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External Services and their Integration as a Requirement in Developing a Mobile Framework to Support Farming as a Business via Benchmarking: The Case of NM-AIST

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ABSTRACT

Research on agricultural and rural development (ARD) systems in general, and farming as a business (FAAB) in particular, face the limitation of availability of credible and reliable benchmarking data, both for on-farm support for farm management decision making and off-farm support for research, investment and policy decision making. One of the main part of this limitation is to obtain reliable benchmarking data for decision making, both for current conditions and under scenarios of changed bio-physical and socio-economic conditions. This paper presents a framework for mobile application development to support farming as a business via benchmarking (FAABB). This is done with a model that distinguishes between internal and external sources of data and between codified and computed information. Also, the paper demonstrates and emphasizes how integration should be considered as a requirement when developing a typical mobile application for ARD. The paper ends with a description of an ongoing research project at Nelson Mandela African Institution of Technology (NM-AIST) in Tanzania that aims to develop a new framework to facilitate development of mobile applications for FAABB.

Keywords: Agricultural and rural development (ARD), farming as a business via benchmarking (FAABB), m-apps frameworks.

1 Introduction

The evolution of the Internet has sparked the development of mobile applications to solve diverse problems in rural communities through online connectivity, removing the limitations of time and distance[1]. Specifically, farming systems for agricultural and rural development (ARD) have recently started to engage smallholder farmers in rural areas to use mobile phones for gaining and sharing knowledge in ARD [2], [3]. Of great interest in recent years is the practice of farming as a business via benchmarking (FAABB)[4]. The term 'benchmarking' is a common type of analysis that allows farming community of practice (CoP) and community of interest (CoI) [5](i.e. farmers and other agricultural value chain actors) to compare how farming-as-a-business (FAAB) stacks up to the farm operations, costs expended by inputs and service providers, revenue gained from sales of farm produce, etc.[6]. Benchmarking gives a more transparent look at what success similar farmers elsewhere may be experiencing and how they may be able to reach a similar success from their own farm operations[4]. It

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can also help to analyse farmers' economic health checks or their qualification for attracting better markets.

Despite the good intentions of online systems for ARD in general and FAABB in particular, most smallholder farmers still suffer from knowledge and information deficits e.g. information about good farming practices, recommended seeds, best market for their outputs, etc. [7]. Most of these problems are associated with the **intensity of data required** to undertake meaningful benchmarking activities and **timely availability** of data to guide benchmarking analysis[8]. According to Franzago et al. [9], the mobile phone applications to facilitate decision making for data intensive mobile applications (FAABB) require domain specific frameworks that serves communities of practice (CoPs) and attract an application developer to instantiate the framework for specialized mobile application that serves a community of interest (CoI) [5].

A FAABB framework, either virtual or real, consists of value chains of CoP that all require integrated processing of data for their decision making. The role of integration has, therefore, become more important as CoP web applications have developed from static home pages to dynamic mash-up applications that integrate with CoI through external APIs and communicate with web services. Modern web services allow applications to communicate with standardized languages, like XML and its derivatives, making integration more manageable [10].

FAABB developers need methods and practices that help them approach new kinds of requirements for rapid application development. Available methods and practices (e.g. waterfall and action research) may be outdated. For instance, they do not emphasize the role of external data processing as essential requirement of the mobile application development.

As an ongoing research at Nelson Mandela African Institution of Science and Technology (NM-AIST), the following research question has generated interest: *How should external data services and their integration be considered when developing mobile applications to support farming as a business through benchmarking?* It is established that benchmarking requirements must be viewed in both internal and external contexts. In addition, integration of (potentially many) external knowledge resources must be emphasized in different phases of the FAABB. This paper is organized into six sections. Section II presents the rationale for having a mobile framework for FAABB. Section III presents the key elements of a FAABB framework. Section IV discusses external services requirements and their integration in a FAABB framework. Section V introduces the ongoing research at NM-AIST as a case study, its methodology and preliminary results. Lastly section VI presents the concluding remarks.

2 Rationale for A Dedicated Mobile Framework for FAABB

In the past few years, the role of mobile application frameworks has been increasing [11]. A framework is an arrangement in which a software artefact provides greater functionality that can be extended by mobile application developers' own codes. A framework allows a standardized way of creating applications and provides functions that are reusable. Therefore, frameworks simplify the process of creating mobile applications so that developers don't have to restart from scratch every time they want to write a new mobile application.

Frameworks provide multiple libraries of start-up activities. Frameworks provide ways of processing requests (URL routing system), use new patterns or technologies, and attach third party packages/resources for utilization and offering extendability mechanisms for developers to add in their domain specific codes. A framework provides standardized way of database manipulation and templating (i.e. structured outputs through standard notation like JSON or HTML). Finally, frameworks provide the basic security features of applications as reusable components. Examples of existing frameworks for mobile application development include: Bootstrap, Ionic, jQuery, Xamarin, Appcerellatot, PhoneGap, React Natives, Meteor, Sencha Touch, Ratchet, Mobile Angular UI.

