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A Conceptual Model for Collaboration-Based Farm Management Information Systems

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Preface

Everybody needs food whether they live in a snow-covered plain, an arid desert or a densely populated forest. Not only is the demands on farmers as the world's population grow increase, but the circumstances surrounding the demands are also becoming less predictable. Increasing frequency of extreme climatic events, the demand for energy crops, the debates surrounding genetically modified crops and ever changing consumer demands obviously has an impact on farmers' ability to plan ahead and manage their farm so as to ensure farm continuity. From a professional perspective, I feel rewarded to have the opportunity to work with various stakeholders in the agrifood supply chain with similar aims and visions. Thus, to create tools to assist our farmers in their endeavor to sustain human existence through food production. I will like to acknowledge some of these wonderful persons who assisted in completing this Thesis.

I would like to thank all the companies and persons that participated in the interviews concerning the organization of FMIS business in Finland, Denmark, Sweden, Estonia, Latvia and Lithuania. I am very thankful to Dr. Henri Holster of the Livestock Research Unit at the Wageningen University & Research Centre, The Netherlands. Also, I will like to show my appreciation to Dr. Claus Sørensen of the Department of Biosystems Engineering, Aarhus University, Denmark; who provided in-depth knowledge on SSM. Thanks to my Thesis supervisors Dr. Thomas Rohweder and Dr. Marjatta Huhta.

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Frederick Kwame Teye

Abstract

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Farm Management Information Systems (FMIS) are designed to assist agricultural farmers to perform various tasks ranging from operational planning, implementation, documentation, and applying for financial subsidies. Different stakeholders such as farmers, governmental organizations, service providers, and machinery manufacturers transfer information amongst each other in FMIS's. Lack of interoperability, stakeholder collaboration and a clearly defined business model has hampered the proper functioning and adaptation of useful technologies for FMIS in the agrifood production chain.

The aim of the study was to identify FMIS stakeholders in Finland, and some selected neighboring countries, and to investigate what their businesses are, how they operate and what is impeding collaboration. The ultimate goal was to propose, based on analysis of stakeholders, a conceptual operation model for a collaborative FMIS business for agriculture in the Nordic and Baltic States. The study employed personal and telephone interviews for business inquiries in 15 FMIS stakeholder companies. Soft systems methodology was used as a primary research method to analyze the businesses of the stakeholders; and eventually propose a conceptual operation model for the FMIS business.

The conceptual operation model developed in the study defined the incentives, value and profit generating mechanisms for collaborative FMIS's for agriculture. This model supports open and strategic collaboration and provides a practical operational framework for farmers, governmental organizations, service providers, and machinery manufacturers in the agrifood production chain.

Key words	agriculture, business, conceptual model, farm management, information systems

Tiivistelmä

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Maatilan tiedonhallintajärjestelmä (FMIS - Farm Management Information Systems) on kehitetty avustamaan maanviljelijöitä erilaisissa tehtävissä kuten töiden suunnittelussa, niiden toteutuksessa, kirjanpidossa ja tukihakemuksien tekemisessä. Erilaiset yritykset ja yhteisöt muun muassa viljelijät, valtio, palveluiden tuottajat ja konevalmistajat välittävät ja siirtävät tietoa toisilleen FMIS:n kautta. Maatilan tiedonhallintajärjestelmän kehittämisen esteenä ovat yhteensopivuusongelmat eri toimijoiden välillä, kokonaisliiketoimintamallin ja yhteistyösopimusten puutteellisuus.

Tämän tutkimuksen tavoitteena oli määrittää FMIS:iin liittyvät toimijat Suomessa ja naapurimaissa, selvittää mitä ja miten eri toimijat tekevät liiketoimintaa ja selvittää mitkä tekijät hankaloittavat toimijoiden välistä yhteistä liiketoimintaa. Selvitysten ja määritysten perusteella luotiin maatilan tiedonhallintaan eri toimijoiden välinen liiketoimintamalli. Henkilökohtaiset ja puhelinhaastattelut suoritettiin 15:sta FMIS:n toimijalle Pohjois- ja Balttianmaissa. SSM - Soft Systems Methodology menetelmää käytettiin liiketoimintamallin kehittämiseen.

Tutkimuksessa kehitetty liiketoimintamalli määrittää kuinka eri tekijät toimivat yhdessä ja kuinka eri tekijät saavat kannustimia, lisäarvoa ja taloudellista hyötyä yhteistyöstä. Kehitetty malli on avoin, se mahdollistaa eri toimijoiden muodostaa strategiansa niin, että ne ovat keskenään samassa linjassa FMIS:n kehittämisen kannalta. Liiketoimintamalli antaa käytännön toimintaohjeita viljelijöille, valtiolle, palveluiden tuottajille ja konevalmistajille maatalouden tuotantoketjuissa.

Avainsanat	maataloustuotanto, liiketoiminta, liiketoimintamalli, tiedonhallintajärjestelmä

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Abbreviations

AAR	Anticipatory Action Research
AFSCN	Agrifood Supply Chain Network
AgroXML	Standardized eXtensible Markup Language for agriculture
AR	Action Research
B2B	Business to Business market
BM	Business Models
BMO	Business Model Ontology
CAN	Controller Area Network
CATWOE	Customers, Actors, Transformation, World-view analysis method by Checkland (1999)
EAI	Enterprise Application Integration
ERP	Enterprise Resource Program
FMIS	Farm Management Information System
GPRS	General Packet Radio Service
GPS	Geographical Positioning System
GSM	Global System for Mobile communications
ICT	Information and Communication Technology
ISOBUS	International Standards Organization CANbus protocol, ISO 11783
MIS	Management Information System
PA	Precision Agriculture
PAR	Participatory Action Research
SMS	Short Message Service
SOA	Service Oriented Architecture
SSM	Soft Systems Methodology
WLAN	Wireless Local Area Network
VRT	Variable Rate Technology
WWW	World Wide Web
XML	eXtensible Markup Language

1 Introduction

Precision Agriculture (PA) is a modern agriculture cultivation method which aims at optimizing production in terms of product output, quality, and operation efficiency. Optimization in PA is fully achieved by adopting the use of modern information technology coupled with approved management techniques and engineering technology (Ess and Morgan 1997: 32). For a fully operational PA farm, there is a continuous need to maintain a steady information flow to and from the farm environment. Information flow provides the farmer with external knowledge and decision support in order to perform efficient field operations, and it serves as a means of transmitting data about farm and field operations. Presently, large amount of data from field operations are collected by agricultural machines and transmitted using various data storage and transmission media (Nikkilä 2007: 18). As an additional benefit, various stakeholders such, as government and legislative bodies, processing industries, and private manufacturing industries, tap into this information system of data flow to collect and transmit information, or provide machinery service support for farmers (Sørensen et al. 2010: 38, Wolferta et al. 2010: 390).

Information systems have evolved from simple record-keeping software to large Farm Management Information Systems (FMIS) in response to the need of communication between databases of different stakeholders. A FMIS is a management information system designed to assist agricultural farmers to perform various tasks ranging from operational planning, implementation, and documentation to assessment of performed field work. To improve functionality, various management systems, database network structures and software architecture have been proposed to serve the purpose (Beck 2001: 120-143, Nikkilä 2010: 332). In FMISs, different stakeholders such as farmers, governmental organizations and machinery manufacturers amongst others have an opportunity to collaborate. In practice, collaboration means more than one stakeholders working within the same business infrastructure synchronously or sequentially. Figure 1 demonstrates the role of IT systems for enhancing collaboration.

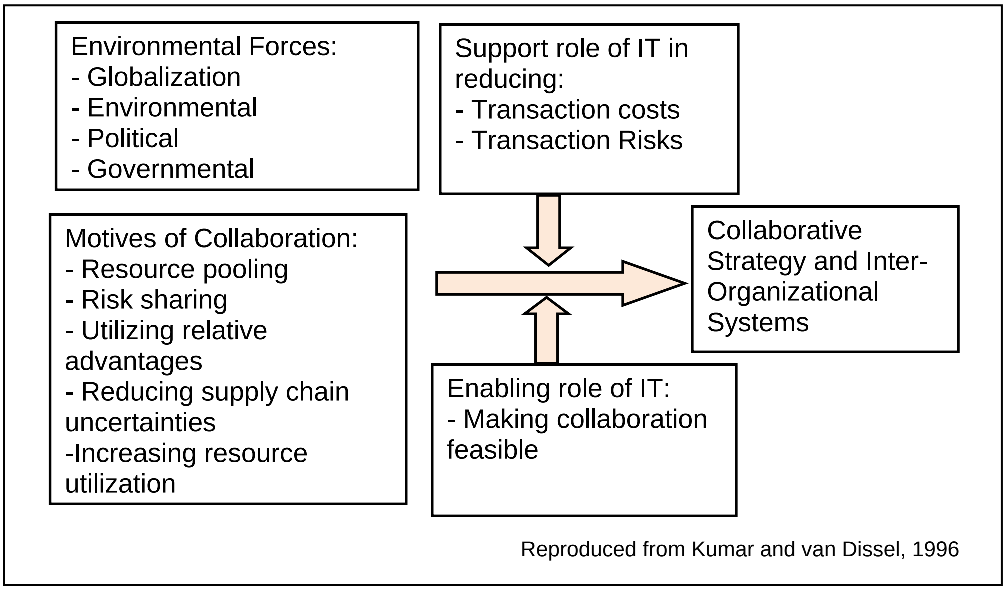


Figure 1. The role of IT systems for collaboration

The main benefits of IT systems such as FMIS for collaboration are to enhance resource pooling, share risks, and optimize resource usage as illustrated in Figure 1.

1.1 Research Problem

Lack of collaboration, property rights, native data formats and stakeholder-specific internal development amongst others, have impeded the emergence of harmonized and inter-operational IT systems between individual stakeholders (Salmenkaita and Salo 2002: 183). The lack of collaboration is thus is a major problem currently facing the agricultural industry. The absence of interoperability and agreed collaboration has also hampered the adaptation of useful technologies available outside the agricultural sector. For FMIS to reach maturity, newly synthesized methods for operating businesses must emerge to put together various technologies and data from the stakeholders in and outside the agricultural sector to enhance the utilization of full potential of FMIS technologies for agriculture production.

Presently, however, very few studies have dealt with identifying who is responsible for managing collaborative farm management systems, for example, in a specific country (Just et al. 2003: 201). Farm management research has been focused more on describing individual farmers' decision-making processes and outcomes rather than on the overall business functioning and management issues related to all the stakeholders of whole farming system. To aid governments to obtain the information they need, governmental agencies usually provide specialized tools for farmers. These normally include various online forms such as subsidy application, farm structure reporting, land parcel registration, and administration amongst a few others (Lankoski et al. 2010: 2). The business of running and managing a profitable agricultural farm is the sole responsibility of the farmer. He is in the middle of a battle between government rules, making profit, environmental constraints, investment and financial management, choice of farming methods and technological know how, processing industry chains and above all the food quality demands of the consumer. Software companies have found this niche very promising and have set up various information services such as FMISs for the farmers to cope with these needs (Nikkilä et al. 2010: 329).

The setup of infrastructure and provision of services for farmers initiated by software companies provides an opportunity for emergence of new businesses at every segment of an operational FMIS. However, for these businesses to emerge there is the need for new markets and a means of creating value for these markets. Because a collaborated FMIS will be a comprise from different stakeholders such as farmers, government, legislative bodies, processing industries, and private manufacturing industries, management of such an infrastructure is not feasible without defining a framework that will outline the scope, functions and limitations for the members in such a stakeholder network. For a functional collaborative FMIS its possible products, customer interface, infrastructure management, cost and revenue structure must be carefully researched.

To achieve these goals, this Thesis investigates the basic framework of collaborative FMIS businesses and outlines the business needs that are presently missing in agricultural FMISs. The Thesis also aims to define the different components and technological possibilities of a collaborative FMIS. Furthermore, this study extracts and analyzes the needs, incentives, value, and revenue generating mechanisms of the different FMIS clientele. A conceptual business operating model that encourages collaboration amongst FMIS businesses is proposed at the end of this study.

1.2 Research Objective

The objective of this Thesis is to answer the following research question:

What is (are) the business operating model(s) of inter-stakeholder Farm Management Information Systems in Finland (and some neighboring countries)?

By answering this question, the business needs that are presently missing can be identified, and a business operating model can be proposed that will enable collaborated agricultural FMIS work better.

To achieve the objective, three issues need to be tackled: a) identify the components (and alternative architectures) of a collaborative FMIS; b) identify and assess the needs of users of a collaborative FMIS; and c) propose a conceptual business operation model for a collaborative FMIS.

In the Thesis, the first issue tackled is the identification of the components (and alternative architectures) of a FMIS. To investigate this, the components of various existing FMIS are studied based on scientific publications and published literature. The key role of collaborative stakeholders namely farmers, consumers, government and legislative bodies, processing industries, and machinery manufacturing companies, are identified. Since agriculture is broad and encompasses a very diverse field of operations, PA based on classical case of weather and disease support for farmers is considered as an example. This is carried out for better analysis of the components of FMIS. General and relevant aspects of operations and farm management practices will are also incorporated and discussed.

The second major issue of this Thesis is to assess the needs of users of FMIS. To achieve this objective, a more detailed analysis of the components identified in the first objective will is conducted by means of interviews. The aim is to identify the specific needs of users and business models of stakeholder companies of collaborative FMIS and where it is possible, the Thesis also enumerates gaps in the system that will require innovative solutions to be provided. The scope within which this objective will be achieved will encompass the operations in a modern technologically oriented precision agricultural farm.

The third and final task of this Thesis is to develop a conceptual business model for sustainable operation of an entire collaborative FMIS. Wherever possible, the Thesis lists the requirements and components of a FMIS and proposes concrete methods for the implementation of this model. Eventually, the Thesis will provide a prototype operation model defining the incentives, value and profit generating mechanisms for FMIS.

1.3 Outline

The content of the Thesis is divided into three main themes. The Thesis tackles these objective themes in the 6 chapters. The first chapter provides a general introduction, defines the research problem, and presents the scope of the Thesis as well as the Thesis structure. The second provides a detailed description of the methodology used in this Thesis. It also presents information about how the stakeholder interview were prepared and carried out. The third gives a systematic description of the agricultural industry and investigates the needs and use of information amongst stakeholders. Generic business models used in farms are also introduced. Providing an answer to the first theme, the chapter presents based on literature review, a description FMIS. The fourth chapter analyzes the results of the concepts of businesses in the scope of collaborative FMIS recorded during the interviews. As a continuation of chapter 3, the components of existing collaborative are identified. The chapter also addresses the second theme that corresponds to the second objective of the Thesis namely identifying the needs of the users of collaborative FMIS. An assessment and discussion on data input sources, user interfaces and revenue generating mechanism of the stakeholder network in the collaborative FMIS is also presented in this chapter. Chapter 5 synthesizes the stakeholder analysis performed in the previous chapter to create a new conceptual model. Discussions on the model framework and implementation amongst the FMIS stakeholders are also made in this chapter. Finally, chapter 6 concludes the Thesis with a summary of the study. The chapter is discusses the managerial implication of the results, the scope of the Thesis, and further research recommendations for collaborative FMIS for agriculture.

2 Research Methodology

In this study, Action Research is the broad research framework used for defining the problems, and the changes needed to enable a collaborative implementation of FMIS for agriculture. To find logical definition of the solution, and propose steps to achieve these solutions, Soft Systems Methodology (SSM) is applied. The following section describes how these two methodologies are used in this Thesis.

2.1 Action Research

Action research (AR) is a scientific research methodological framework for solving a problem in a sector of society. Action research is "a cognitive process in the interaction between the observers and those in their surroundings" (Baskerville and Wood-Harper 1998: 91). This broad definition applies to a range of techniques used in the research of information systems including that under current investigation: FMIS. Action research is an interactive research process that enhances problem solving actions in a collaborative context (Reason and Bradbury 2001: 7).

There are different types of AR. The types of AR relevant to this Thesis are *Participatory Action Research, Cooperative Inquiry*, and *Anticipatory Action Research*.

In practice, AR can be described as an interaction between researcher(s) and the population participating in collaborative analysis or research to improve a situation or solve a problem. The form of AR, where researchers themselves participate in the research, is known as *Participatory Action Research* (PAR). In the present setting of this Thesis, the author is an active researcher collaborating with stakeholders that operate FMIS with an aim of causing a change for the better. In this type of AR, data-driven collaborative analysis from research is performed to understand the underlying cause that enable future predictions concerning the operations of a sector in society or an organization (Baskerville 1999: 2).

Cooperative Inquiry (CI) is a broad term used to describe this inquiry method in PAR. According to the analysis by Heron and Reason (2000: 179-180), the major idea of CI in AR is to "research 'with' rather than 'on' people". Such research helps individuals, teams, organizations become "more capable of self-transformation and thus more creative, more aware, more just and more sustainable" (Torbert 2004: 8). For this type of research, it is of prime importance that all active participants are fully involved in research decisions as co-researchers. The inquiry process can usually be undertaken using different types of questioning methods, such as telephone, personal interviews or questionnaires. The process of change is articulated in four stages. Figure 2 presents the four stages of a cyclic AR process according to the publication of Coghlan and Brannick (2005: 21).

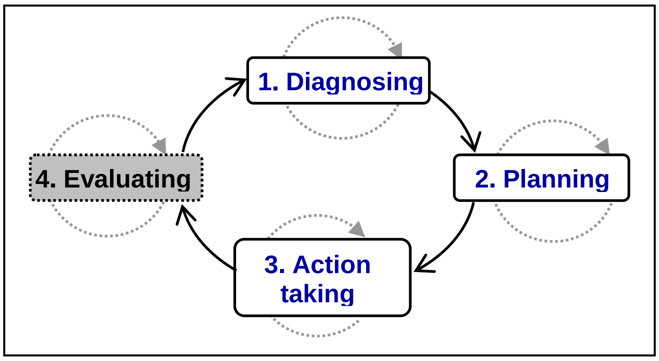


Figure 2. Stages of action research

For any AR, this cyclic process presented in Figure 2 must be adopted. For research into FMIS, this cycle begins with using some form of questioning, to determine the need for change within FMIS systems, and the choices the stakeholders have. The second stage is the definition of the stakeholders see for FMIS. The third step is to assess the current state to determine the work to be done. And finally, the fourth step is to manage the whole transition stage. During these stages, CI method will result in four different types of knowledge: propositional knowing (as the knowledge in contemporary science), practical knowing (the knowledge that comes with doing what you propose), experiential knowing (the feedback in real time on our interaction with the larger world) and presentational knowing (the artistic rehearsal process through which new practices are crafted). In the context of this Thesis, the cycle begins with a series of discussions with the

FMIS stakeholders to define the problems they are facing. This is followed by data gathering, feedback on the results, and joint action planning. The planned action is then taken into practice. The result of the practical implementation of the action is then evaluated to form the aim for initiation of another AR cycle if needed. Each stage of the cycle undergoes its own, internal cycle to refine the process that suit the collaborative partners involved. Altogether, these four stages forms the core definition blocks used with the stakeholders of FMIS to define the key problems, plan actions and evaluate the results.

Though the four stages present the core processes in AR, very often, the results of the first cycle has to be reassessed. The multiple implementations of these cyclic stages in AR can be, therefore, realized through a six-step iterative process, as shown in Figure 3.

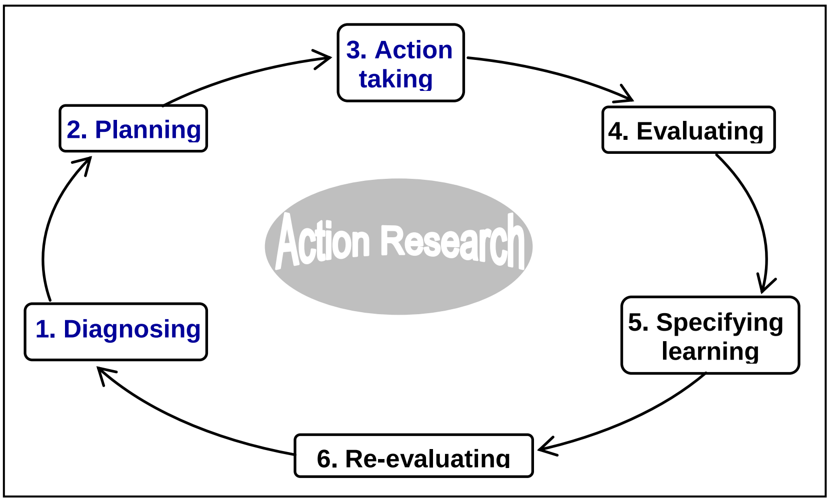


Figure 3. Multiple implementations of cycles in action research (Baskerville 1999: 4)

As shown in Figure 3, the after taking actions, the results have to be evaluated after some lessons have been learnt. As for PAR in this Thesis, the purpose is to anticipate a change in the future through a series of inquiries with the stakeholders. As pointed out earlier, collaboration and inquiry-making play a key role in achieving the aims of this Thesis. Another important research technique, worth noting in PAR, is anticipating for better results in the future.

The second type of AR utilized in this study is *Anticipatory Action Research* (AAR). According to Inayatullah (2006: 657), AAR draws from AR traditions and futures studies to develop a unique style of questioning the future with intent to transform organization and society. Relatively young, anticipatory action learning draws separate but interrelated traditions.

Figure 4 presents the research methods applied in this Thesis and how they are interrelated.

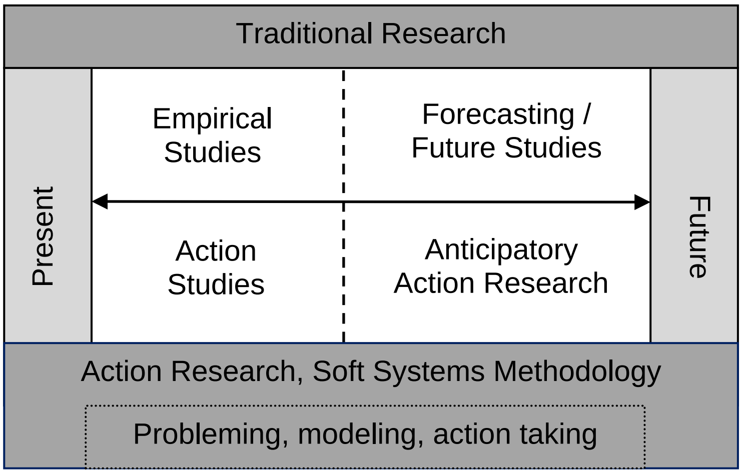


Figure 4. Matrix of research methods adapted in this study

In Figure 4, these traditional methods of research are illustrated as interrelated. In the context of this Thesis, knowledge is drawn by interviewing the FMIS stakeholders, and their answers are questioned to gain some new knowledge from the interaction. In AAR, a crucial factor is that futures must not only be seen as forecasting but as creating confidence with the capabilities to foresee and creatively adapt to new challenges it implies (Inayatullah 2006: 666). By questioning the future, alternative possibilities can be explored, and the preferred future has a greater probability of being realized. Anticipation, thus, becomes a vehicle to explore the meaning of the future, instead of a push for discussions on its mere technology or business.

2.2 Soft System Methodology in Action Research

Different forms of AR have different models, structures and sets of goals. The essential components of any AR are viewed as multi-stage processes; the diagnostic stage analyses the existing situation, and then the therapeutic stage involving change. In these stages change is introduced and the impact or outcomes are examined (Baskerville 1999: 4).

In the diagnostic process, data is collected systematically in relation to some objective or need. The data is fed back to relevant partners in the research for conducting a collaborative analysis of the data. A systematic method is needed to analyze this data that is usually plentiful. With the data at hand, the professionals, researchers and the stakeholders utilize social research techniques such as system thinking to interpret their data or results. System thinking is the process of understanding how things influence one another within a whole (Checkland 1999: 100). The stages in inquiry PAR with anticipation of the future can therefore be divided into what is derived from the real world and what can be deduced using system thinking (Figure 5).

One of the well known methodologies that utilize system thinking is the Soft Systems Methodology (SSM). Within AR paradigm, SSM is a systemic approach for tackling 'purposeful human activities' or real-world problem situations. Soft Systems Methodology not only enhances our knowledge of the problem and situation but comes up with the on a useful intervention for such situations. Johnsson (1991: 371) in his publication noted that in AR tradition reaching practical solutions to the problem is the most important instead of only testing and generating theory. Soft system methodology is a system approach aimed to analyze systems with complex and less clear-cut characteristics (Winter 2006: 803). Soft system methodology is based on systems thinking, which explores problems in the context of holistic system, and focuses on viewing the interactions between components of systems, rather than investigating the isolated components, as proposed in the philosophy of scientific reductionism. Systems theory suggested that a complex system can be appreciated and modeled by integrating the perceptions of different people involved in the system (Andrews 2000: 39). Later this idea was formulated further into a practical SSM methodology in order to help understanding the complex and 'messy' problems in the real world situation (Checkland 1999: A5).

Soft Systems Methodology was developed in the 1970s by a team of academics from the University of Lancaster led by Prof Peter Checkland. In an attempt to tackle management problem situations using a Systems Engineering (SE) approach, the team found that SE, which was a methodology at that time only used for dealing with technical problems, proved very difficult to apply in real world management problem situations. This was especially so because the approach assumed the existence of a formal problem definition. However, it was found that such a unitary definition of what constitutes 'the problem' was often missing in organizational problem situations, where different stakeholders often have very divergent views on what constitutes 'the problem' in SE methodology. Checkland's SSM methodology (Checkland 1999: 127) lies firmly within the tradition of AR which 'aims to contribute both to the practical concerns of people in an immediate problematic situation and to the goals of social science by joint collaboration within a mutually acceptable ethical framework'. Therefore Checkland (1999: A6) in coining SSM focused more upon comparing reality to a set of conceptual models, and less upon a step-by-step process for doing this.

2.2.1 Stages Involved in SSM Analysis

Defined by Checkland (1999: 161) and adapted in this Thesis, SSM (Figure 5) involves seven distinct stages to analyze the complex structures of FMIS organization in reality.

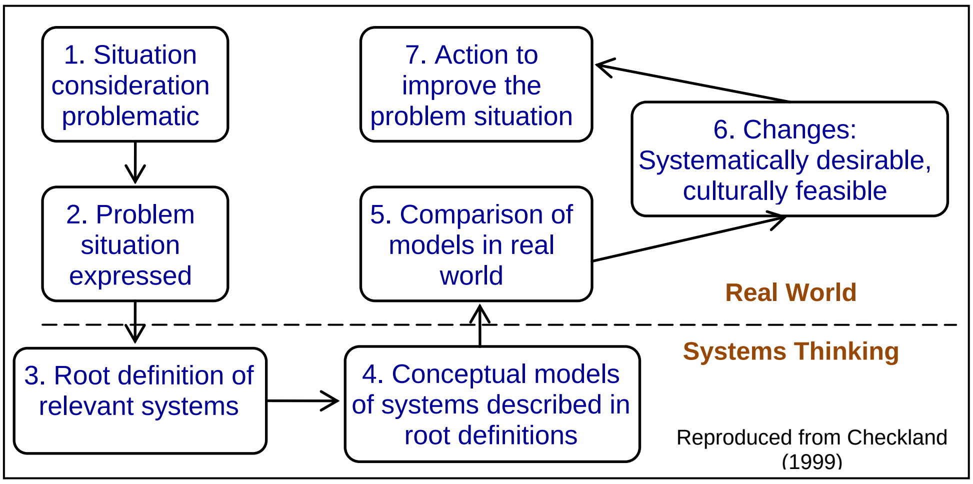


Figure 5. Soft systems methodology in action research.

