Building Successful Environmental Information Systems (EIS)

Wahyudi Agustiono
Department of Informatics, Engineering Faculty, Trunojoyo University

Keywords:

Environmental Information System (EIS)
System Design
Success Factors

ABSTRACT

This study aimed to understand how Environmental Information Systems (EIS) had been successfully developed and what factors might contribute to its demise. This study is timely given increasing demands on environmental management best practices and the current calls on how IS can be designed for such 'green' practices. Drawing from a case study, this paper examined an ongoing design and development of a farm management system seeking to enhance understanding of EIS development and success. The findings identified a number of key issues that were important in the EIS development. These included how the development process, collaboration and involvement, technical aspect, support and participation and support from all stakeholders including smaller ones. The results from this study suggested that EIS development exhibited a lot of challenges because it had involved a number of persons, diverse organizations and non-human aspects such as environmental regulation, standardization and safety aspect. Given this flux nature, it was therefore important for the initiators (e.g. Government and developers) to establish alliances with other interested parties, orchestrate the view of different stakeholders and technical aspects to success the design process.

Corresponding Author:

Wahyudi Agustiono,
Department of Informatics, Engineering Faculty, Trunojoyo University
Jl. Raya Telang PO BOX 2 Kamal, 69162, Bangkalan- Jawa Timur, Indonesia.
Telp. : +62-31-3011147
Email: wahyudi.agustiono@monash.edu.au

1. INTRODUCTION

The environmental sustainable practice recently has been a primary issue in many organizations due to the regulatory requirements, market pressure, environmental deterioration and good business practices [1-3]. This has prompted interest among academia and business to develop IS that can assist organizations with information collection about environmental impact in decision-making, monitoring and/or regulatory compliance. In this study, the typical IS for environmental management is referred as Environmental Information Systems (EIS).

EIS are interesting context to study in their own right, because these deal with complex and contestable environmental impact information that, directly or indirectly, has a broad and diverse audience of users such as government, consumers and environmental groups [e.g. 4, 5]. In addition, EIS are relatively new and have dynamic environment which are significantly influenced by newly information or punctuating events on technology, organization, people and environmental regulation [6-8]. As a consequence, designing such system could present different challenges compared to other 'traditional' IS such as EDI, Accounting systems and SCM where the nature of the information (e.g. Inventory, financial) is better understood. In particular, the challenges are likely to multiply when the EIS are targeted for small businesses including Small Medium Enterprise (SME) which are heterogeneous in term of IS capability, readiness and the level of environmental sustainability commitment.

Drawing from the case study, this paper examines an ongoing design and development of Farm Management System (FMS) intended for use by farmers in Australia which is considered as an EIS. The research sought to understand how such FMS which is considered as EIS had been developed, and what factors may have contributed to its successful and demise particularly when diverse stakeholders including small ones involved and used the system. This study follows Clarke III and Flaherty [9] stage development

approach to identify what went wrong and consider what we can learn from the eight years experience of this FMS development.

2. BUILDING SUCCESSFUL EIS

There is dearth of study particularly which is focusing on EIS design from which to identify what factors may contribute to the success or failure in the design process. Instead, the existing studies generally focus on the technical design of EIS to support environmental management practices [10-13]. The existing studies generally provide understanding on how to success the EIS design from technical aspects (e.g. System configuration, database structure and system architecture). As with many other IS design (e.g. e-commerce, e-government and SCM), the success of EIS design is also constrained by non-technical aspects such as common interests, IS/IT capabilities, human resources, financial and managerial supports [2, 14-17] which may overlook the technical aspects. This is also demonstrated by previous research on IS/IOIS success in which non-technical factors are consistently found to be more important instead of technical factors [18-20]. This in no surprising that the existing knowledge provides simplistic view on what factors which may contribute to the success or failure of EIS design.

Literature in this area also provides limited framework or design method from which we can examine the EIS development process and identify the success or failure. A notable exception by Thies and Stanoevska-Slabeva [21] who identified critical success factors for EIS development including clear value proposition, the role of the platform as enabler and the potential advantage of platforms owned by third parties and operated as clouds, content that is offered, and the users. However the identified factors are too global and provided simplistic view on how to success the EIS design. In fact, EIS is characterized as complex systems as the consequence, the designed is constrained by socio-technical factors as well as environmental sustainability factors.