However, these frameworks lack embedment of data for specific CoP domains like FAABB so that mobile application developers targeting those CoPs do not have to remodel them every time they want to write new applications[12]. For example, while there are different instantiations of the concept of "farm", the framework should provide a template for its definition and location-specific data set for, among farm properties, soil structure, animal breeds, plantations, and water contents. Therefore, another layer of domain specific mobile framework driven by CoP is an essential requirement that needs a new design science research (DSR) consideration.

3 Fundamental Elements of A Mobile Framework For FAABB

In order to better understand a domain specific mobile application development framework for FAABB (m-FFAABB), a simplified model was built based on Xin et al.[1] that can be viewed as the key requirements for domain specific mobile framework. A successful m-FFAABB needs the presence of purpose, members, content and technology.

As indicated in Fig. 1, business logic defines the **purpose** for m-FFAABB and should be established at the first place. A business logic for m-FFAABB can serve the interest of FAABB CoP as **primary** members and in turn attract farmers in a FAABB CoI as **secondary** members. In the CoP, members are trying to achieve similar objectives by sharing a common interest. For example, members of FAABB CoP share benchmarking data, suggest benchmarking strategies and exchange benchmarking knowledge with each other. A mobile application developer may want to enhance the collaboration and information sharing between farmers, their markets and input suppliers as an online CoP for FAABB. The members of a CoI have a common passion to engage with the CoP and add value. In FAABB, a CoI can be for example, agricultural researchers, the funders and lenders, policy makers, advertisers, revenue collection agencies, etc.

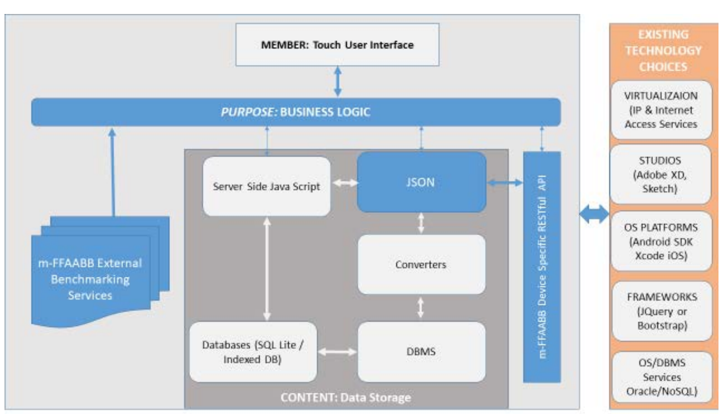

Figure 1: The FAABB Framework Components.

A practitioner (e.g. an extension officer) through a smart phone is the primary user as well as a contributor in a FAABB framework, and needs other CoP actors in order to exist. CoP actors create the **content** for the FAABB framework and very often they also participate in maintenance activities to keep the framework organized.

A m-FFAABB needs a technology platform that consists of one or several applications that are created with different web technologies. Discussion forums, blogs, database management systems, media sharing tools, geographical information systems and virtual words are examples of these applications. When building FAABB framework, different technology strategies can be used. The platform can be implemented with different application programming interfaces (APIs)[13], by using different platforms or with content management systems (CMS)[13]. Existing specialized online applications, such as climate and weather forecast systems[14], or disease control systems[15] can also be included as modeling platforms in m-FFAABB.

4 Requirements In Data Intensive Mobile Frameworks

Although data requirements in FAABB mobile apps are in many ways similar to mobile apps in other domains, there are also many differences. Mobile applications for FAABB are data intensive applications[9]. Data-intensive applications handle datasets on the scale of multiple terabytes and petabytes. Datasets are commonly persisted in several formats and distributed across different locations. The processing requirements scale almost linearly with the data size, and they can be easily processed in parallel. They also need efficient mechanisms for data management, filtering and fusion, and efficient querying and distribution.

Arguably, the m-FFAABB is a broader domain than, for example, a single system design for a crop specific agricultural environment and therefore requirement specification for m-FFAABB differs significantly from traditional single system design and development. In traditional software development models, requirements are gathered from the problem description and from the stakeholders [16].

For instance, we can consider designing a marketing software for maize farmers as an example of traditional requirement gathering and analysis. A company providing mobile app gets specifications of maize and can interview farmers from each grassroots economic group and ask their maize quality and specification. These can then be programed and benchmarking computed against the available market requirements. The mobile apps then need to capture the available markets and their requirements and compare them with the embedded farmer’s produces.

When developing m-FFAABB to be used by an unknown number of anonymous m-app users, it is impossible to, for instance, interview them all and ask what they want − especially before the mobile app release. This is why the requirements specification needs to be divided into two levels: external and internal sources of requirements, relative to the farms under consideration.