From Figure 5, **stage 1** utilizes questionnaires and interview techniques to define an unstructured *problematic situation* amongst the FMIS stakeholders. After obtaining the series of unstructured problems from the FMIS stakeholders, a collection is made to incorporate all the concerns of the stakeholders into proposal to be presented. This is the initial stage where problem owners are aware of the problem situations in a textual format for improvement, and start off the analysis. In **stage 2**, the FMIS *problems* are expressed in the form of "rich pictures". After proposing the problem situation in stage 1, the information of the problem situation is collected, including the structure of the FMIS organization, processes and transformations in the system, and issues proposed by the stakeholders (Checkland 1999: 162). The information is then illustrated in the format of rich picture, which is a graphic representation of the manner one may think about the system. During **stage 3,** the *rich pictures* from different FMIS stakeholders is integrated together to generate an overall rich picture containing perspectives from different stakeholders. The root definition can be inferred from the overall rich picture by naming the relevant systems and identifying the input, output, as well as the transformation process. From a well formulated root definition, six key elements can be drawn out, as proposed in the mnemonic CATWOE (Customers, Actors, Transformation process, Weltanschauung, Ownership, Environmental constraints: discussed in the next section). The *root definitions* stage; stage 3, represents the objectives that the FMIS system has to achieve finally. In **Stage 4,** the *conceptual model* is a model of the minimum set of activities to conform the objectives identified in root definition is given. The conceptual model for the FMIS at this stage is only the perceptive model in our mind; therefore it does not have to include too many activities until the real world is analyzed. In **stage 5**, the real world expressions, as shown in the rich pictures in stage 2, are compared with the conceptual model generated in stage 4. The comparison may lead to re-iterate of previous stages. By trial and error in stage 5, a conscious, coherent and defensible FMIS model can be accomplished. Due to the time limitations in this Thesis the last two stages (stage 6 and 7) are not performed. However, in **stage 6**, desirable changes after the implementation and feasible activities are performed according the FMIS model proposed in stage 5 are identified and implemented in these last two stages. The changes can occur in the following aspects (Doloi 2010: 4): changes in structure of FMIS systems; which applies to the elements of reality in the short term, changes in procedure of implementing the FMIS; which applies to the dynamic elements, and changes in attitude; which applies to the behavior of various roles of the stakeholders within the modeled framework. In **stage 7**, actions are taken to improve the real world problems arising from the long term operation of the new FMIS operational system.

In summary, SSM employed under the general framework of AR include the following steps: examination of the problem situation, analysis of the ingredients (using a rich picture method), coming to a root definition of significant facets of the system of interest, conceptualization and modeling, comparison of concept/ideal to actual, definition and selection of options, design of action programme, and implementation. Employing these steps in this study will help define the problems, changes and actions needed for sustainable and collaborated FMIS whilst elaborating the concrete conceptual steps to achieve a real world solution.

2.2.2 The CATWOE Analysis

As discussed in the previous section, SSM involves seven stages. The CATWOE (Customers, Actors, Transformation process, Weltanschauung, Ownership, Environmental constraints) analysis starts at stage 3 of the process (Doloi 2010: 4). Table 1 presents the components of CATWOE.

Table 1. The CATWOE analysis based on Checkland (1999)

		Checkland’s description
C	Customers	The victims or beneficiary of T
A	Actors	Those who will do T
T	Transformation process	The conversion of input to output
W	Weltanschauung	The world’s view which makes T meaning in context
O	Ownership	Those who would stop T
E	Environmental constraints	Elements outside the system which it takes as given

Performing an analysis of the CATWOE components presented in Table 1 helps in working out a "root definition" and expressing the domain of the problem. The CATWOE Analysis gives a 'Rich-picture' of the root definition. Part of 'problem expression' is identifying the situational elements of present FMIS's and role of all stakeholders involved.

Presented in Table 1, the *clients* are the people who more or less directly benefit or suffer from the machinations of the transformation process e.g. customers. The *actors* are the players or stakeholders (individuals, groups, institutions and agencies), who perform the scenes, read and interpret the script, regulate, push and improvise. Identify and examine the role of local and institutional stakeholders who undertake the transformation in the FMIS sector. The *transformations* (T) are the processes, movements and conversions take place within the system. For the FMIS, the transformation process includes the following questions. What is the nature of the production and service transformations in FMIS? What is the content and processes involved from ingredients to a sandwich, from mixed, varied data to information, from an idea to a performance concept or marketable FMIS products etc? What are the transformations that generate FMIS products or services? How are they achieved? How well are they performing presently? The *Weltanschauung* or world-view defines what goes on in the wider world; that influences and shapes the 'situation' in the FMIS industry. The FMIS activities are ultimately "controlled" or paid for by *owners* or trustees. The *environment* within which the FMIS operate include the trends, events and demands of the political, legal, economic, social, demographic, technological, ethical, competitive and natural environments.

2.2.3 Conceptual Model Development

Discussed earlier, conceptual models of human activity systems are used in SSM to explore the viewpoints of stakeholders in the client organization. The conceptual model is intended to be a representation model of real world states of affairs or proposed state of FMIS for the future. The value of a model is usually directly proportional to how well it corresponds to a past, present, future, actual or potential state of affairs.

By analysis of the FMIS organizational relations and properties, core problems can be defined. By application of the SSM integrating the CATWOE, a conceptual model can be developed. Figure 6 describes how the developed questionnaire (discussed in the next section) will be used to synthesize the conceptual model.

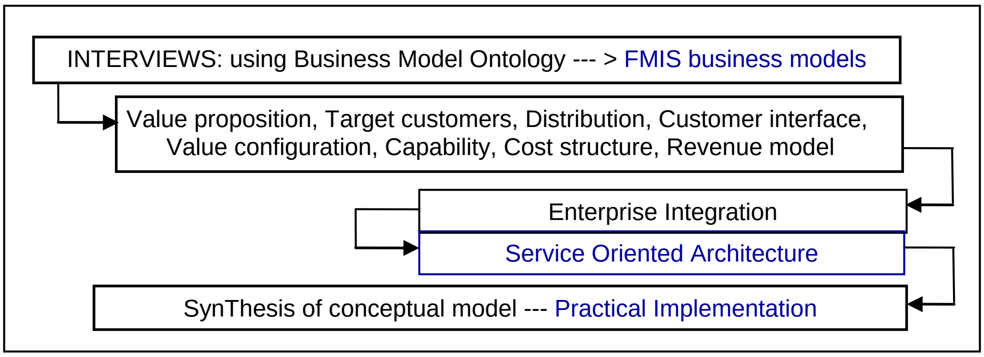


Figure 6. Synthesis of conceptual FMIS business model

Described in Figure 6, interviews are performed to obtained information about the stakeholders' business value proposition, customers, networks and revenue generation. Business analysis ontology is then used for analyzing the businesses of the stakeholder groups. Based on the SSM, rich pictures will be used to present the real work situations. From the links obtained between the individual stakeholders in the rich picture, a conceptual business model for sustainable operation of the entirely integrated enterprise will be developed based on service oriented architecture will be developed. Methods for practical implementation of the conceptual model will then be proposed.

2.3 Questionnaire Development

The following sections discuss the FMIS company background and how the companies collaborate with each other. This information is important for capturing the current situations in FMIS stakeholder companies and for proposing improvement for the future.

2.3.1 Company Background

Company business information profiles are reports that provide an overview of the history, current status, and future goals of a business (Osterwelder 2006: 16). A company background profile is essentially a resume for a company that a person uses to establish his credibility with the market he serves. A company business profile can be as short as a single page, or contain enough data. The company profile helps briefly to understand the business as well as to understand the company's approach, unique strengths, and relevant experience. The company profile can also include data regarding the future plans of the business.

In the development of the semi/structured interview questions, the company profile helps to quickly gain an overview of the core strategy of the company, what they have to offer, who their customer base is, their networks, and monitory flow within the company. To obtain a good picture about the company background, the company's operating business model plays an important role.

Company Business Model

Described by Osterwelder (2006: 14), a business model is not a description of a complex social business itself with all its actors, relations and processes. Instead, a business model describes the logic of a 'business system' for creating value that lies behind the actual processes. A business model is therefore the conceptual and architectural implementation of a business strategy and as the foundation for the implementation of business processes. In terms of an FMIS business, Figure 7 gives the core component logics in the business.

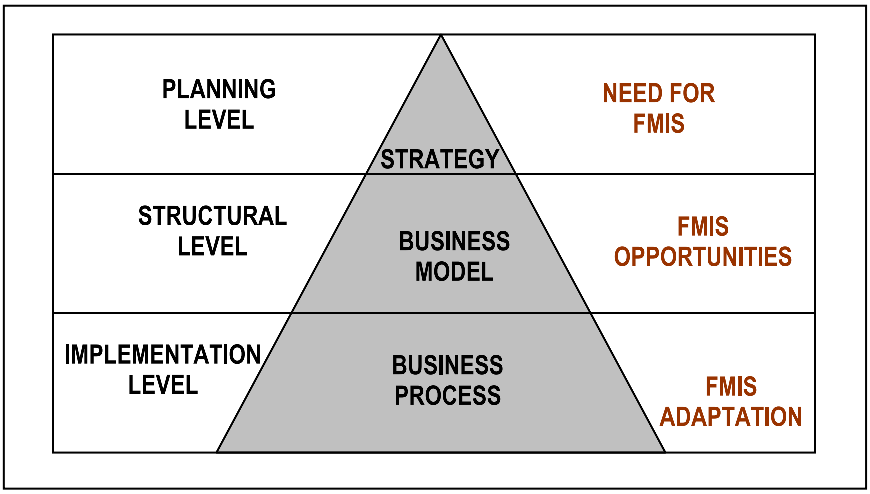


Figure 7. The business logic triangle

As presented in Figure 7, the business model provides basis for planning, structuring and implementation. To describe the structure of business models certain ontologies are adapted.

The ontology of business model describes business model concept, and the relationships that exist between them. Business model ontology allows for a more detailed specification of the relationships on the network of components that make up a business model. The ontology for business models is founded on four main pillars. Figure 8 gives a link between these important pillars in defining the operating model of a company.

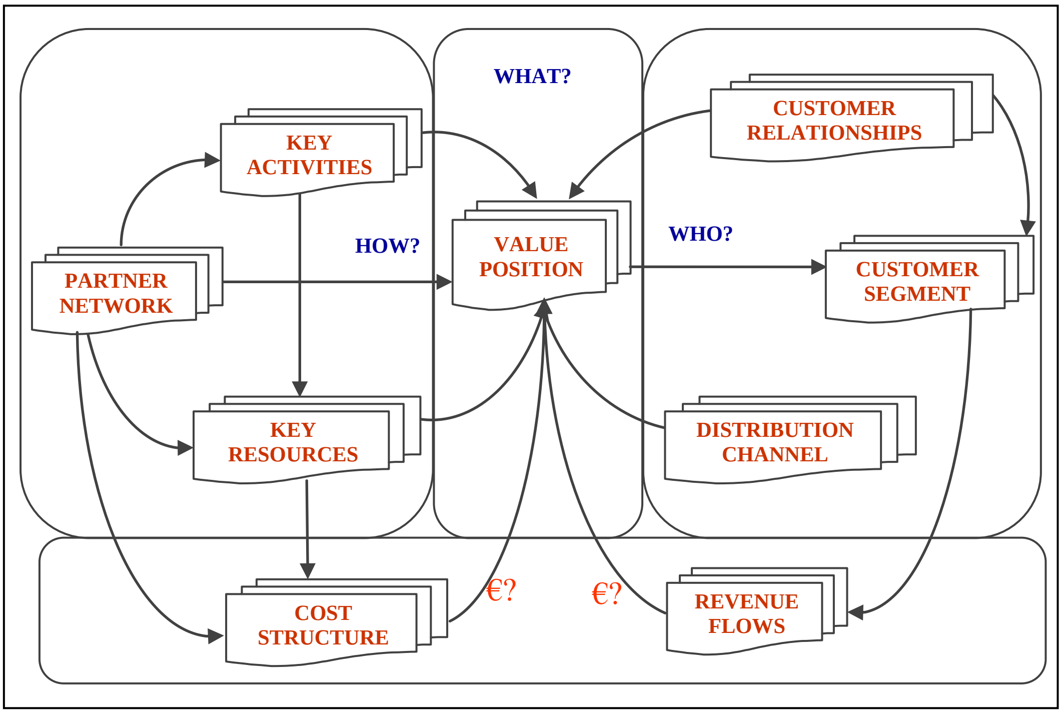


Figure 8. Key questions for determining value offering to customers

Referring to Figure 8, the first pillar is the *products and services* a firm offers, representing a substantial value to the customer, and for which he is willing to pay. The second pillar consists of the *infrastructure and the network of partners* that is necessary in order to create value and to maintain a good customer relationship. The third is the *relationship capital* the firm creates and maintains with the customer, in order to satisfy him and to generate sustainable revenues. The fourth pillar consists of the *financial aspects*, which are transversal and can be found throughout the three former components, such as cost and revenue structures.

To concretize these pillars, the company must ask the specific sets of questions about their company. The company must ask these questions; what products are we offering and what value does it bring to our customers (products)? Who are our target customers that the company wants to offer value to (customer segment)? How to get in touch with customers to make the money (distribution channels)? How do we get in touch with the customers (relationship)? How do we arrange our activities to create value (value configuration)? How do we manage the infrastructure we own? Do we have unique abilities to create value for our customers (capability)? Who are the other companies we cooperate with to function (partnership)? How do we finance our business (cost structure)? And how does our company make money (revenue flows)? A summary of the pillars is given in Table 2.

Table 2. Key attributes of a business model by Osterwalder (2004)

Pillar	**Key attribute**	**Description**
Product	Value offering	A Value Proposition is an overall view of a company's bundle of products and services that are of value to the customer.
Customer Interface	Customer segment	The Target Customer is a segment of customers a company wants to offer value to.
	Distribution channel	A Distribution Channel is a means of getting in touch with the customer.
	Customer relationships	The Relationship describes the kind of link a company establishes between itself and the customer.
Infrastructure Management	Key activities	The Value Configuration describes the arrangement of activities and resources that are necessary to create value for the customer.
	Key resources	A capability is the ability to execute a repeatable pattern of actions that is necessary in order to create value for the customer.
	Partner network	A Partnership is a voluntarily initiated cooperative agreement between two or more companies in order to create value for the customer.
Financial aspects	Cost structure	The Cost Structure is the representation in money of all the means employed in the business model.
	Revenue streams	The Revenue Model describes the way a company makes money through a variety of revenue flows.

Elaborating more on the pillars presented in Table 2, Osterwalder (2006: 42) adopted Balanced Scorecard (BS) approach (Kaplan and Norton 1992: 71-80), and more generally, business management literature (Markides 1999:123) to present a framework that emphasizes on the links between the four pillars of a business model. These links are presented in Figure 9.

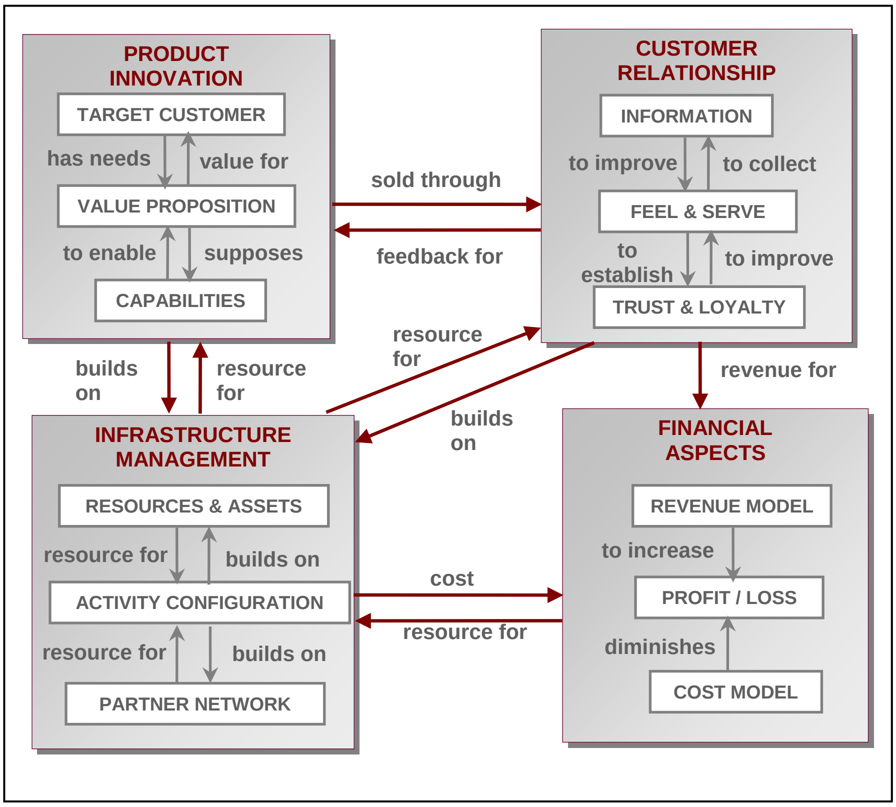


Figure 9. Business model ontology (Osterwalder 2006: 44)

From Figure 9, the **product and innovation element** describes what kind of business the company is in, the products and the value propositions offered to the market. The product description covers all aspects related to the offering of the firm. This comprises not only its products and services, but also the manner in which it differentiates itself from its competitors. In other words, this means not only the firm's market scope (Hamel, 2000: 61) - which customers, which geographical areas and what product segments - but also the explanations of why customers would buy from this firm rather than a competitor. Moreover, the ability to offer value to a customer demands a range of specific capabilities. The element product innovation is composed of the *value propositions* the firm offers to specific *target customer segments* and the *capabilities* a firm has, in order to deliver this value. The outcomes of the product innovation element are marketed through the *customer relationship element*, which at the same time provides a source of feedback for product amelioration. Product innovation is based on the *infrastructure management*, which provides a resource for it.

The **customer relationship element** describes who the company's target customers are, how it delivers products and services, and how it builds a strong relationship with them. The customer relationship element also describes the way a firm goes to market and gets in touch with its customers. Additionally, it contains the strategies of the company to collect and use customer information in order to improve relationships and adapt the firms offering to customer needs. Finally, the company must define and outline its plans to gain the customer's trust and loyalty. Within the customer relationship is also definition of the customer "touch points" (e.g. distribution channels), the information strategy for the collection and application of customer information and the trust & loyalty, which is essential in an increasingly "virtual" business world. The customer relationship element provides feedback for *product innovation* and is based on *infrastructure management*.

Infrastructure management element describes how the company efficiently performs infrastructural or logistical issues, with whom, and as what kind of network enterprise. ICT, and particularly the Internet, have had a fundamental impact on the way companies organize their activities inside and at the boundaries of the firm. Not only have company boundaries have become fuzzier, but increasingly the decomposition and re-composition of the industry value chain has redistributed the activities among existing and new industry actors. Infrastructure management describes the value system configuration (Gordijn et al. 2000: 13) that is necessary in order to deliver the firm's offering and to establish and maintain a customer relationship. It is composed of the activity configuration, in-house resources and assets and the firm's partner network to fulfill these activities. The infrastructure management element is a resource for *product innovation* and *customer relationship*.

The **financial aspects element** describes the revenue model, the cost structure and the business model's sustainability is. The element financials is the culmination of an e-business model. The best products and services and the finest customer relationship are only valuable to a firm if it guarantees long-term financial success. The financials element is composed of the company's *revenue model* and its *cost structure*, which finally define the profit/loss of a firm. This element is a resource for *infrastructure management* and is funded through the sales in the *customer relationship*.

The **Business Financing** or the financial aspects are composed of the company's revenue model and its cost structure. They determine the firm's profit- or loss-making logic and therefore its ability to survive in competition. The revenue model is the element of the business model ontology that measures the ability of a firm to translate the value it offers its customers into money and incoming revenue streams. A firm's revenue model can be composed of different revenue streams that can all have different pricing mechanisms (Figure 10).

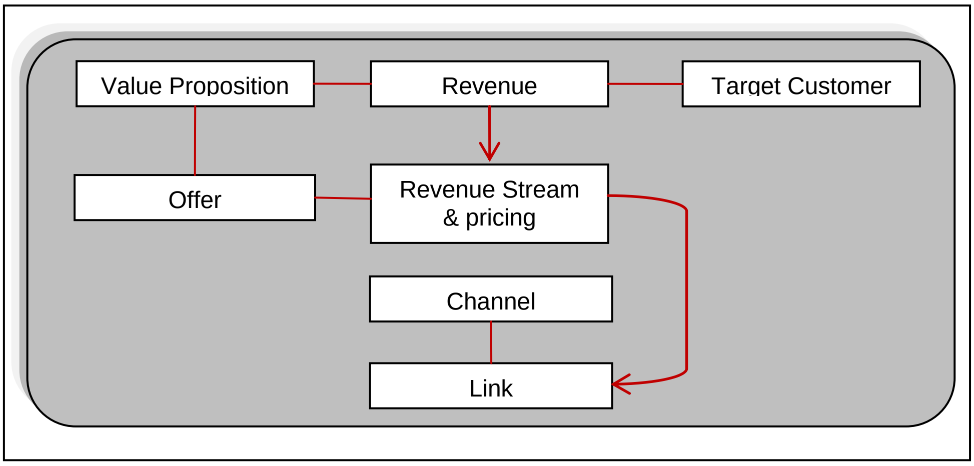


Figure 10. Revenue model of a company (Osterwalder 2006: 96)

Presented in Table 10, the revenue models a company can capture from its value creating activities are pivotal to its long-term survival. A firm can have from one to many different revenue streams and each of them can have one or several different pricing mechanisms. In general it can be said that ICT has helped companies diversify their revenue streams and has facilitated the adoption of more accurate pricing mechanisms.

The great variety of pricing mechanisms enabled by ICT helps companies improve revenue maximization. Particularly the Internet has had an important impact on pricing and has created a whole new range of pricing mechanisms (Klein and Loebbecke 2000: 4). In general the Internet has had a heavy impact on pricing, as it has become much easier to compare prices. As a consequence this will probably conduct firms to abandon fixed or at least comparable pricing. Furthermore, these changes may bring customers the freedom to advance from the simple servitude of the price-taker to a more powerful position of the price-maker (Pitt et al. 1999: 26).

2.3.2 Stakeholder Collaboration

In order to obtain information for analysis during stages 1 and 2 in the employed SSM some method, data collection is needed. Semi-structured interview questions, followed by telephone interviews were used in this study. This technique is used to collect qualitative data because it allows the respondent stakeholders the time and scope to talk about their opinions on the subject of collaborative FMIS for agricultural crop production.

Giachetti (2004: 1150) in his publication presented a framework for enquiring and analyzing information network and integration between enterprises. To be able to perform the analysis, information such as the background of the company, their business model, their financing structure, how they network and collaborate, and how they solve integration problems is needed. The following sections elaborate on the core components used in developing the questions in the semi-structured interview.

The structure and network within and between FMIS organizations is rather complicated. Systematic analysis of the network situations in an organization requires insight in different integrations at different levels. Giachetti (2004: 1151) defined a straight forward framework which is presented in Figure 11.

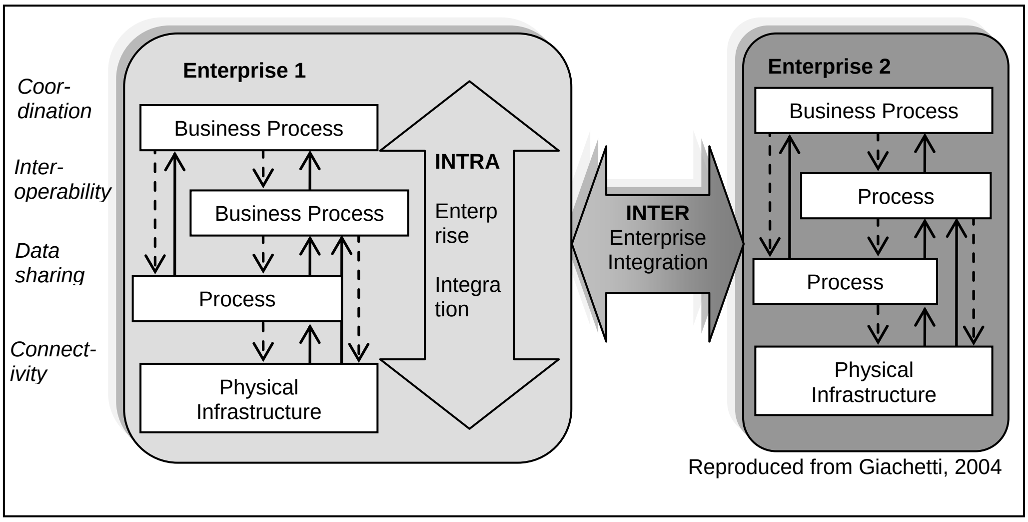


Figure 11. Generic integration framework (Giachetti (2004: 1150)

This framework presented in Figure 11, distinguishes and establishes the analysis between different integration scopes and types. The integration scopes are inter-enterprise and intra-enterprise. *Intra-enterprise* defined the interactions within enterprises to overcome fragmentation between organizational units and systems. *Inter-enterprise* covers the linkages between enterprises to move from operating as an independent and isolated company to a rather virtual enterprise integrated in multi-dimensional networks. In the enterprise, the integration types are process, application and data integration. *Process integration* is the alignment of tasks by utilizing specific coordination mechanisms. In *application integration*, software systems are positioned so that online systems can use data generated by others to enhance interoperability. In *data Integration*, provisions are made to data definitions to enable data sharing between systems. *Physical Integration* is the provision of technical infrastructure to enable communication and connectivity between hardware components.

The analysis of the framework given by Giachetti (2004: 1150) can be used to 'map' the current state of system and information integration in an organization. For each defined type of component (Figure 11), an assessment is made of what kind of integration exists, and if some form of integration exists, which specific approach has been applied. This analysis can be done for all enterprises involved in the FMIS collaboration network. The maturity of integration of single enterprises might differ company to company. Based on the mapping, a plan for further development is drawn up. This development forms the basis of the conceptual framework for organizing the future collaborative FMIS.

2.4 Interview Questions

A set of questions covering the organization, running and collaboration in FMIS's was designed to identify the current situation, problem and possible sustainable organization of FMIS for agricultural crop production. To guide the respondents for better understanding of the questions and appropriate structuring of their responses across the issues, key area were identified and communicated to the stakeholders prior and expanded further during the interview process. The following sections discuss these key areas and their importance in this study.

2.4.1 Company Background Questions

Based on the ontology developed by Osterwalder (2004: 22), and discussed in section 2.3, the interview sought to find out the BM of companies with the questions presented in Table 3.

Table 3. Semi-structured questions for inquiring BM of FMIS stakeholders

Pillar	Question
Product	What products are you offering and what value does it bring to customers?
Customer segment	Who are the target customers that your company wants to offer value to?
Distribution channels	How does your company get in touch with customers to make the money?
Relationship	How do you ensure that you maintain touch with your customers?
Value configuration	How do you arrange your activities to ensure that you create value for your customers?
Capability	How does your company manage the infrastructure you own? Do your workers or employees have unique abilities to create value for your customers?
Partnership	Who are the other companies that you cooperate with to function?
Cost structure	How does your company finance their business?
Revenue flows	And does your company make money?
Open request	Can you provide your business model, outlining your company's visions, mode of operation, financial standing and future plans?

As presented in Table 3, from the 15 companies, questions were asked about their *products and services*, their *infrastructure and the network of partners,* their *relationship capitals* the companies creates, and the *financial aspects* such as cost and revenue structures. The full semi-structures questionnaire is presented on Page 1 of Appendix 1.

2.4.2 Stakeholder Collaboration Questions

The objective is to understand the stakeholder's point of view rather than make generalizations about the current situation. The questions composed conversational-type open-ended questions that were pre-prepared. Though the progress during the interviewing process could not be predetermined, attempts were made by the interview to cover all the questions with each respondent stakeholder as thoroughly as possible. The structuring of the questionnaire (Table 4) was based on the framework by Giachetti (2004: 1148-1150).

Table 4. Semi-structured questions for inquiring collaboration amongst stakeholders

Pillar	**Question**
Business process level	Which relevant data exchanges are used at process level (bottlenecks, challenges)?
Application level	Concerning the business processes mentioned, what (kind of) applications can be mentioned are used? Describe this in common and if relevant by (some) processes.
Data level	Are data definitions available in order to be able to share data with other stakeholders? Describe this in common and if applicable on earlier mentioned processes.
Physical level	Give information about the technical infrastructure available in your company. How is it organized, how is it financed?

