Data Entities and Information System Matrix for Integrated Agriculture Information System (IAIS)

Halim Budi Santoso¹; Rosa Delima²

¹ Information System Department, Faculty of Information Technology, Duta Wacana Christian University, Yogyakarta
² Informatics Department, Faculty of Information Technology, Duta Wacana Christian University, Yogyakarta

Abstract. Integrated Agriculture Information System is a system that is developed to process data, information, and knowledge in Agriculture sector. Integrated Agriculture Information System brings valuable information for farmers: (1) Fertilizer price; (2) Agriculture technique and practice; (3) Pest management; (4) Cultivation; (5) Irrigation; (6) Post harvest processing; (7) Innovation in agriculture processing. Integrated Agriculture Information System contains 9 subsystems. To bring an integrated information to the user and stakeholder, it needs an integrated database approach. Thus, researchers describes data entity and its matrix relate to subsystem in Integrated Agriculture Information System (IAIS). As a result, there are 47 data entities as entities in single and integrated database.

Keywords: Integrated Agriculture Information System, Data Entity, Information System Matrix

1. Introduction

Agriculture is one of the important sectors in Indonesia. Development of Technology in agriculture sector as a government research focus during 2015 – 2045 (Kementrian Riset, Teknologi, dan Pendidikan Tinggi, 2016). Information Technology as one of technologies that is able to support food self-sufficiency through improvement in quality and quantity of agriculture product. This technology is able to support improvement in economic added value for agriculture sector. Implementation of Information System in Agriculture has been implemented in Kenya (Rees, et. al., 2000), Croatia (Renko, Nikolasevic, and Pavice, 2002), China (Wet, et. al., 2007). Farmers are also has been realized that the usage and importance of implementation Information Technology in Agriculture. 76.81% of farmers agree that Information and Communication Technology (ICT) should be optimized in Agriculture sector and they are ready to be trained the usage of ICT in Agriculture sector. This will be a good motivation to implement ICT in Agriculture Sector. Implementation of ICT for agriculture also has been supported by a good communication infrastructure in rural area, such as telephone network, ISP, and wireless connection.

Researchers are conducting study to build Integrated Agriculture Information System (IAIS). IAIS is a system that is developed to process data, information, and knowledge in Agriculture sector. This system has some subsystems which are connected and linked with integrated database. To build IAIS, researchers developed architecture using Enterprise Architecture Method. TOGAF Enterprise Architecture is chosen to build the blueprint and architecture. One elements of TOGAF Enterprise Architecture is Data Architecture. Data architecture is an approach which is needed to understand and address data management issues. TOGAF data architecture is an element that describe the structure of an organization’s logical and physical data assets and management resources. A structured and comprehensive approach to data management enables the effective use of data to capitalize on its competitive advantage. This paper proposes the development of data architecture for integrated
agriculture information system. This architecture is based on TOGAF framework which implements holistic approach starting from its organization, its function, its service, and its goal.

2. Literature Review

2.1. e-Agriculture

Development of Information and Communication Technology is perceived not only by urban community but also rural community. In rural area, development of Information and Communication Technology can be related with area economic development. Furthermore, open access to Information and Communication Technology will be opened rural area to market access. Development of Information and Communication Technology in rural area is able to help local business to be more competitive by increasing production capacity. Thus, development of ICT will bring more opportunity by reduce production cost and increasing investment. Information and Communication Technology also bring a positive impact to agriculture sector, especially in rural area. Implementation of ICT in agriculture sector raised and introduced for the first time during World Summit on Information Society in 2003 (Kamran, et. al., 2016). In this session, e-Agriculture is introduced to public. E-Agriculture has a purpose to increase farmer’s standard of living (Kamran, et. al., 2016).

E-Agriculture is also able to increase standard of living by reducing cost production in agriculture sector, minimize pre-cultivation process and time, and increase the crops. Thus will bring a financial improvement by increasing the farmer’s profit. Farmers are easier to access information that will be useful for agriculture sector. Development of e-Agriculture has some obstacles. Masiello-Riome, et. al. (2008) described that 57% respondent has no attention to e-Agriculture. Farmers are still busy and do not have willingness to change the way they cultivate and process the field. High cost in accessing the Information and Communication Technology is also a challenge. Government should develop less cost information access for rural area.

