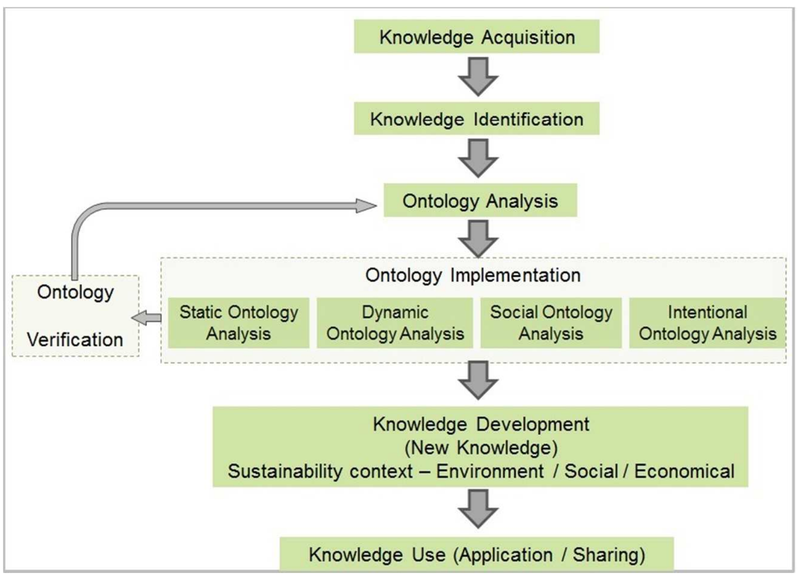

Figure-6: Ontology Based Knowledge Management Process

(Based on (Jurisca et al. 2004; Ku et al. 2008))

Knowledge Acquisition and knowledge identification

Knowledge acquisition is the process of making an investment in knowledge to increase the knowledge base, accumulate specialized knowledge, and/or transfer the knowledge (Ryu et al. 2005). Creating and maintaining the knowledge management process requires an investment of organizational resources consisting technology, process, and human resources. For example, developing and using an environmental management system involves software development, implementation, and on-going management by the user. Usually EMS users work together with other stakeholders such as EMS service providers and catchment management authorities. Such process involves environmental management understanding of the static, dynamic and social aspects of the environmental management issues, reporting structures, and relationship between stakeholders and their intentions. Stakeholders such as the government are able to incorporate their intentions in government regulations. Usually regulatory requirements are implemented and monitored through the catchment management authorities and industry organizations. Governments make sure that the regulatory requirements are addressed by reporting and monitoring processes. Therefore, it is viewed that EMS stakeholders are not limited to farms as CMAs, industry organizations as well as the governments are actively involved in the process. Accordingly, it is necessary that the stakeholder interests are accommodated in the knowledge management. Accordingly, knowledge acquisition must accommodate the information needs of static, dynamic, social and intentional attributes within the acquisition and identification processes.

Ontology Analysis

Once knowledge acquisition and identification are completed, ontologies can be evaluated. Accordingly, static ontology must be evaluated for static aspects such as attributes and relationships with other entities (Jurisca et al. 2004). Dynamic ontology must be evaluated for changing aspects such as state, state transition, and the process. Social ontology must be assessed for the social setting such as organizational structures, business relationships, and interdependencies (Jurisca et al. 2004). Intentional ontology must be evaluated for motivations, intents, goals, alternatives and choices (Jurisca et al. 2004).

Ontology Implementation

For the purpose of illustrating the ontology implementation, we use a hypothetical farm environmental management situation. Farms manage farm nutrients, soil, and pest control requirements. Farm irrigation requirements need to consider type of the plant and the soil conditions. Soil water can be measured and monitored with the help of technology such as “water content reflectometers” and “data loggers” (Campbell Scientific 2012). If the soil water content is not sufficient for the area then water supply is required. Water supply can be obtained by either stored water or rain water. Stored water supply can be either automated supply or a manual. Data can be transferred to the information system to be used by the EMS to make both environmental and operational decisions.

Sustainability Knowledge Development

Sustainability consists of three pillars or dimensions, namely ecological performance, social performance, and economical performance (Melville 2010). The following section outlines the ontological view of the sustainability dimensions and the development of knowledge in sustainability.

Ecological Knowledge for Ecological Performance:

The first dimension in achieving environmental sustainability is the natural environmental performance. Improvements to the natural environment include optimizing resources use such as water and energy use, reducing nutrient use, and reducing pest control chemicals. Based on the hypothetical farm situation, static ontology is used to reflect the environmental management information structure in figure-7.

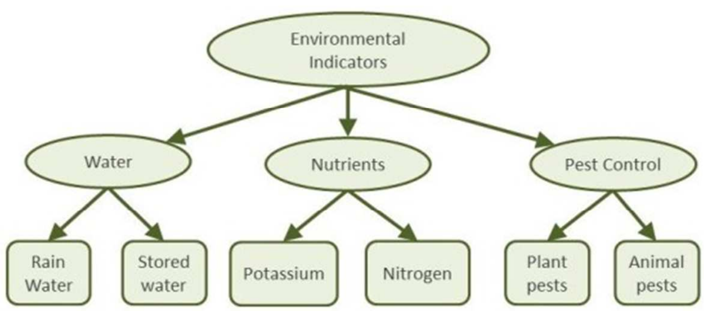

Figure-7: Environmental Management information levels of Static Ontology

We use pest control to provide an example of the dynamic aspect of environmental management. Accordingly, we define the following ontological constructs; the state: infected, state transition: from infected to not infected, the process: application of pest control.

