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Evaluating a Framework for Information Management in E-Agriculture using Expert Opinion

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Abstract:- A number of studies in information systems propose frameworks for addressing envisaged research problems. These frameworks are instrumental in supporting or guiding action in different contexts. It is in rare cases that such frameworks are evaluated to establish their applicability and suitability to the community of practice. This makes such frameworks unusable and redundant amidst the environments for which they are developed. This paper attempts to evaluate a framework for information management in e-agriculture. This framework was proposed by Mugejjera, (2022). A quantitative approach was adopted for this study. Evaluation of this framework was based on expert opinion taking a common criterion focusing on Goal, Environment, Activity and Evolution. A total of 44 experts in information management in the field of e-agriculture was taken. Results show that the framework is composed of the following factors: (i) People and Technology; (ii) Funding, Processes, and Regulations; (iii) Information use outcomes and continuity. The factors labelled (i) and (ii) influence (iii). The framework was found to be valid, reliable and useful in supporting the management of information (agricultural advisory information) in e-agriculture.

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I. INTRODUCTION

Agriculture is a vital sector in a developing economy like Uganda's (World Bank, 2019). ICTs have been used in this sector to avail information and to support different information based agricultural processes in what is called electronic agriculture. Since information is an asset, there is need to manage it (Brous et al., 2020; Eroglu and Cakmak, 2020; DAMA International, 2017). Despite the use of ICTs, access to agricultural advisory information in a developing economy like Uganda's remains problematic. This state of affairs is attributed to inadequate management of agricultural advisory information in e-agriculture. Therefore, Mugejjera (2022) conducted a study to develop a framework for supporting management of agricultural advisory information for small scale farmers engaged in growing of crops aided by ICTs in Uganda's developing economy. The Design Science research method was used to guide the development of this framework. The framework being evaluated in this work was based on a field study using 386 respondents from Uganda's districts of Gulu, Lira, Mbale, Namayingo, Masaka, Wakiso, Mbarara and Ntungamo. Structural equation modeling was used in the design of the framework in order to establish how factors influence one another in the framework.

According to Mugejjera, (2022), the critical success factors for management of agricultural advisory information are: (i) People and Technology; (ii) Funding, Processes, and Regulations; and (iii) Information use outcomes and continuity. The framework is composed of the above factors with (i) and (ii) influencing (iii).

This paper presents the evaluation of this framework based on validity, reliability and usefulness. The framework was evaluated using expert opinion. In the next paragraphs, we present the theoretical foundation for framework evaluation.

II. LITERATURE REVIEW

This section explains the selected evaluation methods among the existing methods and the reasons why these methods were opted for. In addition, this section presents available criteria for artifact evaluation and presents the foundation for the selection of the evaluation criteria employed in this paper.

A. Choice of Artifact Evaluation Methods

There are different examples of artifact evaluation methods documented in literature; among them are the ones documented by Hevner *et al.,* (2004) and Wieringa, (2010). The motivation to select from these methods has been founded, therefore, on their clarity and evidence of their use by prominent researchers.

Hevner *et al.,* (2004) and Wieringa, (2010) categorized the design evaluation methods into three:

- Experiment methods (Field experiment, laboratory experiment and laboratory demo)
- Observational methods (Case study, action research, pilot project, field demo and opinion)
- Descriptive methods (Illustration and benchmark)

For the purpose of this study, opinion was selected for its suitability in this research context. Opinion has been actualized in form of expert opinion. After selecting the design evaluation methods, it was deemed essential to document the criteria for valuation that was followed during evaluation.

B. Criteria for Artifact Evaluation

Criteria for evaluation are essential to enable a uniform yardstick for evaluation of the framework using expert opinion. Prat et al, (2014) provide a detailed criteria and sub criteria. These evaluation criteria fall under five broad dimensions.