Information access is an important issue for e-Agriculture development. Farmers need following information: (1) Technique and Practise in agriculture (57%); and (2) Market information (33%) (Masiello-Riome, et. al., 2008). Thus, infrastructure is needed to prepare information access. In Yogyakarta, available infrastructure for ICT is telephone network, ISP, and wireless network (Delima, 2016). Implementation e-Agriculture has been integrated with agriculture operation to ease farmer’s job, reduce processing time, minimize cost, and prevent environment from hazardous material. Implementation of e-Agriculture with Mobile Driven Extension has been implemented in India and Kenya (Brugger, 2011) by using Information Technology to collaborate with government, research centre, university, and farmer through internet. This model is supported by applying Call Center approach. By using tele-center, user will be helped by an agent. This agent will provide information that user needed, such as: irrigation, pest management, and other information. Research centre, university, and government should be able to update the information and solve user’s problem (Brugger, 2011).

E-Agriculture also provides information about market and the usage of web technology extensively (Kamran, et. al., 2016). Farmer needs following information: (1) Fertilizer price; (2) Agriculture technique and practise; (3) Pest management; (4) Cultivation; (5) Irrigation; (6) Post harvest processing; (7) Innovation in agriculture processing (Delima, 2016). This information is supporting Milavanovic (2014) statement that these information is required by farmers: (1) Information on crops: Farmers need some information related with crops and plants; (2) Information on production techniques; (3) Information on production equipment and agricultural inputs to help farmers to know the tools for soil and plant processing; (4) Market information is an information to support farmers selling the crop during harvest time. These information will be helped to design the data architecture by using TOGAF Framework.

2.2. Data Architecture

The number of data for the enterprise are growing. It encourages the enterprise to depend on data, information, and knowledge in order to run the system and gain the benefit from the system. Thus, it needs to manage data and extract the data in order to get the information and knowledge from the data. Integrated Agriculture Information System as a big system also needs data architecture in order to govern the data. Collection, management, and effective use of data, information, and knowledge are essential ingredients to success of IAIS implementation.
Data architecture comprises data structure and its relationship, principle and guideline governing the design and evolution of data overtime (Hoven, 2004). Data architecture for a business enterprise provides the blueprints for the enterprise’s data resources by providing the vision, principles, and standards to create, use, and manage it. (Hoven, 2004). Dunn and Grabski (2001) stated the same representation of the data architecture. Data architecture represent how the data stored logically and physically, how data is organized for information system purpose, and data’s correspondence with changing tasks are important to task performance (Dunn and Grabski, 2001). Data architecture also provides framework to enable an enterprise to resolve key issues associated with the quality, timeliness, commonality, and accessibility of the data within the enterprise, and to improve the flow of data between systems within the enterprise (Hoven, 2003). Data architecture also provides a guideline not only for transaction purpose but also to help to decide something related with enterprise strategic solution. Thus, data architecture as a part of enterprise architecture should be defined well as a foundation to build information system. TOGAF as an enterprise architecture standard also has guideline to manage and govern enterprise data. A structured and comprehensive approach to data management enables effective use of data to capitalize on its competitive advantages. Some processes in order to develop data architecture: (1) collect data-related models from existing Business Architecture and Application Architecture materials; (2) rationalize data requirement and align with any enterprise data catalogues and models; (3) Update and develop matrices across the architecture; (4) elaborate data architecture views (http://pubs.opengroup.org/architecture/togaf9-doc/arch/chap10.html).

3. Research Methodology

In conducting this research, researchers followed methodologies:

3.1. Initial Study of ICT Development in Agricultural Sector

Initial study was conducted in 2015 by interviewing 77 farmers from Yogyakarta. From this initial study, it found: (1) 75 % farmers in Yogyakarta are 40 years old and graduated from Senior High School; (2) Farmers use smartphone to look information about agriculture; (3) Farmers lack of IT literacy but they have willingness to use the Information Technology in order to increase their productivity; (4) Farmers need information about prices, farming tools and technique, product marketing and sales, land processing technique, and post-harvest product processing (Delima and Purwadi, 2015).

