Workshop

ICT Adoption in Agriculture and Agribusiness

Indonesian E-Agriculture Strategic Framework: A Direction of ICT Usage as Enabler in Agriculture

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Abstract— **As indicated in many studies, a modern agriculture posts several problems. It tends to not environmentally friendly due to chemical usage, produced more waste, and the land is forced to produced exceeding its capacity. Beside that in the modern agricultural supply chain, farmers (producers) always in a weaker position as compare to distributors (intermediaries) and costumers. Lack of access to updated information leads to a poor judgment on what to plant, when to plant, how much to plant, and where to sale. This imbalanced of agricultural supply chain reduced the farm profitability. Furthermore, it creates a structured poverty in the farming communities due to weakened processes of farming resources ability to fulfill sufficient needs. ICTs could help small and medium farmers increase their revenues (which is related to farm profitability), improve their farming practices (which is related to environmental stewardship), and making it possible for them to access information on agricultural know-how through knowledge sharing among them (which is related to prosperous farming communities), and through research center. ICT can help to increase transparency, prevent corruption, optimal price discovery, information dissemination, usability, preservation and management of documents and content. However, it requires network and information security, interoperability, standardization of business processes and for localization and internationalization of content. All these components need to be structured in such a way into an Indonesian E-Agriculture Strategic Framework (IESF). IESF aims at deploying ICTs for sustainable development in agriculture area targeting ultimate beneficiaries (i.e. farmers) by providing direct-link among farmers, merchants, consumers, local governments with global markets, research center, banks, and so forth.**

Keywords- agricultural supply chain; E-Agriculture

I. INTRODUCTION

Indonesia is well known by its rich natural resources, such as petroleum and gas, sea products, and many more, which produce a great economic value. In past years, Indonesian Gross Domestic Product (GDP) has been dominated by industrial sector. According to BPS-Statistics Indonesia [1], manufacturing industries contributed around 26.4% of the total GDP in 2009. However, agricultural sector continues to be the leading sector in terms of the number of workers and it has been recorded that approximately 41% of the total workforce in Indonesia are working in agricultural field (agriculture, livestock, forestry, and fishery). In spite of this, several problems still remain in Indonesian agricultural sector.

One of the most common problems in modern agriculture is concerning the "sustainable agriculture". Although many people may have different meanings, there exist three definitions in relations to the sustainability: sustainability as food sufficiency; sustainability as stewardship; and sustainability as community [1] (see Fig. 1). But in modern agriculture, sustainability is most likely neglected, i.e., overusing chemical or non-organic substance to increase the agricultural production. By using such substance, there are two side effects: the land is forced to produce exceeding its capacity due to the overproduction (which possibly will create economic problems) and the production of waste that could pollute the water and soil (which possibly will create ecological problems) [2]. This kind of problems occurs in most farming communities, and positioned farmers (producers) in a weaker position compared to distributors (intermediaries) and costumers as a result of the lack of updated information needed by farmers.

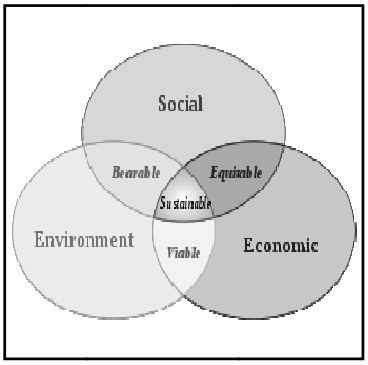

Figure 1. Scheme of sustainable agriculture development [3]

Lack of access to updated information leads to a poor judgment on what to plant, when to plant, how much to plant, and where to sale. This imbalanced of agricultural supply chain reduced the farm profitability. Furthermore, it creates a structured poverty in the farming communities due to weakened processes of farming resources ability to fulfill

[1] www.bps.go.id

sufficient needs. Information Communication Technologies (ICTs) could help small and medium farmers increase their revenues (which is related to farm profitability), improve their farming practices (which is related to environmental stewardship), and making it possible for them to access information on agricultural know-how through knowledge sharing among them (which is related to prosperous farming communities), and through research center. ICT can help to increase transparency, prevent corruption, optimal price discovery, information dissemination, usability, preservation and management of documents and content. However, it requires network and information security, interoperability, standardization of business processes and for localization and internationalization of content. All these components need to be structured in such a way into an Indonesian E-Agriculture Strategic Framework (IESF). IESF aims at deploying ICTs for sustainable development in agriculture area targeting ultimate beneficiaries (i.e. farmers) by providing direct-link among farmers, merchants, consumers, local governments with global markets, research center, banks, and so forth.