The questions presented in Table 4 sought to find how the stakeholder companies collaborated with other companies within enterprises to overcome fragmentation between different stakeholder clusters and systems (page 2 of Appendix 1). Information about business processes, data broke-age and financing was sought. In addition, there were technical questions to inquire about business process Integration: alignment of tasks by coordination mechanisms (coordination). Also there were questions about application Integration: the positioning of software systems so that online systems can use data generated by others (interoperability). Data Integration questions sought to find out about the provision and enablement of data definitions in the companies in order to be able share data between systems to enable business amongst stakeholders. The final questions were concerned with physical Integration. This dealt with what technical infrastructures the stakeholders had in place to enable communication between hardware components with external stakeholders.

2.5 Data Collection

In order to investigate the operation of present FMIS, the first step was to capture the perceived knowledge across large number of stakeholders involved in the operation of present FMIS infrastructures. A literature review was performed to capture the structure of FMIS and the key stakeholders involved. Literature information on stakeholders and their profile was easily available; however, information about the internal structures and how they operate their businesses in the collaborative FMIS was not available. Due to non-accessibility of the documented data on FMIS business models and mode of operations for this study, a semi-structured interview approach was considered as the most efficient tool. For the research a "semi-structured interview template" was developed using a framework in which attention is paid to different integration levels, within as well as between enterprises (Appendix 1). By conducting the interview with the selected professionals covering all the stakeholders; collaborating and contributing information for the functioning of FMIS, the impact of various attributes on the functioning and subsequent improvement, and the overall business picture of FMIS's could be established.

2.5.1 Identification of Attributes

While the published literature gives slight information about the critical components and the structure of FMIS, preparation of a list of comprehensive attributes was a critical first step for the success of this study. By systematically conducting a background review, the significant contributions and attributes associated with the critical components, stakeholders and the structure of FMIS could be identified. In this research, the attributes refer to the components representing a range of properties impacting the sustainable organization and running of FMIS in the context of overall success in a country. A pilot study was also conducted in cooperation with the AgriXchange EU project (http://www.agrixchange.eu) for clarifying and refining the questions before the interviews were undertaken with the remaining stakeholders.

A set of questions covering 14 key attributes covering the organization, running and distribution of FMIS was designed to identify the current situation, problem and possible sustainable organization of FMIS for agricultural crop production. To guide the respondents for better understanding of the questions and appropriate structuring of their responses across the issues, these 14 key attributes were communicated prior and expanded further during the interview process. The base data was then gathered to facilitate the qualitative analysis on the responses to work out a meaningful relationship among the attributes and establish the bases for constructing the conceptual operation model for FMISs.

2.5.2 Respondents Profiles

The respondents for the qualitative interview were selected from a wide range of organizations engaged in the contribution to research, development, regulation, use, and maintenance of FMISs. Since for each company or institution there were numerous possible respondents; a criteria was developed for selecting respondents that provide a rather representative overview of collaborative operation of the FMIS sector. Some of the key criteria used to select the representative respondents were the size and scale of the institution, their market reach across agricultural industry, the profile of the organization, their credibility, connections and collaboration with other FMIS stakeholders, the experience, qualification and availability of interviewee and knowledge of the agricultural sector.

To complete the tasks within the timeframe of the research 6 different component stakeholders were chosen. These included farmers, government official, legislative body official, agricultural food processing company managers, FMIS software company managers and agricultural expert researchers. Interviews were performed in 5 different countries: Finland, Sweden, Denmark, Latvia and Lithuania. In all 15 people were interviewed.

Table 5 gives the profile of the respondents selected for the interview.

Table 5. Respondent profiles

No.	Title	Organization type
1	Farm Manager	Private farm, Central Finland
2	Farm Manager	University farm, Southern Finland
3	Head of data unit	Agricultural statistics, Finland
4	Head of data unit	Agency of rural affairs, Finland
5	Head of product dev.	Private FMIS software company, Finland
6	International relations	Tractor company, Finland
7	Head of IT unit	Government farm advisory, Finland
8	Senior researcher	Agricultural Engineering Research, Finland
9	Senior researcher	Agricultural Economic Research, Finland
10	Head of statistics unit	Board of agriculture, Sweden
11	CEO	Private FMIS software company, Sweden
12	IT head	Knowledge center for agriculture, Denmark
13	Chairman of board	Rural advisory, Latvia
14	CEO	Private FMIS software company, Latvia
15	IT head of Farm advisory	Agricultural advisory services, Lithuania

As presented in Table 5, it can be seen that the 15 different stakeholders to be interviewed were rather different, however, they played a specific role in a collaborative FMIS. For this reason, the stakeholder companies were classified into five groups:

Group 1 consisted of farmers and farm workers. **Group 2** was made up of FMIS software providers. **Group 3** composed government, research, legal and advisory bodies. **Group 4** included service providers; for demonstration purposes, a typical weather information service provider was used. And **Group 5** was made up of farm machinery manufacturers who utilize FMIS in their operations.

A color coded breakdown of the groups and their connections is given in Figure 12.

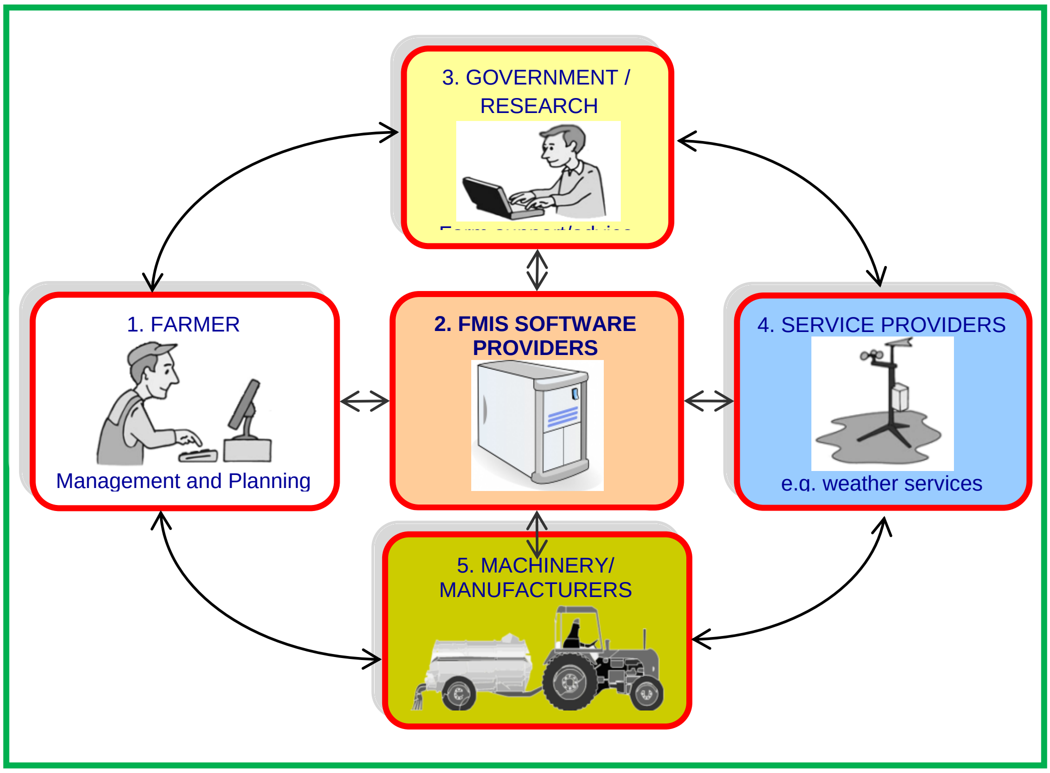


Figure 12. Architectural classification of FMIS stakeholders

In order to obtain the best possible commensurate response from the 5 groups shown in Figure 12, emails were sent or introductory telephone conversations were made with each respondent between February and March 2010 to communicate and make the objectives of the research clear. After this introduction, the "semi-structured interview template" questions were sent to them electronically via email. The interview was then conducted in two phases, initially to gather the firsthand data from the first interview. The interviews were conducted between March 2009 and January 2011. The results of the interview for each respondent was put together and sent to back to the respondents for review. The second interview was, when necessary, to allow the expert to present more information in order to refine the data based on the reflections of the first interview report. Though the sample size was relatively small, the coverage was wide; over five countries, and the quality of the responses was considered to be highly reliable for the research.

In the interview forming the collaborative inquiry general goals about functional FMIS was discussed. Issues concerned with present business models as well as future projections about collaborative FMIS were also discussed. Furthermore, the interview participants were allowed to generate a list of issues that they deemed important, as well as processes that will help facilitate the operation of a functional collaborative FMIS.

Boundaries of the System

To outline the system, the derived picture was used (Figure 12) which focuses on the FMIS and the subsequent information transfer between stakeholders. In the system, two levels of boundaries were defined: the stakeholder bounder and the enterprise boundary (see Figure 12). The red line depicts the stakeholder boundary, and the green lines illustrate the enterprise, or what is referred to as the stakeholder collaborative FMIS boundary. All the other activities and information transfers are defined as external components and not included in the analyses, which is based on the two levels.

2.6 Data Analysis

The following is an analysis and description of the issues that emerged from the interview process leading to the semi-structured interview template for the collection of the research data.

2.6.1 Descriptive Analysis

The semi-structured questionnaire template was designed using the framework adapted from Giachetti (2004: 1148-1150) on data integration as guideline for a systematic analysis of the existing situation. The first set of questioning covered profiling the business models of the companies. Analysis of the *company background and business model* is very crucial amongst the stakeholders; to give a profile of the critical attributes similarities or differences between the companies. Profiling and information about the companies' products and services, their infrastructure and the network of partners that is necessary in order to create value and to maintain a good customer relationship, their relationship capital for generating sustainable revenues and their financial revenue models are of core importance for the interview. The second part of the semi-structured questions dealt with the *structure of FMIS.* Information about the design of different FMIS's and how customers' use is of prime importance in this study. Information about physical integration, standardization of interfaces, data communication between the systems, and how different processes are integrated in the FMIS software is needed. The third question-set sought to find out about how *FMIS stakeholders collaboration with each other.* Information about infrastructure management describes how the company efficiently collaborates, with whom, and what kind of network enterprise. This information is needed for the development of the conceptual model in this study. The third part of the questioning also covered inter- and Intra-enterprise organization in addition to integration at process, application and data integration level between stakeholders. The forth part that was noted as important for the questionnaire. The question sought to find *solutions the FMIS companies have put in place to counter problems and companies' future projections about organization of FMIS.* The question dealt with identification of the role of design complexity, interoperability, financing and what solutions the companies propose for the overall functioning of the infrastructure of a collaborative FMIS.

While the descriptive analysis (Giachetti 2004: 1151) provides a good base to identify the prevailing issues perceived by the respondents from their expertise and experience, analysis using this method is unable to highlight the relative and critical attribute, and their cross-dependent links associated with the inter-organizational and human related activities in a collaborative FMIS. In order to address these challenges, soft system thinking is used to explore the 'messy' and rather problematic situations that arise in human related activity. The soft system provides a means for interpreting the problems and visualizing the interfaces outlined during the interview process, and the responses to the problems presented by each of the interviewees. The next section focuses on how the soft system methodology was applied to obtain a resulting concept model for the collaborative FMIS for agricultural crop production.

2.6.2 FMIS Analysis Using SSM

As a first step of applying the SSM, rich pictures are developed to represent the real work situations based on the raw dataset and preliminary analysis. According to the SSM procedures depicted in Section 2.2.1, the interviews from different perspectives of cost estimation were conducted to develop the relevant rich pictures for representing the concept maps of the stated cost estimation practice. It is worthwhile to note that each of the interviewees was interviewed because of their ability to respond to complex project environment in order to capture the cognitive processes into the rich picture format. Thus, the ability and vision of the interviewees were drawn out through verbal response and then into a graphic interpretation. From the development of individual rich pictures on the broad concept, further mapping were performed to develop the detailed rich pictures for each stage of the process from project inception through to tendering and initiation. The rich picture forms a basic model which is then developed into a basic conceptual model then in turn forming a broader conceptual model of the reality of the market.

From the rich pictures the problems are then be defined as root definition by identifying CATWOE, namely the customers, actors, transformation, weltanschauung (world view), owners, and environmental constraint of the problem (refer to Section 2.2.1).

2.6.3 Conceptual Model Generation Using CATWOE Analysis

The final step of the SSM methodology is the development of concept models out of the rich pictures and CATWOE analysis over all the respective project phases. All the perceptions, information, collaboration and business profiles are integrated together to form the conceptual model. Using iterations, the model is refined several times to eliminate redundant components. By developing the concept models, the processes articulating relational links between stakeholders and associated project related attributes are further refined. The concept models then form a solid base towards establishing the reference models in order for benchmarking the enhanced industry practices.

2.7 Reliability and Validity Considerations

The research and analysis of qualitative data is a creative process and is dependent on the insights and capabilities of the researcher (Patton 1999: 1190). The reliability of a qualitative research depends on whether the research is performed systematically (Denscombe, 2000: 3-8). Validity refers to the accuracy or truthfulness of a measurement. Denscombe (2000:241) pointed out that validity of the collected data can be ensured by polling the same data from at least three different sources. To enhance reliability and validity, the operations of a study should be systematic so that it can be repeated by another researcher to obtain similar results (Yin 2003: 34).

According to Quinn (1999: 1189) three key issues should be taken into account in order to improve the reliability and validity of a qualitative research. The first is to utilize established techniques and methods for gathering and analyzing qualitative data. The second is to ascertain the credibility, competence, and perceived trustworthiness of the qualitative researcher and the participants of the research. The third is to ensure that facts are separated from philosophical beliefs when evaluating results, thus differentiating objectivity versus subjectivity, truth versus perceptiveness, and generalizations versus extrapolations.

Considering the reliability of this study, efforts were made to take into account the three key issues raised by Quinn (1999). An established method by Giachetti (2004: 22) was used in developing the questionnaire for the interview. The respondents of the interview were selected such that all the FMIS stakeholders were covered. To improve validity of collected data, the interviews were repeated in five different countries. In order to ensure the validity of the findings in this study, suitable SSM techniques were used.

The interviews for the key research country, Finland, were conducted in Finnish to improve communication and understanding by the respondents. All the other interviews were conducted in English. All the telephone interviews were recorded, and notes were taken for the face to face interview. The questions were sent to the interviewees beforehand so that the interviewees had time to prepare themselves. The questions were used as the guiding principles during the interviews and also to check the consistency of findings. To ensure that the interview results were representative and not misunderstood, the reports containing the picture of organizing FMIS from the various countries were sent back for approval.

Due to confidentiality and hence the issues pertaining to them, some of the stakeholders were not named and some private and internal processes were omitted from the results of this study. The author of the study has been researching FMIS systems for agriculture for several years. This means that the author has his own opinion about how FMIS should be organized. Efforts were made during the data collection process not to limit the discussions but to be neutral in collecting all information from the stakeholders. During the analysis all the different opinions of the stakeholders were included. Furthermore, the interview participants were allowed to generate a list of issues that they deemed important, as well as processes that will help facilitate the operation of a functional collaborative FMIS for the agricultural industry.

2.8 Summary of Research Procedure

As stated in chapter 1.2, the objective of this Thesis is to determine and elaborate the components, needs and conceptual business operating model that will enable the proper functioning of a collaborative FMIS in Finland. The main issue that has impeded the holistic functioning of FMIS has been: property rights, native data formats and stakeholder-specific internal development amongst others (Salmenkaita and Salo 2002: 184). The impeding problems are a result of stringent rules or operational methods used by the individual or component stakeholders that collaborate to enable a FMIS to functioning. The component stakeholders include amongst others, farmers, government and legislative bodies, processing industries, and private manufacturing industries.

In order for agricultural farm information management systems to work, interaction between specialist researchers and the FMIS component stakeholders must come together in collaborative ways to analyze the problems at hand, research and act on solutions to improve the currently existing problems. As presented in section 2.1, AR method is a scientific method that can be used to achieve this. Because the author of this study is an active part in the research, the method steps of participatory AR are followed. Furthermore, it is anticipated to improve the operation of agricultural FMIS in the future through this research. Therefore the study uses this anticipation to develop a unique style of questioning the future with intent of transforming the FMIS community. In order to perform a complete research within the timeframe of this research, key component stakeholders are identified, a few chosen, and interviewed. For these purposes, two forms of AR: anticipatory action research and collaborative inquiry process of action research are adopted. The AR procedures as utilized in this Thesis are presented in Figure 13.

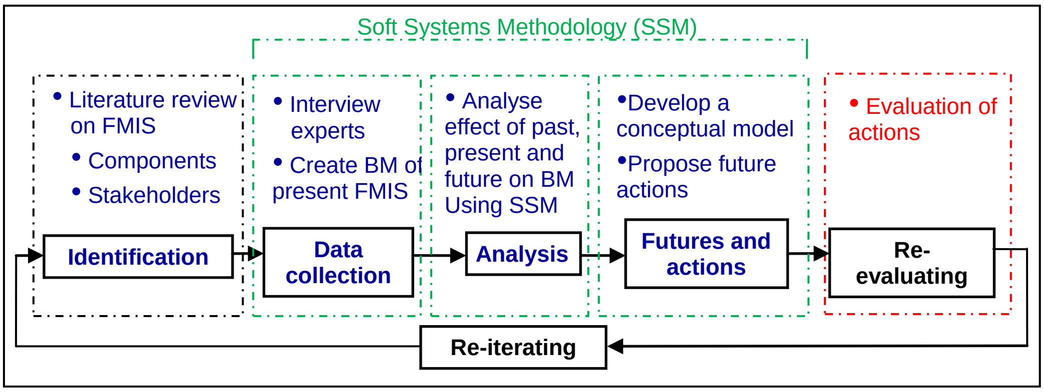


Figure 13. Breakdown of action research processes employed in the study

To follow the procedures in AR presented in Figure 13, a literature review is performed to define the components, of collaborative FMIS. The stakeholders and their needs are identified, and their primary goals are drawn out. A potential interview/inquiry list is then prepared. The list included forward looking, idealized visions for the operation of a collaborative FMIS. Each of the visions represents an area of research for discussion with the experts and stakeholders of the collaborative FMIS.

The next step was to form measurement principles based on the initial literature review and the interview results, to draw up proposals or alternative models for a collaborative FMIS. The opinions of the interview may vary widely, due to individual backgrounds, education, interests and expectations form the FMIS. However, this situation produces richer opinion bank about the FMIS industry as each component stakeholder plays an active role in choosing which interventions are believed to be effective because they are the ones closest to the current challenges. The opinion bank is messy and complicated to analyze. To solve this analysis problem, the soft system methodology is used for analyzing the links, interpreting the problems and visualizes the interfaces gained in the interview process. From the facilitation of the soft system methodology, a conceptual model is drawn up that ensures that all voices are incorporated, and the outcome reflects a path that all participants may implement. The conceptual model is developed for stakeholder in collaborative FMIS for agricultural crop production businesses.

The final stages: the business model implementation (action taking) and evaluation stages are not performed in this Thesis project.

3 The Agricultural Business

Traditionally, agriculture implies production, processing, marketing, and use of foods, fibers and by-products derived from plant crops. Agriculture was the key that led to the rise of human civilization together with the husbandry of domesticated animals and plants (i.e. crops), created food surpluses that enabled the development of more densely populated and stratified societies (Cox 2002: 93; Sigrimis 1999: 3).

3.1 Agricultural Crop Production

In the past, agriculture used a variety of techniques to improve land quality to make it suitable for planting. Agriculture widely employed such methods as the use of animal manure and digging water-channels for irrigation of fields. Modern agronomy utilizes sophisticated plant breeding techniques, pesticides and fertilizers, and exploits automated technological improvements to dramatically increased yields. However, some of these techniques cause widespread ecological damage and negative human health effects (Darnhofer et al. 2010: 546).

Though in the past the demand of crop production was to produce more food thus making agriculture a profitable business, the aim has changed in recent years. Agriculture has presently shifted to a new paradigm paying more attention to the effects and interactions with the surroundings, namely its environmental impact, terms of delivery, and documentation of crop quality and growing conditions (e.g. Sigrimis et al. 1999: 3; Dalgaard et al. 2006: 548). Figure 14 shows the demands associated with agricultural production.

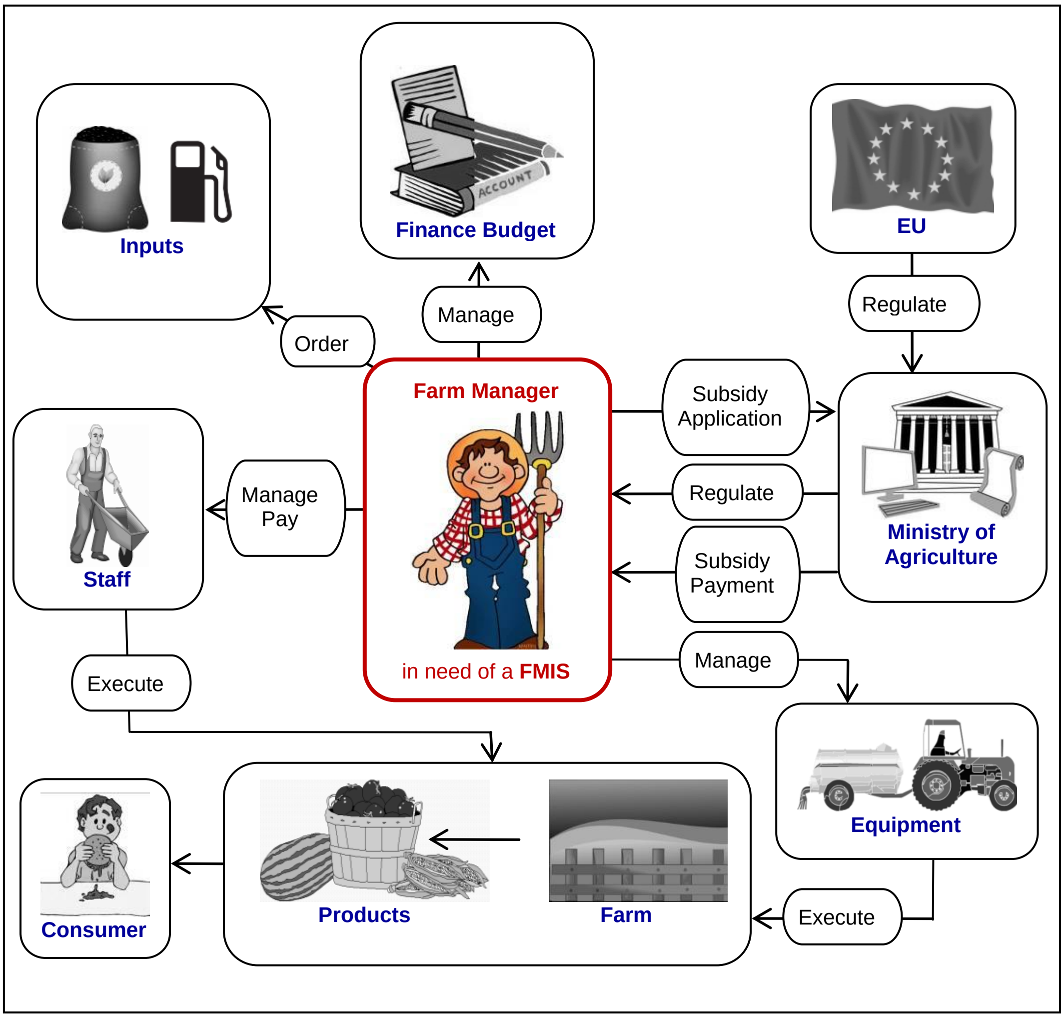


Figure 14. Activities surrounding farm production today (Sørensen et al., 2010: 43)

As presented in Figure 14, there is currently more demand for the farmer to manage the overall agricultural crop production within various externalities. Among other things, these managerial demands are caused by external entities (government and public) applying increasing pressure on the agricultural sector to change the methods of production from a focus on quantity to an alternate focus on quality and sustainability (Halberg 2001: 17-18). This change has been enforced by restrictions in the use of production input (e.g. fertilizers, agrochemicals). Farm subsidies are used as incentive for the farmer to engage in a sustainable production rather than solely on production. In general, this change of conditions for the managerial tasks on the farm has necessitated the introduction of more advanced activities monitoring systems and information systems to secure compliance with the restrictions and standards in terms of specific production guidelines, provisions for environmental compliance and management standards as prerequisites for subsidies. These management aids for agricultural crop production has been put together in a software commonly known as the Farm Management Information System.

3.1.1 Crop Production Systems in Finland and Europe

In Finland, the agricultural sector is very important. In 2009 the total annual flow of money in the agricultural sector was about €24 billion, which is 13% of the Finnish GDP when food export and agricultural support payments are taken into account (Hiemi and Ahlstedt 2020: 10). The area utilized for agricultural production alone amounts to 22,959 km^2 which is 6.8% the total surface area and 7.5% the land area of Finland. In 2009, 29% of farms produced livestock and 65% produced crops.

Traditionally, the main types of crops produced are wheat, barley, oats, rye, potatoes, sugar beets, rape and grass. In horticulture, apples, strawberry, onions, cabbage, and carrots are of importance to the Finnish economy. In recent years, the structure of Finnish agriculture has changed dramatically. Before Finland joined the EU, there were more than 100,000 farms in Finland; now, 15 years later, there are about 64,000 farms left. On average, the number of farms decreased by 3% per year, and even more rapidly in the livestock sector. Although the number of farms has decreased, their average size has grown. Between 1995 and 2009, the average number of farms increased by 54%, from 23 ha of arable land to about 35 ha. More efficient crops and productive animals coupled with better farming techniques have helped raise the overall productivity of Finnish farming. On average, productivity has increased by about 1.15 % annually. However, it was farm subsidies from the government that made up the majority (around 50 %) of the farmers' income. The average age of the farmers who received this kind support from the government was 51.1 years. Presently, older farmers are being replaced by younger workers who are keener on technology and its use in improving farming systems (Hiemi and Ahlstedt 2020: 10-23).

In European agricultural holdings, the situation is less uniform and varied. In Europe, the diversity among holdings in terms of farm type, size, geography, cultural differences, has a significant impact on the decision-making process by farmers (Ohlmer et al. 1998: 274). The total agricultural area within EU-27 is about 183 million hectares. About 85% of the farm holdings have an area below 20 ha, with the farm area varying from an average at about 5 ha per in Greece to 79 ha in the Czech Republic. After Romania and Bulgaria joined the European Union, the number of farm holdings have increased significantly mostly due to numerous small farms in Romania. Presently, about 32% of the European agricultural area is cultivated for producing cereals with wheat being the most common. About 40% of the cereals are produced in France and Germany. In many east European countries, farming has been less intensive, with reduced yields as a consequence, which is obvious in countries like Germany and Poland, where the difference in potato yields is especially significant.

The geographical and climatic variations determine the differences in cropping seasons, solar radiation and precipitation, especially from the north to the south. Most crops such as olives, cotton and citrus, which are common in the Mediterranean countries, cannot be cultivated in the north; while for certain areas and crops it is possible to have several harvests during the same year. Based on these differences, it is evident within the European region, new FMISs must be designed to accommodate the geographical and practical differences.

3.1.2 Precision Agriculture

Precision agriculture (PA) is an agriculture production method aimed at the optimization of production in terms of product output, quality, and operation efficiency. For crop production, PA basically ensures that a crop is cultivated with the right amount of nutrient supply at right time, at the right location and right care over the crops entire growth period. In practice, it means optimization of inputs and output in the course of the crop production. This optimization is achieved by adopting the use of modern information technology together with best management practices and engineering (Ess and Morgan 1997: 7).

Precision Agriculture is defined as farm management strategy that employs information technology to bring data from multiple sources to bear on decision-making in crop production (National Research Council 1997: 44).