Unlike in the EIS literature, the existing IS studies provide extensive discussion on what is considered as the success factors in design and development process. Many studies mention repeatedly a number of factors which is required to success the IS design such as funding support, common interests, value preposition, technology, integration process, trust privacy and security [22-24]. In addition, a large bodies of IS literature also discuss the stage of development process of IS [e.g. 25, 26] and Clarke III and Flaherty's strategy [9] perhaps the most relevant to illustrate the EIS development process. Table 1 illustrates Clarke III and Flaherty's approach which is previously used to describe business community development portals. By using this development stage we can evaluate what is known or went wrong in the development process and consider what we can learn from the experience of this EIS development.

Table 1. The five EIS development strategy, adapted from Clarke III and Flaherty [9]

Stage	Description
Define	Defining EIS objective, Defining EIS business process, Identifying stakeholders and users in the EIS
Design	Designing usability of the EIS and Designing the environmental information that will be managed in EIS
Develop	Developing EIS prototype, Promoting EIS to potential users and stakeholders, Running EIS evaluation and obtain feedback
Deliver	Delivering final EIS based on evaluation and feedback and Incorporating the users or stakeholders needs in the EIS
Defend	Ensuring ongoing EIS viability and Providing relevant supports to continue EIS running

3. RESEARCH METHOD AND DATA ANALYSIS

This study is based on a single case study of an ongoing EIS design for Farm Management System (FMS) intended for use by farmers in Australia. The FMS is being designed to provide a two-way flow of environmental information particularly on land management among various stakeholder groups including government agencies, dairy company and farmers/land managers. Each of these stakeholders has different needs and even conflicting interest regarding the information that is exchanged or stored. Therefore FMS is a fruitful empirical context to understand the successful factors of EIS development as it exhibits dynamic process in aligning different requirements. The case study is also used as an empirical context to illustrate how the challenges and the complexities that surround attempts to tie together diverse organizations/people, technologies, environmental management best practices and business processes into an EIS solution.

Data covering the entire process of FMS design mainly were gathered from semi structured open-ended interviews with people who involved in the design process such as: IT vendor, representatives of Government Agencies and industry. A number of interviews with end-users including field staffs and farmers was also conducted to deepen understanding the use and the problem associate with the FMS. Based on the responses we can identify factors which contribute to the success or failure of the FMS. Secondary data will also be collected such as documents, reports, minutes of meetings, user guides and other archival documents which may contribute to understanding the issues around the FMS development.

The data generated from interview transcripts and secondary are in textual form (e.g. reports, design documents) and analyzed by using qualitative method. This research follows Wolcott's [27] approach in

analyze the data which he distinguishes between description, analysis and interpretation in the data analysis process. Each of these steps can benefit from using content analysis method by using computer software such as NVivo [28, 29]. From this data analysis process we draw out themes (patterns), concepts and conclusions relating to identify the success factor in EIS development as well as lesson learned from the failures.

4. CASE STUDY OVERVIEW

Farm Management System (FMS) design project was initiated in early 2005 by government through the Department Land Resources (DLR) and Department Environment (DE) (pseudonym for the government departments) as part of Environmental Management Systems project. FMS is a web-based farm and catchment information management tool which was primarily designed to enable farmers or land managers to capture spatial data of their properties, natural assets, current and future management activities at farm level. Given the reality that two thirds of the land is used for farming, many of the natural resources (e.g. waterways and vegetation) on it are affected by activities such as fertilising and grassing. Therefore, the government tried to initiate the design and development of a useful and useable tool that can support farmers or land managers in particular with land management. In addition, at larger scale, FMS allows government and catchment planners to access on-farm activities to assist with environmental management, monitoring, reporting and future investment.

This project is timely, given the absence of sound empirical tool based on rigorous science and suitable for a variety of agro-ecological zones to collect, assess, monitor and generate action planning of current environmental support programs at farm level. In addition, there have been extensive farm management tools, however farmers were still reluctant to use those packages for some reasons such as relatively expensive, designed for single purpose and not user friendly [30]. Therefore rather than just pass environmental regulations and provide direct support (e.g. training, funding and subsidy for EMS programs) to farmers, the government worked collaboratively with related department, catchment authorities and other third parties for co-development, trialing and testing the FMS.

