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EXPLORING THE ROLE OF IS IN AGRICULTURE: CREATING AN AGENDA TOWARDS AGRI-INFORMATICS

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Abstract

The use of information systems is common in almost every industry sector. However, in each industry sector systems are being used for specific business processes to attain specific objectives. Health informatics is one such example. At a time where global outlook is emphasizing on the value of food security, it is worth considering the role of information systems in the agriculture sector. This paper provides preliminary findings towards such a discussion. Gathering data from two large commercial farms, this study investigates the types of systems currently in place, user cohorts and the core business processes of an agri-business. It provides a summary of strengths, issues and potential opportunities of the current state of IS in agriculture and calls to consider the establishment of an Agri-Informatics research track to develop and guide a cumulative tradition of research.

Keywords: Information Systems, Agri-Informatics, Case study.

1 INTRODUCTION

The global population growth, climate change and shortage of arable land highlight the importance of future food security, agriculture and farming, where food security has become one of the top priories of the United Nations (Unicef 2015). Almost all countries in the world, emphasize on aspects such as development of rapid yield crops to reduce yield cycles, development of high quality fertilizers, raise low water resilient crops, effective management of supply chain and management to reduce food wastage (Cox 2002; Pasqual 1998). The emphasis of world food security will become even stronger with the predicted population increase. According to United Nation the world population is expected to increase by 2.6 billion by 2050 (UN News 2013). Their report highlighted that the rate of population increase is greater than the rate of food production. While a range of sciences are attempting to address the aforementioned issues through scientific discoveries, the role of information systems (IS) in contributing to this global issue is unsystematic. For example, similar to how IS scholars have rightfully acknowledged *health* information systems (Agarwal et al. 2010), a similar systematic treatment is required to investigate the impacts of IS in agriculture. More from a practical view, though the two most prominent business information systems vendors, Oracle and SAP, have industry solutions for many industry sectors, but they are yet to develop an industry solution on agriculture industry sector (Richardson 1997).

The objective of this research-in-progress paper is to provide an overview of the impact of IS in agriculture and provide research directions. The paper identifies the salient business processes, types of systems, their precise role in agriculture and key stakeholders. The paper makes observations of the aforementioned using data gathered through two case organizations. First, to get an overview of the representation of IS and agriculture research, we reviewed the senior scholars basket of eight journals – MISQ, ISR, ISJ, JIT, EJIS, JMIS, JSIS and JAIS. Then we expanded the search to incorporate I&M, CAIS, ICIS and ECIS from their *inception* to now to understand the status of agriculture related research in IS discipline. Our analysis revealed that there is a paucity of research investigating IS in agriculture. Surprisingly, there were only 11 research papers on IS in agriculture in the 12 outlets in the past 30 years. The focus of the eleven studies that we found were on the digital divide (James 2004; Kanungo 2001), use of mobile internet for training in agriculture industry (Scornavacca 2007), ecommerce/electronic markets in agriculture (Butler et al. 2009; Heezen and Baets 1996; Mola et al. 2008; Parker and Weber 2011), virtual communities in agriculture (Whitaker and Parker 2000), use of real time business intelligence (Baker 2013), prototypes (Hershauer et al. 1989) and decision support systems (Pozzebon et al. 2014) for decision making in Agribusiness. It was highlighted that there is an opportunity for the IS research community to leverage its knowledge to enhance theory and conduct impactful research.

This paper proceeds in the following manner. First, the paper investigates processes, stakeholders and types of systems that are currently within a 'commercial farm.' Herein, we introduce the processes, information systems and stakeholders of a commercial farm. Then, we gather data from two commercial farms to explore the role of IS. As such, data was collected from two commercial farms. Here, the study provides a clear rationale for the selection of the case organizations as well as for the approach employed in the study. The third section of the paper reports the analysis of the study and the then we highlight the results and the discussion. Finally, the paper concludes with research and practitioner implications and future research opportunities.

2 PROCESSES, INFORMATION SYSTEMS AND STAKEHOLDERS OF A COMMERCIAL FARM

As mentioned, this paper provides examples of the role of IS within a 'commercial farm.' The scope of the farm includes; the farmland, machinery, cultivation processes, administrative processes and human capacity. The study acknowledges the wider use of IS beyond the stipulated scope above in area such as seed development, germination, scientific developments of fertilizers, development of genetically engineered smart crops and the management of the supply chain of produced beyond the farmland. Such a defined focus is warranted to make the study findings meaningful and feasible.