Precision agriculture (also known as *Precision Farming*, and sometimes referred to as *Information-Intensive Agriculture*) is a relatively new concept that has only recently become technically feasible. It is well known and accepted that there is variation in the growing conditions and nutritional requirements even within a single farm-field. The goal is to achieve optimum agricultural productivity at a reduced cultivation cost using diversified and resilient agricultural systems. Precision agriculture plays a catalyzing role in achieving harmony between environmental and economic goals. It optimizes agricultural input needs, such as fertilizers, pesticides and water, at micro-field requirement levels. Precision agriculture also includes various tools for information gathering such as soil quality sampling, remote field sensing tools and yield monitors as well as variable input application rate technology (example for fertilizers or tractor guidance systems including such instances as light bars and auto steering). Overall, optimization in PA is focused on increasing yields, reducing costs of cultivation and minimizing environmental impacts through field location-specific management (Gebbers and Adamchuk 2010: 830).

Though there are some success stories pertaining to the use of PA mainly in some developed countries in Europe applying sophisticated mechanized agricultural, automated and inter-market systems. PA is, however, still practiced by a relatively small number of farmers in Europe (Schroers et al. 2010: 418-420).

Precision Agricultural Technology

In PA technology, a key role is played by information such as location-based yield, soil quality and various geographically related data. Information on the soil, crop and yield is used to develop specific management zones over the planting field. Recent advances in agricultural technology, especially in variable rate technology (VRT), remote sensing, Geographical Information Systems (GIS) and Global Positioning System (GPS), in addition to the developments in modeling and simulation in crop production, have provided numerous opportunities for the development of PA. Crop simulation models (CSMs) provide information about potential production under the different scenario of constraints, including weather, soils, crops, cultural practices, which allow for variable rate applications (Gebbers and Adamchuk 2010: 828).

The ISOBUS: ISO 11783 (or ISO Bus or ISOBUS) is a communication protocol based on the SAE J1939 protocol (which includes CANbus) for communication between agricultural machines. The ISOBUS standard describes the serial data network for the control and communications on agricultural tractors or forestry and implements. It enables tractors to control implements behind it e.g. the use of automated variable rate technology. Automated variable rate technologies allow farmers to vary inputs, such as fertilizers, pesticides and seeding rates when they drive through the field based on these management zones (Srivastava 2002: 1). Varying input rates aims at either increasing yields or reducing costs, depending on the farmer’s goal for the production system. Auto guidance systems on the other hand assist equipment operators in driving through the fields so that efforts could be focused on other important tasks. These Precision Agricultural technological tools therefore help reduce redundancy, reduce labor costs and save operation times (Reference needed).

Role of space technologies becomes more crucial in order to address the spatial variability of soils and crops across the various scales of mapping. The space technology inputs also capture the vulnerability and dynamism of agricultural systems. The developments in space-borne imaging sensors, particularly their spatial, spectral and temporal resolutions are well characterized to capture these features. While high spatial resolution images enable mapping and monitoring the structural attributes of agro-ecosystems, high spectral resolution or hyper-spectral imaging addresses their functionalities. The high temporal resolution captures the dynamisms of agro-ecosystems (Srivastava 2002: 1).

Components and Framework of Precision Agriculture

As discussed earlier, PA aims at reducing cost of cultivation through the optimization of farm inputs with the use of improved control technology for increasing resource efficiency. These collections of appropriate technologies make up the FMIS (Figure 15).

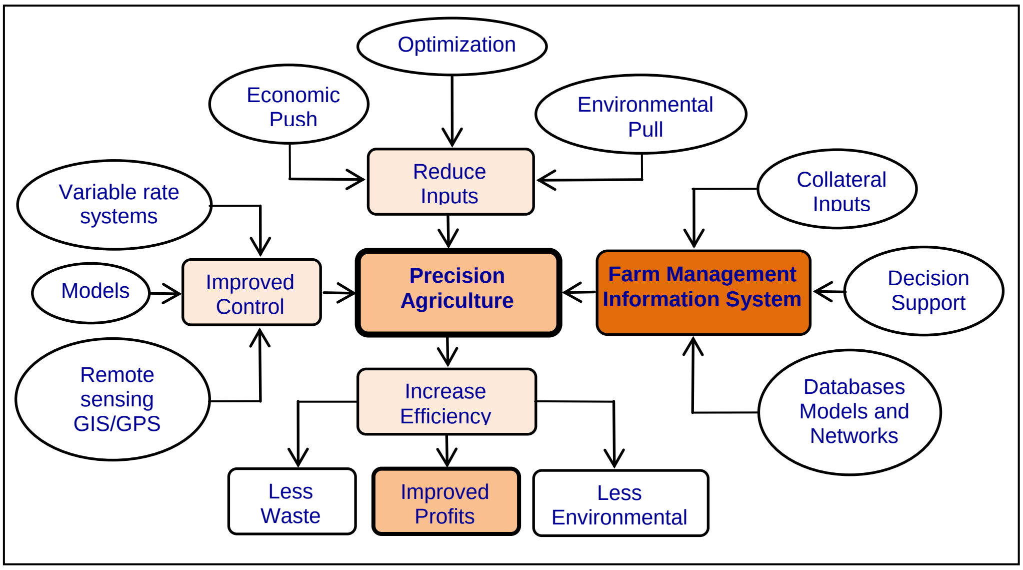


Figure 15. Components of precision agriculture (Srivastava, 2002:1)

While the reduced cost of agricultural farming is achieved through the optimization of inputs with consideration to monitory economic push and influencing factors of environmental pull, the mechanisms for control are achieved with the help of systems such as variable rate technology, crop model outputs and the co-use of GIS, GPS and remote sensing. The FMIS consists of Decision Support Systems (DSS), collateral inputs and inputs for databases of location-specific GIS information of crops, soils and weather (Perini and Susi 2004: 821). As an essential ingredient of FMIS, information inputs from remote sensing about in-season crop conditions, models describing and projecting potential crop production outputs under the different constraining scenario, and information from network soil laboratories and farms; help in maximizing efficiency in PA. Increased efficiency does not only utilize resource efficiently, but also ensure less waste generation for improved gross margin whilst reducing environmental impacts.

Precision Agriculture for that matter calls for the use of available and appropriate tools and techniques, within the set of the framework described above, to address the site-specific variations between available soil resources and crop requirements by applying the right amount of agricultural inputs. Inevitably, it conjugates information from different sources; information and knowledge about the crops, soils quality, ecology and economy information in addition to past and future modeling and control. For these reasons the idea is not only to be able to apply farm inputs that are varied at the local level but also the ability to precisely monitor and assess the overall agricultural systems at a local and farm level. Overall understanding the management processes is essential to be able to cater the individual crop growth processes to be able to apply the inputs in a way as to be able to achieve a particular goal not only maximum yield but to maximize financial advantage while operating within required environmental constraints (Gebbers and Adamchuk 2010: 830). The next section describes the important processes in running a successful agricultural business.

3.2 Agricultural Business Management Process

Locally in Finland, the structure of agriculture is rather intertwined; almost exclusively family farms 88% privately, 10.4% heir owned, 0.9 cooperatively owned and 0.1% government owned in 2009. There are about 90,000 persons employed in agriculture which is 3.7% of the total labor force in Finland (Niemi and Ahlstedt 2010: 28).

Running agricultural businesses is not limited to supervising and handling the day-to-day routine of a farm as usually understood. Agricultural business and for that matter farm management, is much more than that. The Finnish farmer for that matter is not just concerned with the distribution of labor on farm and supplying the needs of crops as a day-to-day operation.

The core responsibility emphasis is on the decision-making function of evaluating and choosing between alternative strategies. The farming markets are changing daily. A major concern is not just about adjustments what is more suitable and profitable and more about exploring new situations and opportunities for maximization of income and satisfying other goals of a farmer. It is the approach under which the opportunity costs of the various resources are evaluated and adjustments in resource-use and enterprise mix are made to secure higher levels of farm income (Sørensen et al. 2009: 5). Figure 16 illustrates the processes in a generic farm business, and the management components. Because in Finland, family farms are of more importance, Figure 16 gives an overview of the links in the development for a family business model, the goals for running their business and how they utilize assets, generate income for a successful retirement form their business.

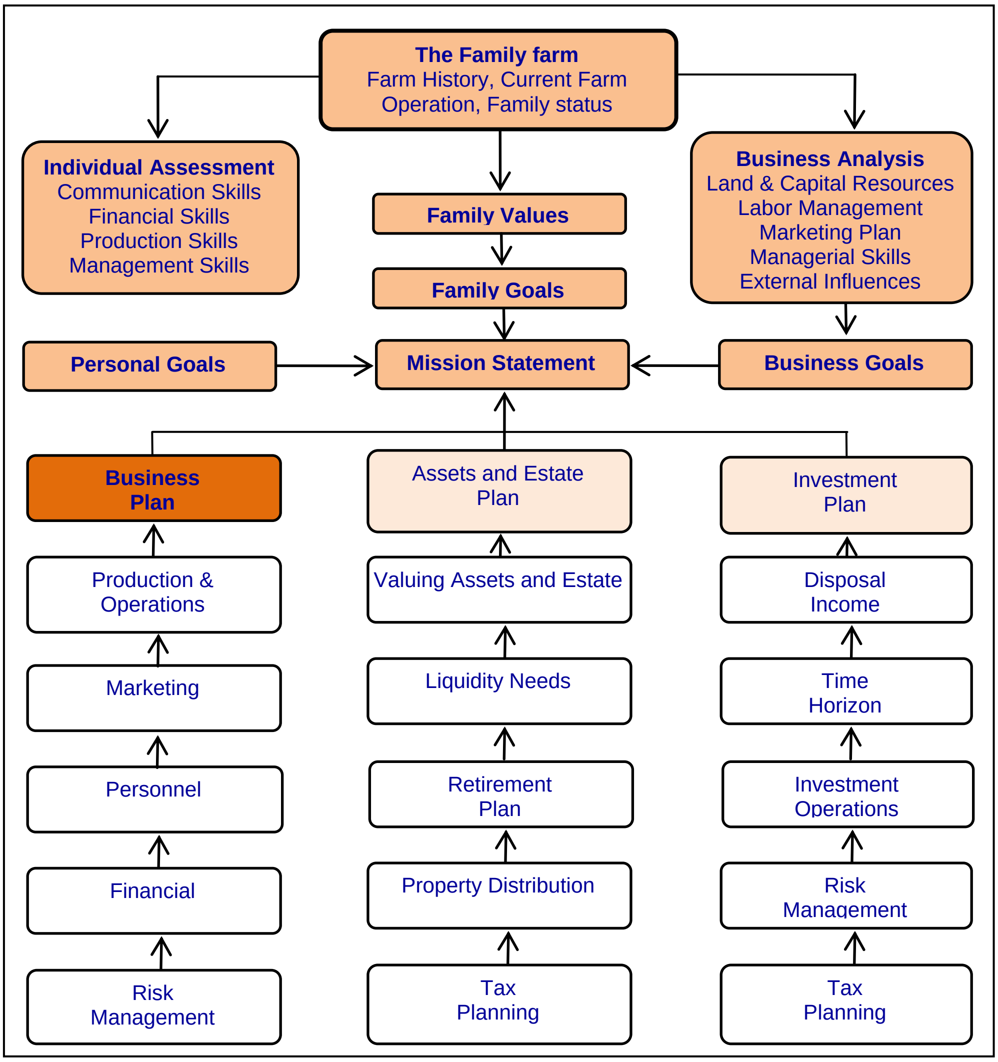


Figure 16. Generic business and management model for agriculture

Described in Figure 16, it is important to critically analyze the environments of the farm being it a new farm of a farm with a history. Family goals, the farm business entrepreneur's personal skills and financial standing are of core importance for the development of a good agricultural farming business. In addition, the whole lifespan of the business has to be assessed if it is meant to be the main source of income for the farmer. This will allow for planning towards retirements.

Farming business requires the application of business methods and efficient management. To be an efficient manager, one must keep oneself abreast of developments in new technology, new practices, price trends, and economic outlook. Again a farm management man should identify the constraints in the external environment conditions, which hamper a farmer's opportunities and plans for making adjustments in his farm organization and render the technically superior production plan economically unattractive to the farmer (Nikkilä 2007: 21).

Business processes are commonly divided into three categories: management processes, which govern the operation; operational processes, which create the primary value stream and supporting processes, which support the former two in their operation. In the context of agriculture, the emphasis is on the first two processes (Wolfert et al. 2010: 390). Supporting processes which include areas such as accounting and recruiting are a considerable element in major corporations but are not particularly distinctive on small to medium sized farms. In agriculture it is also common to have only one actor, namely the farmer, or just a few actors for these business processes.

3.3 Farm Management Information Systems

Some basic concepts need to be elaborated to explicitly describe management information systems. The understanding of the distinction between data and information is one of these basic building blocks. Data is a collection of raw facts, figures and objects. Information on the other hand is used to make decisions (Davis 1984: 640). Data must be processed while considering the context of using it to make decision, in order to transform it from data into information.

In a hierarchy, wisdom for decision is placed at the highest level and data at the lowest (Fountas et al. 2006: 192-193). As one move up this hierarchy, the value of information is increased and volume of data is decreased. Thus, the decision making process is refined as one acquires knowledge and wisdom. Management information systems levels across this hierarchy as well as converting data into information for the final decision maker.

Information systems are integrated software and hardware systems that support data manipulation intelligently. Information systems provide the possibility to measure physical data and process this data in “real-time” enabling a close monitoring of the performance of an organizations operations thereby enhancing the connection between executed operations and the strategic targets of the enterprise (Folinas 2007: 65-66).

Management Information Systems differ from other information systems in the sense that the objective to analyze and present results on other information systems dealing with the operational activities in the organization. Management Information Systems therefore is a subset within the planning, control and execution of activities dealing with the application of operations of humans, technologies available, and procedures of an organization. Management Information Systems has the purpose to combine various resources in order to automate or support human decision making (O’Brien 1999: 512-516).

A Management Information System is a planned system of the collecting, processing, storing and disseminating data in the form of information needed to carry out the functions of management. A management information system (MIS) is composed of all the independent internal components of a business covering the application of people, documents, technologies, and procedures for solving business problems. The term is also used to describe a group of information management methods used in the automation or support of human decision making, e.g. agricultural decision support systems, expert systems, and executive information systems. (O’Brien 1999: 514). Figure 17 shows the concept decomposition of different management systems in an organization (Sørensen et al. 2010: 39).

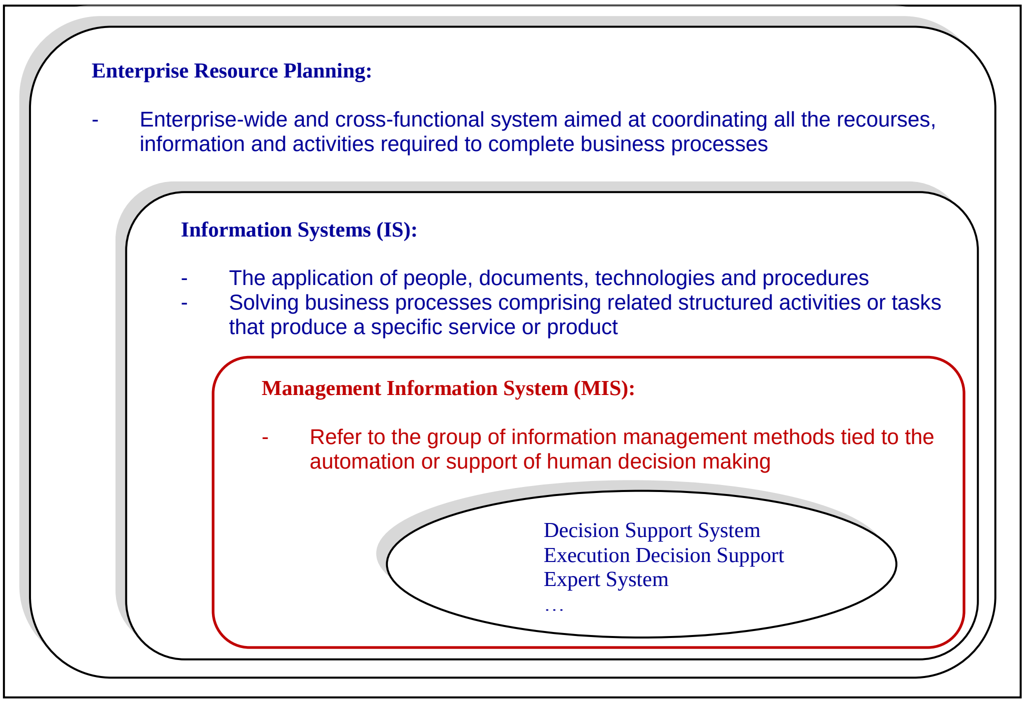


Figure 17. Concept of management information system (Sørensen et al. 2010: 39)

As presented in Figure 17 Management information systems is an integral part of the overall management system in an organization for example agriculture. The system comprises of tools like Enterprise Resource Planning (ERP) and the overall information systems (IS) in addition to others; depending on the sophistication of the organization. Enterprise Resource Planning is a known system in different industries consisting of a set of management activities that support all essential business processes within the enterprise. Analysis results from such a system usually provide key performance indicators (KPI's) that support managerial activities on all levels of an organization including finance and human resources management aspects of the business (Folinas 2007: 66).

Management information systems (MIS) is an integral part of the overall management system in an organization such as agriculture. A MIS designed for managing activities within the agricultural enterprise is known as the Farm Management information systems (FMIS). Unfortunately, there are no two similar conceptual definition and architectural representation of information systems for agriculture; the determinations of the key requirements for the information system design often lack a definitive formulation (Nikkilä 2010: 329). This is because different stakeholders have different perspectives on what forms their core needs and what formulated functions are to be included in the design of an information system. The subsequent chapter tries to draw information from various sources to try to formulate a generic picture of the agricultural FMIS.

Structure of Farm Management Information Systems

A FMIS is a management information system designed to assist in the various tasks related to farm business. Structurally, a FMIS is a planned system of the collecting, processing, storing and disseminating of data to provide value-added information needed to carry out the operations functions of the farm. The conceptual representation of a generic FMIS is given in Figure 18 bearing in mind the typical user as the farmer.

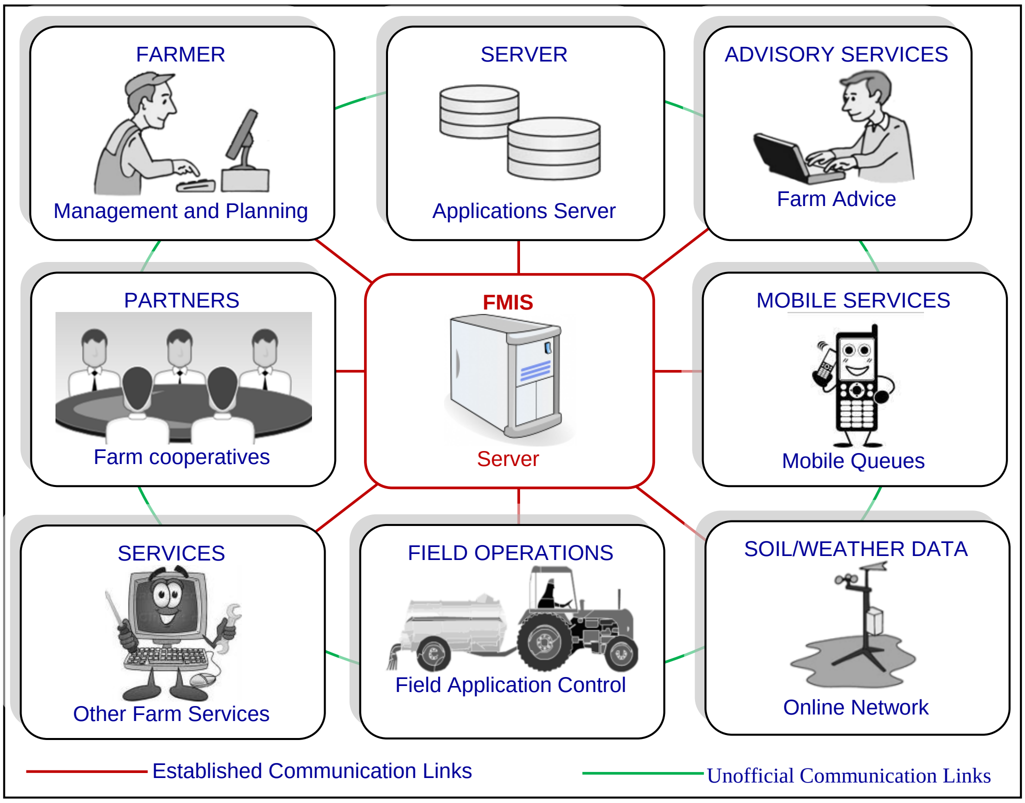


Figure 18. FMIS architecture from user's viewpoint (Pesonen et al., 2008: 45)

There are different ways of looking at the conceptual representation, usually from who is the core user. The concept presented in Figure 18 places the FMIS as the key and central information source of system, to which all other parties are connected. The connecting lines represent inter communication between the different parties which is implemented using various protocol or content management systems. More often, the end user need not know or even care how the communication between the various systems is handled, the only need is to obtain the valued information he or she needs (Pesonen et al. 2007: 45).

Structuring and formulation of ICT-systems, physical, operational and informational entities surrounding the FMIS affects the overall decisional support it provides in the planning, control and operations of farm management (Murakami et al. 2007: 38). By specifying in detail the information the management system should provide, the required input information and the information handling processes, the design, and functionalities of the individual information system components can be derived (Sørensen et al 2010: 38).

General FMIS database contains the same heterogeneous collection of information about the farm that is stored by any commercial FMIS. One difference is that the general FMIS database must also contain information on farm equipment required for PA. The schema of the general FMIS database is complicated by the amount and diversity of the stored information. However, this complexity requires no novel techniques as the design and implementation of similar databases can be considered routine work in software development.

The FMIS as presented in Figure 18 consists of multiple *stakeholders.* The stakeholders are the *farmer*, *FMIS provider*, farm *staff and contractors*, *suppliers* of farm inputs, *customers*, *government*, external *service providers*, and farm *equipment manufacturers*. Collaboration of these stakeholders is eminent for the functioning of the FMIS. The *farmer* is perhaps the most important stakeholder of the FMIS. The FMIS is intended as an assistive tool for the farmer. For these reason, to obtain the maximum benefit of an FMIS, the system should be available, reliable and easily user friendly for the farmer. If these basic needs are met then, the FMIS will be convenient tool for increasing information available to the farmer and making data transfer seamless, saving human effort thereby reducing time costs in seeking and processing information which the FMIS automatically does. Apart from the work carried out by the farmer himself, the farmer very often employs additional labor for various day to day activities of the farm. Some farms employ temporary *staff and contractors* who are not familiar with the whole farm. In this case, the contractor or employee needs to have access to the farm data to obtain the operational plan required to carry out their contracted work. Furthermore the documentation of the tasks carried out by the employee or contractor should be uploaded to the FMIS as a proof for both the farmer and the contractor that the task has been carried out properly. In this case automated work recording plays a key role.

The next important stakeholder is the *FMIS provider.* Provision of the FMIS may be done by two possible stakeholders: the government or a commercial company. The provider of the FMIS develops, manages and maintains the functioning of the components of the whole FMIS. In addition, the provider of the FMIS and arranges the interfaces for inter-stakeholder interactions and agreements. Unless operated by the government, the commercial provider of the FMIS operates the FMIS as running a business with interest of making a profit.

Suppliers of farm inputs also play an important role in the FMIS network. The FMIS needs to be able to contact suppliers of farm inputs to perform orders and also record information about for example suitable chemicals and seeds needed by the farmer. The database of suppliers also provides useful information for the farmer to perform preventive actions such as spraying or fertilizing operations. *Customers* are the stakeholders that acquire directly, the products of the farm. Customers consist of individuals; in terms of small farms companies, or larger bodies such as grocery store chains that have concerns about to the product they purchase from farms. The FMIS can relay documented information about farming system and tasks carried on the farm to prove that the product was produced with the agreed farming practices. This documentation provided through the FMIS is useful to prove for example that a farm is an organic farm. *Government and ministries* oversee and control the operations on the farm. They dictate the dos and the don'ts of the farmer. These include restrictions for farms, such as the use of chemicals, deposition of farm wastes and require the farm to report on its activities. In addition, governments provide financial support in the form of subsidies to the farmer. To reduce the laboriousness of this supervision, it is convenient for both the farmer and the authorities this information can be transferred automatically, reliably with the help of the non-human FMIS. *External service providers* provide value-added services such as weather information and forecasts, financial and accounting services, farm input calculations, soil analysis or mapping services to the farmer. The FMIS is a means by which these external service providers can easily and reliably obtain or transfer data from and to the farmer. Last but not least stake holder of the FMIS is the *Farm equipment manufacturer*: In agriculture, equipment play a very important role, therefore having the farm equipment work reliably when needed is of key importance for the farmer. The farmer needs certain technical details of farm equipment to perform important tasks such how fast the tractor should be driven so that a planting or fertilizing machine will deliver the right amount of seeds or fertilizers at the right place. For reliability and convenience, manufacturers provide this machine-to-machine information by using the functionalities of the FMIS. In addition manufacturer of agricultural information utilize the FMIS for providing key relevant information to the farmer, for performing software updates and providing technical support for the farmer.

For collaboration between the stakeholders in FMIS, Farm Management Information Systems (FMIS) is a tool used. In the next section, the use and importance of FMISs for the stakeholders are discussed.

Farm Management Information Systems

Farm management deals with the organization and operation of a farm with the objective of maximizing profits from the farm business on a continuing basis. Described in the previous section dealing with Agricultural Business Management; it is eminent that farmers have to deal with increasing amount and variety of information (Slavik 2004: 193). Information that farmers in developed countries have to be aware of in order to manage their farms includes global trade requirements, traceability requirements, consumer requirements, Common Agricultural Policies of the EU, environmental requirements, and the multi-functionality of agricultural enterprise and farm economy as a whole (Figure 18). In addition, constantly growing information from these various network segments has to be adapted in their farm management strategies. Farmers also have to deal with various network contributors (providers of resources and information) that influence how they run their farms (Peniri and Susi 2004: 281). The farmer additionally needs to adjust his farm organization from year to year to keep abreast of changes in methods, price variability and resources available to him.

An automated or computerized system that aids or compliments the farmer to fulfill these management duties is a farm management information system (FMIS). Figure 19 present a typical interface of commercial FMIS software (AgLeader SMS, http://www.agleader.com/products/sms-basic).