This paper organized in several parts: Section II reviews the Enterprise Architecture approach in developing E-Agriculture Framework; Section III outlines the domains of the framework; Section IV describes the IESF's building blocks; and conclusion and recommendation are discussed in the final section. The following section provides an overview of the approach used in developing E-Agriculture Framework.

II. THE ENTERPRISE ARCHITECTURE APPROACH

Enterprise has various definitions, depending on the context. In business context, an enterprise is the entire business group or corporation comprising of all local and international main and sub offices, divisions, subsidiaries, and departments. In computer industry, an enterprise is an organization that uses computers. The Open Group provides a broader definition which defines an enterprise as any collections that has a common set of goals. For example, an enterprise could be a government agency, a whole corporation, a single division, and so on. Architecture in other hand is the fundamental organization of a system embodied in its components, their relationships to each other and to the environment, and the principles guiding its design and evolution [4]. This concludes that Enterprise Architecture (EA) is a structure of components (IT services, processes and infrastructure), their interrelationships, and the principles and guidelines governing their design and evolution over time to achieve a common set of goals.

Research shows that Enterprise Architecture (EA) is crucial for the business sustainability [5]. In order to survive and compete in global scale competition, many large scale enterprises established their EA. There are several EA approaches, for instance, the Zachman Framework, the Open Group Architecture Framework (TOGAF), the Enterprise Architecture Planning (EAP), and so forth. The earliest framework was initially developed by Zachman[2] in 1987. Some other frameworks were built upon other framework, for example, EAP were influenced the other frameworks such as Zachman Framework, Federal Enterprise Architecture Framework (FEAF), Treasury Information Systems Architecture Framework (TISAF), and Integrated Architecture Framework (IAF). Figure 2 illustrates the evolution of EA frameworks since 1987. In these various approach in EA, TOGAF may consider as one of the most distinguished approach and widely used.

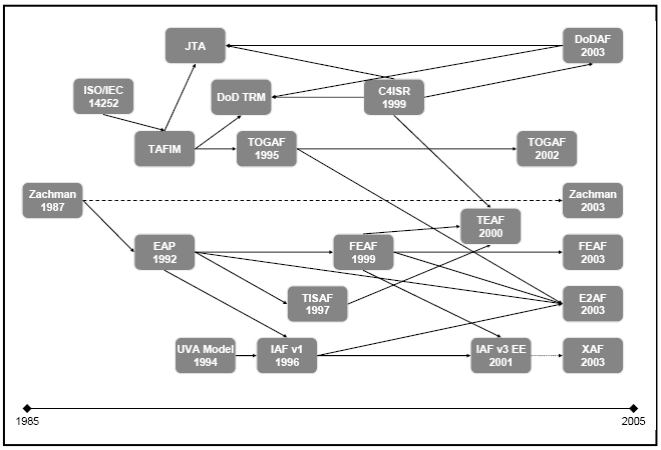

Figure 2. Evolution of Enterprise Architecture Frameworks [6]

TOGAF was developed by the Open Group in 1995. This EAF was influenced by the Technical Architecture Framework for Information Management (TAFIM), developed by the US Department of Defense. The latest version, TOGAF 9 was released in February 2009. TOGAF is based on four pillars:

- *Business Architecture* – defines the business strategy, governance, organization, and key business process of the organization.
- *Application Architecture* – provides a blueprint of the application systems, the interaction between systems, and their relationships to the core business process.
- *Data Architecture* – describes the structure of an organization's logical and physical data assets and the associated data management resources.
- *Technology Architecture* – describes the hardware, software, and network infrastructure needed to support the deployment of core application.

These pillars are used throughout the development process of an EA. To develop the framework, TOGAF uses the Architecture Development Method (ADM) which has iterative and cyclic process (see Fig. 3).