5. RESEARCH FINDING AND ANALYSIS

To achieve those objectives, the government through related departments and four catchment authorities undertook the work in a consortium to start the development of FMS. Based on the information obtained during interviews with participant and the data gathered from secondary sources, this research draws a number of key findings regarding the FMS development process. Table 2 summarizes the analysis of the FMS development process using Clarke and Flaherty's [9] approach.

Table 2. Analysis of FMS development process

Stage	Outcome
Define	• The consortium clearly define the objective of the FMS as discussed in the background of FMS development section. This is because majority the consortium members had previously involved in the environmental project and many of them have been working closely with farmers. Therefore it is not surprising that they could produce a well defined conceptual design as they understand their needs and farmers interests in environmental management. • In addition the analysis also indicated that the FMS development goal is well defined as it is originated from the National Pilot Program on Environmental Management Systems (EMS) and EMS Pathways to Sustainable Agriculture which is previously enacted by the government.
Design	• During the interview with the IT vendor who responsible for the FMS development, it was clear that the FMS business process, system specification and requirement analysis were well prepared. They applied a systematic design approach to develop the FMS such as running series of workshops with potential users for requirement gathering, developing mock up screens to explain the EIS concept to users prior to development and they also held some consultation sessions with government to ensure the design systems were appropriate. • As the FMS was primarily designed to help farmers to reduce the compliance and administrative burden in environmental and farm management, understanding their needs, interests and heterogeneity is important. Therefore to address this need, the consortium also involved farmers in some stage of development including workshops for user requirement gathering, follow up feedback upon the design systems via mock up screens and finally in formal evaluation to test the usability and the usefulness of FMS. The consortium also involved field staffs who assist farmers in farm and environmental management to discuss about the functionalities, design of database tables, what information would be valuable for farmers. • In this stage, some technical workshops particularly with the government people were held to discuss about how the prototype would work in terms of the software technologies, the mapping that the system would need to use, how to handle security and privacy from a technical perspective. The objective of this workshop was to make sure that the design of the FPT prototype was acceptable to government from the technical and architecture perspective. • However investigation found that various environmental information needs among the users has not well