Table 1 presents four different regions of requirement specification, which took place after the idea of developing m-FFAABB was reached. The horizontal axis defines the data acquisition mechanism. The left part is process and stage phase before sharing and the right part is the connect and exchange part. The vertical line in the middle is the time when the m-FFAABB goes online. The right side shows the time when the m-FFAABB is in use and it is refined. In the traditional software development, this could be seen as the maintenance phase of the software life cycle.

Table 1: A template for gathering requirements for data intensive applications.

External Source	**Data Requirements based on External Processing** • Third party apps • Specialized labs • Internet of Things (IoT) • Collaborators • Public Domains (Twitter, YouTube, etc.) • Cloud Computing Services	**Data Requirements based on external codification** • Internet Services • Electronic libraries • Big Data Resources • Common Data Exchange (CDX) Services • Cloud Storage services • KYC services
Internal Sources	**Data Requirements based on internal processing** • Business requirements generators • Modeling tools • Design tools • Code generators • Report generators	**Data Requirements based on Internal Codification** • Data bases • Document management tools • E-Mail Servers • Identity management tools
	Process & Stage	**Connect and Exchange**

The lower part of Table 1 presents internal sources of requirements. The whole lower part could be seen as the ideal traditional enterprise system development process supported by standardised toolkits that come along with the m-FFAABB. All the requirements come from the customer and most of them exist before the development starts. In real life of m-FFAABB, developers will standardise their specification through selected business requirements generators, modelling tools, design tools and code generators, and report generators. New data requirements that emerge during the refinement are traditionally treated as being part of maintenance and they represent a large portion of the framework life-cycle costs. In m-FFAABB development, the changes cannot be called as "maintenance", because improvements are essential for the public success of the system. Therefore, the refinement is a continuous and active process. The new versions with improvements are codified as soon as they can be used through m-FFAABB embedded tools like data bases management systems, document management tools, e-Mail servers, identity management tools, etc.

Also, Table 1 makes the distinction between internal and external sources of requirements. By external we mean here something that does not come from the customer. External requirements may come from other similar applications or they may be something that has even not been invented yet, but so important that they can give an advantage to the m-FFAABB or be even crucial to its success. When considering the upper left corner of Table 1, we are talking about observing the web for new services, to identifying relevant third party applications, teaming up with specialized labs, connecting to the Internet of Things (IoT), working with collaborators, integrating with public domains (e.g. Twitter, YouTube, etc.), and subscribing to cloud computing services. Competitor and trend analyses are the activities to be performed there.

4.1 A. External Data as a Requirement in m-FFAABB

Data requirements m-FFAABB are considered from three complementing views. Benchmarking data for farm characterization, farm optimization, and farm monitoring and evaluation (M&E). Figure 1 presents these views in a three layered data architecture.

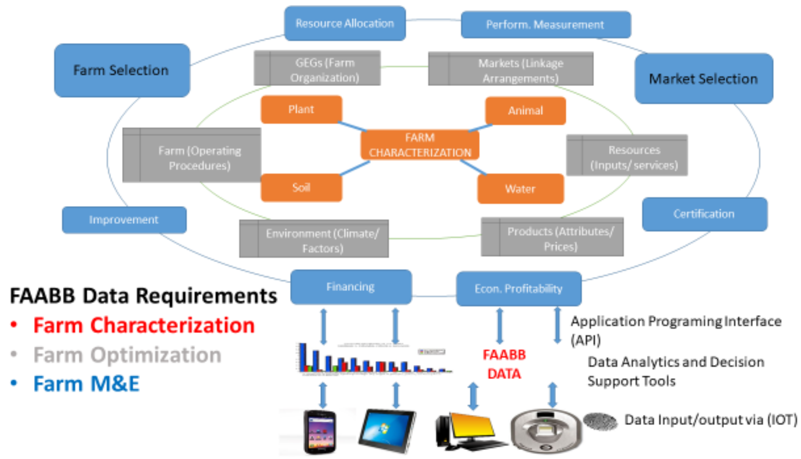

Figure 2: m-FFAABB Common Data Requirements

As shown in Fig. 2, the first view is a farm characterization view. Every farming process requires an understanding and characterization of its farm. At the centre of this characterization is the understanding of the soil structure, water contents, animal breeds and their structure, and plant seedlings and their properties[12]. The farm structure and its characterization for a given location and season is naturally an invariable constituent whose data can be collected, codified and reused over time for the purposes of benchmarking modelling. At its basic level, the farm manager or extension officer (as a critical member of CoP) intends to engage smallholder farmers in farming as a business, conducts benchmarking in order to identify the suitability of the breed or plant to be grown on a given farm location for a given season. To do this benchmarking modelling requires the availability of external data, with similar ecological setup, through which comparative analysis can be conducted to make choices on the type of breeds to encourage for achieving farming as a business. In rural setups, the extension officer applies the benchmarking results for selection of grassroots economic groups (GEGs) to achieve economies of scale. Therefore, online benchmarking is constrained by the availability of external data to be provided by the CoP external to the farm under consideration.

