Big Data for Village-level Smart Farms

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Abstract

The application of big data solutions to village-level smart farms in the Philippines may not happen immediately. The low-fidelity prototype developed in this study should represent a little but determined step closer to such a lofty aspiration. The study aimed to develop a prototype for an information system highlighting the application of Big Data solutions to village-level smart farms in the Philippines. The study engaged potential early adopters in the systems analysis phase and cross-referenced their needs with available technologies. Modeling tools such as the HIPO Chart, Systems Flow Chart, Use Case Diagram, and Data Flow Diagram highlighted the systems design phase. Datastore elements explained the application of Big Data in optimizing crop yields forecast. Village-level data on yield estimate, vegetation indices, pest monitoring, and the relevant analytics can be generated from drone-based, data vegetation indices, and data from sensors and drones. Farmer data are consolidated into Cluster and Group data. Big data strengthened crop yield forecasting to provide farmers with the best option for the next crop while performing analytics to generate highly visual dashboards. The system modules developed for the Farmer, Cluster Technician, and Group Manager proved that Big Data solutions can be applied to smart farms in the Philippine setting. The prototype can be applied in equivalent operational areas in the poultry, livestock, and aquaculture industries. Equally exciting is an application to the development of a coexistence system for genetically modified (GM) and non-GM crops. The systems analysis and design process likewise provide instructional value.

Keywords
Big Data, Smart Farms, Systems Design, Dashboards, and Low-fidelity prototype.

1. Introduction
Baseline income growth relied heavily on projected increases in agricultural productivity (Baldos 2014). Sustainable information-based intensification requires new technologies, such as sensors and artificial intelligence (Grieve 2019). Big data (BD), refers to massive information which requires processing for greater insights (Su 2021) BD is most useful in generating forecast models (Hasani 2015). Smart farming (SF) is the use of data technologies to maximize the efficiency of complex farming operations. (Alfred 2021).

In the journals reviewed, there is very little that discussed cases or studies relating to Big Data in Smart Farming (BD-FS), particularly in the Philippine setting. Bersales (2021) listed a total of sixty-nine (69) recorded BD initiatives from 2004 to 2002, across the globe. Only four out of the 69 projects related to crop production. These four projects include the joint project between the Philippine government and two private corporations, which used data from satellite technology to provide better 2020 crop insurance in the Philippines. Bersales (2021) did not find any other recorded big data initiatives in the Philippines for the period 2004- 2020.

In the Philippines, there appears to be a sense of urgency to fast-track the adoption of modern technologies in farming. Gomez (2020) quoted Secretary William Dar of the Department of Agriculture who said the country needs to prepare for Agriculture 4.0 and smart farms.

The main purpose of the paper is to develop a low-fidelity prototype of a computer-based information system featuring the application of big data analytics on village-level smart farms in the Philippines. Equally important is the opportunity to showcase the applicability of systems design modeling techniques in the field of agriculture.

The study shall pertain only to the application of Big Data to crop production and shall exclude all other possible applications in the agricultural field. At least in this study, Big Data in the Smart Farming (BD-SF) shall be limited to sensing and monitoring, analysis and planning, control, and big data in the cloud. Time constraints were the main limitation of the study. The non-random sample of stakeholders, as subjects of in-depth interviews, provides powerful but limited perspectives on the adoption of BD-SF in the Philippines.

2. Literature Review

Big data can help farmers raise crops with increased efficiency amidst disasters and other uncertainties (Su 2021). Smart Farms apply new technologies such as Big Data, the Internet of Things, and Artificial Intelligence. (Wolfert 2017). Alfred (2021) mentioned that unsustainable rice yield production, productivity, and the inability to handle variations in the farming environment provide justifications to adopt smart farming practices. In the Philippines, there appears to be a sense of urgency to fast-track the adoption of modern technologies in farming. Gomez (2020) quoted Philippine Agriculture Secretary William Dar as emphasizing the role of Agriculture 4.0 in driving the development of smart farms.

A growth smart farm uses a more efficient method to manage sudden variations in crop growth (Kuppusamy 2021). Modern farming technologies like Smart Farming will require a huge amount of data and information from modern sources such as videos and images. Big data applications will modernize how farms are managed. Wolfert (2017) discussed how Big Data is likely to contribute heavily to phases of data collection, data integration, and predictive analysis. Osinga (2022) discussed the application of big data in optimizing crop yield forecasts by improving the current practices related to yield forecasting and farmer technical support systems. Alfred (2021) enumerated the types of big data and their features, in Table 1 below.