Stage	Outcome
	incorporated in the design. Instead, the government's needs are more taken into account in the design which may lead to the failure as contended by the developer, " *and when we originally building FMS, we ask them (Farmers) to identify the EVC(Ecological Vegetation Classification) for each of their paddocks and really that was just beyond them you know*" **[Vendor]**. As the result, although FMS has a lot of potential use for farmers to access aerial photography, property boundaries and satellite data for farm planning. But not many farmers in the pilot group have equipment or confidence to take advantage of FMS for better farm management. In response to this challenges, the developer tried to enhance the FMS by including the analytical and decision support tools such as Farm Nutrient Lost Index (FNLI) which is valuable for farmers in farm and environmental management
Develop	• The development phase was also found well managed. For example, some evidences show after completing the design phase and some revisions, the vendor developed the FMS prototype. The consortium then run a number of workshops and internal trial to ensure that the prototype was acceptable from technical aspect, identify 'bugs' and get feedback for further improvement. Following the prototype development, the government run evaluation to test the usability and usefulness of the FMS. A series of trial and workshop sessions which involved field officers and farmers were held to demonstrate 'proof-of-concept' of the FMS design. • The analysis also found that some strategies in this phase work effectively to success the FMS development. For instance in order to achieve adequate level of participation from users (farmers), the government invited the dairy company to involved in promoting the use of FMS. The company is considered as the key stakeholder as they currently have power by virtue to facilitate or encourage farmers to use FMS as indicated by their field staff, *"It was easy to engage farmers with that area. So the food safety what we focused on first because there is an audit related to that so they set standards are and the farmers need to comply with. anywhere where there is not that's stick to speak, it's been difficult to get them to engage with*" **[Diary Company Field Staff]**. In addition, the company was very keen to assist their farmers by designing the Dairy Management System (DMS) to reduce administrative burden to report upon on-farm environmental management. Therefore, they had strong interest to involve in the pilot testing as they saw FMS is a 'ready-made' tool which could give their DMS extra functions and valuable for their farmers. • The collaboration of the dairy company and the consortium had successfully conducted the pilot program to make the environmental management at farm level burden free for dairy farmers by using the FMS and DMS. In addition, after the evaluation, there had been considerable interest in the prototype from farmers, extension officers and industry. For example, from around 60 farmers participated in the pilot testing in 2006, three years latter 1350 people across 8 of the 10 Catchment Authorities were registered as user, and approximately 700 had actively used the FPT prototype.
Deliver	• As the Environmental Management System (EMS) project was finished in 2007 and the evaluation found that the prototype demonstrated the 'proof-of-concept' of the FMS conceptual design, the consortium then recommended government for future investment into fully system development. However government as the owner had not decided upon the development of the fully system for state-wide roll out and this in turned resulting the uncertainty on FMS design project. Generally, the Government were in favour with the recommendations set by the team, however, within about four years there was no decision made by government as they are reviewing the entire policy on EMS. • At the end, the FMS prototype had some limitations as the growing users and their interests whilst it was designed for only prototype. Without major enhancement during six to seven years, the FMS prototype had reached its useful life in term of the technology, new requirements, funding support and information needs.
Defend	• Given this difficult situation and whilst the users reaction had been extremely positive, the team excluding government then decided to work out to keep FMS prototype 'alive', and they put some funding to cover the expenses, provided basic technical supports and assistance as well as ad-hoc training programs. There was also a great deal of support for FMS prototype continuation and expansion from industry groups and NGO's such as extension support systems development, farm planning program and landscape monitoring. • Finally after for more four years without decision, in mid 2011, the government then decided to provide funding to develop the FMS prototype into fully system which called Farm Management Systems 2.0 (FMS 2.0). At the time of writing this paper, the FMS 2.0 design had been at the development of high level of specification and by the end 2013 the government will have the fully function system.

6. DISCUSSION AND CONCLUSION

The case study shows that at the time of writing the paper, the government has successfully initiated, designed, developed and tested the FMS prototype prior to the development of fully function systems for state-wide roll out. From the end-users' (farmers and field staffs) point of view, it had successfully delivered expected value and provided valuable tool for better farm and environmental best management practices. It also helped make the interaction between government, extension officers, catchment planners and farmers more effective and reduce environmental information asymmetry.

Drawing from the case study one of the key success factors in building the EIS is stakeholder's identification and selection and then reconcile their different or even conflicting interests in the development

process. This is consistence with previous studies [e.g. 31, 32, 33], and particularly in the context of EIS where diverse stakeholders with different interests met. In addition, the development process which was organised by the vendor followed most of principles of IT project delivery from defining the scope, requirement gathering, design process and evaluation prior to system implementation. All those important steps have been acknowledged in the previous study as the design phase. Evident from the case study also indicated that one of the key inhibitors of FMS design project within pre-defined timeline was the inadequate and uncertain supports. This is because the FMS design project relied on the government supports (e.g. funding, infrastructure and field officers) which were heavily influenced by the current government policies. Therefore any changing in the government policy particularly in the environmental program will have impact to the FMS design project.

By using Clarke and Flaherty's [9] approach to understand how the FMS design processes in the complex and dynamic environment, this study in particular has extended previous understanding on success and failure factors of developing IS/IOIS. However, what is important in this findings is that the analysis identifies a number of factors, not discussed in the literature, that are important for designing successful FMS. First, unlike many other IOIS technologies, in agriculture sector the FMS is designed and transferred to a large number of farmers via intermediary agents. This is due to the fact that farmers face a considerable barriers including geographically-disperse, limited resources, knowledge and IT expertise. This in turn requires active participation of stakeholders who can play as intermediary roles such as government staffs, catchment planner and extension officers in grappling with diverse requirements and delivering supports in the implementation. Second, it has been recognised that the stakeholders in FMS design (farmers, field officers, catchment planner, and industry) have different but complementary interests, knowledge and skill in environmental and farm management. Therefore the FMS design for those parties involves an interactive process of co-learning, collaboration, negotiation and communication which have strong parallels to participatory approach.