When considering the use of systems in a commercial farm, we make the observations using its core business processes and stakeholders of each system. Such an approach is consistent with views of Burton-Jones and Straub (2006), where they highlighted the important role of making observations through considerations of (i) user, (ii) technology and (iii) task (in this case the process).

2.1 The key processes within a commercial farm

The following activities of a commercial farm are distilled from the two case organizations through common consensus. The activities in a commercial farm can be consolidated into a number of salient business processes, ranging from site preparation, human capital management, training to management of machinery. The activities can commence from the *planning phase*. Sales forecasting triggers the establishment of the production volumes required based on previous information, including the combination of long-term tread analysis and customer profiles. This leads to the creation of production schedules. The production schedules identify the selection of the crop, site and block allocations and determination of the peripheral engagements like fertilizers and pesticides. Once the crops and the periphery are determined, the process continues through pre-season inspection. This involves site inspection and block preparations. Once the blocks have been prepared, the *planting* schedule is established. The planting schedule includes the type of the crop, human capital engagement, and machinery utilization and maintenance. Next, the 'agronomy processes' commence, which are responsible for monitoring the success of the crop from planting to harvesting. The activities of the agronomy process determine the frequency of site and crop checks, fertilizers and herbicides spray recommendation, determination of withholding records (i.e. where the crop has been sprayed and cannot be harvested until a certain point of time). The activities relating to harvesting are then commenced. Finally, the *post harvesting* activities take place includes quality control, sales and distribution internal activities, developing marketing schedules, storage and safety related activities.

2.2 The current use of IS in a commercial farm

The use of IS in agriculture displays one of the most heterogeneous observations across and within the nations. We reviewed prior literature to understand the different technology options that are available for farming industry and the associated benefits. Primarily, the technological tools available for the use in agriculture can be broadly classified as diagnostic tools or applicative tools (e.g., crop scouting and remote sensing, variable rate application, guidance and navigation) (Aubert et al. 2012). Such diverse technological tools would provide access to the data from different points in the space and time in the crop production thus makes an integrated data source which is important in determining the special variability in fields, requirements of nutrients and the other imbalances in the fields. While we found that some commercial farms employ sophisticated IS approaches, others still engage in primitive, less sophisticated and traditional approaches. Anecdotal commentary suggests that farmers in China, which account for nearly 20% of global food production, seldom use information systems in their management of commercial farms. Moreover, while there has been substantial progress being made in areas like agricultural machinery, crop science, fertilizations and pesticides, there has been far less emphasis on the use of IS in commercial farms.

In the 1990s there was considerable change in IS landscape that opened up new pathways for the industries through such technologies like the advancements of the internet, high bandwidth wireless internet connection, e-commerce and enterprise systems (Davenport 2013; Eden et al. 2012; Lokuge and Sedera 2014a; Lokuge and Sedera 2014c; Risdon 1994 ; Ross and Waksman 2001). Though such technologies were available, the proliferation of these technologies in the agriculture sector has been limited. The lack of IS proliferation in commercial farming is due to several factors: (i) low maturity of IT infrastructure in remote areas where commercial farms are located, (ii) low levels of IS acceptance by stakeholders who are less IT savvy, (iii) lack of specialized systems developed by leading commercial software vendors, (iv) reluctance of the IT consulting companies and (v) reluctance to invest given the high cost of IT implementations (Aubert et al. 2012; Cox 2002). Since the mid-2000s, corporate IT has been presented with a plethora of opportunities triggered by the growth in the consumerization of IT and the advent (and rapid adoption) of mobile technologies, cloud computing, business intelligence and social media collectively referred to as digital technologies (Chee and Franklin Jr 2010; Walther et al. 2013; Yoo et al. 2006; Yoo et al. 2010). Scholars and practitioners argue that digital technologies could represent new ways of how organizations could reap benefits of IS (Berman et al. 2012; Nwankpa et al. 2013; Nylén and Holmström 2015; Stahl et al. 2012; Yoo et al. 2012), especially in the agriculture sector to minimize issues stated above.