If we analyse the social aspect of the same pests control example, we will need to identify actors, actors’ role, and inter-dependencies. Accordingly actors are the farmer, government, and the pests control services company. The farmer tries to control the pests problem so that farmer can manage the farm, the government makes policy decisions in terms of which chemicals can be used and any other controls or reporting. Also, governments will control pest control services, standards, rules and regulations. Pest control services depend on government guidelines to provide services.

Intentional ontology provides the motivations, intents, goals, alternatives and choices within and ecological context. For example, farmer is motivated to manage the environment intending to improve the farm. Farmer may have several alternatives and choices in controlling the pests such as natural processes and chemical uses. In summary, the above examples reflect the ecological knowledge can be developed based on the ontological approaches explained in this research. Such diverse perspectives of knowledge are expected to improve the ecological knowledge in environmental management.

Social Knowledge for Social Performance:

The second dimension to achieving environmental sustainability is the social performance. This consists of meeting or exceeding regulatory requirements and educating employees and the public (Melville 2010; Sharma and Vredenburg 1998). Using the same example as above, meeting or exceeding regulatory requirements requires organizations to collect data about environmental indicators and then compare whether they meet regulatory requirements. Environmental management targets can be set by the governments. CMAs advise farms about these environmental targets and CMA will be helping farmers to achieve the targets. Therefore, CMA must be fluent in legislative requirements as well as farmer requirements. Accordingly it is important that CMA maintains an effective communication and a positive relationship with the farmers as well as with the government.

Additionally, educating employees and the public is an indication of environmental performance (Hillary 2004). Educating public requires informing public about environmental issues (Cloquell-Ballester et al. 2008). Further, employees must be knowledgeable in environmental issues related to the organization. If an employee of the farm knows how to handle pest control chemicals, the employee can make quick decision to address the environmental issue. If the public knows how to dispose products in an environmentally friendly manner, disposing the product could help improving the potential environmental challenges. Therefore educating employees and public could contribute to improvements in environmental management through social performance.

Economical Knowledge for Economical Performance:

The third and the final dimension in achieving environmental sustainability is the economic performance consisting of productivity and profitability (Melville 2010). Organizations are required to maintain operational level monitory transaction records. They prepare management reports based on operational level data. In addition, organizations process operational level data and analyse them to be used for strategic decision making. Such uses of data and information at different levels reflect the structural nature of the data use in organizations. In developing the information for reporting, organizations use auditors and consultants to address industrial and regulatory requirements. The use of external professional services is common among small businesses. Therefore the organization needs to maintain business relationships with business partners in addressing changing societal and industry requirements. Changing societal interests are the norm in contemporary businesses (Wankel 2008, pp. 264-334). Such social changes are reflected in increased legislative requirements related to environmental management (McGrath 2007). Therefore, in addition to the knowledge in operational and management level data, organizations need to maintain relationships among stakeholders within a business process (specifically an environmental process), they must address dynamic changing market and societal interests in environmental issues and finally they must meet the farm's own goals and intentions in environmental management. Such challenges invite farms to view the data from different perspectives where ontological views contribute to a better and more complete understanding of sustainable practices.

Discussion and Conclusion

Discussion

In this research we identify information systems and the sustainability research as key research areas. Ontological views and multi-dimensional nature of sustainability has been explained with examples. Multi-dimensional view of sustainability consisting environmental, social, and economical provide comprehensive knowledge about the sustainability. Similarly ontology can be used to develop multi-dimensional ontological views. In this research we present static, dynamic, social, and intentional ontological views to present sustainability dimensions. Our research suggests that the incorporation of ontological views to view the sustainability can provide multi-dimensional perspectives. Sustainability itself is viewed as collective information about economic, social, and environmental performance. Having these three dimensions sustainability provides a comprehensive indication. Another example is the use of spatial mapping in environmental management (Roberts et al. 2009). The use of spatial mapping allows farmers to view the farm from a specific view or combined view. Similarly, ontological views allow either a specific view (such as dynamic nature of environment) or combined of view. Therefore we argue that the use of ontological views facilitate increased views providing improved knowledge. Information systems are capable of managing complex information in a simple processing such as presenting information in a dynamic graph. Accordingly, environmental management systems can incorporate ontological views to improve the environmental information leading to better decisions.

Conclusion

The objective of this research is to present sustainability knowledge dimensions consisting of ontological views. The study uses farm environmental management systems as an illustration of ontological views. During the research process, it highlights the complexity and the necessity for improved knowledge dimensions in EMS. Ontology has been used effectively to reflect the diverse nature of sustainability performance indicators such as environmental, social and economic. The integration of several research domains encourages researchers to simulate research ideas, encourages research expansion and continuation. For example, the applications of ontological views can be investigated further in specific type of knowledge such as tacit knowledge and explicit knowledge. The research suggests that the ontological views can be incorporated into the EMSs for improved knowledge development resulting in better informed decisions. Consequently, our research helps improving the knowledge management in environmental management and contributes to the academia and practice.

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