3.2. Developing Vision Architecture, Business Architecture

After identify the farmers structure and required information, researchers starting to develop vision architecture and business architecture (Delima, Santoso, and Purwadi, 2016; Santoso and Delima, 2016; Delima, Santoso, and Purwadi, 2017). From the architecture vision, it determined that supporting organization for Integrated Agriculture Information System is study group. This organization has the following vision Achieving Farmers Welfare through Precision Farming Based on ICT. It has three missions: (1) providing services to develop farmer capacity using information and communication technology; (2) develop Indonesian IAIS for precision farming; (3) establish online community for every agriculture stakeholders (Delima, Santoso, and Purwadi, 2016). Stakeholders for Integrated Agriculture Information System are categorized into four categories: (1) Farmers; (2) Researchers; (3) Public Sector; and (4) Business sector (Santoso and Delima, 2016). Every stakeholders are analysed and grouped into several group based on its power and interest which reflect the participation of each stakeholders in the development of IAIS and interest in implementation of IAIS (Santoso and Delima, 2016).

Developing vision architecture is followed by developing business architecture. From the business architecture, it is determined that IAIS has four main functions: (1) System, Information Technology Infrastructure, and Organization Standardization; (2) Developing, managing, and maintaining application and infrastructure; (3) IAIS Implementation; (4) Management and Organization. (Delima, Santoso, and Purwadi, 2017). There are 10 available services for IAIS: (1) User Registration; (2) Requesting application services; (3) Requesting ICT Services; (4) Tendering services; (5) Requesting services; (6) Requesting information; (7) Information sharing; (8) Consulting; (9) Recording and observing user specific data; (10) Giving agriculture information and knowledge (Delima, Santoso, and Purwadi, 2017).
3.3. Data requirement for Integrated Agricultural Information System

Delima and Purwadi (2015) studied that farmers need information about prices, farming tools and techniques, product marketing and sales, land processing techniques, and post harvesting processing. Farmers and stakeholder in agriculture sector needs some following information: (1) Fertilizer price; (2) Agriculture technique and practise; (3) Pest management; (4) Cultivation; (5) Irrigation; (6) Post harvest processing; (7) Innovation in agriculture processing. Thus, Integrated Agricultural Information System is able to store data about farmers data, farmers community data, farmers farming activity, daily price, farming technique and processing which will be included in the training session and accommodate by expertise from academician, e-commerce as a place to buy and sell agriculture product.

3.4. Set Up Data Architecture for Integrated Agricultural Information System

In this paper, two components of Integrated Agricultural Information System Data Architecture will be discussed, including: (1) Data entity / Data Component Catalogue; (2) and System / Data Matrix.

4. Analysis and Discussion

4.1. Data Entity / Data Component Catalogue

Data entity is a part of TOGAF data architecture. This data entity identify and maintain a list of all data use across IAIS. Data entity also brings clear definition of where data is stored, either physically or logically.