Table 1. Current application of Big Data to Smart Farms (Alfred,2021)

Farming Activities	Types of Big Data and Features
Predicting yield estimation	**Sensor and Drone-based Data:** High-resolution images, Soil (temperature, moisture), Wind (direction, speed), Air Temperature, Water temperature, % Relative Humidity, Rainfall **Vegetation Indices and Remotely-sensed data**: Hyperspectral images, Enhanced Vegetation (EVI), Land-Surface Water (LSWI), Modified Normalized Difference Water (MNDWI), Normal Difference Vegetation (NDVI), C-Band Synthetic Aperture Radar (SAR),
Monitoring disease	**Sensor and Drone-based Data:** High-resolution images, Soil temperature, Wind direction and speed, Air temperature, Rainfall **Vegetation Indices and Remotely-sensed data:** SAR, Hyperspectral images
Monitoring growth	**Vegetation Indices and Remotely-sensed Data**: Hyperspectral images, Leaf Area Index (LAI), EVI, LSWI, NDVI
Assessing quality	**Sensor and Drone-based Data:** Soil (Nutrients, Moisture, pH), Nitrogen, Sonar **Vegetation Indices and Remotely-sensed Data:** LSWI, EVI, NDVI, LAI, Hyperspectral Images

The systems analysis and design of a new information system involve tools and techniques. The needs of potential users and stakeholders of a new information system must be determined at an early stage (Osinga 2022) Insights from potential early adopters of BD-SF applications can be referenced with available BD-SF technologies highlighted in past studies. The Hierarchical Input-Process-Output (or HIPO) model is an effective technique used in the top-down design of systems and as final programming documentation (Stay 1976).

In addition to tools such as data flow diagrams and use case diagrams, prototypes can help develop tests before the product is available to reduce costs and risks of failure (Tilley 2019). A low-fidelity prototype is an effective product development tool to capture users' insights and needs (Dos Santos 2021).

Alfred (2021) identified four (4) farming activities that can be the proper subject for the application of big data in smart farming. In developing a low-fidelity prototype for a BD-SF information system, the aforementioned systems analysis and design tools proved very useful.

3. Methods

The development of a low fidelity prototype for the new information system involves two main steps – systems analysis and systems design. Figure 1 shows the detailed steps in the process, which were successfully adopted and followed in this study.

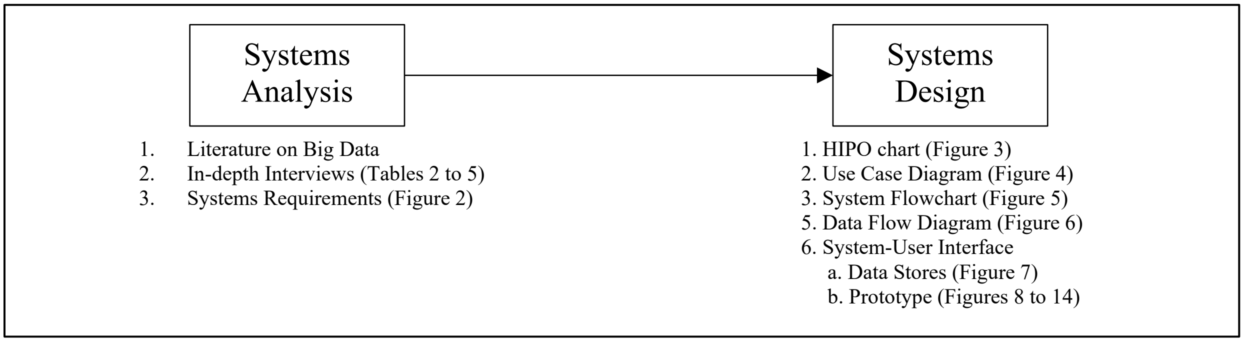

Figure 1. Systems analysis and design approach

Systems analysis relied on available literature on BD-SF cases and insights from the in-depth interview results of potential early adopters of BD-SF technology applications. Research on case studies and grounded theories from existing works of literature was conducted. In addition, a semi-structured interview format was adopted as the primary research tool. For this purpose, a non-random purposeful sample of four (4) stakeholders was chosen as respondents based on their knowledge and experience relevant to the study subject matter. Findings led to the determination of the (5) categories of systems requirements – input, output, processes, performance, and control.

A questionnaire was developed and designed for the in-depth interview of potential early users of Big Data for Smart Farming in the Philippines. Insights using the Technology Adoption Model and the Theory of Planned Behavior were generated. Table 2 shows constructs and statements, which respondents assessed using a 5-point Likert scale, from 1 (strongly agree) to 5 (strongly disagree).

Table 2. Interview Questionnaire: Constructs and measures

Model	Constructs	Statement	Reference
Technology Acceptance Model	Perceived Usefulness	Big Data in Smart Farming (BD-SF) will deliver information useful to my needs	New
		BD-SF makes it easier to manage my farms	New
		BD-SF will increase my productivity in farming	New
	Perceived Ease of Use	BD-SF should be easy to use	New
		BD-SF should be convenient for me to use	New
		I think that I can learn to easily use BD-SF.	New
Theory of Planned Behavior	Attitude	BD-SF is a good idea	New
		BD-SF will benefit farmers like me	New
		I think BD-SF has great significance	Ong (2022)
	Subjective Norm	Most people important to me will support my use of BD-SF	Ong (2022)
		Most people influential to me will support my use of BD-SF	Ong (2022)
		I feel obligated to learn and prepare for BD-SF	New
	Behavioral Control	I believe in the ability that I can use BD-SF	New
		I am confident with the reliability of BD_SF	Ong (2022)
		I think I know how I can use BD-SF for my farming needs	New
		I intend to seek more information about BD-SF.	New

	Intention	I am willing to use BD-SF when it becomes available	New
		I intend to recommend BD-SF to other farmers	New

A Hierarchical Input Process Output (HIPO) model started the Systems Design phase which discussed the scope of the proposed system. Use Case Diagram, System Flowchart, Data Flow Diagrams, and Data Stores were developed to map the proposed processes. The output of the Systems Design phase is a low-fidelity prototype for a BD-SF information system, applicable to village-level farms in the Philippines.