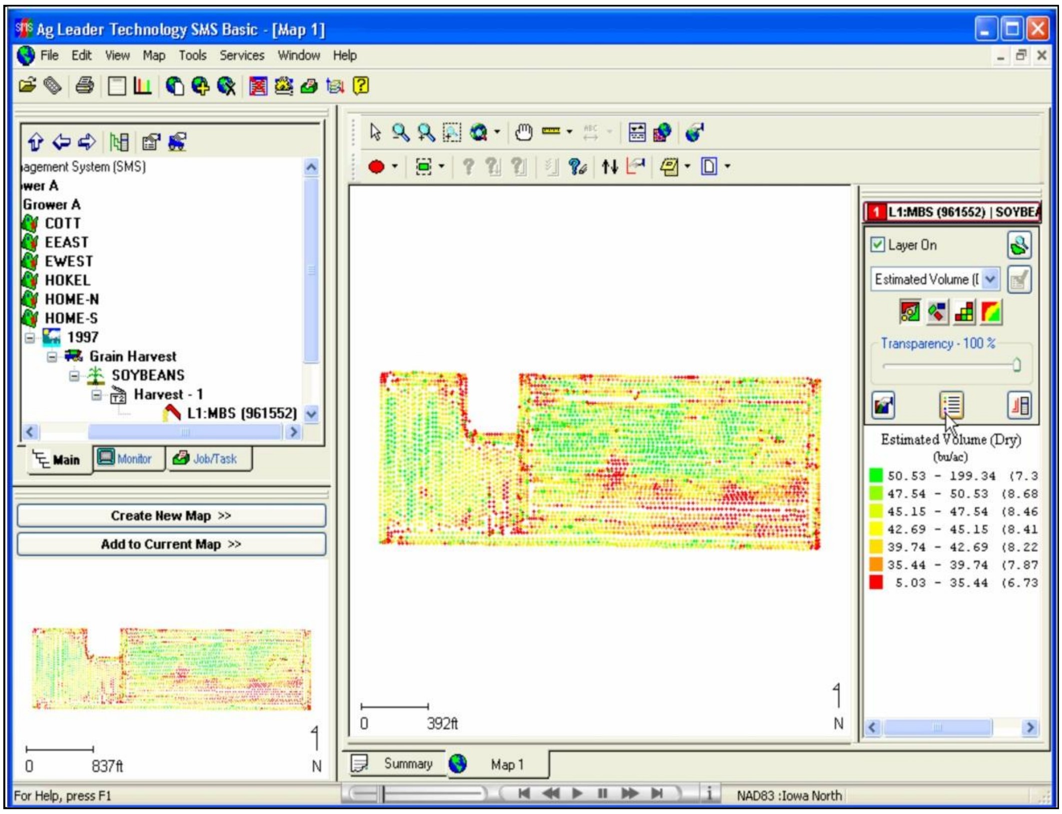


Figure 19. Interface of Agleader SMS farm management information system

Figure 19 shows a map produced form a harvesting task on the farm. As presented in the figure, a FMIS is an information system designed to assist in the various tasks related to farm management. It brings together different layers of farm management processes such are general agricultural farming processes, business management processes, utilization of different technologies and integration of different sources of agricultural data. Figure 20 shows a typical implementation of these layers in a FMIS.

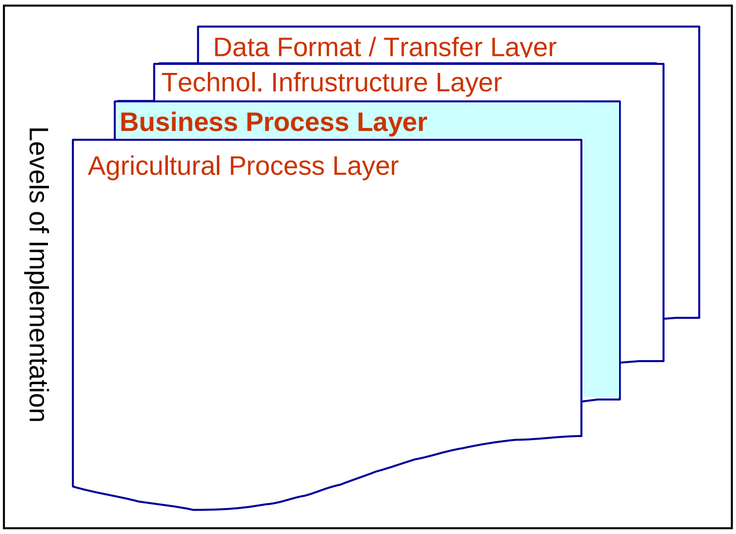


Figure 20. Levels of implementation of different components in a FMIS

To be able to implement the components in Figure 20, a management information system must connect to different sources of data both internal and external. These sources must allow data to be modified and structured in different ways as different decisions need different sets of information. Figure 21 gives an overview of the communication within an agricultural production system.

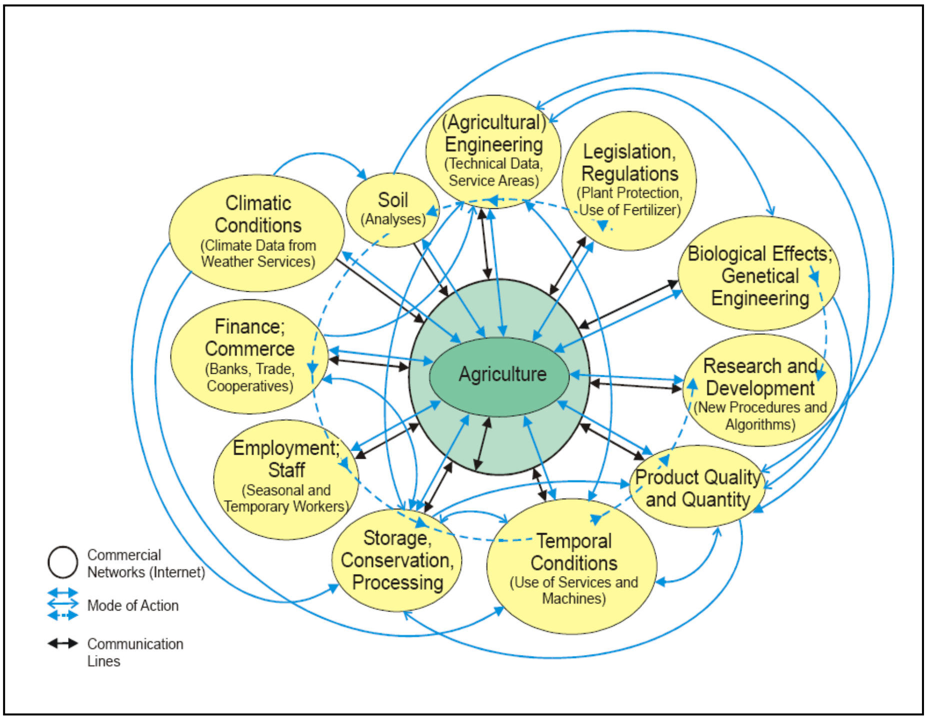


Figure 21. Data communication in agriculture (Munack and Speckmann, 2001: 3)

From Figure 21 it can be realized that the communication between the different components in the FMIS is rather complicated. This is because current demands in agricultural farming calls for better analysis and transformation of available and collected data, and the integration of this data into the planning and control functions in farming operations and business management. There also need for communication also from and between FMIS systems, farm machines, biological and soil measurement devices, and meteorological conditions of the environment (Kuhlman and Brodersen 2001: 71-72). Furthermore there is communication with stakeholders such as governmental regulation bodies, and research. Subsequent collaboration with different stakeholders in the system is paramount for sustainable operation of FMISs. The next section describes how stakeholders collaborate in sustaining the agrifood supply chain.

3.4 Collaboration in Agrifood Supply Chain Network

Agrifood Supply Chain Network (AFSCN) refers to the entire vertical inter-enterprise chain of activities: from production on the farm, through processing industries, distribution, and retailing right to the consumer - in other words, the entire spectrum, from farm gate to the consumer's plate, regardless how it is organized or how it functions (Roekel et al. 2002: 5).

Agrifood Supply Chain Network is a very old principle known in the buying and selling of food products. With the evolution of information technology in the 1980s, it has now become possible to extend the supply chain management further to include close links to the final consumer and the suppliers. The supply chain has typically dealt with product-specific sub-sector of the Agrifood system. For example supply chain for tomatoes. Supply chain management refers to the total management of the entire set of processes in the production, distribution, and marketing that deliver agricultural food products to consumers. For the supply chain to function, different stakeholders such as suppliers, government, farmer, advisory services, retailers, processing, logistics and retail companies have to collaborate amongst each other or in a linear chain-like fashion. Figure 22 shows a typical transfer of information within the AFSCN.

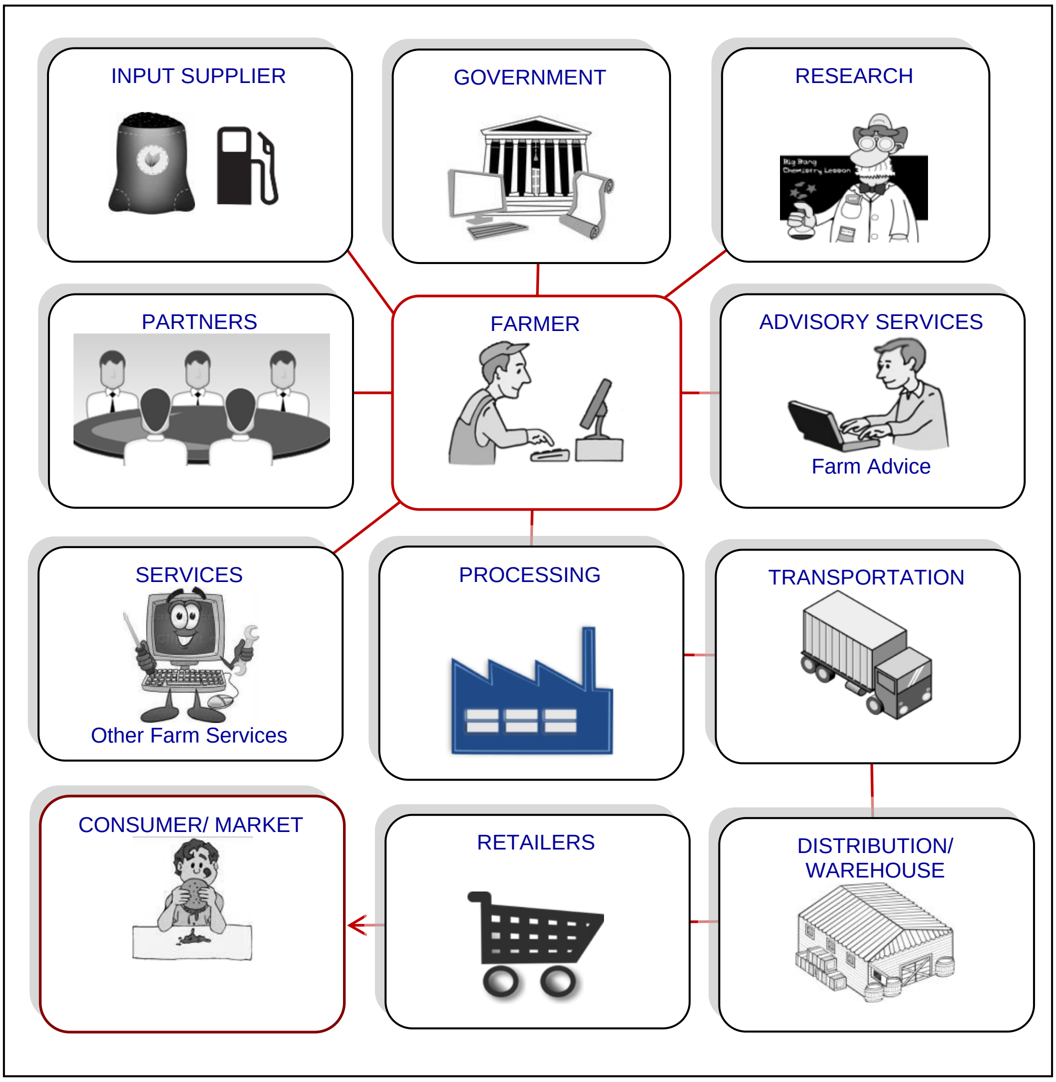


Figure 22. Collaboration in the Agrifood Supply Chain Network (AFSCN)

Governments play a very important role in AFSCN's. A fundamental question is whether or not public sectors should get involved with the development of supply chains? The public sector has a basic choice to make with respect to supply chain as a strategic priority. The choices are to do nothing, regulate the market or take a strategic action.

If the government *does nothing,* some supply chain formation will occur as a natural development of the marketplace and small farmers will be left in marketplace to survive on their own. On the other hand, if the government chooses to tightly *regulate the market* thus regulate the actors and actions; this will lead to concentration and multinationalization, which in turn will drive competition. Small farmers find these changes in institutions, organizations, and technologies challenging. The last choice for the government is to *take Strategic Action* to initiate supply chain formation in pro-active manner and to help equip poor farmers to compete. The public policy should lay an important role in the development of supply chains to create an enabling environment for private sector supply chain development. In addition, good policies should set and ensure enforcement of transparent and consistent rules and regulations.

Supply chain formation within agri-food system is driven by the desire to improve competitiveness. Some key market drivers enhance supply chain formation in developed economies. The first key driver is the need for *food safety and quality assurance.* This is the requirement of the development of detailed quality assurance systems from primary production to retail. This type of market driven chain may be small scale or involve an entire sector strategy involving major producer organizations and large scale food processors and retailers. The next driver is if companies develop *product innovation and differentiation.* This type of market development typically involves the development of niche markets and is most appropriate for smaller organizations working to develop specialist markets. The final driver is the need for *lowering systemic cost.* The drive to reduce logistics costs which can include a range of transaction, delivery, warehousing, and delivery costs creates the need for developing the agricultural supply chain. Typically these chains require a strong operations research focus to identify system bottlenecks and to seek out inefficiencies best suited for improvement. The development of the communication networks starts form the company's internal operations and links to the entire food supply network as presented in Figure 23.

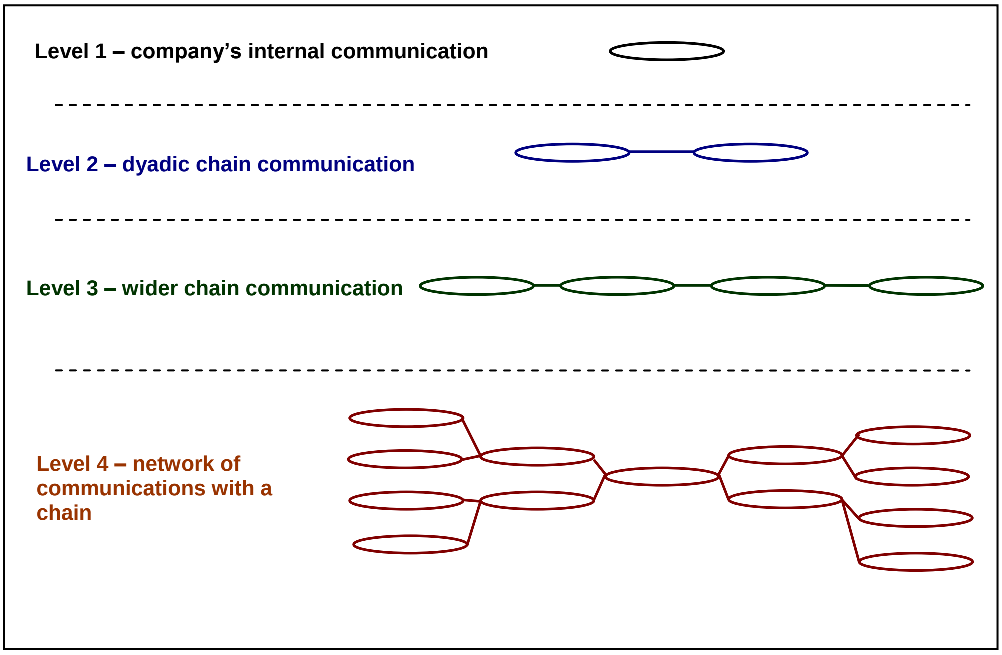


Figure 23. Four levels of relationships in supply chains (Harland, 1996: 65)

According to CGI (2006), companies must be prepared to share standards-based data free of charge. Sharing information between trading partners will result in an improved information flow and, as a consequence, improved collaboration to better serve the consumer. Within the Agrifood Supply Chain Network, information sharing is an important issue. The AFSCN is complex, however, existing information systems lack standardization at all levels. Currently, there is data exchange within the AFSCN which affects the efficiency of business processes. In reality, most 'chains' in agriculture are loose, fragmented, and unstable over time (Roekel et al. 2002: 6). Collaborative information transfer platforms dealing with inter and intra enterprise communication and information transfer; as presented in Figure 23 could assist the efficiency and development in the AFSCN.

Different technologies can be adopted to enhance information transfer within the AFSN. Service-Oriented Architecture has been proposed in the past Nikkilä (2010: 332). Service-Oriented Architecture (SOA) is a software architecture where functionality is grouped around business processes and packaged as interoperable services. A technical architecture based on SOA consisting of three layers in presented in Figure 24.

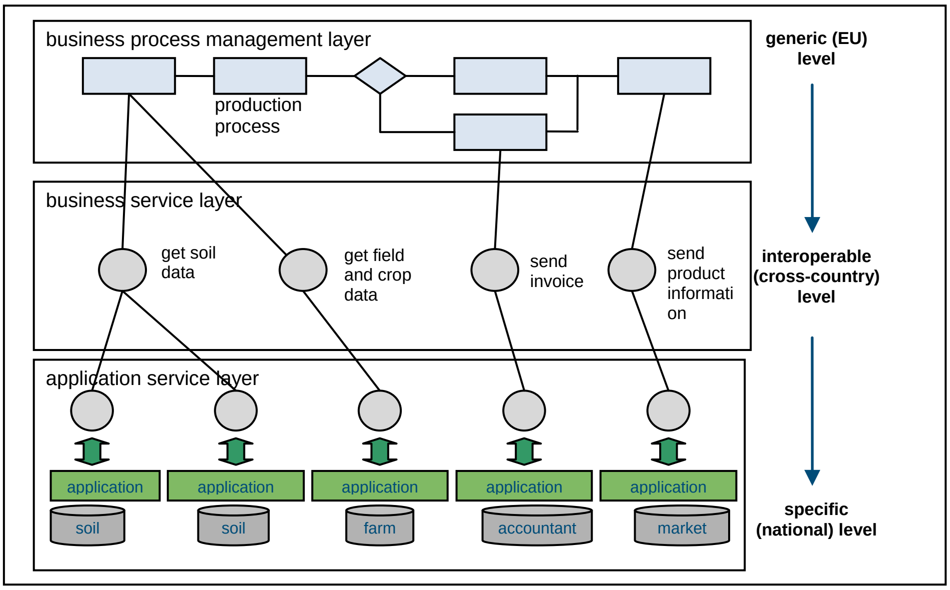


Figure 24. Knowledge about chains and within chains (Wolfert et al 2010: 396)

The evolvement of SOA combines different principles; business process management, business services, and practical service application into one integrated system. The aim is a loose coupling of services with operating systems, programming languages and other technologies, which underlie applications. SOA separates functions into distinct units, or services, which are made accessible over a network to be combined and reused in the production of business applications. These services communicate with each other by passing data from one service to another, or by coordinating an activity between two or more services. Service providers publish web services in a service directory, service requestors search in this directory to find suitable services, bind to that service and use it, based on information from the directory and standardized procedures (Wolfert et al 2010: 396). So, SOA provides the technology that enables timely and flexible sharing of information demands in the AFSCN.

4 Results and Discussions

The following section presents the results of the interviews with 15 different FMIS stakeholders from Finland, Sweden, Denmark, Latvia and Lithuania. The analysis of the results also utilizes SSM. Based on SSM, rich pictures are developed to represent the real work situations. This section also discusses the links between the individual stakeholders in rich picture detailing present situations in stockholders' businesses, and how they want FMIS it to be organized in the future.

4.1 Soft Systems Methodological Analysis of Present FMIS Businesses

As a first step of applying SSM, rich pictures were developed to represent the real work situations based on the raw data set and preliminary analysis. According to the SSM procedures described in the methodology (Section 2.2), the interviews with different stakeholder companies using FMIS were conducted in order to develop the relevant rich pictures representing the concept maps of the current practices. Based on the ontology developed by Osterwalder (2004: 14), and discussed in Section 2.3, the questions in the interviews with the 15 interviewees focused on the key pillars of their operations, their *products and services*, their *infrastructure and the network of partners*, and some *financial aspects* such as cost and revenue structures. After describing the individual stakeholder company's key pillars (Figure 8), the links between these components, or pillars, were identified and used to compose a business model defining the profiles of the companies. It is worthwhile to note that the interviewees were chosen based on their ability to respond to complex enterprise environment. It was done to capture the cognitive processes in the rich picture format. Thus, the ability and vision of the interviewees were obtained through their verbal responses and then combined into a graphic interpretation. From the development of the individual rich pictures, further mappings were performed to develop detailed rich pictures for the stakeholder groups in the FMIS network. From the rich pictures, the problems were then defined and presented as root definition by applying CATWOE, namely the customers, actors, transformation, weltanschauung (world view), owners, and environmental constraint analysis of the problem that are discussed in subsequent sections.

The rich picture obtained from each stakeholder group, forms a basic model which is then developed into a basic conceptual model. These models are in turn, integrated into a broader conceptual model illustrating the reality of the market.

4.2 Interviews on FMIS Software in the Nordic and Baltic States

The semi-structured interviews included group 1: farmers, group 2: FMIS software companies, group 3: government organizations, group 4: service providers, and group 5: agricultural machinery manufacturers. These categorizations are described in Section 2.5.2. Interviews with 15 people were performed in 5 different countries: Finland, Sweden, Denmark, Latvia and Lithuania (Table 5). The results of the interviews are presented in the following sections.

Crop Production Business

The results from the interviews showed that crop production in the Nordic and Baltic States is dominated by cereals; mostly barley, oats and wheat, as well as by grassland, and to some extent potatoes. The, farm size amongst the interviewed ranged from 45 to 100 ha. According to the interview small family farms are dominant in Finland; however, the respondents from Denmark reported that cooperate farms were more common, with the farm sizes over 200 ha reaching almost 10% of the total farms in Denmark. Analysis of the financial revenue flow of a Finnish farm (the size of 50 ha) showed that for a farm producing on average 3.5 tons/ha of grain, a farmer will have a turnover of about €60 000 per year. Typically, government provides about €550 per ha (accounting for about 50% of farmers turnover) and the sale of 1 ton of grain generated about €150 in 2010. Most farmers usually have loan financing for their businesses which need to be paid for. The interviews revealed that for this reason Finnish farmers derive about 50% of their profits on the average from their annual turnovers. However, fully owned farms of the size about 50 ha without debts could make an annual profit of up to €40 000 per year. The cost of the commercial FMIS software packages in the interviewed countries ranged between €220 and

€590 per year, with the cost of yearly support and update subscriptions ranging from €90 to €300.

FMIS in Finland

In Finland, about 90 % of the farmers use FMIS, at least to some extent. There are three main FMIS software companies in Finland: ProAgria Oy (http://www.proagri.fi); with the software developed by Bitcomp Oy (http;//www.bitcomp.fi); Suonentieto Oy (http://www.suonentieto.fi), and Softsalo Oy (http://www.softsalo.fi). ProAgria develops the WISU FMIS, Suonentieto develops the AgriNeovus FMIS and Softsalo the PeltotkuiPro FMIS. These companies cater for over 95% of the farmers (about 20,000 FMIS software users) in Finland. Among these companies, the shares of official licensed users amount to 10,000 for WISU, 6,000 for AgriNeuvos, and 4000 for the PeltotukiPro FMIS software.

FMIS in Denmark

In Denmark, the FMIS is run by Danish Agricultural Advisory Service. Once a year, all the farmers are officially obliged to present a fully documented report on nitrogen usage in their farms. Usually, about 80 % of the farmers ask for advisory services to assist them in preparing these reports, which can be done electronically with the FMIS run by the farmers' union and the government. In addition, approximately 60-70% of the farmers use the various advisory services to collect their EU-support and subsidies. The rest fill out the application form themselves for submission to the authorities. If done by themselves, it is done fully electronically between the FMIS run by the farmers union and government. From 2011 it is obligatory to hand in the documentation on spraying operations on farm once a year as well. This has to be done fully electronically, if the farm size is more than 25 ha.

FMIS in Sweden

Farm management information systems are important parts in agricultural production in Sweden. There are four common FMIS software providers in Sweden. DataVäxt AB (http://www.datavaxt.se/) provides comprehensive software for managing crop production. In addition to the desktop client version, there are versions for mobile phones. Another FMIS software is produced by Datalogisk (http://www.datalogisk.dk/), originally a Danish company. As with DataVäxt, the software by Datalogistik provides solutions for management and PA for planning, documentation, and accounting. Lantmännen (http://www.lantmannen.com/), one of the largest groups within the Swedish food sector also provides FMIS software including an internet version for use by farmers. Finally, the agricultural advisory institution in Sweden (Swedish Board of Agriculture, http://www.jordbruksverket.se) offers management support, including internet services, voice recording and electronic feedback for farmers.

FMIS in Latvia

Presently, three FMISs are dominant in Latvia. At the moment, for crop production planning and event recording, Bitfarm (Latvian adaptation of WISU software, manufactured by Bitcomp Oy, a parent company from Finland) is in use by the Latvian Rural Advisory and Training Center. (http://www.llkc.lv). The second FMIS software used in Latvia is produced by Datalogisk (http://www.datalogisk.dk/), ACLatvia (http://www.aclatvia.dk/s%C4%81kumlapa-11.html) originally a Danish company. The software by Datalogistik provides solutions for management and PA intended for planning, documentation and accounting. The third FMIS provided by enAgro (http://www.enagro.eu), offers services via cooperation with Farmers Parliament (http://www.zemniekusaeima.lv/). Farmers and farm advisers can use the online "CropManager" program planning, registration and control related issues in their crop production.

FMIS in Lithuania

In Lithuania, both farmers and advisors use various FMIS tools for facilitating agricultural crop production. The Lithuanian Agricultural Advisory Service use different kinds of advisory tools. These tools include orthophotographic maps manipulation software, online databases for animal registers and crop declarations. In addition, there are computer programmes for fertilizer planning, planning the use of plant protection means, and manure storage assessment and design. For private farm planning and data management, there is an independently developed online FMIS software (cooperatively developed by Farmers Parliament (NGO) and the Danish Government), used for the fertilizer planning and filling in various applications requested by the government. The private software, *CropManager* offered by enAgro (http://www.enagro.eu/lv/login.asp?lang=lv?reload), has versions for internet web-browsers, PC's and mobile phones. In addition to CorpManager, there are other tools by enAgro for book-keeping and accounting, and calculating mineral fertilizer amounts.

In summary, it can be said that FMIS is familiar to the farmers of the five countries interviewed. In almost all the countries interviewed, it was acknowledged that adaption of FMIS technologies is lower in older farmers than in younger farmers. In the Baltic countries interviewed, data integration at process level for FMIS was not officially organised at intra-enterprise and inter-enterprise level. However, in the Nordic countries interviewed, i.e. Finland, Denmark and Sweden, information transfer between FMIS components was well organized though there were instances of problems with standardized interfaces for data communication.

Due to EU CAP (Common Agricultural Policy) legislations, obligatory registering of parcels and animals has been set up in the interviewed countries. In interviewed Baltic and Nordic states, databases for registering land parcels are shifting towards open systems, portals or shared databases for easier data transfer between systems. The respondents from the countries noted that EU CAP as a boosting instrumentation of data communication between FMIS systems.

In the interviewed countries, PA was hardly used by farmers. The respondents of the interviews reported PA and the usage of geo-referenced farming to exist mainly in experimental or research farms. The initiation of integration between PA and FMIS systems was noted to be brought by manufacturers of agricultural machines. The respondents stated that newer farm machines are increasing their interest in the adaptation of PA as new machined are equipped with ISOBUS.

The following sections present the results of the analysis of the stakeholders categorised into the 5 groups described in Section 2.5.2.

4.3 Analysis of Group 1: Farmers and Crop Production Companies

The following sections present the analysis of the results utilizing SSM. This section presents and discusses the links between the individual stakeholders in rich picture detailing present situations in stockholders' businesses. CATWOE analysis of the rich pictures is also performed.

Group 1: Farmers and Crop Production Companies

To outline current situation and derive a rich picture focusing on the farmer and everyday farm management operations, the detailed scheme reflecting the products, services, customers, partners, capitals and financial was created to give an overview of the business model, as recommended by Osterwalder (2004: 14). The outcome of the analysis is given in Table 6.

Table 6. Business model of farmer with reference to FMIS usage

PARTNER NETWORK	KEY ACTIVITIES	VALUE OFFERING	CUSTOMER RELATIONSHIP	CUSTOMER SEGMENT
• Government • Machine manufacturers • Processing companies • Software developers • Network providers • Database companies	• Land preparation • Planting • Harvesting • Storage • Transportation of food products	• Provide high quality food products • Document all processes • Environmentally friendly production • Information for government and research	• Good quality food products • Documented production process information	• Public domain • Retailers • Transportation and storage • Processors • Animal produces
	KEY RESOURCES		**DISTRIBUTION CHANNEL**	
	• Network infrastructures • Database servers • Software programmers		• Machine manufacturers • Government subsidy system	

COST STRUCTURE	REVENUE STREAMS
• Machines/production inputs costs • Infrastructure and warehousing storage costs • Land and maintenance costs • Computer hardware, software, network and database costs • Hired labour and personnel costs	• Sales of crops • Renting of machines • Renting of farms

As presented in Table 6, the farmer has tight business links to the government, machines and machinery manufacturers, service providers and FMIS companies and their provided software. These links were carefully analyzed based on the attributes of Table 6 to obtain a representation of a rich picture outlining how these stakeholders collaborate with reference to the effects of FMIS on these business process links. The outcome of the analysis is shown in Figure 25.