Once the decision to farm is made, the farm manager requires additional farm inputs and extension services in order to optimise the production[17][18]. The common data requirements for undertaking benchmarking for farm optimization is the second view (marked grey in Fig. 2) which includes identifying (i) environmental conditions and their influence on farm production, (ii) product quality attributes preferred by the market providers, (iii) availability of farm inputs and resources from the suppliers, and (iv) farm operating procedures imposed by local authorities. Again, for a given location and season, this data is potentially static and once provided by members of CoP, it can be codified and reused for facilitating benchmarking activities for farm retuning.

The third view (marked blue in Fig. 2) is the availability of benchmarking data for monitoring and evaluation[19][19]. The CoI influences the decisions for continuing to engage in the same farming at the end of the season and provides information that influences changes in both the farm characterization and optimization requirements. By nature, CoI is external to the operations of farm and provides data necessary for undertaking benchmarking for: (i) farm profitability to determine the economic viability of the farming business, (ii) resource allocation and utilization to determine their influence on farm yield, (iii) farming process audit for the purpose of certification, (iv) market pricing structures for the purpose of selecting the preferred market for a given commodity, (v) farm performance evaluation for the purposes of applying for additional financing, etc. A greater part of data required for undertaking such benchmarking from CoI is relatively static and can be codified and reused overtime through various modelling.

In the absence of a framework for capturing and codifying such data and information to facilitate benchmarking, mobile applications to support FAABB will be expensive to build since developers of specific apps may have to develop and manage tens if not hundreds of APIs for every FAABB use case. Embedding these external data and their structures in a m-FFAABB is definitely a major boost for mobile apps developers. The m-FFAABB will not only continuously collect necessary data from various potential sources but also codify them for the purposes of reuse by mobile application developers.

Unfortunately, to date there is no single institution in Tanzania that provides support for FAABB external benchmarking. Mobile apps developers are individually struggling to acquire external data but end up being frustrated because most of the data needs subscription and fees for their access.

4.2 B. Data Integration as a Requirement in m-FFAABB

In Section IV (A), we discussed the difference in the nature of requirements in generic mobile frameworks and data intensive m-FFAABB. There is also another difference that is more technical or functional by nature: integration. The main motivation for performing integration as part of the framework is that it is often more reasonable to use existing information, functionality and services rather than reinventing the wheel [20]. For example, if the application needs to show weather forecasts or use location services, it is reasonable to use existing APIs and web services to have this functionality. Although there is not much published research available about integration in mobile frameworks, the world economic forum[21] has developed guidelines to be used when building partnerships for sustainable agriculture and food security. Integration requirements in m-FFAABB are considered from complementary views: integration through a common system of access and use in developing mobile apps or integration through a central data exchange (CDX) system. Figure 3 presents an architecture for realising these views[22].

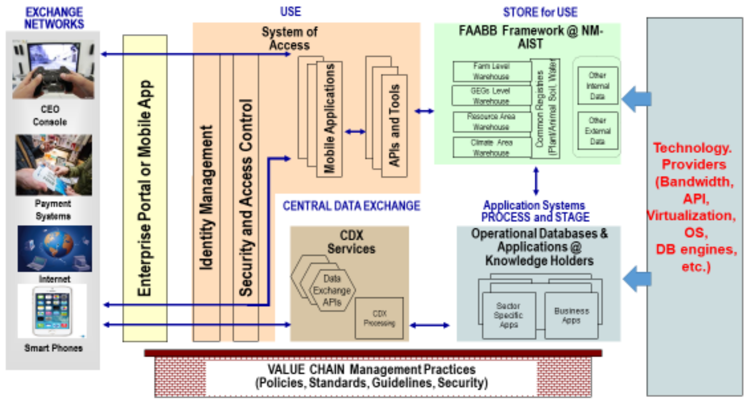

Figure 3: The enterprise architecture and its orientation to support m-FFAABB.

4.2.1 Integration through a Common System of Access and Use

When considering the business model one can decide to use m-FFAABB service to fabricate a mobile application using framework placeholders to external content and service providers. If the external content provider has some chargeable content, the m-FFAABB can use, for example, PayPal to get their payment. Through m-FFAABB (as a common system of access), application developers can aggregate data from other sites, integrate to e.g. maps from Google, and weather forecast from weather channels. Authentication can be made, for instance, through Facebook or OpenID. By integrating to existing m-FFAABB tools and services, frameworks save time and money and get quality service to application developers to start building their own mobile apps quickly.