2.3 Key user groups of a commercial farm

As mentioned above, the advent of packaged IS in the 1990s made a transition from in-house, custom-made, stand-alone legacy IS applications to integrated, customizable applications. This has provided organizations an opportunity to employ systems to integrate all internal key user groups. The IS literature identify three key users. They are; (i) operational, (ii) managerial and (iii) executive users (Grabski et al. 2011; Kang and Santhanam 2003). For example, operational users would use a system to complete their routine business transactions on a day-to-day basis as a transaction processing system. The managerial staff engages with IS for management decision-making, largely based on the transactions created by the operational staff. Similarly, the executive staff engages with IS for strategic management purposes. These three user groups tend to be hierarchical in their needs of information requirements, structure and management approach. In addition to these three groups of employment, commercial farms have field staff that is disjointed from the traditional pyramid of employment (users). In general, similar to that in mining, farming field staff has shown resistance to the adoption of technologies. Moreover, the traditional technology providers have been unable to provide acceptable IS to less IT-literate staff that is appropriate to be used outdoor. The integration of all key user groups through IS has the potential to provide organizations with great value through standardization of information, automation of processes and improvements in transparency (Morris and Venkatesh 2010; Seddon et al. 2010; Strong and Volkoff 2010). As alluded earlier, IS adoption remains an issue within farming community (Maertens and Barrett 2013). As Isgin et al. (2008) mentioned the field staff's (farmers) education levels are found to be significant determinants of technology adoption decisions, farmers less techno-savviness remains a major challenge in utilizing technology in agriculture. On the other hand the processes and practices within farming are not homogeneous but are unique, different and complex (e.g., Farmar-Bowers and Lane 2009; Noe and Alrøe 2012; Sørensen et al. 2010) as well as the systems used in the IS context (e.g., Aubert et al. 2012; Cox 2002; Hassall 2010) unlike in other industries such as manufacturing. Furthermore, in order to optimize these potential capabilities of IS, all key user groups must jointly adopt this technology innovation in a synergistic fashion (Lokuge and Sedera 2014b; Sedera and Dey 2013; Sedera et al. 2016).

3 RESEARCH METHOD

A qualitative study approach was followed as it allowed the researchers to capture the qualities, rationales and processes that followed for exploring the system use and related issue, that cannot be measured or quantified in terms of amount, frequency and intensity (Walsham 1993). The investigation in the present study can be characterized as multiple case-studies. Our interest in exploring the impact of IS in agriculture justifies the use of a multiple case study method as the systems are used only in real life context and it enables comparison across cases (Eisenhardt 1989). The unit of analysis in this study is the organization. The study sought commercial farms with a portfolio of systems that had been implemented more than three years ago at the time of data collection (2014-2015). The 3-year time span is generally considered sufficient for the users to get familiar with the system and the organizations to reach the benefits out of a system (Markus and Tanis 2000; Swanson and Dans 2000).

Preliminary data was gathered from two organizations identified herein as FARM1 and FARM2[1]. FARM1 is a leading producer of fruits and vegetables – had operations only in Australia. FARM2 is a leading Sri Lankan agricultural producer and has extended the business to South Asian region. The main informant sought in these case organizations was the chief information officer (CIO), or the individual holding an equivalent position (i.e. chief technology officer or technology leader). The targeted CIO sample was appropriate for the study objectives, as these personnel would be able to comment knowledgeably on behalf of the organization in relation to IS use and impact (Ross and Feeny 1999). As Grover et al. (1993) explain, a CIO manages the information resources that influence organizational strategy and has the direct responsibility for the planning of the IS framework necessary to cope with an organization's competitive environment. A CIO can provide an overall opinion about the organization and the industry and also knowledgeable about the organizational policies, culture, initiatives and strategies (Ross and Feeny 1999). Further, we collected data from managers and employees of the two organizations as well. Each case organization was profiled using additional information gathered through the organization's website and annual reports, and through general web searches of the organization's name.

Two organizations following the required criteria were contacted for the interview process. Consent was obtained from the CIO and managers for participation in the subsequent interview. The organizations were contacted during the period from July 2014 to October 2015. All the interviews were based on the same case protocol, which included interview guidelines with open-ended and semi-structured questions. This included questions about the users, processes and the systems used in each case organization.

4 ANALYSIS

We analyzed each case organization for information related to agricultural activities, the systems involved, the users of each system and the issues pertaining to these systems. We developed a table summarizing the findings of the case organizations (Table 1). In the preliminary analysis we collected data related to three overarching business processes (planning stage, planting stage and harvesting/final stage). In each stage the activities that organizations carry out, systems involved in each activity, the objective of the system, whether the system is off-the-shelf or built-in-house systems, users involved in each activity, whether the system is integrated with any other systems and the extent to which the users are connected to the system in each activity were analyzed.