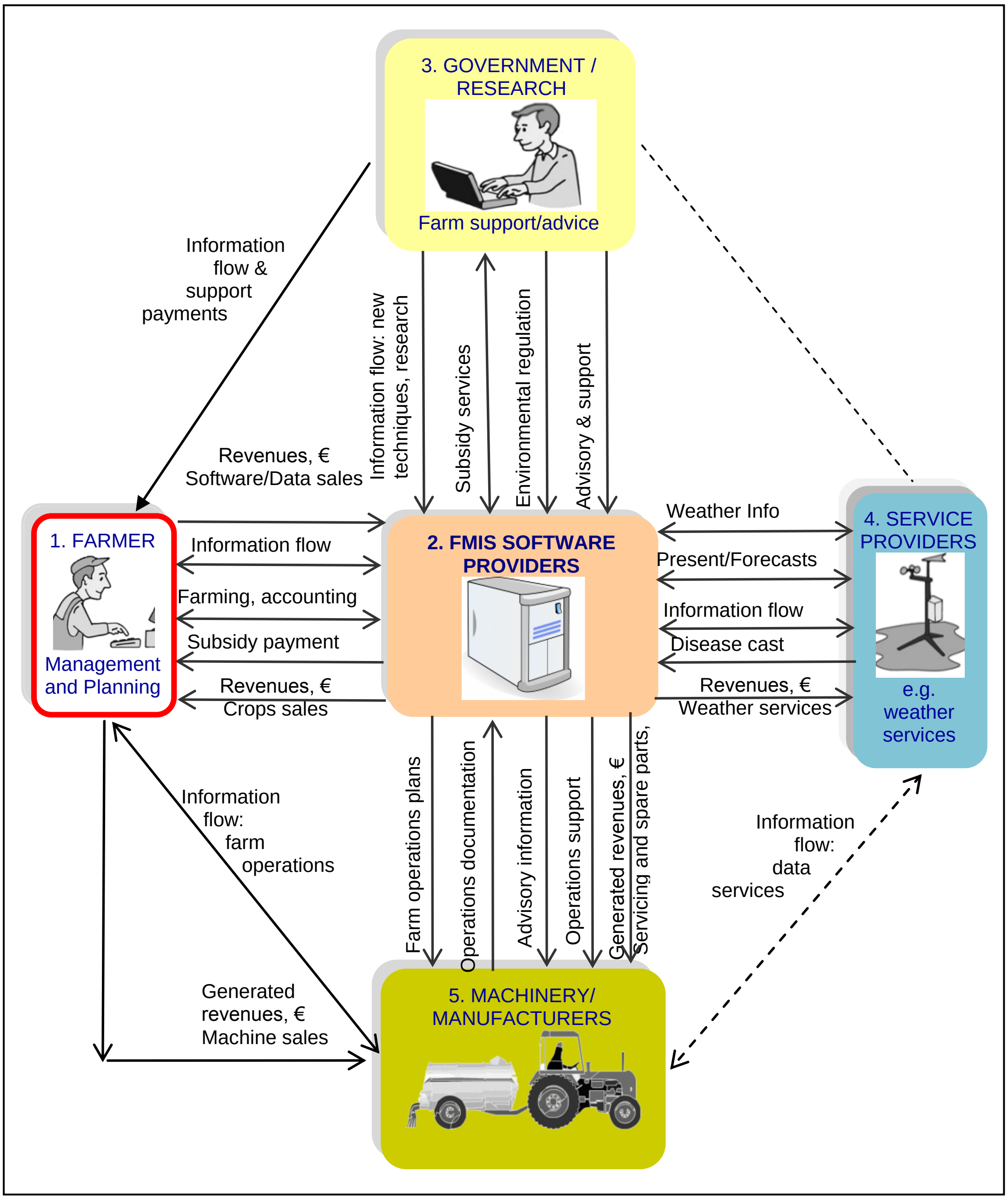


Figure 25. Rich picture of collaboration and the use of FMIS in farmer's business

Based on the business model attributes identified in Table 6, and the core business links in Figure 25, a current situational elements CATWOE analysis were performed and is presented below.

Group 1: Customers

The CATWOE analysis revealed that the *primary* customer of the farmer is the farm produce buyers, which are mostly the processing companies. The *secondary* customers are the transportation companies that transport crops from the farm to the processing companies. Sometimes, secondary customers may be represented by retail companies buying produce directly from the farmers. These types of customers are typical for greenhouse (vegetable) producing farms. *Tertiary* consumers usually acquire produce in rather smaller amounts. Tertiary consumers in farmers' businesses include the public domain representatives that visit the farms to buy local farm produce for personal or family consumption. In addition, tertiary consumers may include neighboring farms that buy, for example, grass, hay and silage that the farmer produces rotationally on crop fields.

Group 1: Actors

The actor is the individual operating the farm, which in our case, is the farm manager or some other farm staff using the FMIS software services.

Group 1: Transformation process

The transformation process involves the utilization of the farmer's fields for turning the farm inputs such as seeds, water, and fertilizers into crop produce as an income source. This transformation is performed utilizing FMIS as an aid facilitating planning, documentation, and decision-making processes in crop production.

Group 1: Weltanschauung (World-view)

The World-view is the hypothesis that makes farmers wants to use FMIS in their transformation process. In this case, the view is that operational data is easily acquired and can be used to improve management decision-making throughout the production cycle, and that the same data may be used to demonstrate to external agencies the farm's compliance to farming standards.

Group 1: Ownership

The owner is the farm manager in the way that he has everyday decision-making responsibility in the farming business, and decides what activities should take place and how he utilizes FMIS as a support system.

Group 1: Environmental constraints

Environmental constraints are the external factors that influence crop production in farm businesses. The primary environmental constraints include natural constraints in such as weather, water, and farm inputs. The secondary constraints include governmental and legal regulations regarding environmental and cultural practices in the farming business. Other aspects of the secondary constraints include financial constraints that can affect inputs, machinery, infrastructure, and the overall farm's maintainability. Tertiary constraints include usability and performance of the FMIS and its interfaces to meet the expectations of the regulators for readily-available information. Its main purpose is usually to audit farmers' compliance with the standards and regulations, as well as the reliability and structure of the information technology (networks, communication, servers, and databases infrastructures).

4.4 Analysis of Group 2: FMIS Software Companies

The outline of the current situations for creating the rich picture focused on the FMIS company's businesses, management, distribution and maintenance operations. Detail inquired information consisting of products, services, customers, partners, capitals and financial were inquired to give an overall picture of the business model as recommended by Osterwalder (2004: 14). There were different types of information received ranging from small size companies of size below 10 people as found in Latvia and Lithuania, sizes of about 20 found in Finland to governmental FMIS software developers and support workers in Denmark with over 50 people. Section 4.2 gave an overview of the current situation in the Nordic and the Baltic states.

Overviews of all the software companies were made and an analysis of the different models of operation of the companies was composed to integrate them to a representative business model. The outcome of the analysis is presented in Table 7.

Table 7. Business model of FMIS software companies

PARTNER NETWORK	KEY ACTIVITIES	VALUE OFFERING	CUSTOMER RELATIONSHIP	CUSTOMER SEGMENT
• Farmer • Government • Machine manufacturers • Processing companies • Software developers • Network providers • Database companies • Weather service providers • Map service providers	• Developing software • Standardizing data • Software maintenance and support • Indexing / programming **CAPABILITIES** • Excellent network infrastructures • Reliable database servers • User friendly software programming	• Provide an easy way for data management • Marketplace for selling data • Channel for machine diagnosis • Information on food tractability • Farm process documentation	• Provide excellent software with customer support • Tied service structure **DISTRIBUTION CHANNEL** • Machine manufacturers • Government subsidy system	• Crop farmers • Animal farmers • Manufacturing industries • Machine manufacturers • Food retailers • Food processors • Government • Weather forecasters • Value added map service providers

COST STRUCTURE	REVENUE STREAMS
• Indexers/ standards / programmer salaries • Support personnel salaries • Database hardware costs • Office premises and overhead costs • Network costs	• Software sales • Yearly subscription / data hosting • Information and data package sales • Data hosting and security

From Table 7, the key stakeholder components include the FMIS companies' provision of a software platform management and information transfer to farm managers, government, research, standardization and regulating companies. Additionally, business links for farmers' machines and machinery manufacturers, and key service providers. These links were carefully analyzed based on the attributes of Table 7 to obtain a representation of a rich picture outlining how FMIS software companies collaborate and link other stakeholder in the agrifood production and supply chain network. The outcome of the analysis is presented in Figure 26.

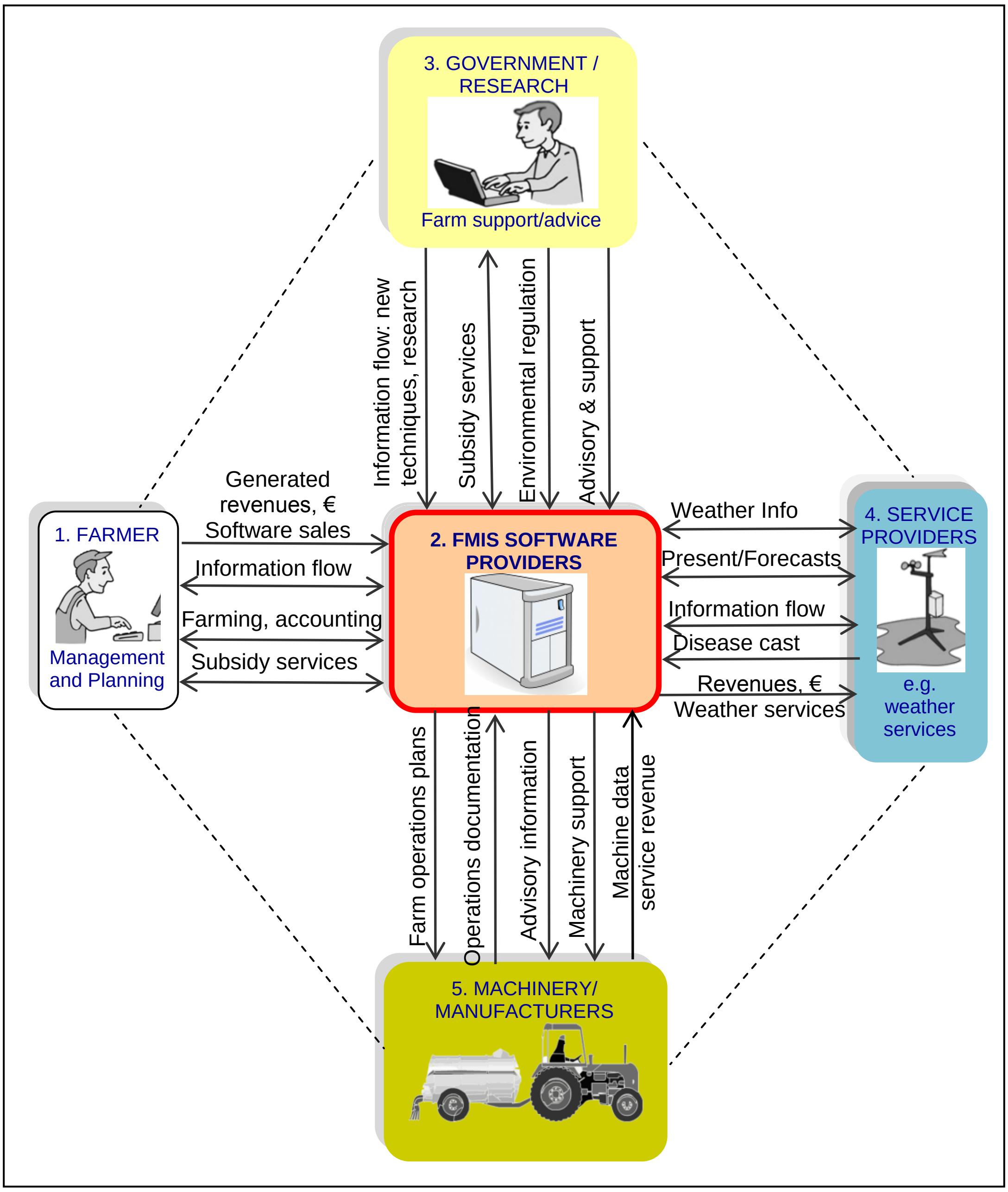


Figure 26. Rich picture of FMIS software companies

Combining the content of the analyzed software companies' business model identified in Table 7 and the core business links in Figure 26, a current situational CATWOE analysis is presented below.

Group 2: Customers

The primary customer of software companies is the farmer. The farmer utilizes the FMIS software for planning, managing and operation of farm practices. In these farm operations, additional support from government, machinery manufacturers, and other added value external services. The government, machinery manufacturers, and other added value external services are the secondary customers for FMIS software companies.

Group 2: Actors

The main actor is the one developing the FMIS software, which in this case is the FMIS developing company. Other actors are the farmer, machinery manufacturers, service providers, and government and regulating companies.

Group 2: Transformation process

The transformation process involves the conversion of operational farm field data from farmers, whilst integrating additional external sources of data from different service providers, into value added tool and information support for regulatory purposes, and decision making processes in crop production.

Group 2: Weltanschauung (World-view)

The World-view is that the software produced by FMIS software companies can enhance profitability and added value in crop production. In this case, the view is that management and decision-making is eased with good software for saving farmer's time, and providing information for service providers such as government and farm machinery manufacturers.

Group 2: Ownership

The owner is the FMIS developing company is in the way that it owns the overall software platform. In addition, its other responsibilities include the development of software, standardization and integration of data from different sources, and maintenance of the overall operation of FMIS.

Group 2: Environmental constraints

The constraints include usability and performance of the FMIS and its interfaces to meet the expectations of the regulators for readily-available information to audit compliance with the standards and regulations on the farm, as well as the reliability and structure of the information technology (networks, communication, servers, and databases infrastructures). Other constraints include different standards in technology such as data transfer standards e.g. ISO 11784, AGROXML, and regulations in the data transfer and telecommunication industry.

4.5 Analysis of Group 3: Governmental Organizations

Detail inquired information consisting of products, services, customers, partners, capitals and financial (Osterwalder 2004: 14) were obtained from the government, research and advisory companies. The semi-structured questionnaire and interview process provided information for creating a rich picture of the current situation in the government, research and advisory company's businesses in terms of management, maintenance and collaboration endeavors.

Apart from Denmark where the government plays an important role in the organization of FMIS systems, FMIS systems in the Nordic and Baltic countries are organized by private companies. Because of underdevelopment in FMIS infrastructure in Lithuania, government puts a lot of effort in obtaining required information from farmer since most of the data collection systems are not automated. Section 4.2 provides more information on government involvement in the organization of FMIS systems in the Nordic and the Baltic states. The business structures of interviewed government organizations and influence of advisory, regulatory and research institutions were analyzed and integrated in to a unifying presentation of a representative business model for this FMIS stakeholder category. The outcome of the analysis is presented in Table 8.

Table 8. Business model of generic government organizations with respect to FMIS

PARTNER NETWORK	KEY ACTIVITIES	VALUE OFFERING	CUSTOMER RELATIONSHIP	CUSTOMER SEGMENT
• Farmer • Software developers • Network providers • Database companies • Weather service providers¨ • Land and mapping organizations	• Administer EU support • Collect data on farm and environmental accounting • Protect environment • Administrate, regulate and research on farming	• Provide profitable incomes for farmers • Provide farm advice • Ensure sustainable farm production • Protect the environment from farm pollutants • Provide information about future farming systems	• Excellent farm advice • Financial support • Research funding	• Farmers • FMIS software companies • EU • Public domain • Researchers • Retailers • Machine manufacturers • Food retailers
	CAPABILITIES		**DISTRIBUTION CHANNEL**	
	• Network infrastructures • Database servers • Software programmers		• Online • FMIS • Visit to farms • Research publications	

COST STRUCTURE	REVENUE STREAMS
• Indexers/ standards / programmer salaries • Support personnel salaries • Database hardware costs • Office premises and overhead costs • Network costs	• Government budget • EU subsidies • Data service sales

Based on the business model attributes of the government organizations and influence of advisory, regulatory and research institutions identified in Table 8, a rich picture was draw to represent the current situation and presented in Figure 27.

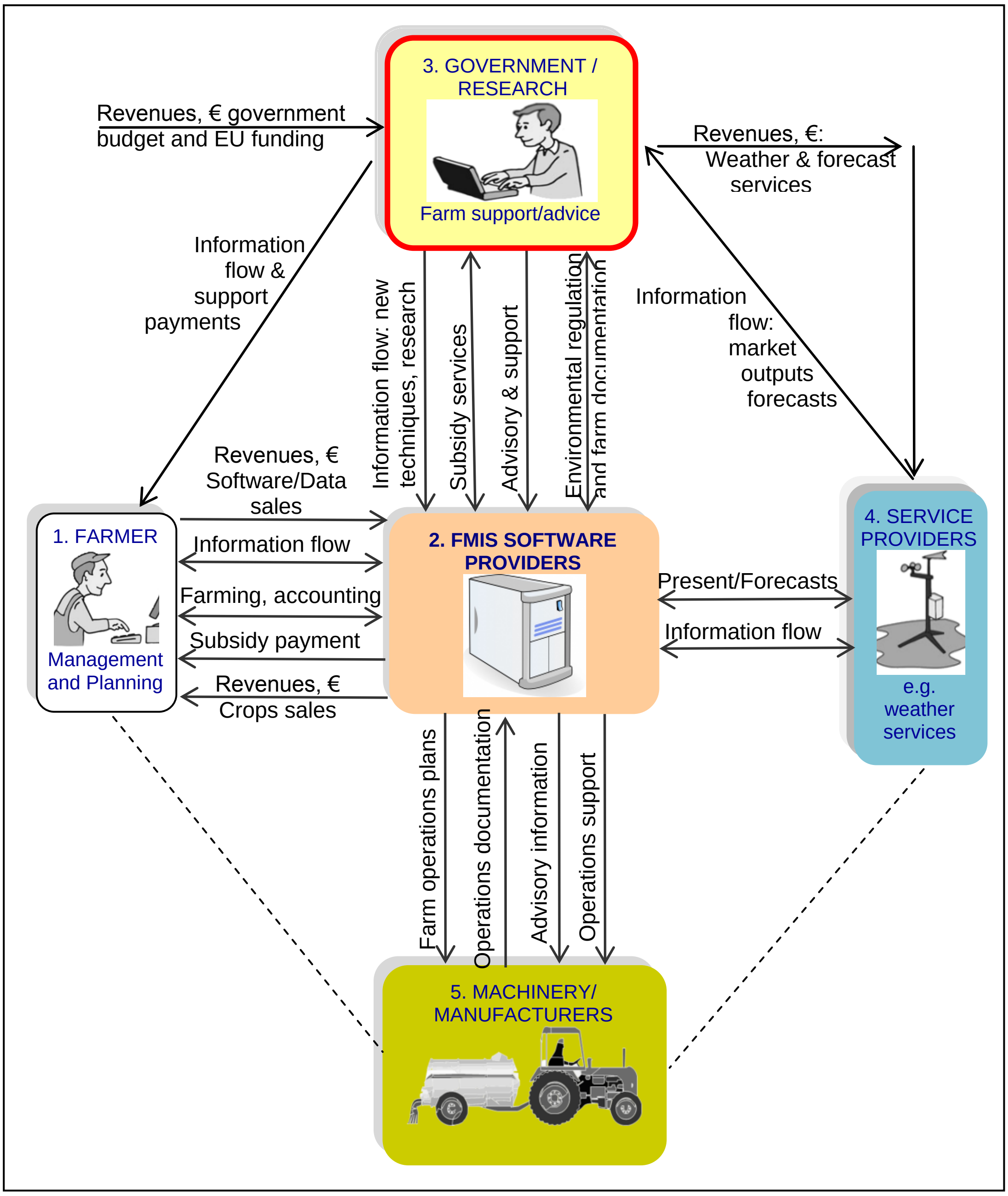


Figure 27. Rich picture of generic governmental organizations with respect to FMIS

From the business model attributes of the government organizations and influence of advisory, regulatory and research institutions identified in Table 8 and the core business links in Figure 27, a current situational elements CATWOE analysis were performed and is presented below.

Group 3: Customers

The primary customer government organizations and influence of advisory, regulatory and research institutions is the farmer (Figure 27). The government takes contact with farmers to administer EU support, collect data on farm and environmental accounting, protect the environment from the effects of farming, and obtain data for research on improving crop production. The government also utilizes independent services from software developers, network and database providers. In addition the government utilizes land and mapping organizations to define the boundaries of farmer’s land parcels in order to properly administer EU support for farmers. Some of the governmental agricultural ministries also utilize external weather, disease and economical forecasting service providers to project the trends of the future in the agrifood supply chain.

Group 3: Actors

The actor is the government organization. The government organization acts with the help of independent advisory, regulatory and research institutions to provide services to farmers.

Group 3: Transformation process

The transformation process involves the provision of financial support and incentives for farmers in the business in order to ensure food security for citizens. Through this process, the government ensures that registered or financially supported farmers, environmental friendly farming practices and better agricultural food produce. The transformation is done utilizing FMIS as an aid for collecting documented data on field operations for regulatory purposes, and facilitating advisory information transfer to farmers.

Group 3: Weltanschauung (World-view)

The World-view is that if financial incentives are given to farmers, they will utilize environmental friendlier farming practices and standards. The FMIS is viewed by the government as a tool for obtaining transparent information on compliance in farming practices, and a tool for channeling information from advisory, standardization and research organizations to the farmer.

Group 3: Ownership

The government organization is the owner in the way that it has to sole digression to administer EU support and regulate how farming is done in the country. The FMIS to the government is a mere supporting tool to achieving it aims.

Group 3: Environmental constraints

The primary constraints influencing government organization is solely governmental policies, governmental budget for farming and EU financial allocation for farmers. Secondary constraints include natural constraints in terms of weather, water and how the farming season goes in order to provide a secured food supply source for citizens. Tertiary constraints include reliability, usability and performance of the FMIS and its interfaces to meet the expectations for audit compliance standards, as well as the reliability and structure of the information technology (networks, communication, servers, and databases infrastructures).

4.6 Analysis of Group 4: External FMIS Service Providing Companies

As means of demonstrating the relevance of service providers in the FMIS stakeholder network, a weather information service provider analysis was used as a use case in this study. The weather information service providing company provided information on their products, services, customers, partners, capitals and financial during the interview process. The analysis of the data obtained for the process was used to create a rich picture of the current situation in weather information service provision for use by FMIS stakeholders. In addition a business analysis was made on the how the weather service provider operates, manages, maintains, bills stakeholders and collaborate. Weather information service providing company play an important role in the organization of FMIS systems in the Nordic and Baltic countries. Some of them are run by governmental meteorological institutions in the Baltic States whilst private companies provide these services in Nordic countries with additional infrastructural support for the governmental organizations. The outcome of the analysis is presented in Table 9.

Table 9. Business model of generic weather companies with respect to FMIS

PARTNER *NETWORK*	KEY *ACTIVITIES*	VALUE OFFERING	CUSTOMER *RELATIONSHIP*	CUSTOMER *SEGMENT*
• Farmers • Software developers • Network providers • Database companies • Government • Land and mapping organizations	• Measure current weather information • Develop models for weather forecast • Model disease forecast • Sell weather measurement products	• Provide weather info for farmers • Forecast weather • Inform farmers when to spray • Warning for farmers • Crop performance projections for farmers	• Accurate & reliable weather info & forecast • DSS systems for farmers • 24 hr support	• Farmers • FMIS software companies • Public domain • Retailers • Transportation and storage
	CAPABILITIES		DISTRIBUTION *CHANNEL*	
	• Efficient model development • User friendly mobile and web software • Hardware configuration		• Online • FMIS • Visit to farms • Research publications	

COST STRUCTURE	REVENUE STREAMS
• Indexers/ standards / programmer salaries • Support personnel salaries • Database hardware costs • Office premises and overhead costs • Network costs • Weather station acquisition and maintenance	• Service sales of nowcast and forecast weather information • Disease forecast • Economical, harvest and yield projections subscriptions

Identified in Table 9, the key stakeholder network includes the weather service provider in the center with links to the farmer through the FMIS software provider, the government, for transporters to retailers, and agricultural machinery manufacturer. Additionally, business links for farmers' machines and machinery manufacturers, and FMIS provide key information on present weather information, forecast on future weather conditions, warning for farmers on initiation of spraying, prognosis on disease initiation and projections for government on crop performance forecasts. These links were carefully analyzed based on the attributes of Table 9 to obtain a representation of a rich picture outlining how FMIS software companies collaborate and link other stakeholder in the agrifood production and supply chain network. The outcome of the analysis is presented in Figure 28.

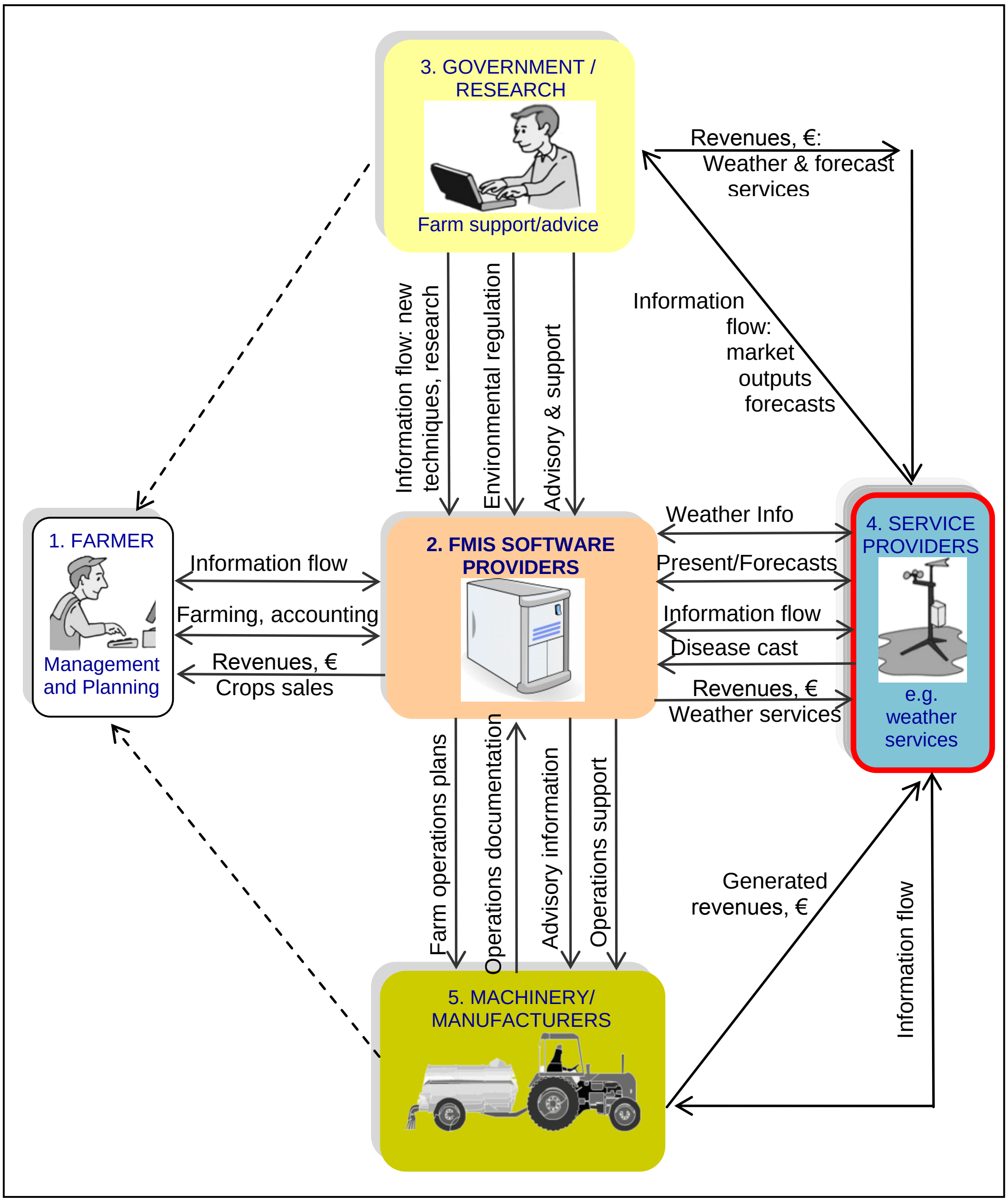


Figure 28. Rich picture of weather service providers organizations FMIS usage

Combining the content of the analyzed weather and disease service providers' business model identified in Table 9 and the core business links in Figure 28, a current situational CATWOE analysis is presented below.