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- **Goal.** This dimension includes the following criteria: Efficacy, validity and generality.
- **Environment.** This dimension includes the following criteria: Consistency with people, consistency with organization and consistency with Technology.
- **Structure.** This dimension includes the following criteria: Completeness, simplicity, clarity, style, homomorphism, level of detail and consistency.
- **Activity.** This dimension includes the following criteria: Completeness, consistency, accuracy, performance and efficacy.
- **Evolution**. This dimension includes the following criteria: Robustness and learning capability.

Informed by the information system artifact evaluation criteria described in the previous paragraphs, evaluation of the framework was conducted. The data collection instrument mirrored the criteria described by Prat et al, (2014).

III. METHODOLOGY

To ensure that the framework is accurate in supporting management of agricultural advisory information in e-agriculture in Uganda, it was taken to the community of practice mainly experts in information management. These experts include those who have written papers concerning information management frameworks, small scale farmers, researchers in agriculture and extension workers that have been involved in information management in agriculture. Design Science is the general methodology underlying the evaluation of this artifact in form of a framework. With its roots in engineering and the sciences of the artificial, Design Science is a problem solving method or paradigm that seeks to enhance human knowledge with the creation of innovative artifacts and the generation of design knowledge (DK) via innovative solutions to real-world problems (Hevner, March, Park, and Ram 2004). Design Science has three cycles: the rigor cycle, the design cycle and the relevancy cycle (Hevner *et al.,* 2004). Design science emphasizes iterative activities like construction, evaluation, and refining an artifact based on findings from the community of practice (Hevner, 2007).

A quantitative research approach was adopted in the evaluation of this information management framework. Quantitative methods are suitable because they enable researchers to answer scholarly and practical questions that relate to human interaction with artifacts like frameworks and computer related systems and applications (Avison and Pries-Heje, 2005).

Forty-four (44) practitioners and/or experts in information management (selected authors in information management, small scale farmers, researchers in agriculture and extension workers) were selected to participate in the evaluation of the information management framework. This choice of the number 44 was based on the central limit theory that allows a sample size of 30 or more participants (McLeod, 2019). The researcher targeted scholars who developed related information management frameworks. The other respondents that were considered as experts were those stakeholders in agricultural advisory information management that had been doing this for five and above years. The questions used in evaluation are based on the criteria shown in section 2.2. An online questionnaire was used to collect responses from these experts, afterwards, the data underwent statistical analysis.

IV. RESULTS OF EVALUATION

This section of the paper presents the results of evaluation of the framework for information management in e-agriculture based on the opinion of experts in information management in e-agriculture. Expert opinion plays a significant role in decision making (Beaudrie et al., 2016).

The Evaluated Framework. The framework for information management in e-agriculture that is evaluated in this study is presented below in figure 1 based on Mugejjera, (2022). This framework was obtained based on analysis of agricultural advisory information in e-agriculture and it was therefore named the Framework for Management of Agricultural Advisory Information (FMAAI). FMAAI is the abbreviation that we use for this framework henceforth. FMAAI was based on the framework by Nguyen et al., (2014). It is composed of three factors: Factor 1: People and Technology (PAT), Factor 1: Processes, Funding and Regulations (PFR) and Factor 3: Information Use Outcome and Continuity (IUO). Factor 1 and Factor 2 influence Factor 3.