4. Data Collection

Respondents for the in-depth interviews were chosen based on their knowledge and experience which make them potential early users of BD-SF when the technology becomes available in the Philippines. Table 3 below shows the profile of the selected respondents.

Table 3. Profile of Respondents

Interviewee	# 1	# 2	# 3	# 4
Age	27	30	39	42
Farm/Residence	Pangasinan	Agusan Del Sur	Isabela	Nueva Ecija
Civil Status/Children	Single/0	Married/3	Married/2	Married/3
Education	BS Agriculture (Pangasinan State University)	BS Agriculture (Agusan Sur State College & Ag Technology)	BS Agricultural Engineering (Isabela State University)	BS Biology, (Central Luzon State University)
Work Experience	4 years	6.5 years	16 years	22 years
Size farm now	2 hectares	1 hectare	7.5 hectares	15 hectares
What planted now	Sitao, Ampalaya	Sweet corn	Sugar cane	Palay, Onion
Farming experience	6 years	2 years	5 years	10 years
Will still farm next 5years?	Yes, if results continue to be encouraging	Yes, if work and farming can be done at the same time	Yes	Yes

From Table 3, a potential early BD-SF adopter, as represented by the respondents, is between 27 to 42 years old, holds a science-related degree, has corporate experience, and is an experienced farmer who intends to continue to engage in farming, at least for the next five (5) years.

5. Results and Discussion

5.1 In-Depth Interviews

The four (4) respondents were asked about information, data requirements, and information source. Table 4 below summarized the results.

Table 4. Information, data requirements, information source

Interviewee	# 1	# 2	# 3	# 4
Source of Information	internet	Department of Agriculture (DA)	DA, social media, internet, from the current company	DA, social media, internet, from the current company
Data requirement	Supply of vegetables, the crop growth stage of similar crops, vegetable market prices	Market information crops adaptable to own area; crop growth stage of similar crops; supply situation in potential market	Soil and water data; market information on similar crops	import information, supply, and demand, planting forecast, climate, manpower, cost, cold storage (first storage)

Aware of Smart Farming (SF)?	Yes	Yes from Facebook	Yes, heard from Facebook	Yes
Aware of Big Data (BD)?	No	No	No	No

From Table 4, the respondents were all aware of Smart Farming. However, none were aware of the concept of Big Data. Sources of information were mostly the Department of Agriculture and the internet. Data requirement referred to the opportunity to apply BD in their farming operations. The information required by the respondents can be classified into two (2) groups: product factors and market information. These represent the kind of information that Big Data should be able to provide promptly. Table 5 below shows the results of the in-depth interviews generated insights from the four (4) respondents about the potential adoption of the new technology.

Table 5. TAM and TPB insights from potential early users of Big Data in Smart Farming

Statement	#1	#2	#3	#4
Big Data in Smart Farming (BD-SF) will deliver information useful to my needs	1	1	1	1
BD-SF makes it easier to manage my farms	1	1	1	1
BD-SF will increase my productivity in farming	1	1	1	1
BD-SF should be easy to use	2	3	2	2
BD-SF should be convenient for me to use	2	3	2	2
I think I can learn to easily use BD-SF	2	2	1	1
BD-SF is a good idea	1	1	1	1
BD-SF will benefit farmers like me	1	1	1	1
I think BD-SF has great significance	1	1	1	1
Most people important to me will support my use of BD-SF	1	1	1	1
Most people influential to me will support my use of BD-SF	1	1	1	2
I feel obligated to learn and prepare for BD-SF	2	2	1	2
I believe in the ability that I can use BD-SF	2	2	1	3
I am confident with the reliability of BD_SF	3	3	2	3
I think I know how I can use BD-SF for my farming needs	2	3	1	3
I intend to seek more information about BD-SF.	2	2	1	1
I am willing to use BD-SF when it becomes available	1	2	2	1
I intend to recommend BD-SF to other farmers	1	1	1	1

5.2 Systems Analysis and Design

A deliverable for the systems analysis phase is a list of systems requirements. Input, output, processes, performance, and control, which comprise the five (5) categories of systems requirements are shown below in Figure 2.

1. OUTPUTS

a. System should verify user log-in credentials.
b. System should provide details of gap reported.
c. Inventory system must evaluate options to address gap.
d. System should update Farmer, Cluster, and Group Plans.
e. System should generate dashboards for Farmer, Cluster Technician and Group Manager

2. INPUTS

a. Users must enter usernames and passwords to gain access.
b. Farmer must input gaps or deviations from Farmer Plans
c. Technician must recommend options to address gaps from Farmer Plan.
d. Technician must submit regular Cluster Plan.
e. Group Manager must approve option to address gaps.
f. Group Manager must approve proposed Cluster Plan.

3. PROCESSES

a. System uses Big Data to determine best option to address gaps against plans
b. System updates Farmer, Cluster, and Group crop plans

4. PERFORMANCE

a. System must support at least 30 users simultaneously.
b. Response time must not exceed 5 seconds.