Group 4: Customers

The primary customer of the weather and disease service provider the FMIS service provider to the farmer (Figure 28). The FMIS service provider plays a key role because it can provide a broad base for distributing content information to other stakeholders such as the government, transporters, retailers, and agricultural machinery manufacturer.

Group 4: Actors

The weather and disease service provider is the main actor who provides value added information in a presentable format to other actors such as the FMIS software providers, farmer, machinery manufacturers and governmental organization.

Group 4: Transformation process

The transformation process involves the conversion of measured weather, soil and biological crop parameters, into useful information for improving crop production in agriculture. By integrating measured weather, crop and soil parameters, weather service providers create value added support information for decision making processes and regulatory purposes in crop production.

Group 4: Weltanschauung (World-view)

The world-view is that the weather information and forecast is needed to make crucial decisions that the success, profitability, quality of produced agricultural crops. The view is that management and decision-making is eased with forecasts for saving farmer's input resources, time, and providing information for government and farm machinery manufacturers.

Group 4: Ownership

The weather and disease service providing company is the owner in the way that it owns its software and hardware platform. However, the some of these services and platforms may be outsources as occurs in some Nordic countries. In addition, other owning responsibilities include the developing of software, standardization and integration of data from different sources and maintenance of the overall operation weather station infrastructure.

Group 4: Environmental constraints

The constraints include usability and performance weather information provision software, hardware and its interfaces to meet the expectations of the regulators for readily-available information, as well as the reliability and structure of the information technology (networks, communication, servers, and databases infrastructures). Other constraints include different standards in technology such as data transfer standards e.g. ISO 11784, AGROXML, and regulations in the data transfer and telecommunication industry.

4.7 Analysis of Group 5: Farm Machinery Manufacturing Companies

An interview was conducted with a farm machinery manufacturing company in Finland to find out about how relevant FMIS software is relevant to their products, services, customers, partner networking, capital and revenue generation. The analysis of the data obtained for the process was used to create a rich picture of the current situation how machinery manufacturers benefit from FMIS services and stakeholder collaborative networks. In addition a business analysis was made on the how machinery manufacturers operate, manage diagnostics and service request networks on their machines, and collaborate with other stakeholders with the FMIS settings. The outcome of the analysis is presented in Table 10.

Table 10. Business model of agriculture machinery companies with respect to FMIS

PARTNER NETWORK	KEY ACTIVITIES	VALUE OFFERING	CUSTOMER RELATIONSHIP	CUSTOMER SEGMENT
• Farmers • Researchers • Software developers • Network providers • Database companies	• Manufacturing farm machines • Building servers • Sell machines • Provide after sale services	• Provide good and affordable farming equipment • After sale services • Excellent replaceable parts	• Excellent and reliable farm machines • 24 hour support • Weather reliable machines	• Crop farmers • Retailers • Repair and service companies • Importers
	CAPABILITIES		**DISTRIBUTION CHANNEL**	
	• Designing machines • Manufacturing • Good ales personnel • Servicing		• Machine manufacturers • Government subsidy system	

COST STRUCTURE	REVENUE STREAMS
• Support personnel salaries • Database hardware costs • Office premises and overhead costs • Warehousing costs • Raw materials • Transportation and logistics • Manufacturing equipment	• Machine sales • Replacement parts sales • Servicing • Tractor pulling competitions

Analyzing the business links identified Table 10, a rich picture of the present situation produced and presented in Figure 30.

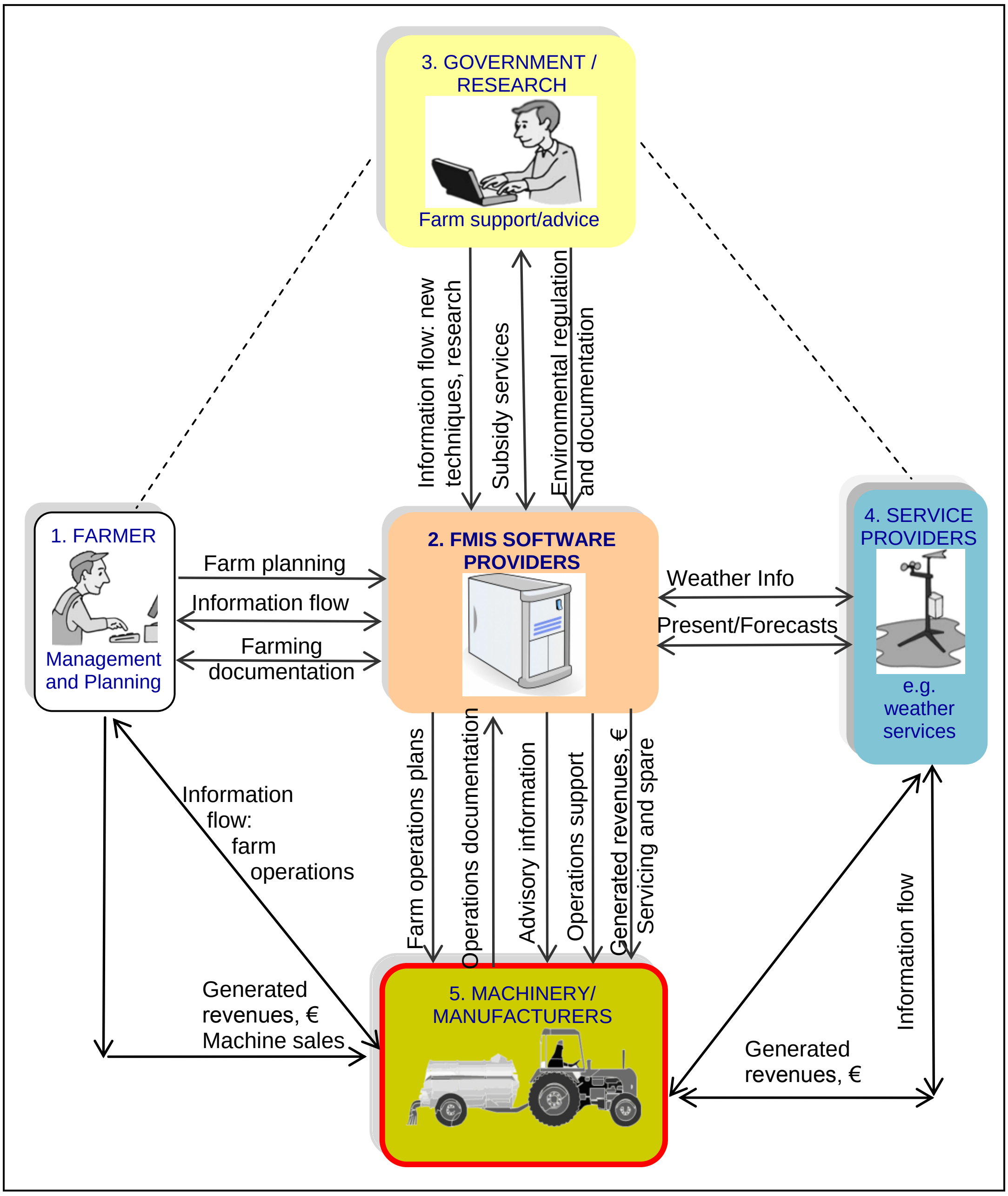


Figure 29. Rich picture of usage of FMIS by agriculture machinery manufacturers

Integrating the content of the analyzed agricultural machinery manufacturers’ business model presented in Table 10 and the core business links in Figure 30, a current situational CATWOE analysis was conducted. The results are presented below.

Group 5: Customers

The primary customer of the agricultural machinery manufacturer is the farmer (Figure 30). The FMIS service provider plays a key role because it provides an interface for connecting to the farmers machines to monitor the technical performance. In addition FMIS software is able to provide information on the number of hours agricultural machine has worked and can be used as a means of providing software and hardware controller updates.

Group 5: Actors

The agricultural machinery manufacturer and the farmer are the main actors, whilst the FMIS software manufacturers act as a channel for connecting the actors.

Group 5: Transformation process

The transformation process involves the transmission of measured technical parameters on agricultural machinery performance and technical conditions to manufacturers (remote monitoring) as a means of added value diagnostic and service information service for farmers. By integrating measured technical machinery performance parameters, machinery manufactures create value added such as been able to detect faults on farmers’ machines even before the farmers realize it.

Group 5: Weltanschauung (World-view)

The world-view is that remote monitoring of machinery performance both by machinery manufacturers (and also farmers e.g. remote monitoring harvesting equipment) helps make crucial decisions on servicing, adjustments for optimum operating efficiencies, and ordering of replaceable parts for machines. The view is that remote monitoring save farmer's time, and provides diagnostic information for farm machinery manufacturers.

Group 5: Ownership

Ownership in this case is rather difficult to define, because once a farmer buys a machine, he owns the information that the machine produces. For this reason, the farmer has to provide the manufacturer rights to access this information. The FMIS software provider has to code these privacy rights into the software to be turned on if the farmer wishes for remote monitoring and diagnostics services.

Group 5: Environmental constraints

The constraints include usability and performance of Electronic Control Units (ECU) that transmits diagnostics information to the FMIS software, as well as the reliability and structure of the information transfer systems (networks, communication, servers, and databases infrastructures). Other constraints include different standards in technology such as data transfer standards e.g. ISO 11784, AGROXML, and regulations in the data transfer and telecommunication industry.

4.8 Integrated Analysis of all Stakeholders in Collaborative FMIS

In this section the analyzed rich picture from all the stakeholders in the FMIS network is integrated together. The most important issue to note that in a collaborative FMIS stakeholder network model, the FMIS service provider plays the central role in holding the whole system together. The business model analysis of a collaborative FMIS business model emphasizing how things are presently in the agrifood supply chain network is presented in Table 11.

Table 11. Integrated business model for FMIS companies

PARTNER NETWORK	KEY ACTIVITIES	VALUE OFFERING	CUSTOMER RELATIONSHIP	CUSTOMER SEGMENT
• Farmer • Government • Machine manufacturers • Processing companies • Software developers • Network providers • Database companies • Weather service providers • Map service providers	• Collaborating with other stakeholder • Developing software • Software maintenance and support	• Provide an easy way for data management • Marketplace for selling data • Channel for machine diagnosis • Information on food tractability • Farm process documentation • Develop open platforms for service expansion	• Provide excellent software with customer support • Tied service structure	• Crop farmers • Animal farmers • Manufacturing industries • Machine manufacturers • Food retailers • Food processors • Government • Weather forecasters • Value added map service providers • Etc.
	CAPABILITIES		**DISTRIBUTION CHANNEL**	
	• Excellent network infrastructures • Reliable database servers • User friendly software programming		• Machine manufacturers • Government subsidy system	

COST STRUCTURE	REVENUE STREAMS
• Indexers/ standards / programmer salaries • Support personnel salaries • Database hardware costs • Office premises and overhead costs • Network costs	• Software sales • Yearly subscription / data hosting • Information and data package sales • Data hosting and security

The key stakeholder; the FMIS company provides and open (could be open source model software type) software platform for farm management and information transfer to farmers, government, research, standardization and regulating companies. Additionally, business links for farmers' machines and machinery manufacturers, and key service providers is provided. The main idea is that all stakeholders evolutionally and continuously develop the system to meet changing trends to benefit of the whole agrifood supply chain network.

By analyzing the integration of all the stakeholders in a unified business (Table 11), a rich picture outlining how FMIS software companies collaborate and link other stakeholder in the agrifood production and supply chain network can be drawn. This representation of the current rich picture of how all the stakeholders collaborate in sustaining the agrifood supply chain network is presented in Figure 30.

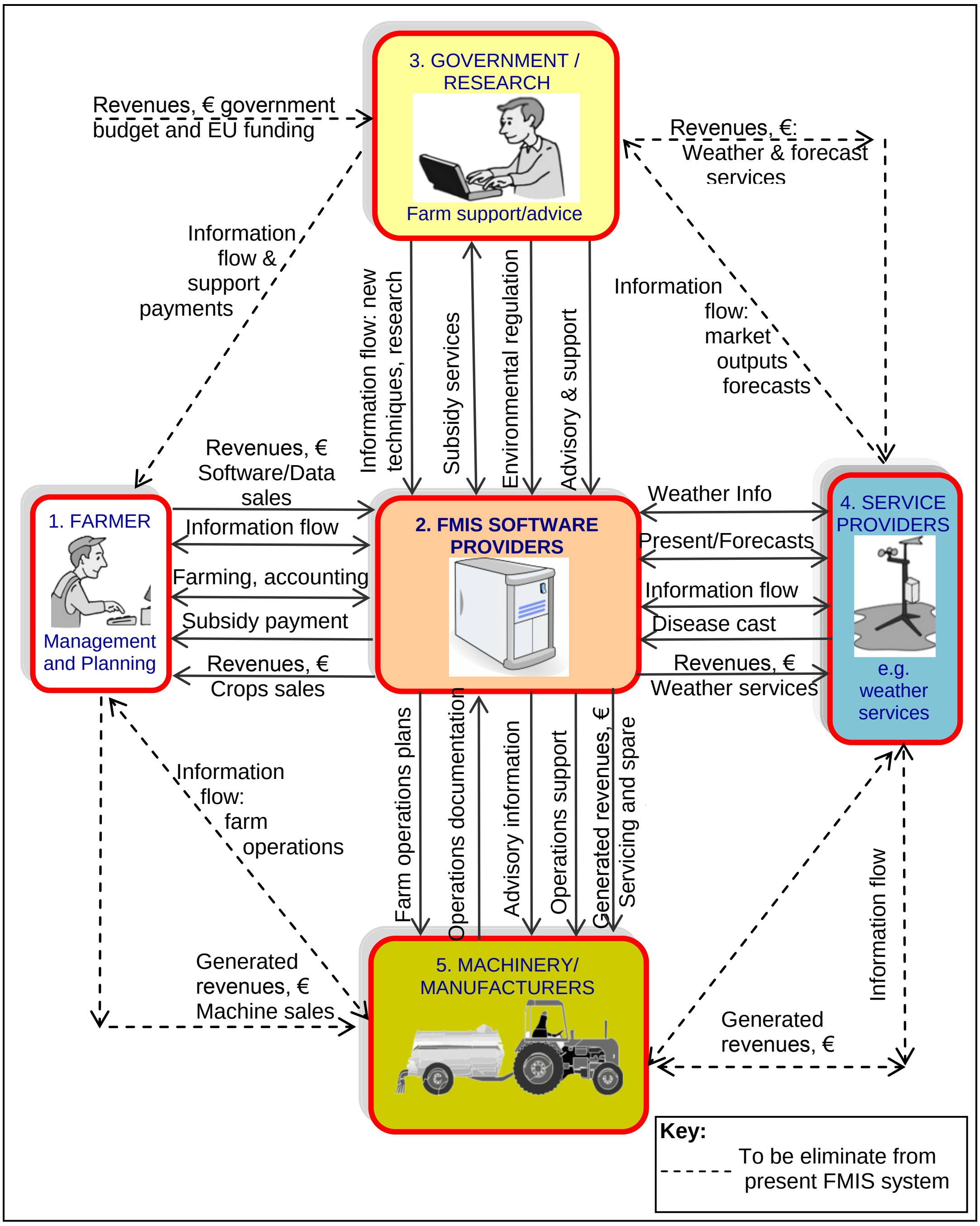


Figure 30. Rich picture of current integrated FMIS for agricultural businesses

A breakdown of current situational CATWOE analysis based on Figure 30 is as follows.

Collaborative FMIS: Customers

The primary customer of the proposed collaborative FMIS information system is the farmer (Figure 30). It should be recognized that the farmer is the main reason that the FMIS exist. Other co-equal customers are the government, transporters, retailers, agricultural machinery manufacturer, transportation companies, and the public domain (for transparency).

Collaborative FMIS: Actors

The leading actor is the one developing and maintaining the FMIS software, which in this case is the FMIS developing company. Other actors are the farmer, machinery manufacturers, service providers, and government and regulating companies.

Collaborative FMIS: Transformation process

The transformation process involves the utilization of the farmers fields for transformation of farm inputs like seeds, water, fertilizers to crop produce as and income source. The transformation is done utilizing FMIS as an aid for planning and documenting field operations data for regulatory purposes, and to ease decision-making processes in crop production.

Collaborative FMIS: Weltanschauung (World-view)

The World-view is the hypothesis that makes farmers wants to use FMIS in their transformation process. In this case, the view is that operational data is easily acquired and can be used to improve management decision making throughout the production cycle, and that the same data may be used to demonstrate to external agencies the farm's compliance with standards. By integrating measured parameters, service providers create value added support information for decision making processes and support in crop production.

Collaborative FMIS: Ownership

There is co-equal ownership in the sense that the evolution of the integrated FMIS must be built with recourses from all network partners: FMIS developing companies, the farmer, machinery manufacturers, service providers, and government and regulating companies.

Collaborative FMIS: Environmental constraints

The constraints influencing crop production in farm businesses. Primary constraints include natural constraints in terms of weather water and farm inputs. Secondary constraints include governmental and legal regulations regarding environmental and cultural practices in the farming business. Other aspects of the secondary constraints are financial constraints that affect inputs, machinery, infrastructure and the overall farm's maintainability. Tertiary constraints include usability and performance of the FMIS and its interfaces to meet the expectations of the regulators for readily-available information to audit compliance with the standards and regulations on the farm, as well as the reliability and structure of the information technology (networks, communication, servers, and databases infrastructures).

5 Conceptual Operating Model for Collaborative FMIS

In this section, the direct unofficial communication and collaboration links between stakeholders in present collaborative FMIS (Figure 30) are analyzed. Unofficial communication links are usually unstandardized therefore should be avoided. After eliminating these links, a rich picture of the concept of the proposed conceptual FMIS model is illustrated in Figure 31.

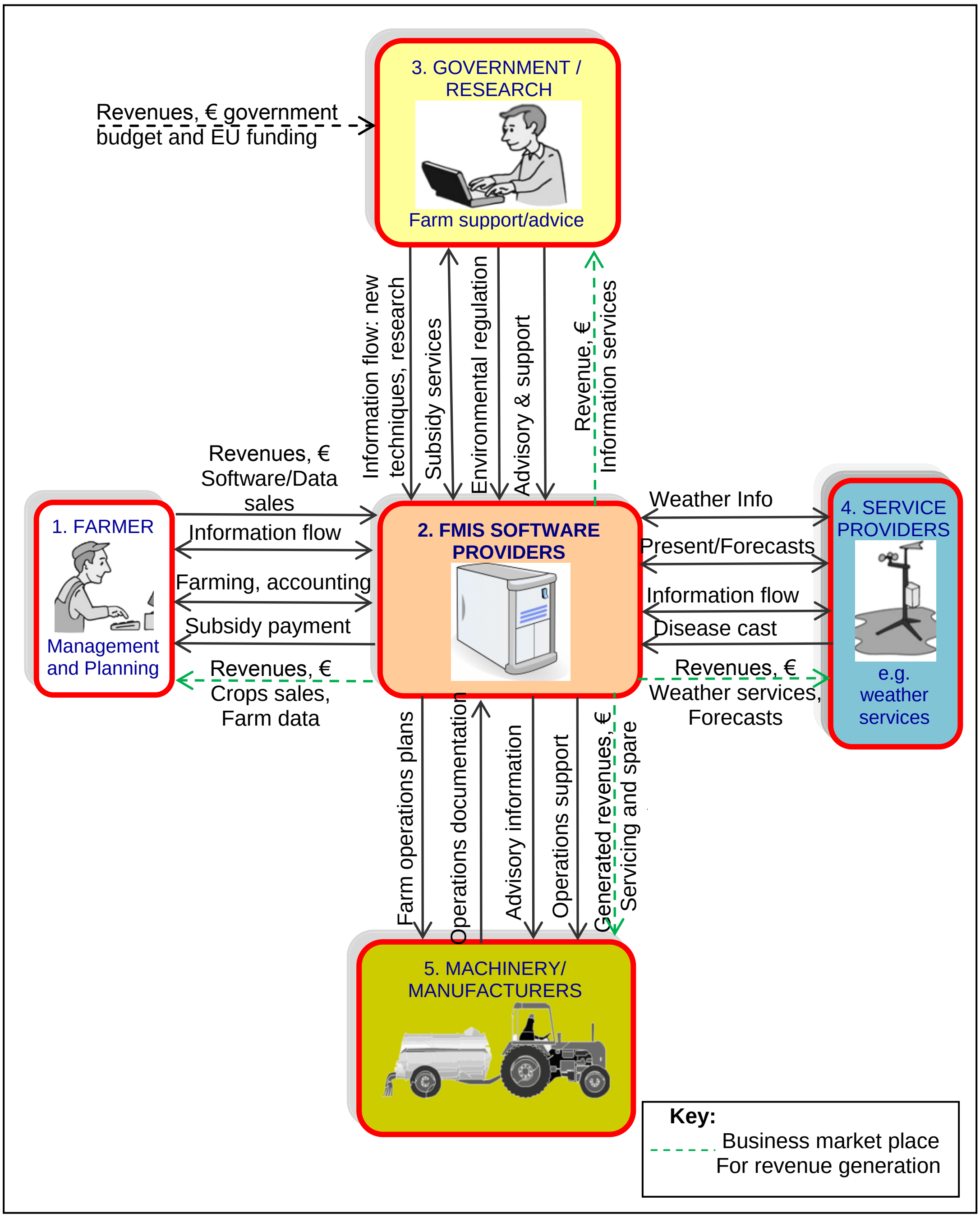


Figure 31. Conceptual operation model for collaboration amongst businesses

It can be seen from Figure 31 that the system comprises simplified but comprehensive links for stakeholders' information transfers and revenue generation, within the infrastructure for crop production. The boundaries (marked in red) around each stakeholder in Figure 31 represent a standardized interface for the transfer, reception and interpretation of data and service information. The transfer and acquisition of data in the conceptual model complement the monitoring of the operational activities. Furthermore, the structure and standardized interface of the conceptual FMIS proposition will enable the interaction with external systems such as financial markets, administration databases and other communication systems. It should be stressed that the independent stakeholder boundaries of conceptual FMIS model in itself does not have any value. As such, they represent a mere open (source) platform or infrastructure that is co-developed by all FMIS collaborating stakeholders. The content or added value to be placed in this infrastructure is the business that these stakeholders do. For this reason, the conceptual model can be seen as an open market place for sharing information between stakeholders within a standardized framework.

The conceptual model presented in Figure 31 depicted how the operational field data is collected and transformed by FMIS for value addition and utilization. Privacy and authorization of information (external as well as internal field operation data) should be organized such that it is performed integrally or independently by the farm manager (and other stakeholders) for each operational activity with FMIS. By doing this, the farmer and each stakeholder can choose what information to share or receive, sell or buy, and with whom to perform these interactions. This relates to all issues such as support, advice, accounting and management information to and from administration, regulations and service providers. Based on this, an execution plan can be generated and sent to the executer (e.g. the equipment, staff or service provider to carry out the operation) and finally, a record of the executed operations will be prepared.

The financial and revenue generation activities (arrowed in green) in the conceptual model (Figure 31) can be pictured as a form of multiple revenue generation from services (service layer architecture). For example, in farm planning activities, the farmer plans and sends information to the farm machine using FMIS. The farming operation is documented and sent back to the farmer. The farmer then uses this documented information to fill in the subsidy application forms and submit them to the government. Because this operation and value addition is done by the FMIS service provider, the farm pays to have this service.

Based on this representation of the conceptual model for FMIS a tabulated business model was developed for the operations as recommended by Osterwalder (2004). This business model is presented in Table 12.

Table 12. Conceptual business model for collaborative FMIS stakeholders

PARTNER NETWORK	KEY ACTIVITIES	VALUE OFFERING	CUSTOMER RELATIONSHIP	CUSTOMER SEGMENT
• Farmer • Government • Machine manufacturers • Processing companies • Software developers • Network providers • Database companies • Weather service providers • Map service providers	• Collaborating with other stakeholder • Developing software • Software maintenance and support	• Provide an easy way for data management • Marketplace for selling data • Channel for machine diagnosis • Information on food tractability • Farm process documentation • Develop open platforms for service expansion	• Provide excellent software with customer support • Tied service structure	• Crop farmers • Animal farmers • Manufacturing industries • Machine manufacturers • Food retailers • Food processors • Government • Weather forecasters • Value added map service providers • Etc.
	CAPABILITIES		**DISTRIBUTION CHANNEL**	
	• Excellent network infrastructures • Reliable database servers • User friendly software programming		• Machine manufacturers • Government subsidy system	

COST STRUCTURE	REVENUE STREAMS
• Indexers/ standards / programmer salaries • Support personnel salaries • Database hardware costs • Office premises and overhead costs • Network costs	• Software sales • Yearly subscription / data hosting • Information and data package sales • Data hosting and security

Table 12 presents the key partners, their activities, customers, cost structure and revenue generating mechanisms for the conceptual model. For the conceptual business model to work the role of the stakeholders and how the work with each other is defined based on the business developed model. Integrating the content of the proposed business model presented in Table 12 and the core business links in Figure 31, a CATWOE analysis was conducted and is presented below.

Conceptual Model: Actors

The leading actor is the one developing and maintaining the FMIS software, which in this case is the FMIS developing company. Other actors are the farmer, machinery manufacturers, service providers, and government and regulating companies.

Conceptual Model: Transformation process

The transformation process involves the utilization of the farmers fields for transformation of farm inputs like seeds, water, fertilizers to crop produce as and income source. The transformation is done utilizing FMIS as an aid for planning and documenting field operations data for regulatory purposes, and to ease decision-making processes in crop production.

Conceptual Model: Weltanschauung (World-view)

The World-view is the hypothesis that makes farmers wants to use FMIS in their transformation process. In this case, the view is that operational data is easily acquired and can be used to improve management decision making throughout the production cycle, and that the same data may be used to demonstrate to external agencies the farm's compliance with standards. By integrating measured parameters, service providers create value added support information for decision making processes and support in crop production.

Conceptual Model: Ownership

There is co-equal ownership in the sense that the evolution of the integrated FMIS must be built with recourses from all network partners: FMIS developing companies, the farmer, machinery manufacturers, service providers, and government and regulating companies.

Conceptual Model: Environmental constraints

The constraints influencing crop production in farm businesses. Primary constraints include natural constraints in terms of weather water and farm inputs. Secondary constraints include governmental and legal regulations regarding environmental and cultural practices in the farming business.

Other aspects of the secondary constraints are financial constraints that affect inputs, machinery, infrastructure and the overall farm's maintainability. Tertiary constraints include usability and performance of the FMIS and its interfaces to meet the expectations of the regulators for readily-available information to audit compliance with the standards and regulations on the farm, as well as the reliability and structure of the information technology (networks, communication, servers, and databases infrastructures).