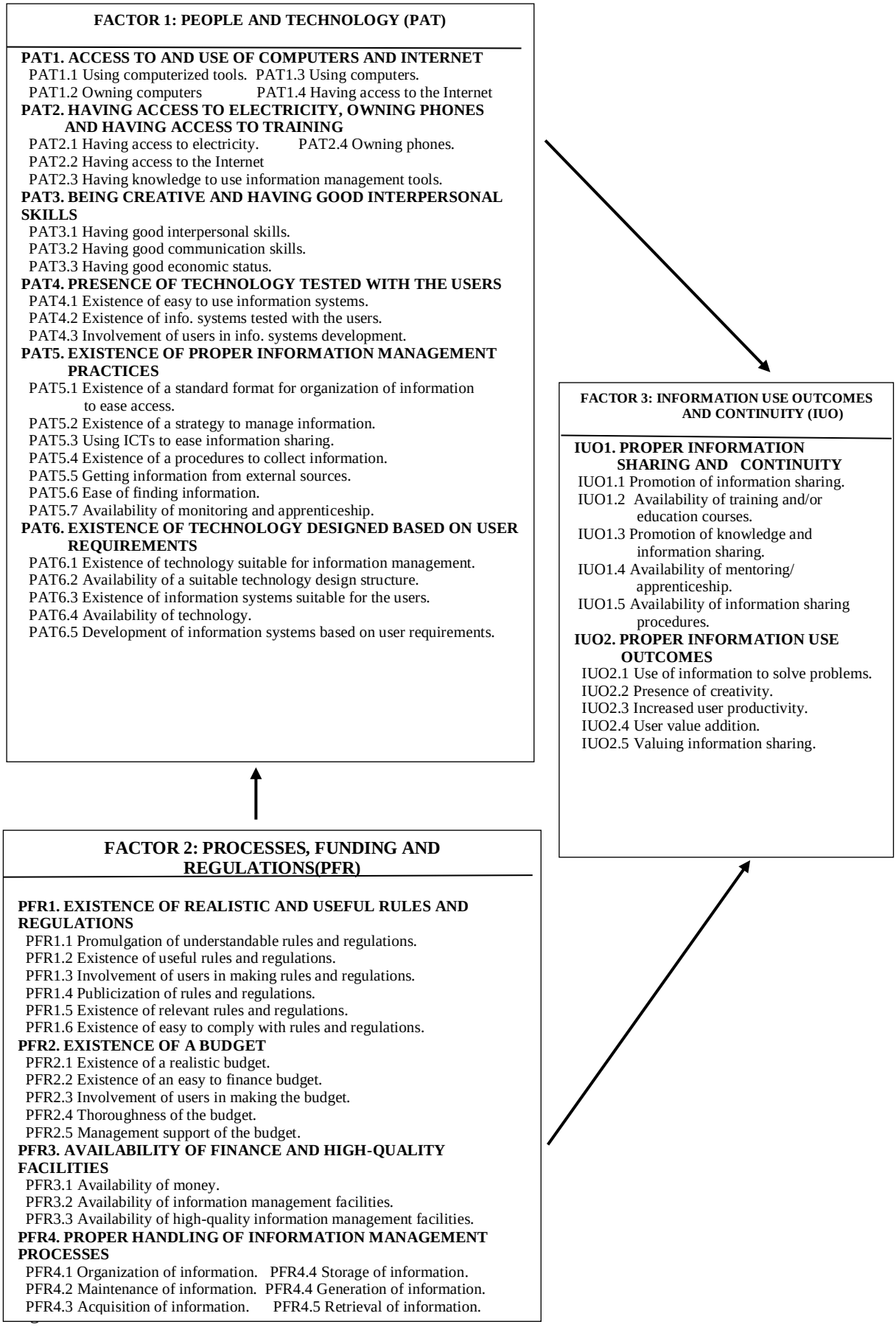

Fig. 1: Detailed Results of Evaluation

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V. DESCRIPTIVE STATISTICS FOR THE FACTOR OF PEOPLE AND TECHNOLOGY

This section presents the descriptive statistics of respondents to the validation questionnaire. These questions were composed based on the critical success factors that influence agricultural advisory information management as highlighted in the FMAAI. Statistics on how different respondents agree or disagree with these factors that form the framework are presented.