Another main part of TOGAF is the enterprise continuum. The Enterprise Architecture Continuum is the taxonomy for all the architecture assets, both within the enterprise and in the IT industry at large, that the enterprise may consider when developing architecture. To develop the Enterprise's Continuum, TOGAF provide two references: The TOGAF Foundation Architecture and TOGAF Resource Base. Because TOGAF is a generic framework, the content

[2] www.zachmaninternational.com

framework could be adapted in many ways and in different kind of organizations, including in agricultural industry. Thus, we propose TOGAF as the generic approach in developing Indonesia E-Agriculture Strategic Framework (IESF).

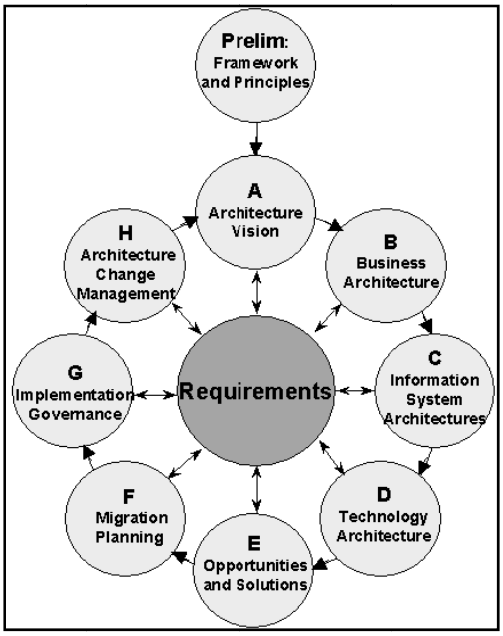

Figure 3. TOGAF architecture development method (ADM) [4]

III. INDONESIAN E-AGRICULTURE STRATEGIC FRAMEWORK (IESF)

There are four architecture domains that are commonly accepted as subsets of an overall enterprise architecture: Business, Application, Data, and Technology Architecture. These four domains make up the initial architecture for the IESF and must be aligned with each domain.

A. Business Architecture

Business Architecture (BA) defines the business domains, business functions, business processes, and governance, policy, and resources of the organization. There are few representative questions that could be addressed in BA:

- Who are the key decision makers, what are their roles and behaviors insofar as decision making is concerned?
- What are the essential questions that as users must be able to answer for strategic and day to day decision making?
- What core business processes are necessary to support decision making?
- What policies and laws are necessary to support the initial development and implementation of the IESF?
- Who will be responsible for the maintenance and the integrity of the IESF?

These questions must be answered in order to define all of the BA deliverables. First we must identify the stakeholders in the IESF to describe the business domains and functions.

Business Domains & Functions

The stakeholders in IESF comprises of the actors involved in agricultural supply chain events. There are two types of stakeholders' involvement in the supply chain, direct and indirect involvement.

Actors who have direct involvement in the supply chain comprises of:

- Farmers/producers;
- Distributors/intermediaries;
- Food industries;
- Merchants/traders; and
- Consumers.

Subsequently, actors who are indirectly involved in the supply chain include:

- Government agencies;
- Agricultural associations;
- Research and development institutes;
- Non Governmental Organizations (NGOs); and
- United Nations Organizations (WHO, WTO, UNDP).

These stakeholders collaborate to achieve the agricultural sustainability (social, environment, and economic sustainability). IESF aims at deploying ICTs for sustainable development in agriculture area. In national scale, the key decision maker is the Government Agencies (i.e. Ministry of Agriculture). The ministry covers all of the organization's functions through the Directorate Generals by setting agricultural policies and standards. But they are lacking in agricultural data. There are limited resources that could be used to make strategic and day to day decision making. In the future, IESF must have the ability to provide all the information needed by the ministry so that the decision makers could answer even the simplest question, such as "How is the rice production quantity for this month?". This problem could be solved by providing the needed updated agricultural information. To identify the needed information, first we must break down the business processes in the agricultural supply chain.