5. CONTROLS

a. System must provide log-on security for users.
b. Only HR can authorize editing of employee-user records
c. The system must maintain separate levels of security for users and system administrators.
d. All transactions must have back up copies
e. All transactions must have audit trails
f. The system must create an error log file that includes the error-type, description and time

Figure 2. Systems Requirements

The scope of the process in the proposed system is illustrated in the Hierarchical Input-Process-Output Chart as shown in Figure 3 below. In this system design stage, three (3) processes were identified in the HIPO chart – planning, generating dashboards, and updating. The proposed system must facilitate these 3 processes while providing dashboards for three (3) identified users - Farmer, the Cluster, and the Group (Figure 3).

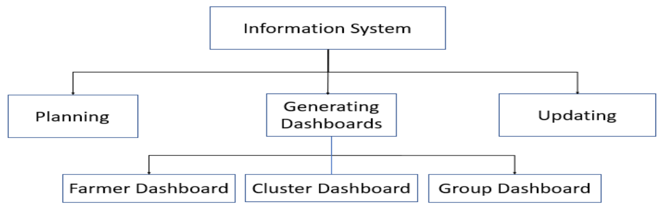

Figure 3. Hierarchical Input-Process-Output (HIPO) Chart

The new system proposes three (3) users – the Farmer, the Cluster Technician, and the Group Manager. A Farmer typically has 1-3 hectares and is recruited by the Technician to join a Cluster. A Technician supervises a Cluster, providing technical support to ten (10) farmers in the Cluster. A total of ten (10) clusters make up a Group, headed by a Group Manager. Figure 4 below shows a Use Case Diagram, illustrating the interaction of the three users with the proposed system (Figure 4).

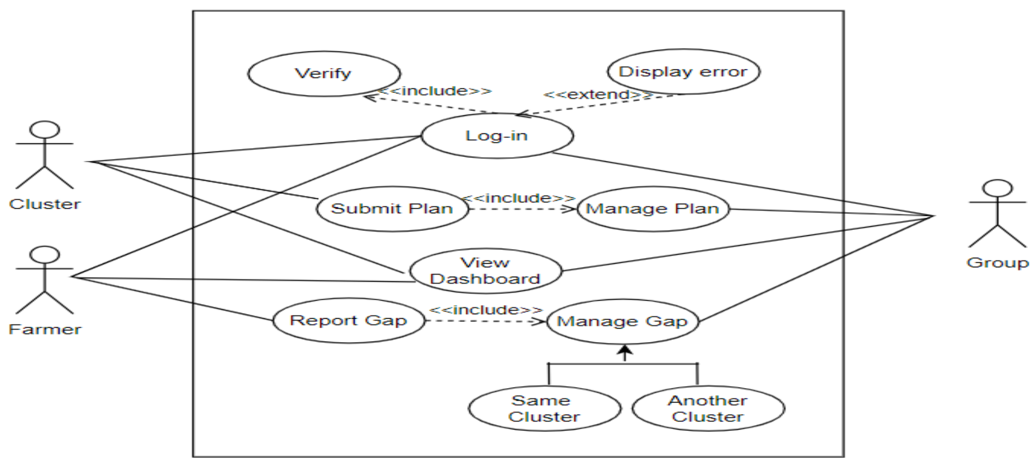

Figure 4. Use Case Diagram

As shown in Figure 4, users log in to the system. A Cluster Technician is responsible for submitting a regular monthly production plan for the Cluster. In case of exceptions or events which will likely lead to deviations or gaps in the submitted plans, the Farmer concerned shall report such exception or "gap". The regular plan is captured as part of managing the plan while reported gaps are reflected under managing gaps. In cases of gaps against plans, the Manager needs to decide where to recover these gaps– either from within the same cluster or from another cluster. The users keep abreast of their progress by viewing their respective dashboards. Another perspective of the proposed system is the Systems Flowchart, as shown in Figure 5 below.