It should be noted here that during the stakeholder interviewing process it was noted that Denmark was rearranging its FMIS network towards the direction of the conceptual model proposed in Figure 31 using Web Services (WS) approach. Figure 32 shows the representation of the FMIS in Denmark (provided by the Danish Agricultural Advisory Service) as at the time of conducting the interviews at the later part of 2010.

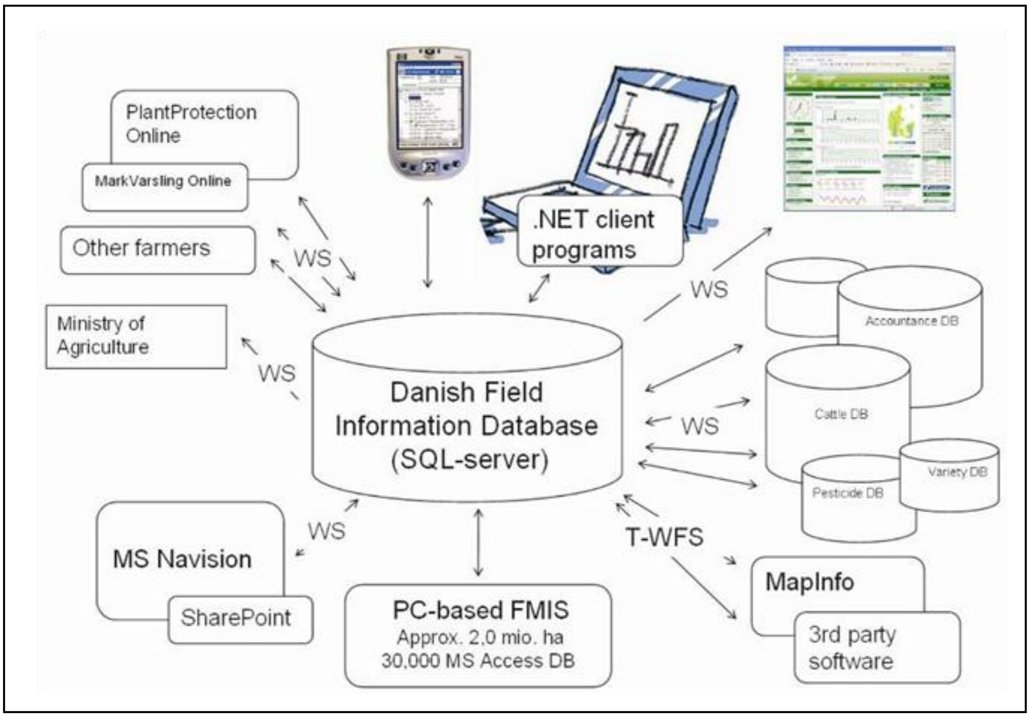
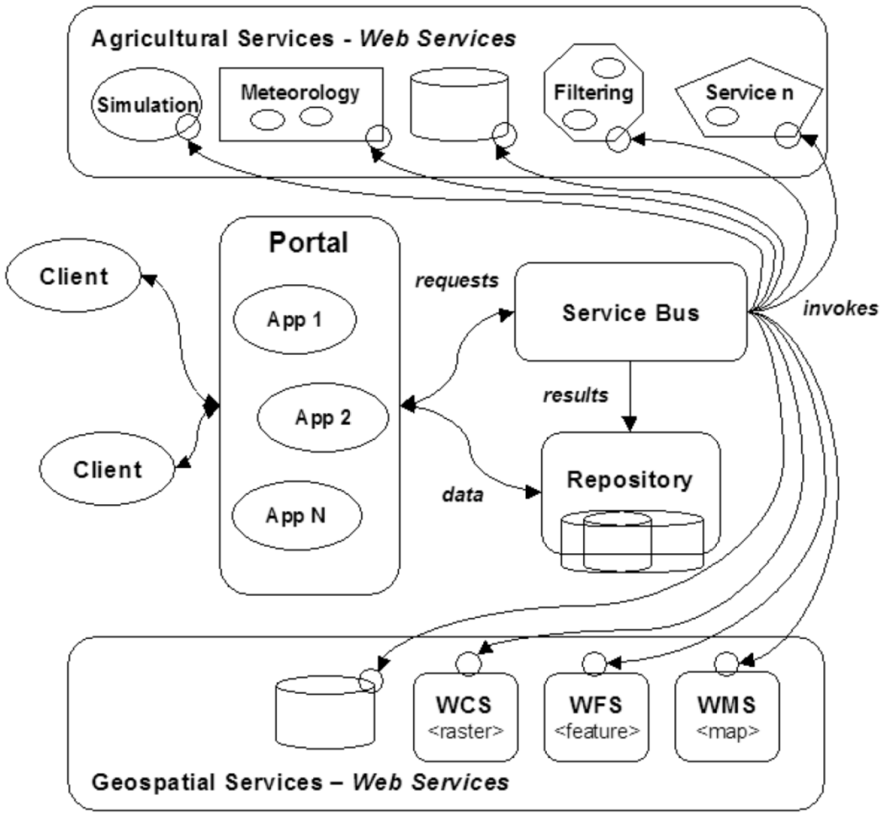


Figure 32. The Danish field information database

In Figure 32, it is obvious that WS approach is utilized between the different interfaces. However, detailed questioning of the structure of the central FMIS database system showed that the direct unofficial communication and collaboration links between stakeholders in the Danish FMIS were still present.

5.1 Practical Implementation of the Conceptual Model

Murakami et al. (2007) proposed an infrastructure for the development of FMIS, based on SOA, for PA. Figure 33 illustrates this infrastructure.



Adapted from Murakami et al. (2002 :40)

Figure 33. Overview of the architecture for FMIS

As shown in Figure 33, the purpose of the publication by Murakami et al. (2007) was to support software engineers in the development of an information system for PA and related areas, using open patterns and free software tools. The infra-structure contains the following components: reference architecture for PA information systems; a standard language for data exchange between the agriculture services; a bus for connecting the agriculture services; a geospatial service provider; and a portal, using the Internet, for agricultural services.

In Murakami et al. (2007) proposition, clients access the applications using the portal that offers easy and standard interfaces to the users. As a demonstration (Figure 33), the bus service receives requests from the portal applications and invokes the appropriate services (Agricultural or Geospatial). When processing is finished it stores the results in the repository and notifies the client. The architecture is organized into layers, increasing the reusability and modifiability of the systems, because each layer just knows the neighboring ones.

Nikkilä (2010: 332-333) also proposed similar software architectures based on SOA and Wolfert (2010: 396) separated the SOA in his publication based on management, business and application service layers.

Unfortunately, these publications do not deal with the e-commerce aspect of using their SOA propositions. In this study an attempt was made to include the e-commerce layer to the SOA architecture based on the proposition by Chun-mei et al. (2005: 2). A pictorial representation of the e-business layer for the conceptual model for the collaborative FMIS is given in Figure 34.

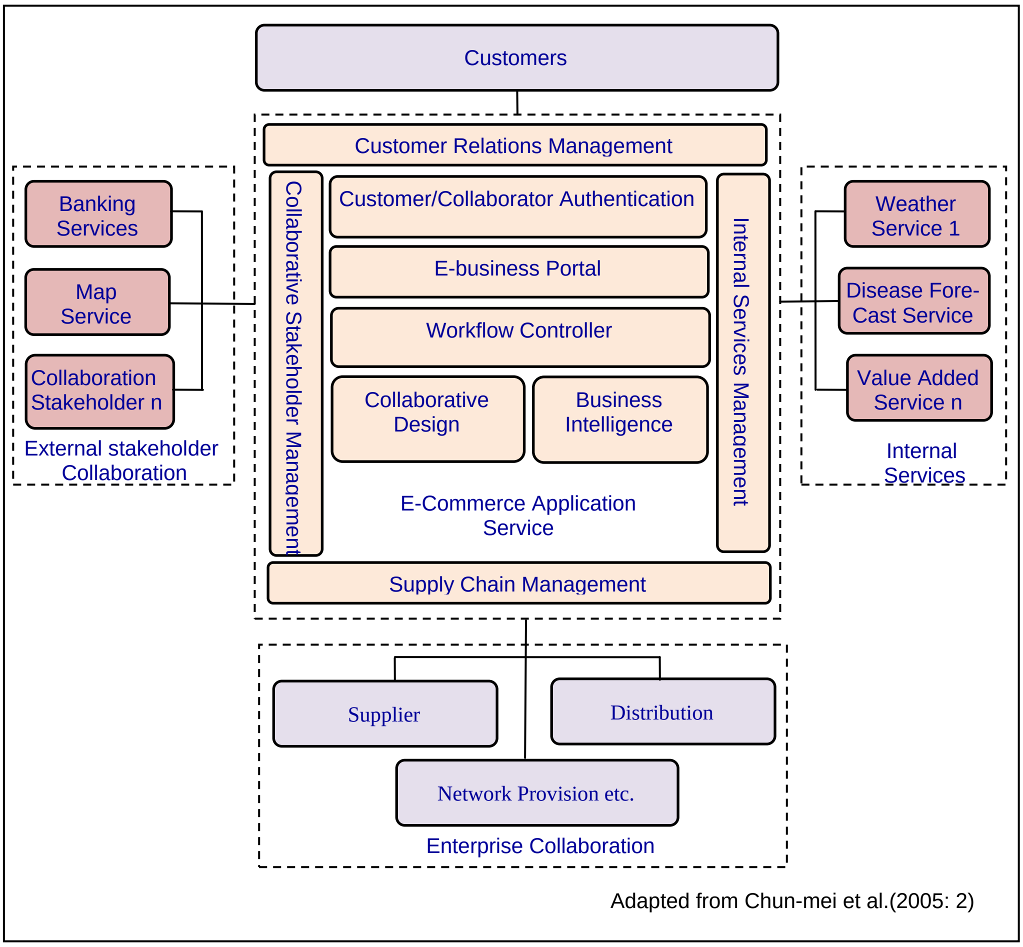


Figure 34. E-Business layer of the conceptual model

Collaboration means more than one stakeholders working within the same business infrastructure synchronously or sequentially. In order to realize the collaboration in e-Business (conducting product or service business on the Internet) among collaborating FMIS stakeholders, the e-Business platform must integrate certain applications. Collaborative e-Business is not the mere traditional business electronization (B2B or B2C), but processes rebuilt and optimized within the FMIS infrastructure to enhance multi-functional and multi-stakeholder information sharing, collaborative planning, collaborative design and collaborative trading. Figure 34 shows the design of collaborative e-Business architecture which was adapted from Chun-mei et al. (2005).

The architecture of the proposition in Figure 34 utilizes the thinking of business integration and collaboration. Integration is the base of collaboration among FMIS stakeholders and collaboration is the aim of integrating the business processes. In Figure 34, four kinds of integration and collaboration are implemented. They are the integration and collaboration of: e-Business platform for the enterprise internal services, e-Business platform for other collaborating stakeholders, e-Business platform for external enterprises outside the FMIS, e Business platform for customers and users.

The integration of the e-Business with the enterprise inside service systems can increase the efficiency of combining and processing bills. System drives operations automatically, so that the bill processing time and cost are decreased. Inside integration is the base of the outside collaboration agreed at the authentication level. The integration with partners in the Supply Chain (SC) is the main content of collaborative the e-Business marketplace. In addition the proposed collaborative Business platform integrates the function of Supply Chain Management (SCM) and Customer Relations Management (CRM) to building the collaboration approach of channeling from the suppliers, logistic, distributors, network providers and subcontractors, to customers. The collaboration in SC can optimize the total SC, increase the capital turnover and shorten the Time-to-Market, so all the enterprises in the SC can get more benefit and enhanced the whole competitive advantages. The enterprise often needs to communicate with government departments, banks for payment transactions and other service providers such as a company providing maps etc. The Collaborative Stakeholder Management (CSM) integration interface replaces these locale affairs with standardized Web Services interfaces. With the competition increasing, it seems that the collaboration, other stakeholders and customers is becoming more and more important, because the customers are not satisfied to accept products and services passively. They want participate in the overall portal process, products and services design; the Collaborative Design (CD) interface provides possibilities for this.

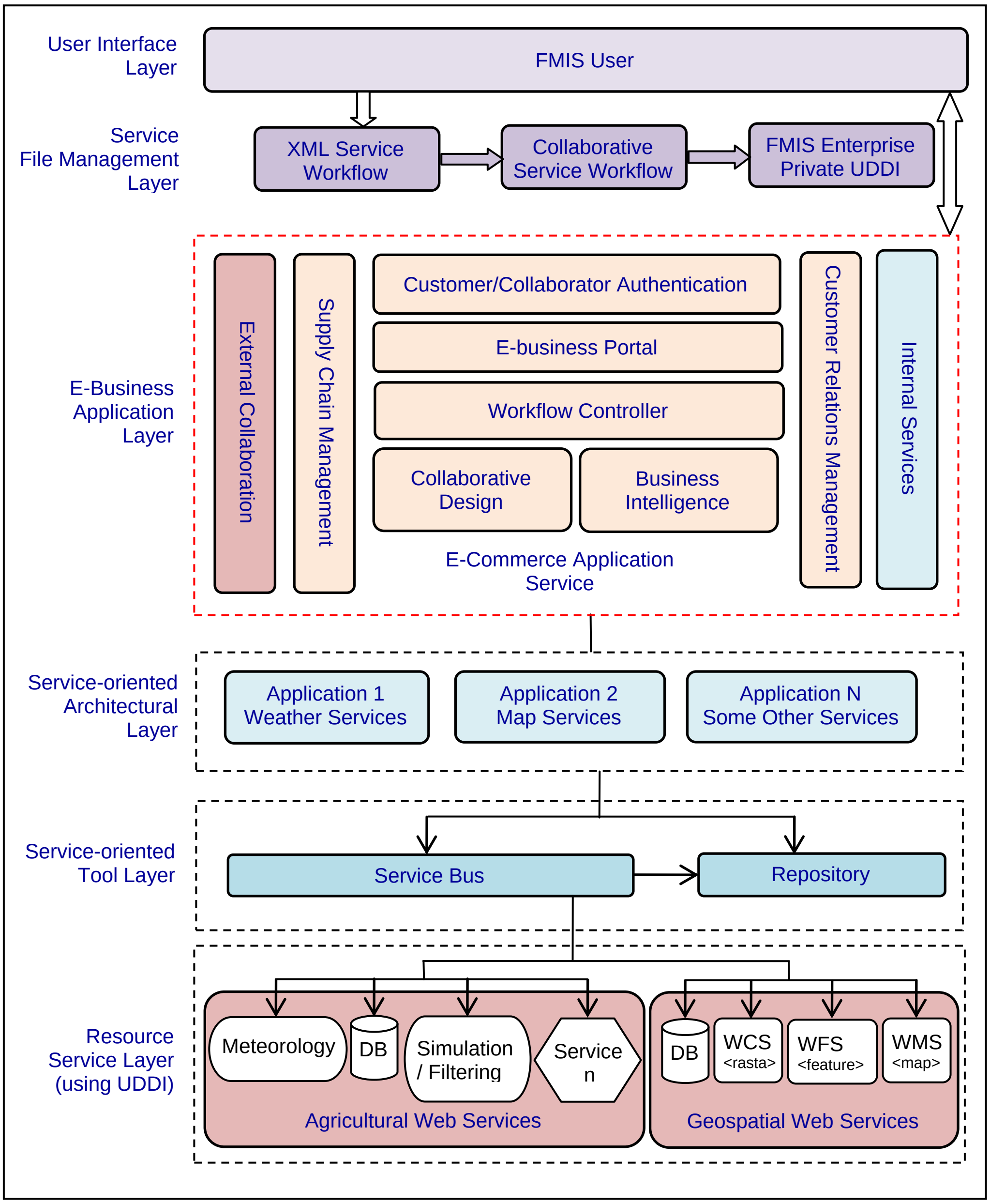


Figure 35. Architecture of conceptual operation FMIS mode based on SOA

The collaborative e-Business platform can then be integrated into SOA previously proposed by from Murakami et al. (2007: 40). The SOA integration is presented in Figure 35 on the previous page.

The implementing system for the conceptual model based on SOA can be divided into six layers. The architecture is organized into layers, increasing the reusability and modifiability of the systems, because each layer just knows the neighboring ones.

The topmost or first layer is user interface, which provides variable interfaces for users. The FMIS is a multi-stakeholder collaboration, so the important aspect is that the FMIS should be able to provide different interfaces to the system as each stakeholder has slightly different requirements for their interface. Most interfaces are simple data transfer between the FMIS and other stakeholders or services, though the format of this transfer is greatly dependent on the individual stakeholder or particular service. The communication with the customers and suppliers of the farm is essentially service-based business-to-business needs, which justifies the use of SOA and related technologies. The interfaces for the stakeholders can take various forms. Some of the interfaces as proposed by Nikkilä (2010: 333-334) are: The *Standard browser interface,* the *mobile browser interface,* the *administrative interface* and the *partner interface*. *Standard browser interface* is the interface that offers the full selection of the FMIS capabilities for user (typically the farm manager). The decision making and plan generation performed by the farm manager are influenced by a number of factors, such as experience, preferences, the availability of best management practices (BMP's), the social context surrounding the manager and chosen management strategy. As recommended by Nikkilä (2010: 333-334), to assure compliance with standards and prevent dependencies on browser vendor or version, this interface is in XHTML and as per the W3C recommendations (http://www.w3.org) it should be served with specification on the document type including an appropriate header information. Because the XHTML interface as such somehow limited in its features, Nikkilä (2010: 333-334) recommended the complimented use of technologies such as AJAX (Asynchronous JavaScript and XML) and Java could be used to provide greater usability for this interface for the standard browser. The *mobile* *browser interface* is similar to the normal browser interface in that it is also in XHTML with the difference that the interface is designed for features relevant to small mobile devices. This interface can be implemented as a subset of the standard browser interface. The *administrative interface* is for the system administration of the FMIS. Like the interfaces for users, this interface is in XHTML but additional interfaces such as a direct SQL command interface to the databases can be provided. Unlike the user interfaces, however, the administrative interface is meant for professionals familiar with the technical details of the system and as such, the usability of this interface is of lower concern than that of the other user interfaces. The administrative interface is linked to the Service-oriented Tool Layer (Figure 35). The *partner interface* is for the partners of the farm that include both the customers and suppliers of the farm. The partner interface bears close resemblance to business-to-business communication, hence this interface can be implemented with the FMIS acting as a Web service using the technologies and protocols of SOA.

Bound to the user interface layer is the second layer; the service-flow management layer, which has three parts: collaborative service-flow description based on XML, Collaborative Service Flow Engine (CSFE) and enterprise UDDI (Universal Description, Discovery and Integration) registry. The service-flow is described XML. The CSFE will subsequently invoke the services described in service-flow file. In addition, all services should be registered in the enterprise UDDI registry. This registration enables different engines to easily search and find the proper Services to complete the collaborative e-Business process.

The third layer is the application layer, which includes all the collaborative e-Business services and other enterprise application services. The enterprise application services, agreed partner communicating services, external partner services and the customer interactive services are integrated into this platform. The authentication service integration also can protect the enterprise existing investment by encapsulating the enterprise legacy system for the new integration.

The fourth layer which is the service oriented layer invokes the different bundles or packages of services each customer is entitled to. This layer is located above the computational resources layer, providing interface access to the underlying layer. Job submission and monitoring service from this layer allows users to submit and monitor jobs, suspend operations, and conduct the remote operation. Data resource management can process data distribution, replication, resource synchronization, and can also manage meta-data.

The fifth, the Service-oriented Tool Layer, performs computations by calling or connecting to various resource services to provide the value-added service application for the customer. After computations, data information is then stored in the repository database for future use. The Service-oriented Tool Layer provides developers with a consistent user and access interface (such as Web-based service portal). Also, it provides programming modeling tools for debugging and simulation, monitoring and management workflow for the grid application. A variety of tools and API simplify use for application development, deployment, debugging and management.

The sixth and bottom layer is the resource service layer. It provides basic resource services for the applications. This layer represents the computing resources and data resources that are distributed on the Internet, and provides various resource call services such as the computing power storage capacity and security. It is the resource foundation of the collaborative e-Business platform. It registers its services so to the UDDI that systems can easily find, bind and invoke them. In addition, the resource layer is also able to find and utilize all other services registered into the enterprise UDDI registry. The layer integrates applications business services required for the complete execution of a business process, including services based on OGC, Web Feature Service (WFS) and Web Map Service (WMS) resources, data base applications, legacy systems and other devices required for precision agriculture as presented in Figure 35.

6 Conclusions

6.1 Summary

The study aimed to define the roles of FMIS stakeholders, and propose ways to improve collaboration in agricultural FMIS. To achieve this purpose, action research method was used, based on the interview of a total of 15 FMIS stakeholders in Finland, Sweden, Denmark, Lithuania and Latvia. The interview of the 15 stakeholders helped to identify five categorical stakeholder groups: a) farmers and farm workers, b) FMIS software providers, c) governmental institutions, d) farm service providers, and e) farm machinery manufacturers. Based on business analysis procedures, the interviews also revealed basic information concerning stakeholders' business operations, products and services, infrastructures, network of partners, capitals, and revenue generating mechanisms. SSM was applied to analyze the businesses of the stakeholder groups. Based on the SSM, rich pictures were developed to represent the real work situations. The rich pictures identified specific needs and, business models of stakeholder companies as well as the gaps in FMIS that require innovative solutions. Based on the links obtained between the individual stakeholders in the rich picture, a conceptual business model was drawn up which aims to support sustainable operation of the entire collaborative FMIS. This conceptual model also defined the incentives, value and profit generating mechanisms between the collaborative FMIS.

6.2 Implications for FMIS Enterprises

This Thesis studied FMISs in 5 different countries: Finland, Sweden, Denmark, Latvia, and Lithuania. The results showed that the structure of existing FMIS in these countries is rather unstructured. Therefore, SSM was used to systematically analyze the current use of FMIS in their respective agrifood supply and management chain. As a result of this analysis, a description of FMIS software architecture was suggested that meets the identified requirements of the end user. The presented FMIS architecture differs from existing FMIS by utilizing the popular Web Service application architecture. McCown (2002: 180) argued that in designing an information system, the emphasis should be placed less on design and more on learning what the farmers do and how they act, instead of letting researchers impose their own views on farm management. This Thesis, attempted to coin the web-based FMIS according to the real needs of farmers. Furthermore, the existing FMIS was improved in terms of collaboration, automated acquisition of operational farm data, and integration with the overall FMIS. In this regard, it was shown that the enhancement of FMIS is mostly influenced by common business factors and drivers and the specific demands in farming activities. The proposed system integrates the planning and execution of farm operations as well as monitoring, modeling and simulation of biological, physical and chemical agricultural processes. The model also suggests a provision of specialized value-added support and usable services that can be included in the proposed FMIS model.

The conceptual model developed in the study also defines the incentives, value and profit generating mechanisms for the collaborative FMIS in agriculture. This model is designed to support open and strategic collaboration and provides a practical operational framework for farmers, governmental organizations, service providers, and machinery manufacturers in the agrifood production chain. To give instructions for practical application of the proposed conceptual model, an architecture based on SOA was proposed. The proposed model utilizes Web Service application architecture in order to provide optimal combination of features, ease-of-use and encourage the adaptation of open-source collaboration platforms. The proposition is, however, quite general and has to be further refined depending on the technology adopted for its practical implementation. The Thesis strongly recommends that care be taken in the design of user interfaces, as poor interfaces have been identified as a probable cause for low adoption of information systems in agriculture. The use of Web Service application architecture is sometimes criticized for problems with availability of the system in the absence of Internet connection. To cater for this problem, the model considers partial or complete off-site storage of applications and data. Complete off-site storage of farm data is in the best interest of the farmers, as their data is considerably more secure in a central backed-up system than on a volatile local farm PC.

In general, this Thesis used a heuristic approach to propose an example model for the agrifood supply chain network. This process is not yet complete and meant to be a starting point for improving the functioning of FMISs for the benefit of the farmer

6.3 Validity and Reliability

This research has shown the benefit of using dedicated system analysis methodologies as a preliminary step to the actual design of a novel business model for FMIS. It demonstrated that the use of SSM facilitates the fundamental analysis, which includes the identification of the changes required, and, most importantly, it allows for unstructured analysis to identify the existing constraints, and possible future solutions, which may not be achieved using more structured methods.

While the current research suggests significant improvement to the existing organization of FMIS in agriculture, the Thesis is not exempted from shortcomings and constraints. Among the shortcomings are, first, that SSM can easily ignore environmental and structural determinants, and the question of larger stakeholders' monopoly and power. It is obvious that organizational members do not have equal choice in the organization of FMIS, and not everyone is able to openly discuss their problems, perceptions and put forward their needs. For this reason, there is a need for a strong leader to revolutionaries how FMIS operate, which can be represented by FMIS software companies or the government (such as the case in Denmark).

Secondly, because of the time limitations for this study, the interview list was not as comprehensive as it could be, though efforts were made to include different representatives of the stakeholder groups. Some stakeholders, such as those from food regulation institutions and food transporter companies, were not included, and the effects of these exclusions on the outcome of the conceptual model are not known. Thirdly, the study was a qualitative one, and the model was built on experts' subjective opinions on how things are currently, and should be in the future.

This means that, interviewing more people will improve the outcome of the model because the answers obtained for the interviews were relative depending on the person interviewed. Fourthly, the conceptual model requires some form of validation or testing with a real FMIS and the stakeholders, which was not done in this Thesis. Fifthly, based on the conceptual model developed, all the relational and structural links between stakeholders need to be tested in order to evaluate the revenue generation impacts of each individual factor on the overall cost performance in the FMIS. This is needed for the businesses to thrive and grow, which is impossible without sustaining continuously generating revenue.

6.4 Further Research

Implementation of the proposed conceptual model will be a new and innovative step; therefore, its outcome cannot be fully predicted. It may so happen that the final outcome will not completely match the planned change for a collaborative FMIS. In practice it will mean that the existing FMIS stakeholders must be willing to compromise some of their current practices for the benefit of the whole collaborative FMIS. This will assist in creating a clearer ownership, and define the roles of those FMIS stakeholders, who hold the reins of power (the decision-makers) in their hands. It is necessary to implement and closely steer the development of this model in practice instead of watching process veer into an infinite loop without any support or benefits for AFSCN.

Hopefully, all outcomes (such as definition of the problem, rich picture, root definitions and proposed changes) are valuable and have provide a clearer idea of how collaborative FMIS be innovatively organized. The next step is to interview all the other stakeholders and include their views to improve the system. All the different stakeholders that were not included in this study have different worldviews and this should be explored in further research. The suggested definitions and conceptual model will be more informative if more representatives give their in this field. Finally, an implementation of the proposed conceptual model should be put to test for stakeholder evaluation, which will benefit the whole agrifood supply chain network.

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Semi-structured Interview Questions

In collaboration with

FMIS STAKEHOLDER INTEVIEW QUESTIONS

Company background questions:

Products: What products are they offering and what value does it bring to our customers?

Customer segment: Who are the target customers that your company wants to offer value to?

Distribution channels: How does your company get in touch with customers to make the money?

Relationship: How do you ensure that you maintain touch with your customers?

Value configuration: How do you arrange your activities to ensure that you create value for your customers?

Capability: How does your company manage the infrastructure you own? Do your workers or employees have unique abilities to create value for your customers?

Partnership: Who are the other companies that you cooperate with to function?

Cost structure: How does your company finance their business?

Revenue flows: And does your company make money?

Can you provide your business model, outlining your company's visions, mode of operation, financial standing and future plans?

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MTT In collaboration with agriXchange network for data exchange in agriculture

FMIS STAKEHOLDER INTEVIEW QUESTIONS

Stakeholder collaboration questions:

Business process level:

Which relevant data exchanges are used at process level (bottlenecks, challenges)?

Application level:

Concerning the business processes mentioned, what (kind of) applications can be mentioned are used? Describe this in common and if relevant by (some) processes.

Data level:

Are data definitions available in order to be able to share data with other stakeholders? Describe this in common and if applicable on earlier mentioned processes.

Physical level:

Give information about the technical infrastructure available in your company. How is it organized, how is it financed?