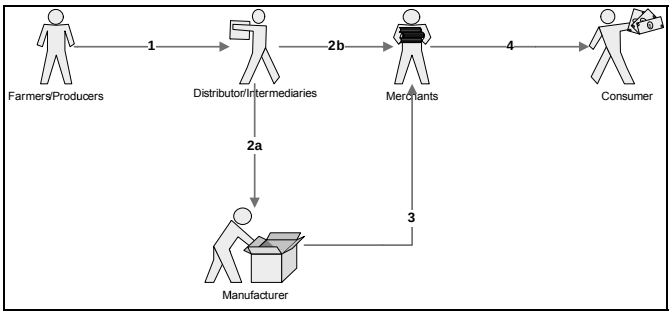

Figure 4. Agricultural supply chain

Business Processes

Fig.4 illustrates the agricultural supply chain. Farmers hold the key role in the agricultural supply chain since in view of the fact that they are the producers of agricultural products. The main characteristic of the producers is they reliance on the weather conditions. Good harvest comes only with a great weather that meets the crops' requirements. Distributors as the other stakeholder then collect and distribute the products. Their profit depends on the price margin between producers and food industries/merchants. In many cases, farmers always in a weaker position and forced to sell their products to distributors at any price because the lack of the needed information that leads to lack of judgment. This condition advantages the intermediaries who sell the products to food industries or merchants. Both food industries and merchants depend on distributors to run their business though they have different purposes. Food industries process the agricultural products as raw materials before they distribute the end products to their food chain (supermarkets, restaurants, etc.). On the other hand, the merchants resell the products straight the end consumer in a specific place (i.e. the market). Consumers who buy the products are the last stakeholder in the agricultural supply chain. However, the consumers are the driver the overall agricultural products demand. The next step is to identify the key process business in each business domain exist in the agricultural supply chain.

Table 1. Key business process in agriculture area

Business Domain	Business Processes	Information Needs
Producers	• Seeding • Planting • Fertilizing • Harvesting • Selling	• What to plant? • When to plant? • Where to buy the seed, fertilizer, and other farming materials? • How much to plant? • Where to sale?
Distributors	• Buying products • Selling products	• What to buy? • When to buy? • Where to buy? • Where to sale?
Manufacturers	• Buying products • Processing • Selling products	• What to buy? • When to buy? • Where to buy? • How much to process? • Where to sale?
Merchants	• Buying products • Selling products	• What to buy? • When to buy? • Where to buy? • Where to sale?
Consumers	• Buying products	• What to buy? • Where to buy?

Table 1 shows the key business processes in agriculture area which categorized by business domain. There are five key business processes in the producers/farmers domain: seeding, planting, fertilizing, harvesting, and selling. To improve the farming process, producers needs various information, such as, "What and when to plant?"; "How much to plant?"; "Where to buy the farming resources?" and "Where to sale?". The next business domain is the distributors and merchants which have similar roles: buying and selling agricultural products. To improve distribution process, distributors need information like "What, when, and where to buy"; .and "Where to sale?". The manufacturers also need the information to improve the production efficiency which comprises of three business processes: buying, processing, and selling products. The information needed by manufacturers covers from "What, when, and where to buy?"; "How much to process?"; and "Where to sale?". The last business domain is the consumers. As a buyer, their role is to buy agriculture products and the only information they need is concerning what and where to buy. This concludes all of the IESF information needs. Next step is to identify the governance, policy, and resources needed to develop IESF.

Governance, Policy & Resources

The governance of the IESF has to be aligned with the national ICT governance policy. Therefore, IESF must adopt the National ICT Governance Model which endorsed by the National ICT Council, Republic of Indonesia[3] (see Fig. 5). The model is focused on the management of ICT processes through policy and monitoring & evaluation mechanisms. There are two main components in this model:

- *Structure and role* – describes the structure and roles in managing ICT processes;
- *Processes* – describes the processes to ensure the governance's main goal could be achieved, especially which related with organization goal achievement, resources management, and risk management.