Finally, the main challenge in the FMS design is how to design the systems that enable the Environmental Information (EI) sharing across different organisations. The EI is characterised by its complexity which dealing with changing regulation, contestable, voluminous and unstructured data. The distinctive nature of EI made the information exchange in FMS is different compared to traditional information (e.g. inventory, financial) in IOIS which is well discussed and understood in the literature. In addition, the diverse participating organisations in the FMS have different or competing and even conflicting of what is considered as the EI. As consequence, designing such systems involves two complementary but distinctive approaches, technical and non-technical. The technical approaches include the processes of defining systems architecture, components, modules, interfaces, and environmental data requirements to address technical problems in EI sharing. While non-technical strategy has its root in social, cultural, and psychological aspects of the EI needs. Therefore, it is important to adopt appropriate strategies to manage the different interests, organisational background and management strategy of participating organisations which influence the design of the systems.

REFERENCES

[1] V. Biondi, F. Iraldo and S. Meredith S. "*Achieving sustainability through environmental innovation: the role of SMEs. International Journal of Technology Management*" 2002;24(5/6):612-26. PubMed PMID: None.

[2] R. Lanteigne and V. Laforest, "*Specifications for an internet based clean technology information support system for SMEs. Journal of Cleaner Production"*, 2007;15(5):409-16. PubMed PMID: None.

[3] Haddock-Fraser JE, Tourelle M. "*Corporate motivations for environmental sustainable development: exploring the role of consumers in stakeholder engagement. Business Strategy and the Environment"*. 2010;19(8):527-42. PubMed PMID: None.

[4] Perl-Vorbach E. "*Communicating Environmental Information on a Company and Inter-Organizational Level. Organizational communication and sustainable development: ICTs for mobility"*. 2010:115.

[5] MP. Sharfman,TM. Shaft and RP. Anex Jr. "*The road to cooperative supply-chain environmental management: trust and uncertainty among pro-active firms. Business Strategy and the Environment"*. 2009;18(1):1-13. PubMed PMID: None.

[6] Guide Jr VDR, Srivastava R. "*Buffering from material recovery uncertainty in a recoverable manufacturing environment. Journal of the Operational Research Society"*. 1997:519-29.

[7] PM. Wognum, H. Bremmers, JH.Trienekens, JGAJ Van der Vorst and JM Bloemhof, "*Systems for sustainability and transparency of food supply chains - Current status and challenges. Advanced Engineering Informatics"*. 2011;In Press, Corrected Proof.

[8] L. Chunjiao, S. Zhihui, L. Yuhong and L. Dongmei, Study on the Information Disclosure of Environmental Accounting. Intelligent Information Technology Application Workshops, 2009 IITAW '09 Third International Symposium on; 2009.

[9] Clarke III I, Flaherty TB. Web-based B2B portals. Industrial Marketing Management. 2003 1/1/;32(1):15-23.