After the framework is launched it is important to see how developers, CoP and CoI members come to the framework and what they are looking for. There are analytical tools to be integrated with in order to see what is happening in the framework application. It is possible to see what content people are looking for and how long they stay in the framework by using analytics tools. Also, content management systems (CMS) provide their own tools, for instance, to see what search words have been used. A framework should therefore be seen as a system of use by providing standard APIs and ready-made tools for fabricating mobile applications as Instances of m-FFAABB.

4.2.2 Integration through Common Data Exchange Services

Integration is more than just having m-FFAABB prefabricated applications. It involves connecting to third party applications that are already providing the services required by CoP and CoI. In Fig. 3, the Central Data Exchange (CDX) is the portal for entry for FAABB data in Tanzania as well as the node on the FAAAB Information Exchange Network, which links extension officers, the CoP, and CoI stakeholders over the Internet. Most of the development to date has focused on submitting information electronically, but the CDX can support paper, magnetic media and optical media submissions as well. In brief, CDX provides the following services: receives data, either in paper or electronic form, performs security and archiving functions, edits data and converts formats, distributes the data to CoP and other CoI appropriate systems, and supports external users.

The CDX offers industry, states, tribes, and other stakeholders a faster, easier, and secure reporting option. CDX provides built-in quality checks, standard file formats, and a common, user-friendly approach to exchanging data. As part of e-government initiative, CDX will help ensure that both the public and regulators can access the information needed to document farm performance, understand environmental conditions, and make sound decisions to assist smallholder farmers.

For the application developers, CDX:

- eliminates redundant infrastructure and its associated cost;
- Enables faster, lower-cost implementation of new or modified data flows;
- Integrates data to Agency data repositories;
- Establishes consistent procedures for electronic signatures;
- Decreases time to make information publicly accessible;
- Improves data quality;
- Reduces record management costs by eliminating redundant record keeping; and
- Establishes NM-AIST's presence on the Global Information Exchange Network;

For Industry, Government and researchers, CDX:

- Reduces overall reporting burden;
- Improves access to data;
- Reduces time and costs associated with benchmarking data submission requirements;
- Simplifies reporting to a single point in the Agency instead of many separate Programs;
- Allows faster securing of submission through built-in edit and data quality checks;
- Improves security and transmission of confidential business information (CBI) through registration and authentication;
- Reduces burden of complying with new or changing requirements;
- Streamlines reporting through the Exchange Network and Web Services.

5 THE m-FFAABB CASE STUDY AT NM-AIST

As a contribution to ARD for Tanzania, a Design Science Research (DSR)[23] through Soft Systems Methodology (SSM)[24] was established at Nelson Mandela African Institution of Science and Technology (NM-AIST), to spearhead the development of m-FFAABB. DSR involves a rigorous process to design artifacts to solve observed problems, to make research contributions, to evaluate the designs and to communicate the results. DSR not only helps to build innovative artefacts, but also to codify knowledge about creating other instances of artefacts that belong to the same class [25]. Existing iterative methodologies applied to DSR include prototyping methodology (PTM), action research methodology (ARM) and Soft Systems Methodology (SSM). After considering all these possible methodologies, the SSM was found suitable and therefore chosen for managing iterations for DSR in developing m-FFAABB.

5.1 Methodological Approach for Developing m-FFAABB

The Soft Systems Methodology (SSM) is suited for dealing with ill structured complex problem situations that have human activity component [24]. SSM is a prominent systems science approach to social-technical problems. Since it emerged from the juncture of action research and systems science, it is regarded as a form of action research. SSM differs from other methodologies that try to solve hard problems that are technologically oriented. Soft problems are complex while hard problems are easy to define in such a way that the HOW and WHAT can be defined before obtaining a solution [26].

As shown in Fig. 4, an artefact of a DRS can be defined as a framework (vocabulary and symbols), a model (abstractions and representations), a method (algorithms and practices) and an instantiation (prototype systems) [19]. Producing the m-FFAABB as an artefact is the most important property of DS and a desire for NM-AIST to develop as part of its contribution to Agricultural and Rural Development (ARD). The quality and efficiency of the framework shall be evaluated constantly through Soft Systems Methodology (SSM)[24]. This way, DSR also has a dual nature: to make theoretical contributions and to assist FAABB practitioners in their problem solving. DSR through SSM is going to be utilized in the project. In the first phase of the DSR process, a through literature review was undertaken to determine the problem and motive for FAABB. A problem was discussed with all the stakeholders of the project and requirements for the CoP have been gathered as a real world of concern for FAABB in Tanzania (through SSM).