Table 1. Data Entity / Data Component Catalogue

| Data Entity | Description | Logical Data Component | Data Category | Physical Data Component |
|-------------|-------------|------------------------|---------------|------------------------|
| User        | Save and record master user data | Master_user | Master | Disk1 |
| Master Category | Save and record master category data | Master_kategori | Master | Disk1 |
| User Category | Save and record master user category data | Master_user_kat | Master | Disk1 |
| Log User Transaction | Save and record user activity transaction log | Log_user_trans | Log | Disk1 |
| Organization user | Save and record personnel data that are involved in Agriculture Information System Study Group | Master_user_org | Master | Disk1 |
| Organization unit | Save and record organization unit data in Agriculture Information System Study Group | Master_org_unit | Master | Disk1 |
| Forum category | Save and record discussion forum category data | Master_kategori_topik | Master | Disk1 |
| Forum topics | Save and record forum topics data | Trans_topik_diskusi | Transaction | Disk2 |
| Forum Comments | Save and record forum comments | Trans_komentar_diskusi | Transaction | Disk2 |
| Farmers Community | Save and record farmers community master data | Trans_struk_org | Transaction | Disk2 |
| Farmers Community Organization Structure | Save and record personnel data that are involved in management farmers community | Master_kel_tani | Master | Disk1 |
| Farmers | Save and record farmers personal data | Master_petani | Master | Disk1 |
| Farmers membership | Save and record farmer’s membership in the community / union | Master_petani | Master | Disk1 |
| Crop Morphology | Save and record crop morphology | Master_morf_tanaman | Master | Disk1 |
| Crop Species | Save and record crop species | Master_spesies_tanaman | Master | Disk1 |
| Farming Activity | Save and record farming activity master data | Master_activitas | Master | Disk1 |
| Species Activity | Save and record farming activity and its relation with each species | Master_activitas_spesies | Master | Disk1 |
| Farmers Activity | Save and record farming activities that are done by farmers | Trans_petani_aktivitas | Transaction | Disk2 |
| Yields | Save and record farmer’s yield / harvest | Trans_harga_panen | Transaction | Disk2 |
| Cropping Calendar | Save and record cropping calendar data | Trans_kalender_tanam | Transaction | Disk2 |
| Tool, material, and Equipment Category Data | Save and record tool and equipment category data | Master_kategori_alatbahan | Master | Disk1 |
| Farming Tools | Save and record farming tools | Master_alat_tani | Master | Disk1 |
| Farming materials | Save and record farming materials | Master_bahan_tani | Master | Disk1 |
| Supplier Category | Save and record supplier category data | Master_supplier | Master | Disk1 |
| Supplier | Save and record supplier | Master_supplier | Master | Disk1 |
| Agricultural Product | Save and record agricultural product | Master_produk_tani | Master | Disk1 |
| Agricultural product price | Save and record daily agricultural product price | Trans_harga_prod | Transaction | Disk1 |
From table 1, there are 47 tables are involved for Integrated Agricultural Information System. Those 47 data entities are derived based on the information needed by farmers and stakeholder in agriculture sector. Those 47 tables are involved and related to 9 information systems in Integrated Agricultural Information System.

| Data Entity                     | Description                                                                 | Logical Data Component          | Data Category | Physical Data Component |
|---------------------------------|-----------------------------------------------------------------------------|---------------------------------|---------------|-------------------------|
| Agricultural Product Offer       | Save and record supplier offering data of agricultural tools, materials, and equipment. | Trans_penawaran_prod_tani       | Transaction   | Disk2                   |
| Agricultural Product Demand      | Save and record agricultural product demand                                | Trans_permintaan                | Transaction   | Disk2                   |
| Agricultural Product Offer Log   | Save and record supplier offering log data                                | Log_penawaran_prod              | Log           | Disk3                   |
| Agricultural Product Demand Log  | Save and record demand log data                                            | Log_permintaan                  | Log           | Disk3                   |
| Chart of Account                 | Save and record farmers chart of account                                   | Master_kode_biaya               | Master        | Disk1                   |
| Budgeting                        | Save and record farmer’s production budget                                 | Trans_anggaran                  | Transaction   | Disk2                   |
| Budgeting Detail                 | Save and record farmer’s production detail budget                          | Trans_detail_anggaran           | Transaction   | Disk2                   |
| Realization                      | Save and record production cost realization                               | Log_biaya_keluar                | Log           | Disk3                   |
| Services Request                 | Save and record services for Integrated Agriculture Information System     | Master_serv                     | Master        | Disk1                   |
| Services Activity                | Save and record log services activity                                      | Log_activity_serv               | Log           | Disk3                   |
| Training request                 | Save and record training request from farmers community                    | Trans_permintaan_train          | Transaction   | Disk2                   |
| Fasilitator                      | Save and record facilitator detail data                                    | Master_fasilitator              | Master        | Disk1                   |
| Training administration          | Save and record training administration data                               | Trans_pelaksanaan_pelatihan     | Transaction   | Disk2                   |
| Training activity                | Save and record log training activity data                                 | Log_aktivitas_train             | Log           | Disk3                   |
| Learning Material                | Save and record learning materials                                         | Master_materi_ajar              | Master        | Disk1                   |
| Learning Material Detail         | Save and record learning materials data detail                            | Master_detail_materi_ajar       | Master        | Disk1                   |

Figure 1. Data Entity Class Diagram

Figure 1 shows the class diagram of the data entities. There are 3 kinds of data entity: (1) Master Data Entity (Colour: Pink); (2) Log Data Entity (Colour: Blue); and (3) Transaction Data Entity (Colour: Green). There are 9 information systems are involved in Integrated Agriculture Information System: (1)
Agriculture Integrated Portal; (2) Farmer and Farmer Community Information System; (3) Farmers and Production Activity Information System; (4) Cropping Calendar Information System; (5) Agriculture e-Commerce; (6) Production Budgeting; (7) Service Information Systems; (8) Training Management System; (9) Learning Management System for Farmers.