[10] R. Carlson, M. Erixon, P. Forsberg and AC. Pålsson, "*System for integrated business environmental information management. Advances in Environmental Research*". 2001;5(4):369-75.
[11] B. Funk, A. Möller and P. Niemeyer, "*Integration of Environmental Management Information Systems and ERP systems using Integration Platforms. Information Technologies in Environmental Engineering"*. 2009:53-63.
[12] B. Funk, A. Möller and P. Niemeyer, "*A reference architecture for the integration of EMIS and ERP-systems. Lecture Notes in Informatics"*. 2009;154:3393-401.
[13] A. Moeller and A. Rolf, "*IT Support for Sustainable Development in Organizations. In: Berleur J, Hercheui M, Hilty L, editors. What Kind of Information Society? Governance, Virtuality, Surveillance, Sustainability, Resilience. IFIP Advances in Information and Communication Technology"*. 328: Springer Boston; 2010. p. 281-91.
[14] V. Puranik, G.Yaranal and S. Kulkarni, "*Management information system for energy and environmental aspects of small and medium scale industries"*. 2004. IEEE.
[15] A. Maijala, L. Linnanen and T. Pohjola, "*Web-based environmental management systems for SMEs. The business of sustainable mobility: from vision to reality*". 2006:196.
[16] A. Maijala, L. Linnanen and T. Pohjola. "*Web-Based Environmental Management Systems for SMEs. Enhancing the Diffusion of Environmental Management in the Transportation Sector Sustainability Accounting and Reporting. In: Schaltegger S, Bennett M, Burritt R, editors.: Springer Netherlands*". 2006. p. 655-77.
[17] S. Burke and WF. Gaughran, "*Intelligent environmental management for SMEs in manufacturing. Robotics and Computer-Integrated Manufacturing*". 2006;22(5-6):566-75. PubMed PMID: None.
[18] NWT. Quinn, "*Environmental decision support system development for seasonal wetland salt management in a river basin subjected to water quality regulation. Agricultural Water Management"*. 2009;96(2):247-54.
[19] R. Clarke and M. Jenkins. "*The strategic intent of on-line trading systems: a case study in national livestock marketing. The Journal of Strategic Information Systems"*. 1993;2(1):57-76.
[20] P. Finnegan, R. Galliers and P. Powell, " *Inter-organisational systems, strategy and structure: The case for planning environments. Australasian Journal of Information Systems"*. 1998;6(1).
[21] H. Thies and K. Stanoevska-Slabeva. "*Towards Inter-Organizational Environmental Information Systems for Sustainable Business Networks"*. AMCIS 2011; 2011.
[22] JT. Mentzer, W. DeWitt, JS. Keebler, S. Min, NW. Nix, Smith CD, et al. *Defining supply chain management. Journal of Business logistics*. 2001;22(2):1-25.
[23] Kwon I-WG, Hamilton JH, Hong S-J. *Trust and Transaction Cost in Supply Chain Cost Optimization: An Exploratory Study. Inter-Organizational Information Systems and Business Management: Theories for Researchers*: IGI Global; 2012. p. 70-82.
[24] C. Ranganathan, TSH. Teo, J. Dhaliwal, "*Web-enabled supply chain management: Key antecedents and performance impacts. International Journal of Information Management"*. 2011;31(6):533-45.
[25] P. Jones, E. Muir, P. Beynon-Davies, "*The proposal of a comparative framework to evaluate e-business stages of growth models. International Journal of Information Technology and Management*". 2006;5(4):249-66. PubMed PMID: None.
[26] Rao SS, Metts G, Monge CAM. Electronic commerce development in small and medium sized enterprises: a stage model and its implications. Business Process Management Journal. 2003;9(1):11-32. PubMed PMID: None.
[27] HF. Wolcott, "*Transforming qualitative data: Description, analysis, and interpretation: Sage Publications, Inc*". 1994.
[28] MB. Miles and AM. Huberman, "*Qualitative data analysis: A sourcebook of new methods: Sage publications*". 1984.
[29] KA. Neuendorf, "*The content analysis guidebook: Sage Publications Inc"*. 2002.
[30] K. Lowell, L. Smith, I. Miller, C. Pettit and E. Seymour, "*Extension Activity Support System (EASY): A Web-Based Prototype for Facilitating Farm Management. Future Internet*". 2012;4(1):42-64.
[31] L. Ballejos and J. Montagna, "*Stakeholders Selection for Interorganizational Systems: A Systematic Approach. The Past and Future of Information Systems"*. 1976–2006 and Beyond. 2006:39-50.
[32] M. Ruohonen, "*Stakeholders of strategic information systems planning: theoretical concepts and empirical examples. The Journal of Strategic Information Systems*". 1991;1(1):15-28.
[33] A. Boonstra, D. Boddy, S. Bell, "*Stakeholder management in IOS projects: analysis of an attempt to implement an electronic patient file. European Journal of Information Systems"*. 2008;17(2):100-11.

BIBLIOGRAPHY OF AUTHOR

Wahyudi Agustiono. He is a lecturer at Informatics Department, Engineering Faculty of Trunojoyo University. He received Master degree in Info-Telecom Socio-Economics, Network Business and Policy Area from Graduate School of Global Information and Telecommunication Studies, Waseda University Japan in 2008. He is currently undertaking his research on the area Inter-organizational Environmental Information Management Systems. His research is looking at how such IOEIMS had been designed and what particular strategies may contribute to its success in design process.