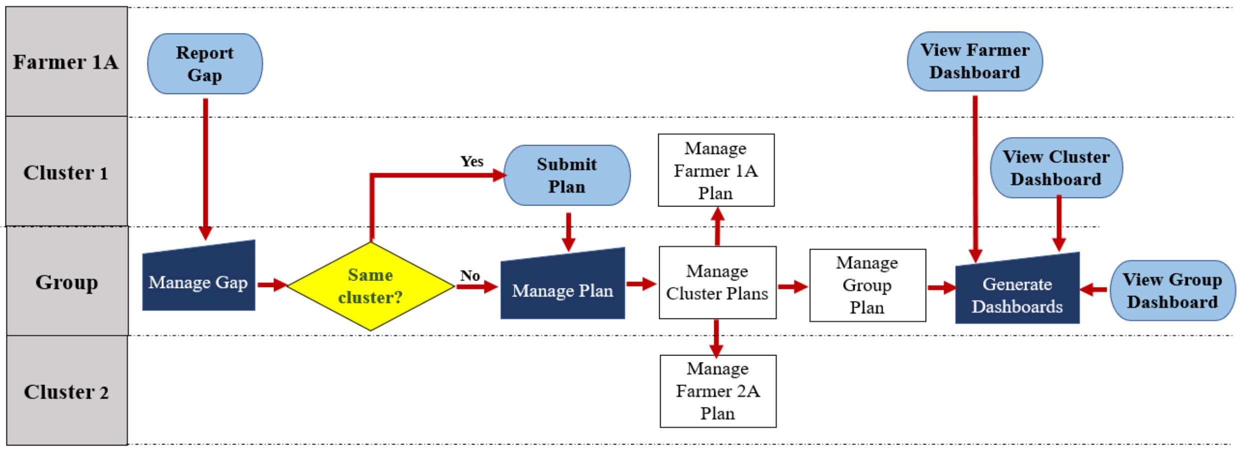

Figure 5. Systems Flowchart

The systems flowchart shows five (5) starting points. In addition to the (3) viewing of dashboards, Farmer 1A reports a gap (or exception) and the Cluster Technician submits the proposed regular plan. As in Figure 5, the use cases of “manage gap” and “manage plan” happen at the Group level. The flow of data (see Figure 6 below) is further clarified by a Data Flow Diagram (DFD).

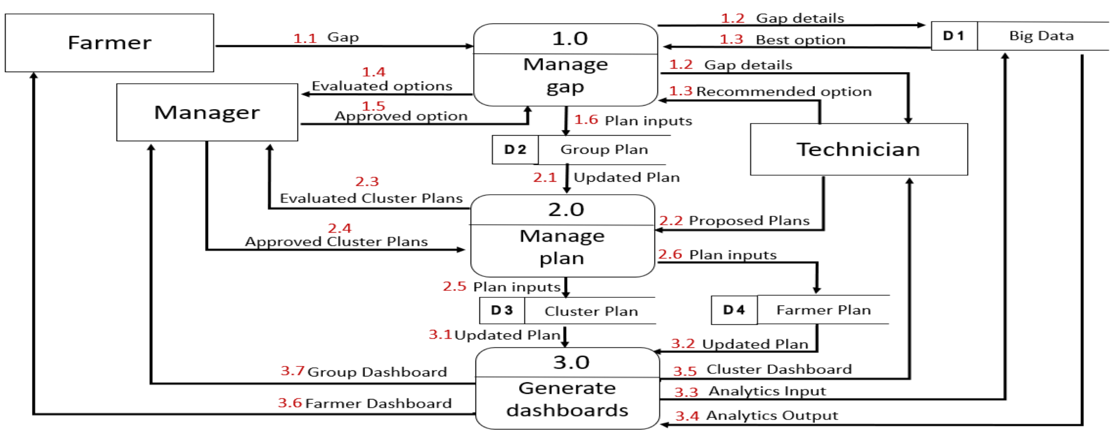

Figure 6. Data Flow Diagram (DFD)

The sequence of data flow for each of the three processes is indicated by the numbers in the red font. Figure 6 highlights BD application in the proposed system, particularly the “Manage Gap” and “Generate Dashboard” processes. Big Data analytics provides the Group Manager with the best option, based on yield estimates, vegetation indices, pest, and disease monitoring, and other relevant analytics of the current crops and the equivalent substitutes. The “Manage gap” process (1.0) starts with the Farmer reporting a gap (1.1). Details of the gap are relayed by the system to the Technician and the Big Data, D1 data source. The system relays both the best option coming from D1 and the recommended option from the Technician. The Group Manager decides and relays the approved option to the system (1.5). Any update enters the “Manage plans” process (2.0), alongside the submission of the Cluster plans by the Cluster Technician (2.1). As in the first process, the Group Manager reviews and approves the Cluster plan (2.4). The third process is “Generate dashboards” (3.0). Updated Cluster and Farmer Plans (3.1 and 3.2) are fed into the system and become vital inputs for the D1 data store or Big Data (3.3). Analytics output (3.4) flows into the system and is processed to deliver the dashboards for the three systems users (3.5, 3.6. and 3.7). The Data Flow Diagram (Figure 6) introduced the four (4) data stores. Figure 7 below shows these data stores and their elements.