4.2. System and Data Matrix

The purpose of the creating matrix of System and data is to depict the relationship between applications and the data entities that are accessed and updated by them. The mapping of the System and Data Entity relationship is an important step as it enables to assign access of data to specific applications in the organization, understand the degree of data duplication within different applications, and the scale of the data lifecycle, understand where the same data is updated by different applications, and support the gap analysis and determine whether any of the applications are missing and as a result need to be created. System and Data Matrix for IAIS can be seen in table 2.

**Table 2. System and Data Matrix for IAIS**

| Application | Application Description | Data Entity |
|-------------|-------------------------|-------------|
| Agriculture Integrated Portal | This system is developed as a portal for integrated agriculture information system. This system also to fulfill farmer required innovation in agriculture processing and technique. | master_kategori, master_user, master_user_kat, master_user_org, master_org_unit, master_kategori_topik, Trans_topik_diskusi, trans_komentar_diskusi, Log_user_trans |
| Farmer and Farmer Community Information System | This system is developed as a data center for farmers and farmer’s membership in community. This system is to help farmer community in order to organize its member and organization. This system is the foundation to build other system. | Master_user, master_kel_tani, master_petani, Trans_struk_org, trans_ang_petani |
| Farmers and Production Activity Information System | This system is designed for farmers as a tool to learn. | | |
| Cropping Calendar Information System | This system is developed as a data center for farmers and farmer’s membership in community. This system is to help farmer community in order to organize its member and organization. This system is the foundation to build other system. | Master_user, master_petani master_kel_tani, master_morf_tanaman, master_spesies_tanaman, master_aktifitas, master_aktifitas_spesies, Trans_ang_petani, trans_aktifitas_pertanian, trans_hasil_panen |
| Agriculture e-Commerce | This system is developed a gateway for farmers and business sector (private sector) can meet and sell their product. This system is to help farmer to get information about price and supply for product, tools, and materials. | Master_user, master_petani master_kategori_elaibahan, master_alat_tani, master_bahan_tani, master_jenis_sup, master_supplier, master_prod_tani, Trans_hasil_panen, trans_harga_prod, trans_penawaran_prod, trans_permintaan, Log_penawaran_prod, log_permintaan |
| Production Budgeting | This system is developed to help farmers manage their production cost. | Master_user, master_petani, master_aktifitas, master_aktifitas_spesies, masterkode_biyaya, Trans_aktifitas_pertanian, Trans_anggaran, trans_detail_anggaran, Trans_realisasi biaya, log_biaya_keluar |
| Service Information System | This system is developed to help farmers get information and services from Integrated Information System, such as information on pest management, innovation in agriculture processing. This system also helps farmers meet the expert. | Master_user, master_pelayanan, Trans_permintaan_pelayanan, Log_aktifitas_pelayanan |
| Training Management System | This system is developed to help farmer community to arrange training for its member. System will help to find the appropriate facilitator based on their expertise and research interest. | Master_user, master_fasilitator, master_materi_pelatihan, master_materi_ajar, master_detail_materi_ajar, Trans_permintaan_pelatihan, Trans_pelaksanaan_pelatihan, Log_aktifitas_pelatihan |
| Learning Management System for Farmers | This system is designed as a tool for farmers to learn about technique and processing practise. It is also helps farmers to get information about pest management, new products and techniques. This system is designed for farmers as a tool to learn. | Master_user, master_fasilitator, master_materi_pelatihan, master_materi_ajar, master_detail_materi_ajar, Trans_permintaan_pelatihan, Trans_pelaksanaan_pelatihan, Log_aktifitas_pelatihan |

Table 2 gives the detail system and its data entity for the system. There are 9 systems are involved and used the following data entity. This system will be developed gradually. The first phase is to build the Agriculture Integrated Portal, Farmer and Farmer Community Information System, and Farmers and Production Activity Information System. Implementation of the system build in the first phase will be followed by farmers training and empowerment to use the system.
5. Conclusion