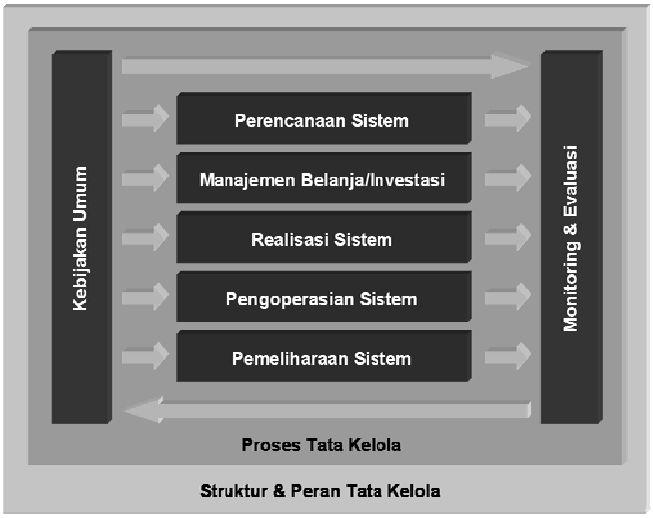

Figure 5. National ICT Governance Model [7]

In the process component, there are five processes:

- *Systems planning* –identifies the organization needs and formulates ICT initiatives in order to fulfill them;
- *Investment management* – managing the ICT investment;

[3] www.detiknas.org

- *Systems realization* – deals with selection and aquisition of ICT systems and the project management;
- *Systems operation* – handles ICT operation which ensure the service level and security of the system;
- *Systems maintenance* – maintain ICT assets to support optimal systems operation.

There are two process mechanisms to ensure the alignment between the processes and organization needs:

- *Policy* – to give limitation to ICT processes;
- *Monitoring and evaluation* – to ensure the feedback of ICT management represented with certain performance indicators.

Using the National ICT Governance Model could ensure the governance, policy, and resource management of the IESF. The National ICT Council has made E-Agriculture as one of the Strategic Programs. However, in order to develop the IESF, policies and regulations related to IESF establishment must be formulated and public-private partnerships must be built. This concludes the IESF's Business Architecture. Next section describes the Application Architecture.

B. *Application Architecture*

Application Architecture (AA) provides a blueprint of the application systems (software applications), the interaction between systems (interfaces between applications), and the user interfaces. There are few representative questions that could be addressed in AA:

- What are the initial key applications a minimal IESF must be able to deliver?
- How will applications that have a requirement to be linked be able to do so?
- How should the user interface work?

These questions must be answered in order to define all of the AA deliverables. First we define the key applications that must be deliver to support decision making in the IESF.

Software Applications

The initial key applications in the IESF could be categorized as the "Key Operational" in McFarlan Strategic Grid [8]. Key operational applications aim to sustain the existing business operations and play important role for survival in the industry. In agriculture context, the key software application deals with the transactional data. But in order to sustain the future business strategy, "Strategic" applications are mandatory. Table 2 describes several key applications related with the corresponding information needs.

There are four web-based key applications that could be used by the stakeholders:

- *E-MarketPlace* –an agribusiness portal to buy and sell products;
- *E-Consultation* – an application to discuss with experts about farming techniques;
- *AgricultureDB* – a database in agriculture area containing information about company list, agriculture product price list, etc.;
- *Farming Website* – a website contains important agricultural knowledge;
- *Simulator* – simulation tools to forecast farming productivity.

Table 2. Key business process in agriculture area

Business Domain	Information Needs	Key Applications
Producers	• What to plant? • When to plant? • Where to buy the seed, fertilizer, and other farming materials? • How much to plant? • Where to sale?	• E-MarketPlace (KO) • E-Consultation (KO) • AgricultureDB (KO) • Farming Website (KO) • Simulator (S)
Distributors	• What to buy? • When to buy? • Where to buy? • Where to sale?	• E-MarketPlace (KO) • AgricultureDB (KO)
Manufacturers	• What to buy? • When to buy? • Where to buy? • How much to process? • Where to sale?	• E-MarketPlace (KO) • AgricultureDB (KO)
Merchants	• What to buy? • When to buy? • Where to buy? • Where to sale?	• E-MarketPlace (KO)
Consumers	• What to buy? • Where to buy?	• E-MarketPlace (KO)

The context diagram of the system is illustrated in Fig. 6 below.