Code	***Rate how these People and Technology factors (as they appear in the FMAAI) support management of agricultural advisory information in e-agriculture in Uganda.***	***Mean***	***Standard Deviation***
SF2	*Access to electricity, phones and information management training* supports management of agricultural advisory information in e-agriculture in Uganda.	4.622	0.716
SF1	*Access to and use ICTs like computers and Internet* supports management of agricultural advisory information.	4.422	0.657
SF14	*Proper information management practices* support management of agricultural advisory information.	4.511	0.549
SF8	*Testing Technology used for information management with the users* supports management of agricultural advisory information.	4.489	0.506
SF7	*Designing Technology used for information management based on user requirements* supports management of agricultural advisory information.	4.622	0.576
SF4	*Creativity and good interpersonal skills of people involved in information management* support management of agricultural advisory information.	4.533	0.589
	Any other, please specify		

Table 1: Responses from the CSF 1: People and Technology

VI. INTERPRETATION OF FINDINGS UNDER THE FACTOR OF PEOPLE AND TECHNOLOGY

In this section we sum up the respondents' responses as presented in table 1 in order to obtain the mean of responses by using strongly agree (SA) as 5, agree (A) as 4, Not Sure (NS) as 3, disagree D as 2 and Strongly Disagree (D) as 1. The interpretation of findings from the questionnaire representing the key factors that constitute the FMAAI is presented below based on table 1:

From table 1, a mean of 4.622 of responses confirm that *Access to electricity, phones and information management training* supports management of agricultural advisory information in e-agriculture in developing economies like Uganda's. From the same table 1, the standard deviation from the mean is a low value of 0.716 meaning that the responses deviate from the mean with a low value. This makes the sub-factor (SF2) as it appears in the framework in figure 1 pass the test of experts and/or practitioners in managing agricultural advisory information. This factor is therefore retained as part of the framework.

A mean of 4.422 (tending to strongly agree) confirm that *Access to and use ICTs like computers and Internet supports management of agricultural advisory information.* This makes the sub-factor (SF1) as it appears in the framework in figure 1 pass the test of experts and/or practitioners in managing agricultural advisory information. The deviation from the mean is a low value of 0.657. This factor is therefore retained as part of the framework.

The responses provide a mean of 4.51 (tending to strongly agree) confirming that *Proper information management practices support management of agricultural advisory information.* This makes the sub-factor (SF14) as it appears in the framework in figure 1 pass the test of experts and/or practitioners in managing agricultural advisory information. The deviation from the mean is a low value of 0.549. This factor is therefore retained as part of the framework.

The responses provide a mean of 4.489 (tending to strongly agree) confirming that *Testing Technology used for information management with the users supports management of agricultural advisory information.* The deviation from the mean is a low value of 0.506. This makes the sub-factor (SF8) as it appears in the framework in figure 1 pass the test of experts and/or practitioners in managing agricultural advisory information. This factor is therefore retained as part of the framework.

A mean of 4.622 (tending to strongly agree) confirm that *Designing Technology used for information management based on user requirements supports management of agricultural advisory information.* The deviation from the mean is a low value of 0.576. This makes the sub-factor (SF7) as it appears in the framework in figure 1 pass the test of experts and/or practitioners in managing agricultural advisory information. This factor is therefore retained as part of the framework.

The responses provide a mean of 4.533 (tending to strongly agree) confirming that *that Creativity and good interpersonal skills of people involved in information management support management of agricultural advisory information.* The deviation from the mean is a low value of 0.589. This makes the sub-factor (SF4) as it appears in the framework in figure 1 pass the test of experts and/or practitioners in managing agricultural advisory information. This factor is, therefore, retained as part of the framework.

In summary, all the factors specified under people and technology in the framework in figure 1 pass the test after evaluation by experts and/or practitioners in managing agricultural advisory information. All these factors pass with the values of mean tending to strongly agree and with small values of standard deviation (the responses do not

deviate widely from the mean) making it reasonable to accept these factors as part of the FMAAI.