Based on the analysis, it can be concluded that:

1. IAIS data architecture contains 47 data entities which are categorized into three: (1) Master Data; (2) Transaction data; and (3) Log data.
2. There will be 9 systems involved in Integrated Agriculture Information System. Those systems are: (1) Agriculture Integrated Portal; (2) Farmer and Farmer Community Information System; (3) Farmers and Production Activity Information System; (4) Cropping Calendar Information System; (5) Agriculture e-Commerce; (6) Production Budgeting; (7) Service Information System; (8) Training Management System; and (9) Learning Management System for Farmer. In the first phase, it will develop agriculture integrated portal, farmer and farmer community information system, and farmers and production activity information system.

References

[1] Brugger F 2011 Mobile Application in Agriculture (Basen: Syngenta Foundation).
[2] Delima R 2016 Analisis Kondisi dan Kesiapan Masyarakat Tani di Daerah Istimewa Yogyakarta untuk Memanfaatkan TIK di Bidang Pertanian (Yogyakarta: Universitas Kristen Duta Wacana).
[3] Delima R, and Purwadi J 2015 Analisis Situs Web Pertanian Berbahasa Indonesia Prosiding Seminar Nasional Komputer dan Informatika Terapan pp 1–5.
[4] Delima R, Santoso H B, and Purwadi J 2016 Architecture Vision for Indonesian Integrated Agriculture Information Systems Using TOGAF Framework Int. Conf. on Informatics and Computing (Lombok: APTIKOM).
[5] Delima R, Santoso H B, and Purwadi J 2017 Business Architecture Development for Integrated Agriculture Information System (IAIS) Using TOGAF Framework. Researchers World VIII 2(1) pp 1043-113.
[6] Dunn C, and Grabski S 2001 An investigation of localization as an Element of Cognitive Fit in Accounting Model Representations Decision Sci. pp 55-94.
[7] Hoven J v 2003 Data Architecture: Principle for Data Information Sys. Management pp 93-6.
[8] Hoven J v 2004 Data Architecture Standards for the Effective Enterprise Information Sys. Management pp 61-4.
[9] Hutabarat T W 2012 Mirisnya Menjadi Negara Pengimpor ed K. Lumbanradja Retrieved Januari 7, 2017, from Mirisnya Menjadi Negara Pengimpor: http://blog-berbagi.blogspot.com/2012/07/indonesia-negara-agraris-omo.html
[10] Kamran M, Anjum M, Rehman M, Ahmad H, and Kamran M A 2016 Classification of Information Systems in e-Agriculture: A Mapping Study Int. J. of Comp. Sci. and Information Security 14(9) pp 1043-77.
[11] Kementrian Riset, Teknologi, dan Pendidikan Tinggi 2016 Rencana Induk Riset Nasional 2015-2045.
[12] Masiello-Riome C, Heller N, Rudgard S, and Schneider R 2008 Analysis of e-Agriculture Survey Agricultural Information Worldwide 1(1) pp 11-8.
[13] Rees D, Momanyi M, Wekundah J, Ndungu F, and Odondi J 2000 Agricultural Knowledge and Information Systems in Kenya - Implication for Technology Dissemination and Development Agricultural Research and Extension Network (London).
[14] Renko N, Nikalosevic S, and Pavicic J 2002 The Market Information System and State Support for the Market of Agricultural Products in Croatia British Food J. 104(7) pp 543-71.
[15] Santoso H B, and Delima R 2016. Stakeholder Definition for Indonesian Integrated Agriculture Information System (IAIS) The Int. Conf. on Information Tech. and Digital Applications (Yogyakarta: Universitas Islam Indonesia) pp 103-9.
[16] The Open Group 2011 Architecture Development Method [Online] Available: http://pubs.opengroup.org/architecture/togaf9-doc/arch/chap10.html
[17] Wen G, Zetian F, Daoliang L, Longyong Y, Jian X, and Xiashuan Z 2007 AgrInfo: an Agricultural Information System Based on a Call Center in China New Zealand J. of Agricultural Research 50 797 – 806.
Acknowledgments

Special thanks to Ministry of Research, Technology, and Higher Education who give grant to fund our research. Researchers also thanks to Duta Wacana Christian University as our base who provides facility in doing this research.