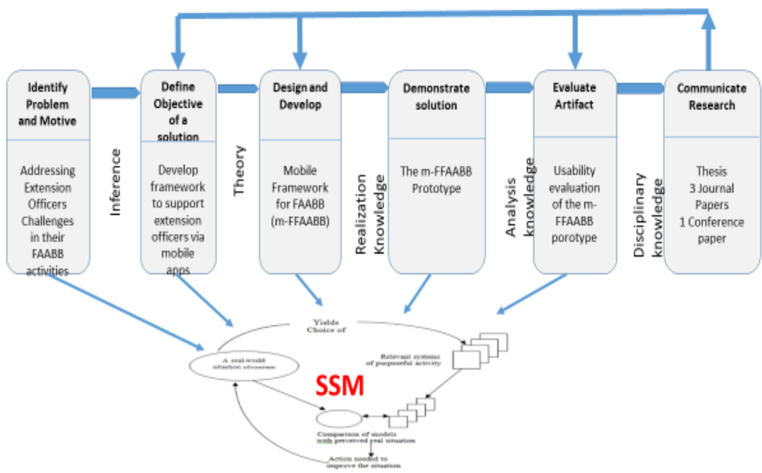

Figure 4: The Design Science Research (DSR) through Soft Systems Methodology (SSM) Iterations

A shorter version of SSM as advocated in [26] was adopted as a means of iterations for m-FFAABB DRS (see Figure 5). In SSM, the problem situation which exists in a real world of ARD must, first, be identified by the researcher. Then relevant systems of purposeful activities are selected with the purpose of improving the situation of concern. The purposeful activities involve any system/action which is implemented to improve the problem situation. The models from the relevant systems are then compared with the perceived real world and again purposeful action is taken to improve the problem situation. This mostly initializes another cycle of problem solving; thus the process is a cyclical process.

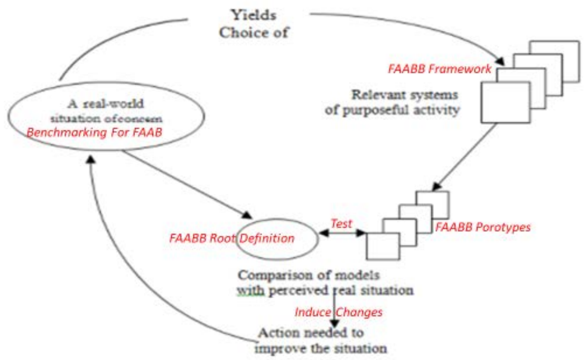

Figure 5: A shorter version of SSM adopted for FAABB.

5.2 Basic Components of m-FFAABB

As mentioned in Section III, the m-FFAABB needs the presence of the four foundations i.e. the purpose, members, content and technology.

FAABB Purpose: Figure 1 present the purpose of m-FFAABB (also defined through SSM as a root definition for FAABB) consisting of five basic benchmarking goals in conducting farming as a business: stage1 (domain recognition), stage2 (the product characterization), stage 3 (farm management), stage 4 (limiting factors control) and stage 5 (post farming evaluation) [12].

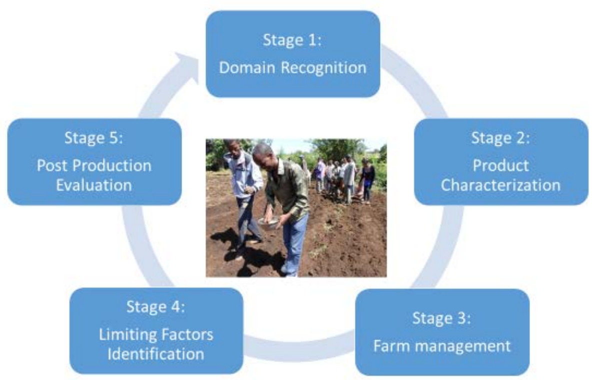

Figure 6: FAABB Process Lifecycle (As a root Defining).

FAABB Membership: In establishing the membership for m-FFAABB, we initially defined the CoP consisting of four members: the extension officers (Eos) in rural settings who need benchmarking information to assist their farmers to undertake farming as a business, the potential market providers for various products produced by farmers and their standard requirements, the potential inputs and service providers to farms and their services, and the local government who sets the compliance rules of the production environment. The CoI of the m-FFAABB were latter defined as part of the definition of external service providers.

FAABB Content: The basic content and their structures for m-FFAABB were developed and simulated through a requirement specification template presented in Table 1. These components as shown in Fig. 7 provide a set of benchmarking content generated through process and stage components (shown in fig. 7 as boxes with round edges) as well as connects-and-exchange components (shown in fig. 7 as rectangular boxes). The interconnection and interrelationships were designed to operate through a system of integration that included two extra components i.e. "FAABB knowledge-codifier" and "FAABB data-collector" components.