In addition to the questions that tested if the availed factors (those factors as they appear in figure 1) under people and technology, are suitable to be part of the framework, the respondents were provided with an unstructured question that enabled them to add any other factor that they feel appropriate, as experts and/or practitioners in agricultural advisory information management, to be part of FMAAI. Their responses are provided below:

SF7: Any other, please specify 44 responses
None
Easy to use technologies.
User friendly technology should be emphasized. ***(CSF1...SF8... ..1)***
Nothing more
Record keeping ***(CSF2 ...SF9 ...4)***
Must, be down to the farmers to get more information ***(CSF1 ...SF7 ...4)***
User friendly with appropriate and simplified language that avoids Jargon ***(CSF1..SF7 ...3)***
Ease of use of the technology should be considered at both the input and output level e.g. report generation ***(CSF1 ...SF8 ...1)***
Nothing for now
People using information management should be trained ***(CSF1 ...SF2 ...3)***
We are using a web-based application ***(CSF1 ...SF14 ...3)***
N/A
Involve the end user in doing this so that they can accept it as their own ***(CSF1 ...SF8 ...3)***
n/a
Usability & user interface design shd also be emphasized ***(CSF1 ...SF8 ...3)***
Some villages have a challenge of network ***(CSF1 ...SF1 ...4)***
*The information channel or system should be affordable (****MF1 ...SF4 ...3)***
*Different languages should be considered (****CSF1 ...SF7 ...3)***
information should be tailored to critically address the prevailing challenges in a given setting, hence should be specific to a given area.
Training in simple relevant ICT packages to small scale farmers ***(CSF1 ...SF2 ...3)***
Timeliness of information
Not really

Fig. 2: Respondents suggesting another factor.

All the factors that the respondents highlighted as suitable additions to the FMAAI are presented. The highlights indicate where those additions were already catered for in the framework that was taken for evaluation (see figure 2). For example, if the highlight is like (***CSF1 ...SF2 ...3)*** this means that the item suggested has been catered for already under CSF 1, sub factor 2, item number 3. It is evident therefore that most of the suggested additions had already been catered for. Nevertheless, two main suggestions (as bolded above) that is (**information should be tailored to critically address the prevailing challenges in a given setting, hence should be specific to a given area.) and (Timeliness of information)** are worth of particular attention.

Although these two attributes (suitability and timeliness of information) are key, attributes of information in this research were not investigated and thus were taken as a given. These attributes therefore, although highlighted by experts and/or practitioners in agricultural advisory information management in e-agriculture, have not been included as factors in the FMAAI for that reason.

VII. DESCRIPTIVE STATISTICS FOR THE FACTOR OF FUNDING, PROCESSES AND REGULATIONS

This section of the questionnaire focuses on the second major factor of the FMAAI. Findings from this section are presented in the table 2 below. The questions requested respondents to present their level of agreement or disagreement with the following assertions.

Code	***Rate how these funding, processes and regulations factors support management of agricultural advisory information in e-agriculture.***	***Standard Deviation***	***Mean***
SF10	*Realistic rules and regulations that govern information management* support management of agricultural advisory information in e-agriculture.	4.422	0.657
SF12	*A good budget for information management* supports management of agricultural advisory information in e-agriculture.	4.556	0.687
SF11	*Finance and high-quality facilities for information management* supports management of agricultural advisory information in e-agriculture.	4.267	0.504
SF9	*Proper handling of information management constituent processes like acquisition and storage of information* supports management of agricultural advisory information in e-agriculture.	4.489	0.589
	Any other, please specify.		

Table 2: Responses from the CSF 2: Funding Processes and Regulations

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VIII. INTERPRETATION OF FINDINGS UNDER FUNDING, PROCESSES AND REGULATIONS

In this section we sum up the respondents' responses as presented in table 2 in order to obtain the mean of respondents that strongly agree (SA) (5), those that agree (A)(4), those that are not sure (NS) (3), those that disagree (D) 2 and finally those that strongly disagree (DA) 1. The interpretation of findings from the questionnaire representing the key factors that constitute the FMAAI is presented below based on table 2:

A mean value of 4.422 (tending to strongly agree) accepted *that Realistic rules and regulations that govern information management support management of agricultural advisory information in e-agriculture.* The standard deviation from the mean was 0.657 which is a small value meaning that the responses did not deviate greatly from the mean. This makes the sub-factor (SF10) as it appears in the framework in figure 1 pass the test of experts and/or practitioners in managing agricultural advisory information. This factor is therefore retained as part of the framework.