Based on the preliminary data collection we identified the technology sophistication of each of the organization, the user group reach and the business process coverage. The following criteria were selected considered when categorizing each of these attributes. (i) Technology sophistication – the extent to which the organization is using off-the-shelf, generic software. Further, if the software integrates well with other software then the technology sophistication is considered as high. For example, if an organization is using SAP for a particular business activity the technology sophistication is considered as high. (ii) User group reach - the extent to which the organization has given access to or connect with diverse user base. For example, if an organization has connected or given access to field staff and use systems to manage these staff the user group reach is considered as high. (iii) Business process coverage – the extent to which the business processes and activities are carried out through systems. For example, if an organization has computerized their business

[1] The cases selected here are referred to with pseudo-names due to the confidentiality agreements signed between the organization and the university.

activities, then business process coverage is considered as high. Based on the above criteria we analyzed the two organizations and the result of this preliminary analysis is discussed under results and discussion.

PLANNING STAGE			PLANTING STAGE			HARVESTING STAGE		
Activity	**FARM1**	**FARM2**	**Activity**	**FARM1**	**FARM2**	**Activity**	**FARM1**	**FARM2**
Nursery Mgmt	Paper based, Nursery Management System	Paper based, PAM Enterprise	Fleet Mgmt	Fleet Mgmt system	Truck Tracker	Production	Production System	SAP
Knowledge Mgmt	Spread Sheets, email	Email, Intranet, Sparq	Agronomical activities	Email, In-house system	Paper based, SAP	Sales	Paper based & Sales system	SAP
Budget	Paper based, Unit Budget System	SAP	Order processing System	OPS System, email		Bills Mgmt	Paper based & BMS	
HRM	Email, HRM system	Workforce Planner, ADI	Payroll	Paper based, In-house system		Harvesting & Packaging activities		SAP
Occupational Health & Safety		CAMS				Inventory Mgmt	Inventory Mgmt system	SAP
Procurement	SAP, email	SAP, email				Sales & Operations Planning		Excel
Maintenance Mgmt		SAP						

Table 1. The summary of the systems and processes

5 RESULTS AND DISCUSSION

The preliminary analysis revealed that the business processes in a commercial farm can be broadly categorized into common, specialized and value-adding business processes. Examples of common business processes include workforce management, procurement and sales processing. The specialized processes in commercial farms included such activities like nursery management, administering crop lifecycle, growing processes and harvest operations. Value-adding processes were unique to each environment and were determined by their own priorities. Overall, there was a high level of consensus for the common business processes and farming centric specific specialized business processes. However, the specialized and value-adding processes were vastly different across the three cases. For example, farms show differing levels of priority in relation to legislative standards on food labelling, field staff management and geospatial maps. At the time of data collection, FARM1 was prioritizing labor hire and time management mandated by the federal government, while FARM2 was embarking on voluntary food labelling initiative.

In relation to user groups in farm context contrary to popular views held in the literature, the analysis revealed that the field staff was eager to use technology solutions. However, their willingness to adopt technology had a strong association with aspects like ease of use and ease of learning. For example, FARM1 and FARM2 had successfully introduced mobile technology solutions to field staff, where more than 50% of staff had successfully adopted them within the first three months of launch. Operational and management staff too was eager to use new technologies that provide them with better and new insights and value. For example, operational staff was keen to use new business intelligence tools introduced in FARM1. Owner/Management was the most tenacious user group, where they showed strong reluctance to use any new technologies. Though further investigation is required, initial observations highlighted that some reasons for management reluctance to use IS include too much transparency, not seeing the value of IS and lack of user knowledge.

In relation to the systems in-use, it was revealed that all three cases, common business processes were carried out using an enterprise system. For specialized business processes, the three case organizations primarily have used off-the-shelf systems, while they looked into digital technologies for their value-adding business processes. The major issue they had with these systems was that these systems were not integrated to their ES. Even though all three case organizations have implemented popular off-the-shelf ES, these systems were not supporting the integration of these specialized systems. This highlights a major caveat in introducing agricultural specific solutions by the popular vendors. Further, both FARM1and FARM2 highlighted that the solutions that are available are costly and the farm management is reluctant to invest on these. However, FARM1 has introduced mobile and cloud solutions, whereby they communicate and disseminate critical information with the field staff. FARM1 analyze this information using business intelligence reporting, generates useful information and has experienced a substantive improvement in their organization. This highlights that the farming organizations have an extensive opportunity in introducing IT solutions such as mobile, cloud and business intelligence.