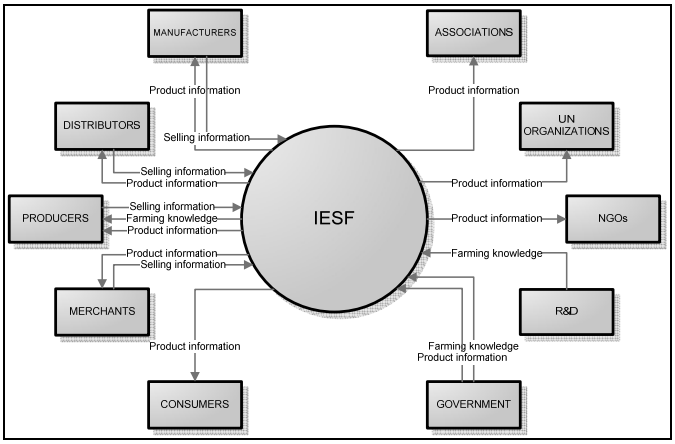

Figure 6. IESF context diagram

The external entities represent all of the stakeholders in agriculture area. All of them could share common information, which is product information. Some of them share selling information, like Producers, Distributors,

Merchants, and Manufacturer. To improve farmer's position, knowledge about the product and farming techniques are provided by the R&D institutes and Government Agencies. Rest of the entities (NGOs, Associations, and UN Organizations) only capable to view and monitor the product information. Next part describes how to link between the applications.

Interfaces between Applications

Since all of the application developed in web-based, the interface that could be used is web application programming interface (API). An API is typically a defined set of Hypertext Transfer Protocol (HTTP) request messages, along with a definition of the structure of response messages, which is usually in an Extensible Markup Language (XML) as an open architecture to ensure the interoperability between applications. API could be used to share content such as, photos, embedded content (i.e. pdf), video, and so forth.

User Interfaces

User interface is the system which users interacts with the applications. Type of user interface used in the IESF is web-based user interfaces (WUI). The interfaces accept input and provide output generating web pages which transmitted via the internet and viewed by users using web browser program, for example, Internet Explorer, Mozilla, etc. This concludes the IESF's Application Architectre. Next section describes the Data Architecture.

C. Data Architecture

Data Architecture (DA) describes the structure of an organization's logical and physical data assets and the associated data management resources. There are few representative questions that could be addressed in DA:

- What are the essential core and common data necessary to support information and evidence for decision makers?
- What data sources contain these data and what can be linked for use form existing operational systems?
- What is the link between essential minimum data sets and global programme?

These questions must be answered in order to define all of the DA deliverables. First we define the core and common data in the IESF.

Core and Common Data

Below is the core and common data that the IESF have:

- Agricultural products;
- Product categories;
- Producers;
- Location;
- Users;
- Product info;
- User categories; and
- Activities.

The logical data model is illustrated in Fig. 7. Next, we describe the data sources for the IESF.

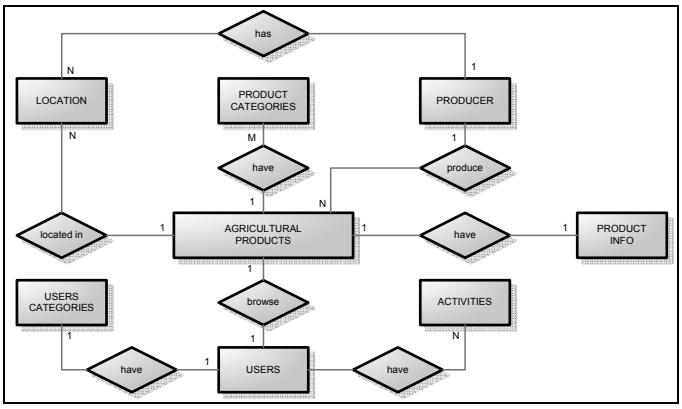

Figure 7. IESF logical data model

Data Sources

The only official data sources are provided by Government Agencies either the BPS-Statistics or the Ministry of Agriculture. Nevertheless, NGOs and agricultural associations may provide the additional information to enrich the Indonesian agricultural profile. All of the data should be standardized in order to ensure the accuracy and interoperability between applications. This data should be an accurate reference for all stakeholders, especially for international organizations like UN.