A mean value of 4.556 (tending to strongly agree) accepted that *a good budget for information management supports management of agricultural advisory information in e-agriculture.* The standard deviation from the mean was 0.687 which is a small value meaning that the responses did not deviate greatly from the mean. This makes the sub-factor (SF12) as it appears in the framework in figure 1 pass the test of experts and/or practitioners in managing agricultural advisory information. This factor is, therefore, retained as part of the framework.

A mean value of 4.267 (tending to strongly agree) accepted *that Finance and high-quality facilities for information management supports management of agricultural advisory information in e-agriculture.* The standard deviation from the mean is a small value of 0.504. Therefore, the sub-factor (SF11) as it appears in the framework in figure 1 passes the test of experts and/or practitioners in managing agricultural advisory information. This factor is therefore retained as part of the framework.

A mean value of 4.489 (tending to strongly agree) accepted *that Proper handling of information management constituent processes like acquisition and storage of information supports management of agricultural advisory information in e-agriculture.* The standard deviation is 0.589 which is a very small value of deviation from the mean. This makes the sub-factor (SF9) as it appears in the framework in figure 1 pass the test of experts and/or practitioners in managing agricultural advisory information. This factor is therefore retained as part of the framework.

In summary, all the factors specified in the framework in figure 1 relating to funding, processes and regulations, pass the test after evaluation by experts and/or practitioners in managing agricultural advisory information. All these factors pass with a mean above 4.2 making it reasonable to accept these factors as part of the FMAAI.

The other question that required respondents to provide additional factors to those that had been specified in the structured questions. In this section, we provide the findings from that unstructured question in figure 3:

SF12: Any other, please specify14 responses
None
Nothing more
n/a
N/A

Quality of information managed.
None

Source of information should be supervised

Fig. 3: Respondents' suggestions of additional fact*ors*

From the above responses in figure 3, two are of specific importance (Quality of information managed) and (Source of information should be supervised). These factors or attributes are attributes of information which were taken as a given in this research. Based on this reasoning, we do not append these attributes to the FMAAI.

Based on Prat *et al.*, (2014), the framework was also subjected to evaluation to establish if the goal, environment, structure, activity and evolution criteria were met by this FMAAI. Below are the findings from that evaluation. Table 3 provides responses about those criteria (Goal, environment, Structure, Activity and Evolution) from respondents that were contacted.

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	Rate how you agree or disagree with the following factors related to goal of the Framework	***Mean***	***Standard Deviation***
	I think the components of the framework as presented in section A and B are logical	0.603	4.334
	I think the components of the framework as presented in section A and B can support not only agricultural advisory information management but also other information management contexts.	0.654	4.400
	Environment		
	The framework is useful to small scale farmers engaged in management of agricultural advisory information in e-agriculture in Uganda.	0.523	4.334
	The elements of the framework are understandable	0.739	4.000
	The framework is easy to use (It is easy to see the components of the framework that support information management and follow them)	0.701	4.089
	The framework is useful in management of agricultural advisory information in e-agriculture in Uganda.	0.588	4.200
	The framework fits in the context of small-scale farmers engaged in management of agricultural advisory information in Uganda	0.757	4.044
	STRUCTURE		
	The framework is complete	*0.725*	3.556
	The framework is simple	*0.723*	4.022
	The framework is clear	0.701	3.911
	The framework is not very different from other information management frameworks	0.690	3.578
	The framework provides sufficient details	0.753	4.022
	The framework is consistent with other frameworks	0.737	3.844
	ACTIVITY		
	The framework is accurate	0.737	3.844
	The framework can support agricultural advisory information management	0.570	4.244
	Small scale farmers can use the framework to get value of agricultural advisory information.	0.712	4.244
	EVOLUTION		
	The framework can continue to be used even if extension information evolves to formats	0.723	4.022