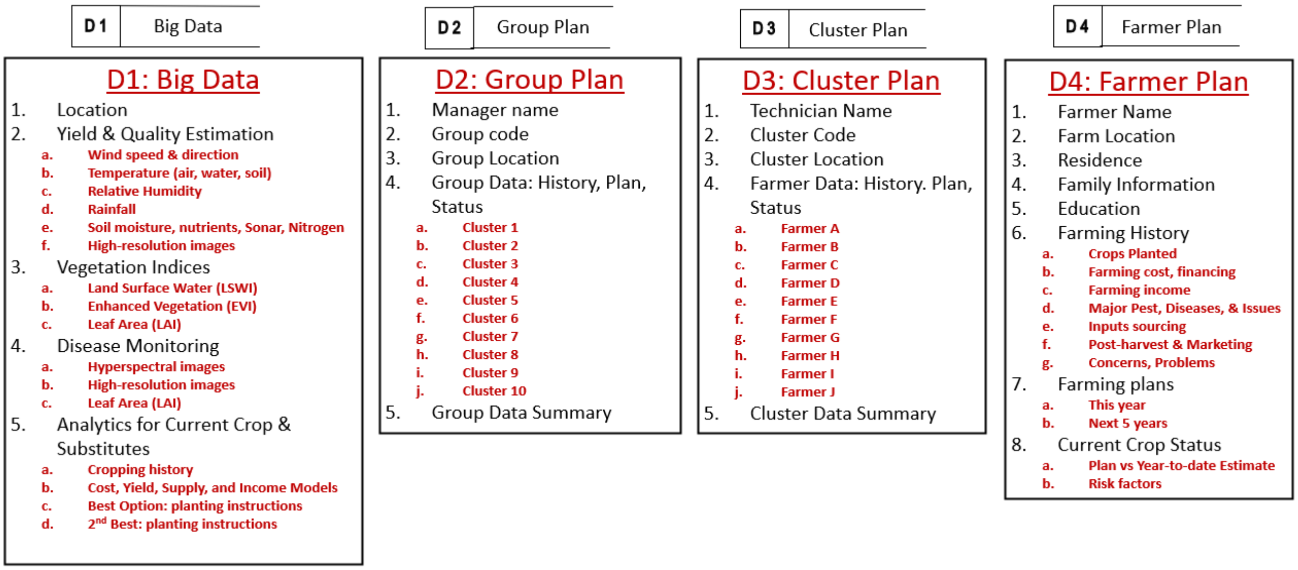

Figure 7. Data Stores and Elements

As in Figure 7, Big Data (D1) provides real-time information to provide ratings for yield and quality estimates, pest and disease control, vegetation indices, and analytics for both current and equivalent crops. Incidentally, these are the same information that proved valuable, at least based on the in-depth interviews of the potential early adopters of BD-SF technology. Group Plan data store (D2) is a mere consolidation of the Cluster Plan (D3), which in turn consolidates Farmer Plan data (D4). Aside from personal information, D4 contains farming history and plans, as they relate to the current crop status for each Farmer. Figure 8, below, shows the boundaries of the system/user interface represented by Frame A and Frame X.

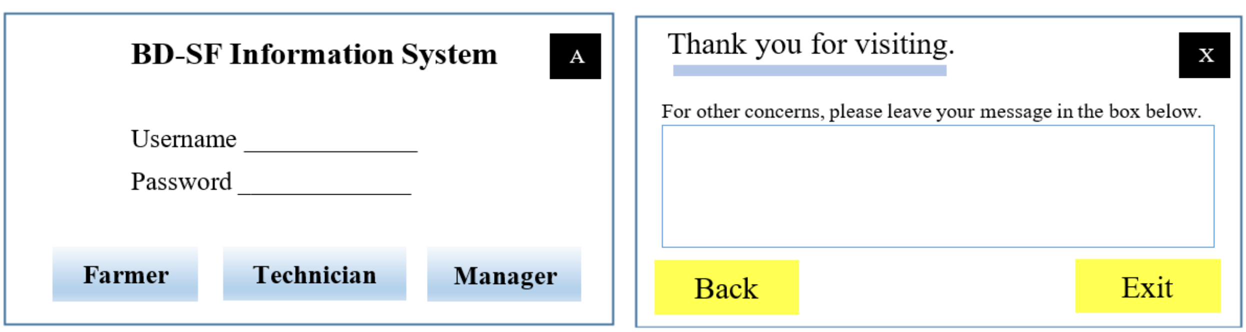

Figure 8. System Boundaries for Proposed System

As shown in Figure 8, the proposed system starts with the Log-in page (Frame A) and ends with the "Thank You" page (Frame X) providing an opportunity for the user to make a comment or input any concerns not covered by the dialog boxes in the system before exiting. The user interface starts at the Log-in page (Frame A). The Log-in page welcomes three (3) users – a Farmer, a Cluster Technician, and the Group Manager. The user inputs his username and password and confirms his user classification. Once credentials are verified, the user is directed to any of the three (3) windows – Farmer Module, Technician Module, and Manager Module. A Farmer will be directed to the Farmer Module (Frame B). Figure 9 shows the Farmer which provides a menu with (2) options – "Submit exception" (B1) and "View Dashboard" (B2).

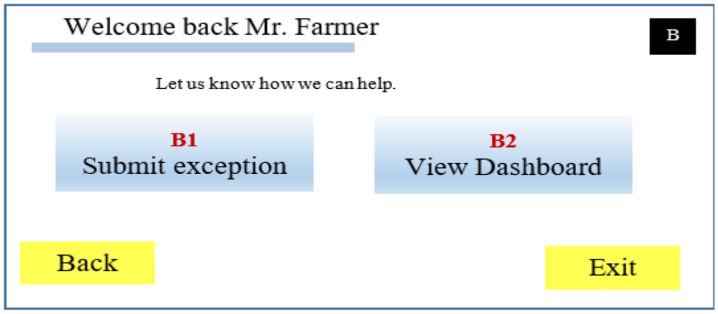

Figure 9. Farmer Module

As in Figure 9, the Farmer reports a potential gap compared to plans by submitting an exception report (B1). In the meantime, the Cluster Technician logs in with his credentials as the second user in the system. Once verified, the Technician is directed to the Technician Module (Frame C) with three (3) options – "Recommend option" (C1), "Submit Plan" (C2), and "View Dashboard" (C3), as shown in Figure 10.