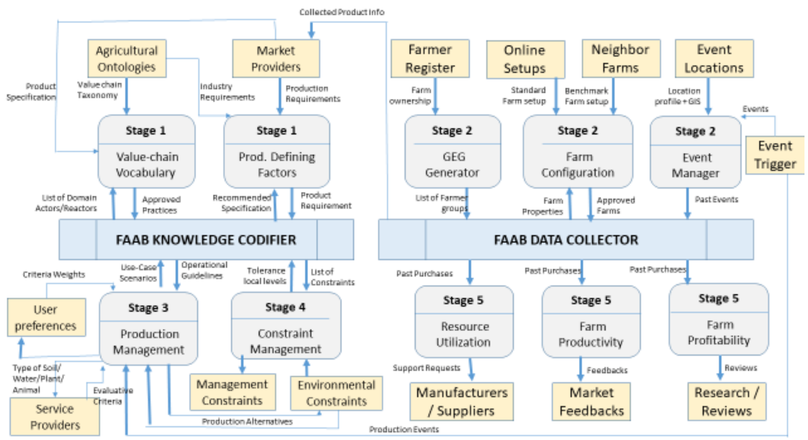

Figure 7: Components of m-FAABB Business Logic

FAABB Technology Choices: The technology choices were largely influenced by locally available software development companies interested in developing mobile apps for ARD. There are already few application developers that have adopted the m-FFAABB to develop their applications (e.g. Kilimo Maendeleo) which focuses on crops sub-domain of agriculture.

The system was developed and deployed based on Infrastructure-as-a-Service ("IaaS"), which is a form of cloud computing that delivers fundamental computing, network, and storage resources to consumers on-demand, over the internet, and on a pay-as-you-go basis. In an IaaS model, a cloud provider hosts the infrastructure components traditionally present in an on-premises data center, including servers, storage and networking hardware, as well as the virtualization or hypervisor layer. The IaaS provider also supplies a range of services including detailed billing, monitoring, log access, security, load balancing and clustering, as well as storage resiliency, such as backup, replication and recovery.

As shown in Fig. 8, the configuration supports the bus or pipeline architecture where each submodule could be added as it is developed and integration through data exchange between modules is seamlessly addressed. On the left and right of the pipeline are the core modules presented in fig. 8 including both implementing the process and stage components as well as the connect-and-exchange components. Also, integration with extremal resources is managed through dedicated external APIs.

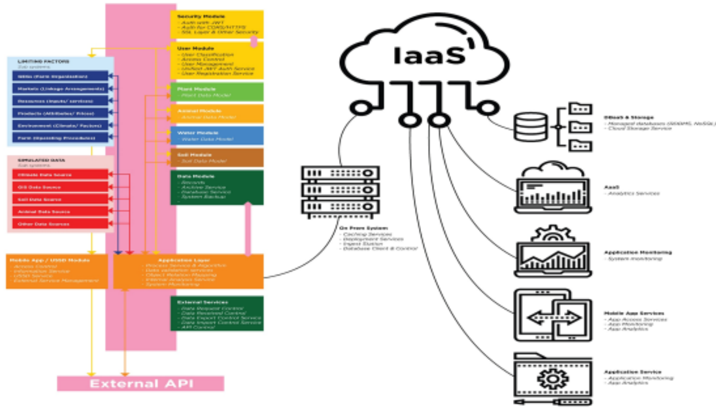

Figure 8: The m-FFAABB Infrastructure implemented through IaaS Architecture.

5.3 m-FFAABB Preliminary Results

The Kilimo-Maendeleo Prototype was developed to provide full functionality for the m-FFAABB components shown in fig. 6 and tested through a number of benchmarking use cases and produced good results. Figure 9, provides a snapshot of modules provided by "Kilimo-Maendeleo" mobile app that has been developed based on m-FFAABB. The system was tested through a number of benchmarking use cases and below only two are presented.

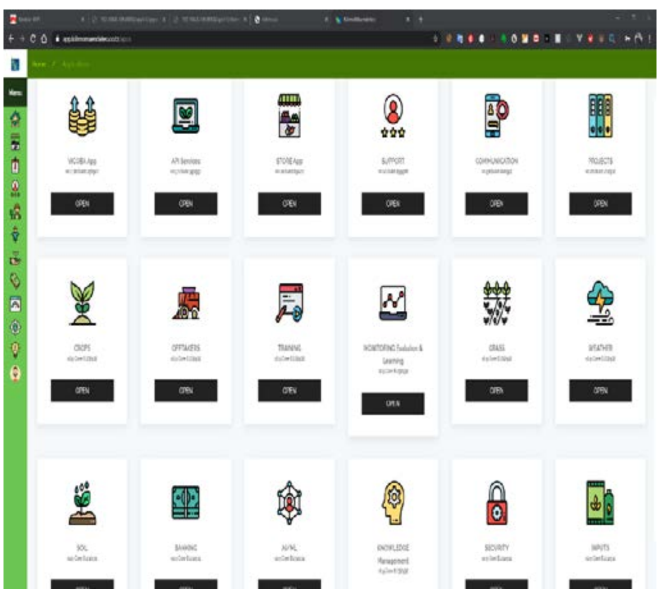

Figure 9: Modules of m-FFAABB Prototype for Crops

Use Case 1: *Benchmarking for farm selection*: It is important to identify areas that are performing well and can be regarded as places to invest-in. Achieving scales of economies to attract good markets requires the involvement of many farmers investing on one product. The enquiry was to identify the regions with potential for maize farming with the benchmark of engaging at least 20,000 farmers.