Link with Global Programme

The data used in the IESF could be linked with other global programme, for instance the Millennium Development Goals (MDGs). Several MDGs target is improve the sustainability of environment, which is one of sustainable agriculture components. Many other MDGs indicators may also be referred to IESF data bank to provide an accurate profile about Indonesia. This concludes the IESF's Data Architectre. Next section describes the Technology Architecture.

D. Technology Architecture

Technology Architecture (TA) describes the hardware, software, and network infrastructure needed to support the deployment of core application. There are few representative questions that could be addressed in TA:

- What are the requirements for information to be captured, data entered, tagged, communicated, managed, and disseminated?
- What is the minimum ICT capacity needed across the country to support access to the applications and disseminations of information?
- How will new classes of electronic devices, communication networks, and related ICT be leveraged over the next 5 to 7 years?

These questions must be answered in order to define all of the TA deliverables. In this section, we define the technological component (hardware, software, and network infrastructure) to support the IESF.

Hardware, Software, and Network Infrastructure

The technological solutions that are used to implement the IESF must have the capability to link with other applications (web-based). Therefore, these following principles are mandatory in IESF technological implementation:

- Using open standards (hardware, software, and network)
- Standardize common data (i.e. formats)
- Ensure interoperability

Moreover, the solution must be leveraged over the next 5 to 7 years. Thus, the data should be accessed with other electronic devices other than PCs or laptops (e-Agriculture). In the future, the data should be accessed with mobile phones (m-Agriculture) and any other electronic devices (u-Agriculture). The architecture of u-Agriculture is illustrated in Fig. 8 below.

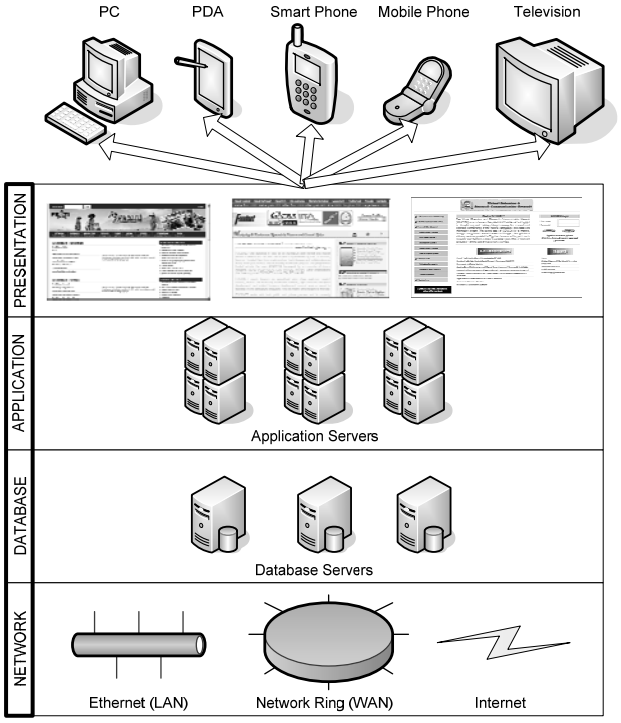

Figure 8. u-Agriculture architecture

This concludes the IESF's Technology Architectre. Next we conclude our discussion about IESF.

IV. CONCLUSION AND RECOMENDATION

In this paper, we present the Indonesian E-Agriculture Strategic Framework (IESF) using TOGAF Enterprise Architecture approach. There are four domains in the framework: Business (BA), Application (AA), Data (DA), and Technology Architecture (TA). BA defines the business domains, business functions, business processes, and governance, policy, and resources of the organization in agriculture area. AA provides a blueprint of the application systems (software applications), the interaction between systems (interfaces between applications), and the user interfaces. DA describes the structure of an organization's logical and physical data assets and the associated data management resources. Finally, TA describes the hardware, software, and network infrastructure needed to support the deployment of core application. This IESF provide guidelines for deploying ICTs for sustainable development in agriculture area.

There are several important points to be noted before implementing the IESF technological architecture:

- Formulate ICT governance, policy, and resources for IESF sustainability;
- Ensure the interoperability between applications through the usage of standardized data, open standard technologies, etc.;
- Formulate Certificate of Authorities (CA) and Public Key Infrastructure (PKI) to manage data accessibility;
- Collaboration with Research and Development (R&D) institutes in IESF is essential for agricultural sustainability.

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