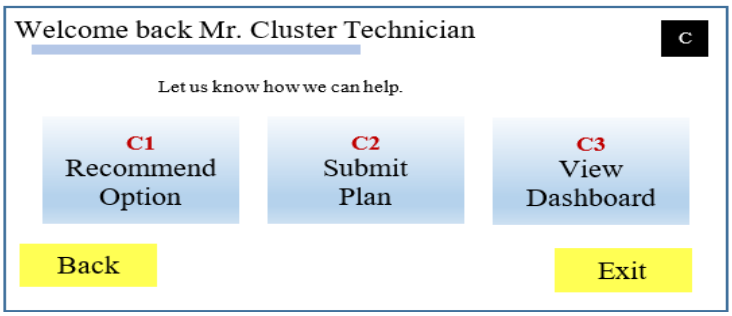

Figure 10. Cluster Technician Module

Note that in Figure 10 and 11, the Technician recommends an option (C1) to possibly address the exception reported by the Farmer in B1. Between the recommended option by the Technician (C1) and the best option based on Big Data analytics, the Group Manager approves the option to be implemented. Figure 11 welcomes the Group Manager with three (3) options – "Approve Option" (D1), "Approve Plan" (D2), and "View Dashboard" (D3).

Figure 11. Group Manager Module

As shown in Figure 11, the Group Manager likewise approves the Cluster plan proposed by the Technician. A common element in the Farmer, Technician, and Manager modules is the option to "View Dashboard". Figure 12 shows the Summary frame for the sample Farmer Dashboard.

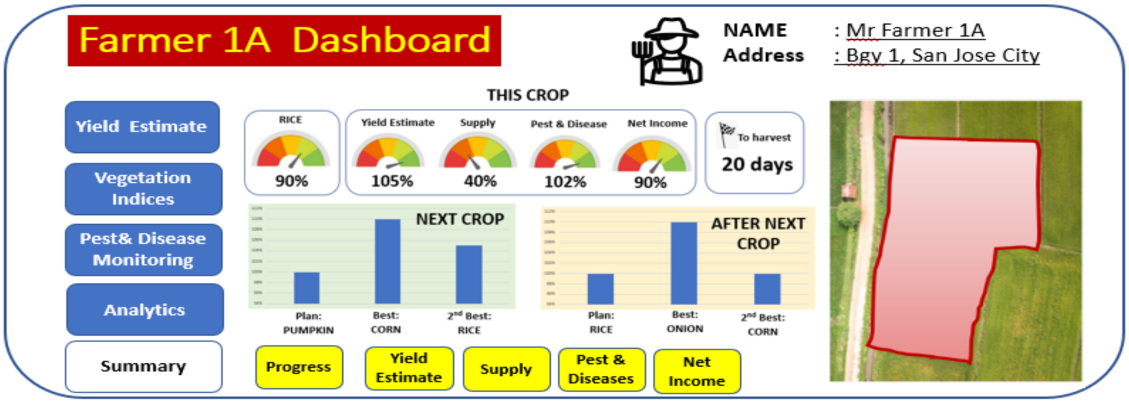

Figure 12. Farmer Dashboard

A summary of the information valuable to the Farmer relating to his current crop and recommendations for the next two cropping seasons is shown in Figure 12. In the dashboard example, Farmer 1A is currently at 90% compared to his plan for the current crop. After harvesting his current rice crop in 20 days, Farmer 1A plans to plant pumpkin and rice again afterward. Big data analytics disagrees and recommends a corn-onion crop sequence for Farmer 1A's consideration. Farmer 1A can also check details related to yield estimate, vegetation indices, pest and disease monitoring, and other relevant analytics for his farms. Similar information for all the other nine (9) farmers is consolidated into the Cluster 1 Dashboard as shown in Figure 13 below.

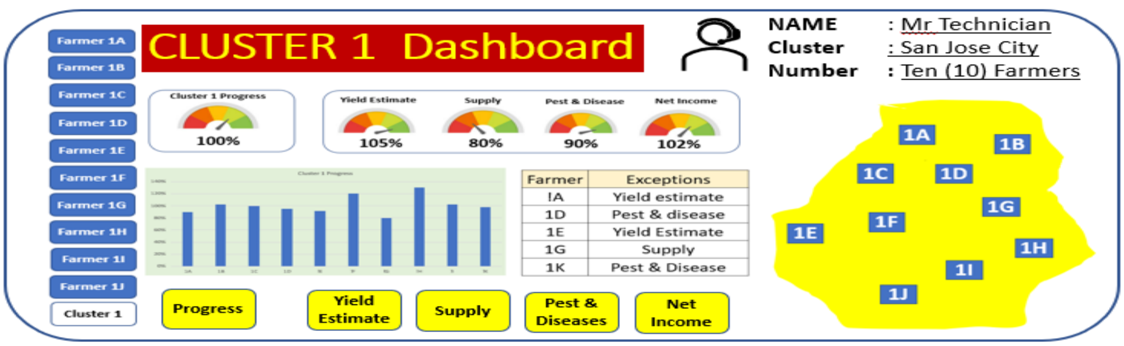

Figure 13. Cluster Technician Dashboard

In the sample cluster dashboard shown in Figure 13, the Cluster 1 Technician is provided with Cluster 1 progress while being notified of issues needed to be addressed in Farmers 1A, 1D, 1E, 1G, and 1K. Similar information from the other nine (9) Clusters are in turn consolidated in the Group Dashboard as shown in Figure 14.