As shown in fig. 10, both the table at the top right corner and the bar chart at the bottom left corner indicates the best seven regions with high number of maize farmers. These regions exceeded the benchmark of having at least 20,000 farmers involved in maize business.

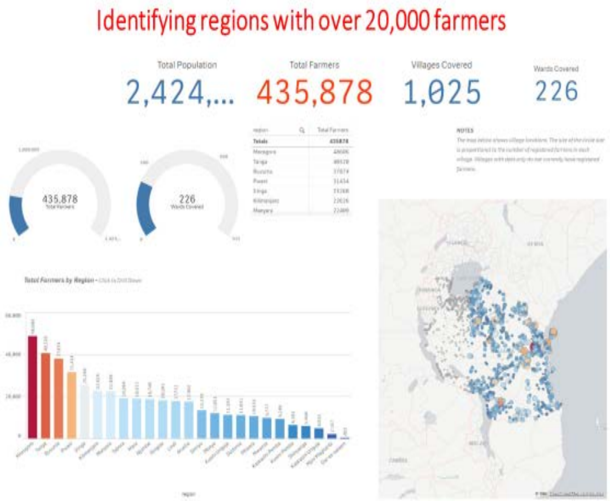

Figure 10: Benchmarking for maize farm selection in Tanzania.

Use Case 2: *Benchmarking for Grassroots Economic Groups (GEGs) performance:* Comparisons of the performance of the smallholder farmer's business with the benchmark farm are made at a Grass-root Economic Group (GEG) level as opposed to individual farmers. These gaps can suggest weaknesses within the farming system and the reasons for them.

As shown on the report (fig. 11), the acreage covered in maize is only 11,620 compared to the total available acreage of 34,767 acres in the Songea rural district in Tanzania. The report further indicates that GEGs in only seven villages contribute to the high number of sales and have the highest reserves that contribute to food security. These revenue differences can suggest areas to influence interventions for low performing GEGs.

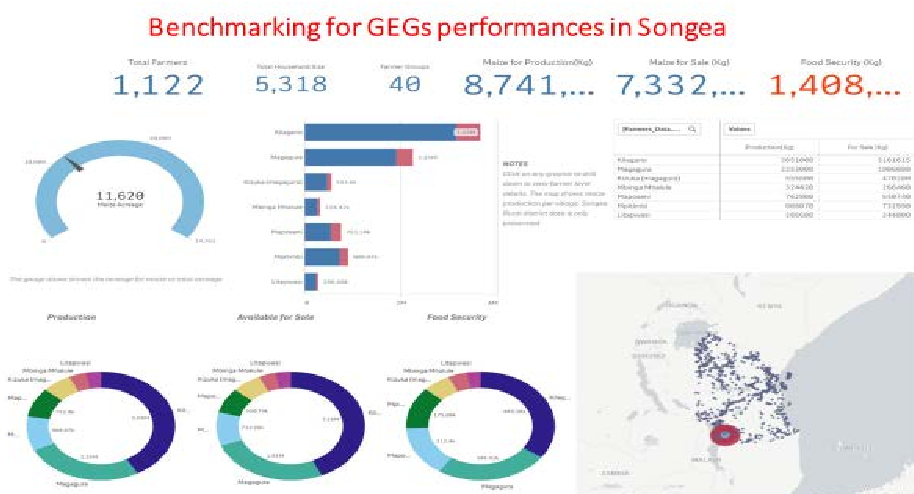

Figure 11: Benchmarking for GEGs performances for Maize Farming in Songea, Tanzania.

6 Conclusion

Presented in this paper is a discussion about how requirements should be viewed in mobile framework development for FAABB. It points out the key role of integration that can be considered at different levels in a mobile application development process. Finally, a proposal for a developing m-FFAABB at NM-AIST is presented and its preliminary results reported. The proposed m-FFAABB uses the DSR through SSM to build a domain specific framework for ARD and produces a new model for rapid development of data-intensive mobile applications to facilitate FAABB.

This research work is at its infancy and will require more case studies and tests in the field before its utility is optimised and realised in solving the real challenges faced by ARD. More m-apps will have to be developed and validated based on this framework. More data will also have to be collected and stored at NM-AIST to provide a wider coverage and make NM-AIST a framework host and external data service provider for m-FFAABB.

Authors invite policymakers, agriculture specialists and practitioners to join the m-FAABB DSR to add own contributions on the current version of the m-FFAABB architecture and m-apps development. Contributions could come from mathematical modelling, m-apps development, technology options, agronomical practices, data collection and data structures, big-data hosting, information security, etc.

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