Figure 1 provides a high-level illustration of the technology sophistication vs. user group reach in the two farms. It highlights the potential areas for growth for each organization and in general for the industry sector. FARM1 is using SAP for most of their core activities and off-the-shelf systems for specialized farming activities. However, FARM1 has not extended the capabilities of their SAP system to their field staff. As such, their user group reach is considered low. FARM2 is using group management systems to connect with farmers and field staff. However, surprisingly, in some activities FARM2 is not using the available functionality of their enterprise-wide system, SAP. Three interesting questions arise in this context. First, how could consumerization of IT help agricultural firms to integrate their user base? Second, how could the agri-ecosystem members could be integrated to organizational IT platform to enhance the value? Third, what are the implications of extending the agri-ecosystem and the limitations of platform innovation?

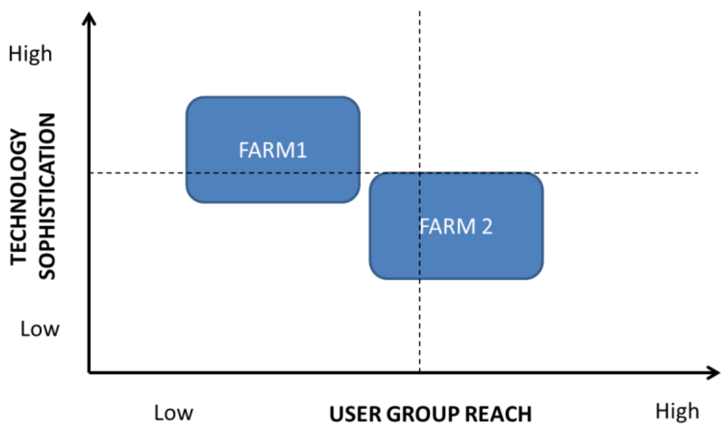

Figure 1. Technology sophistication and user group reach

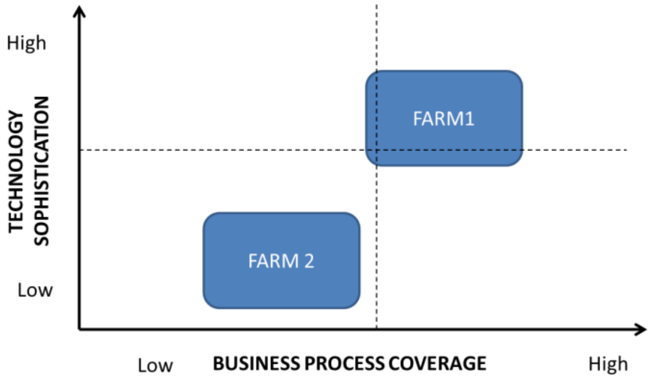

Figure 2. Technology sophistication and business process optimization

Figure 2 represents the business process coverage and the technology sophistication of the two case organizations. FARM1 and FARM2 both use SAP for most of their business activities. However, FARM2, even though they have sophisticated systems use manual methods to complete the business activities. Even though there are cost effective, easy-to-use systems available in the market most of the agricultural firms rarely use these systems. It is interesting to study the consumer perspective of the agricultural firms.

6 CONCLUSION

In conclusion, we believe that this study provides initial observations of systems, users and processes of what is considered to be a global priority. The preliminary findings presented herein offer broad descriptive insights, identification of issues and opportunities. Further studies are required in agri-informatics to deepen our understanding of how technology is shaping this vital area of study. Overall, we call the information systems academia to establish a cumulative tradition of research by establishing a research track on agri-informatics.

The research has significant implications for research. There are only few industry sectors essential for life quality and social wellbeing. One of them is agriculture which has a direct impact on world food security. This is a research priority and national agenda in many countries. Yet, in IS research this has not being recognized. This research highlighted areas of similarities and differences between agri-informatics and other paradigms. While some research contexts like ES are similar to other established research contexts, other areas like field staff of commercial farms were highlighted as unique research opportunities. The inventory of system provides researchers to develop frameworks and strategies specific to agri-informatics.

This research has several practical implications. A comparative matrix of systems, key user groups and business processes will allow software vendors to develop unique targeted industry solutions. As highlighted in Figure 1 the integration between processes provide opportunities for system integrators and for service providers. Finally, FARM1 highlighted the emergence of digital technologies which in itself is a phenomenon of interest globally. There are several limitations in this study. First, due to space limitations a large comparative table of systems, processes, key user groups and their relationships, integrations could not include in the current submission. However, this can be made available upon request. The case selection can be further strengthened in future studies by selecting commercial farms from a range of different countries. The influence of the technology sophistications and the IS savviness of the management can be minimized through a diverse case selection.

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