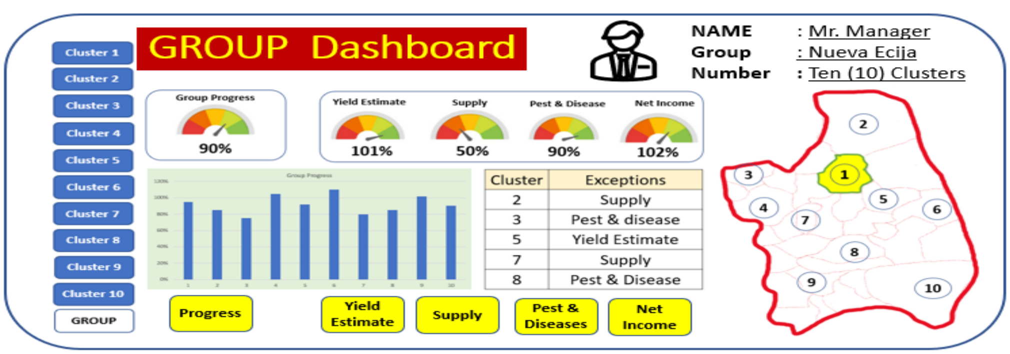

Figure 14. Group Manager Dashboard

In the sample dashboard in Figure 14, the Group progress is rated at 90% with the Group Manager advised to address the indicated exceptions in Clusters 2, 3, 5, 7, and 8.

5.3 Proposed Improvements

The insights and discussion from this qualitative study will be enhanced by a more detailed study to feature both qualitative and quantitative methods. Time constraints did not allow for a more comprehensive study which should be the suggested approach for future research in the field. Knowledge about the potential of the technology can be strengthened with an increase in the number of respondents, to ensure that respondents in future studies fairly represent the real stakeholders in the adoption of BD-SF in the Philippines.

6. Conclusion

Stakeholders consider access to visualizations and data analytics, among others, as important factors in considering whether big data solutions could improve productivity (Osinga, 2022). The study aimed to develop a low-fidelity prototype for an information system highlighting the application of Big Data solutions to village-level smart farms in the Philippines. The prototype developed in this study featured dashboards to deliver equivalent functionalities.

The value of BD-SF technology must be matched to the needs of the targeted technology users. A potential early BD-SF adopter is between 27 to 42 years old, holds a science-related degree, has corporate experience, and is an experienced farmer who intends to continue to engage in farming, at least for the next five (5) years. To kick-start the sustainable adoption of BD-SF, at least ten (10) village-level farmers fitting this profile should be identified and organized into clusters to be supervised by a Cluster Technician. In turn, at least ten (10) of these clusters can be organized to form a group, to be headed by a Group Manager.

In the systems analysis phase, the study engaged potential early adopters and cross-referenced their needs with available technologies in establishing the systems requirements for the proposed information system. Modeling tools and techniques such as the HIPO Chart, Systems Flow Chart, Use Case Diagram, and Data Flow Diagram highlighted the systems design phase. Defining the elements of the Data Stores explained the application of Big Data in optimizing crop yields forecast. Village-level data on yield estimate, vegetation indices, pest, and disease monitoring, and the relevant analytics can be generated from vegetation indices and data from sensors, remote-sensing, and drones. Farmer-level data are consolidated into Clusters, and subsequently, into Groups.

The application of big data to smart farms in the Philippines was highlighted in the incorporation of dashboard analytics in the proposed information system. A low-fidelity prototype featured modules for three users – Farmer, Cluster Technician, and Group Manager. Use cases for managing the plan, managing gaps (against the plan), and generating reports culminated in the design of Farmer Dashboards, Technician Dashboards, and Group Manager Dashboards. These dashboards provided the access and visualization functionalities important to the stakeholders, represented in the study by the potential early adopters.

Organizing the Group into Clusters and Farmers provided a good framework for managing both the physical and system environments. The Cluster Technician proposes the regular plans for the Farmers in the Cluster. In case of potential gaps against these plans, the Farmer reports these gaps while the Technician recommends the option to manage the gap. As a choice, Big Data help provide the best option based on village-level data. In both cases, the Group Manager decides on the critical steps in the Manage Gap and the Manage Plan processes. Updated Farmer, Cluster, and Group plans provide inputs for Big Data analytics to generate the user dashboards. The system modules developed for the Farmer, Cluster Technician, and Group Manager proved that Big Data solutions can be applied to village-level smart farms in the Philippine setting in improving crop productivity. Big data strengthened crop yield forecasting to provide farmers with the best option for the next crop while performing analytics to generate highly visual dashboards for the Farmer, Cluster Technician, and Group Manager.

A similar system should find useful applications in the equivalent operational areas in the poultry, livestock, and aquaculture industries. Equally exciting is an application to the development of a coexistence system for genetically modified (GM) crops such as Golden Rice and Bt eggplant. The methodology applied in the study provides instructional value. The detailed steps involving the selected modeling tools represent a simple and effective illustration of the systems analysis and design process. This can be used as instructional material for college-level courses in the systems design and management information systems domain. The emphasis on prototyping as a process opens the possible integration of systems design into the academic curriculum of the agricultural and biosystems engineering field. The application of big data solutions to village-level smart farms in the Philippines may not happen immediately. However, the low-fidelity prototype developed in this study. should ably represent a little but determined step closer to such lofty aspiration.

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