Table 3: Responses about those criteria (Goal, environment, Structure, Activity and Evolution)

A. GOAL

Table 3 shows that a mean of 4.334 and a standard deviation of 0.603 respondents agree that the components of the framework as presented in are logical. A mean of 4.400 and a standard deviation of 0.654 of the respondents concur that the components of the framework as presented can support not only agricultural advisory information management but also other information management contexts.

B. ENVIRONMENT

A mean of 4.334 and a standard deviation of 0.523 respondents agree that the framework is useful to small scale farmers engaged in management of agricultural advisory information in e-agriculture in Uganda. A mean of 4.00 (meaning Agree) and a standard deviation of 0.739 of the respondents agree that the elements of the framework are understandable. A mean of 4.089 and a standard deviation from the mean of 0.701 of the respondents agree that the framework is easy to use (It is easy to see the components of the framework that support information management and follow them). A mean of 4.2 and a standard deviation of 0.588 agree that the framework is useful in management of agricultural advisory information in e-agriculture in Uganda, while a mean of 4.04 and a standard deviation of 0.737 of respondents agree that the framework fits in the context of small-scale farmers engaged in management of agricultural advisory information in e-agriculture.

C. STRUCTURE

A mean of 3.556 (tending to agree) and a value of standard deviation of 0.725 of the respondents agree that the framework is complete. A mean of 4.022 (Agree) and a standard deviation from the mean of 0.723 of the respondents agree that the framework is simple. A mean value of 3.911 (agree) and a small value of standard deviation of 0.701 agree that the framework is clear. A mean of 3.578 (tending to agree) and a standard deviation of 0.690 of respondents agree that the framework is not very different from other information management frameworks. A mean of 4.022 and a standard deviation of 0.753 of the respondents agree that the framework provides sufficient details. Lastly on this component, a mean of 3.844 (tending to agree) and a standard deviation of 0.737 of the respondents agree that the framework is consistent with other frameworks.

D. ACTIVITY

A mean value of 3.844 agree that *the framework is accurate.* The standard deviation from that mean is a small value of 0.737. A mean of 4.244 and a standard deviation of 0.570 agree that *the framework can support agricultural advisory information management.* A mean of 4.244 and a standard deviation of 0.712 agree that *the small-scale farmers can use the framework to get value of agricultural advisory information.*

E. EVOLUTION

A mean of 4.022 and a standard deviation of 0.723 agree that *the framework can continue to be used even if agricultural advisory information evolves to other formats*.

IX. GENERAL EXPERT RECOMMENDATIONS FOR AN IMPROVED FMAAI

In the previous section, findings from the questionnaire to the experts and/or practitioners in agricultural advisory information management have been presented. We present the key effects that the findings have caused to the original framework.

- The name of the framework was adjusted from Farmers Information Management Framework (FIMF) to the framework for managing agricultural advisory information (FMAAI). This decision was reached after detailed discussion with experts in information management. Following this counsel, the researcher adopted the name FMAAI. This name is suitable for this framework because the framework was not only for farmers, although these were key respondents, but for practitioners in agricultural advisory information management.
- The wording of the factors in the framework was adjusted following the rules of presenting factors or attributes.
- The framework retained all the elements that it previously had in figure 1.

X. CONCLUSION

Conclusively, this paper presented the results of evaluation of a framework for management of agricultural advisory information (FMAAI) in e-agriculture. The evaluation was based on expert opinion. The experts confirmed that the FMAAI is composed of the following factors: (i) People and Technology; (ii) Funding, Processes, and Regulations; and (iii) Information use outcomes and continuity. The framework is composed of the above factors with (i) and (ii) influencing (iii).

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