

Prototyping for an In-month Seed Forecasting System

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Abstract

The current COVID pandemic saw a surge in the demand for vegetable seeds in the Philippines. Local farmers continued to try new vegetable crops using seeds in small packets. Seed distributors struggled to keep up with the increased demand. This positive market development amidst the uncertain times necessitated the need for an improved sales forecasting system for business organizations distributing seed products. This study aimed to develop a low fidelity prototype for an in-month seed sales forecasting system. A systems analysis of the current process observed in typical seed distribution operations confirmed an opportunity for a computer-based forecasting system. During the Systems Design phase, a Hierarchical Input-Process-Output chart, a Use Case Diagram, and Data Flow Diagrams were generated. Microsoft Access was used to develop the database. Tables, queries, forms, and reports were likewise generated. Low fidelity prototyping was used using Justinmind. Compared to the current process, the new system provided several advantages. Flexibility and capability were afforded to a seed distributor, in strengthening the forecasting process to cope with the growing demand for vegetable seeds amidst the uncertainties brought about by the pandemic. An exciting opportunity is an application to the development of a coexistence system for genetically modified (GM) crop seed production. More importantly, highlighting the tools and processes leading up to the development of a simple, low-fidelity prototype provided great academic opportunities, particularly in the design of improved agricultural systems,

Keywords

Seed forecasting, In-month forecasting, Low-fidelity Prototyping, Systems design, and Coexistence systems

1. Introduction

The current pandemic has restricted the movement of food products in the Philippines. Such uncertainties under the “New Normal” increased activities at the farm level with a dramatic increase in demand for agricultural inputs. In the Philippines, farmers trying new crops or varieties are likely to buy in small packaging units or packets. Business organizations engaged in the distribution of vegetable seed products or seed distributors see an opportunity to sustain business growth and increase trial usage of vegetable seeds.

The development of a computer-based information system to help strengthen the existing sales forecasting system becomes a necessary business tool for seed distributors in the Philippines. Design ideas for this improved system can be tested through rapid prototyping of a user interface. Prototypes can either be high-level or low-level, depending on considerations of cost, and accuracy. Despite its importance, not much has been studied in the field of product forecasting in agriculture. Adding to this apparent knowledge gap is the fact that there appears to have been less study of how design process outputs such as rapid prototypes of concepts (e.g., drawings, scale models) are used in implementing novel agricultural system concepts (Klerkx, 2012).

To possibly address this gap and advance the literature in this field, this paper aims to study the concept of prototyping as applied to improving existing sales forecasting systems for agricultural products. The objective is to develop a low fidelity prototype of a computer-based information system for an in-month seed forecasting system. Specifically, the new system should be able to provide organizations engaged in the business of distributing seeds the flexibility in adjusting to the increase in market demand of vegetable seeds during these uncertain times of the pandemic. Equally important is the opportunity to showcase the applicability of modeling techniques in systems analysis and design in the field of agriculture.

2. Literature Review

Demand for vegetable seeds in the Philippines is expected to increase during the pandemic. Recommendations to mitigate the impacts of COVID-19 include promoting urban agriculture with efficient food distribution and cash support and supporting small-holder farmers for procurement and adequate functioning of the supply chain system in the Asia Pacific region (Kang, 2021). Seed distributors in the Philippines need to develop improved sales forecasting techniques to cope with this dynamic situation.

Sales forecasting is among the fundamental inputs for planning decisions throughout the supply chain (Sagaert, 2018). Forecasts drive supply chain decisions, and they have become critically important due to increasing customer expectations, shortening lead times, and the need to manage scarce resources (Boone, 2019). Much has been studied about the sales forecasting process as a concept with very few about seed forecasting and none about the concept of an in-month process involving external actors like a seed distributor. Forecasting involving agricultural products presents challenges. Production-related factors are very difficult to measure and influence both the supply and demand of agricultural products. The weather is one such example because the composition of this factor is very complicated, and includes temperature, precipitation, and wind intensity, to name a few (Li, 2022). Most of the current sales forecasting methods mainly rely on historical market demand and merely react to what happened in the past, i.e., they forecast reactively (Van der Auweraer, 2019). An improved, proactive forecasting system does not need to be complicated. Compared to complex forecasting methods, relatively simpler and computationally less expensive approaches may provide similar or even better results in terms of inventory service levels, at lower computational costs (Spiliotis, 2021).

In developing an improved forecasting system, the analysis of current systems and the design of a new one involves tools and techniques. The use of personal observations of actual operations provides the knowledge needed to test or install future changes and can help build relationships with the users who will work with the new system (Tilley, 2019). 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, systems analysts can use a prototype to develop testing and training procedures before the finished system is available which reduces the risk and potential financial exposure that occur when a finished system fails to support business needs (Tilley, 2019).

The complex challenges facing agricultural systems require problem-solving processes and systems analysis tools that engage multiple actors across disciplines (Ditzer, 2018). Design ideas for new systems are tested out on potential users with a prototype that is relatively quick and inexpensive to construct (Fay, 1991). Prototypes are an efficient communication tool for the user involvement (UI) process translating the language of engineering into the language of users and vice versa, allowing discussion among these stakeholders (Dos Santos, 2021). The use of prototypes allows users to express their opinion and enrich product design while fostering the creation of new knowledge for the engineering team (Dos Santos, 2021). A goal of low fidelity prototyping like the Wizard of Oz approach is to explore innovation with technologies that may exist but are not yet prototyped, the main example being an unfinished design (Arnowitz, 2007). The low fidelity prototype is an early product representation, usually an incomplete and unfinished product outline with limitations on functionality and user interaction, and it is intended to encourage users to provide feedback regarding the product concept. This type of prototype is most effectively used early in product development as a tool for conveying new ideas and capturing suggestions, identifying users' initial needs, and creating new concepts and alternatives for product design and layout (Dos Santos, 2021). While users' reactions to a low-fidelity prototype were generally similar compared to those from a high-fidelity prototype, caution needs to be exercised in basing design decisions on users' reactions to low-fidelity prototypes (Fay, 1991).

3. Methods

The development of a low fidelity prototype for an in-month seed forecasting system involves two main steps – systems analysis and systems design. Figure 1 shows the steps in the prototyping process.

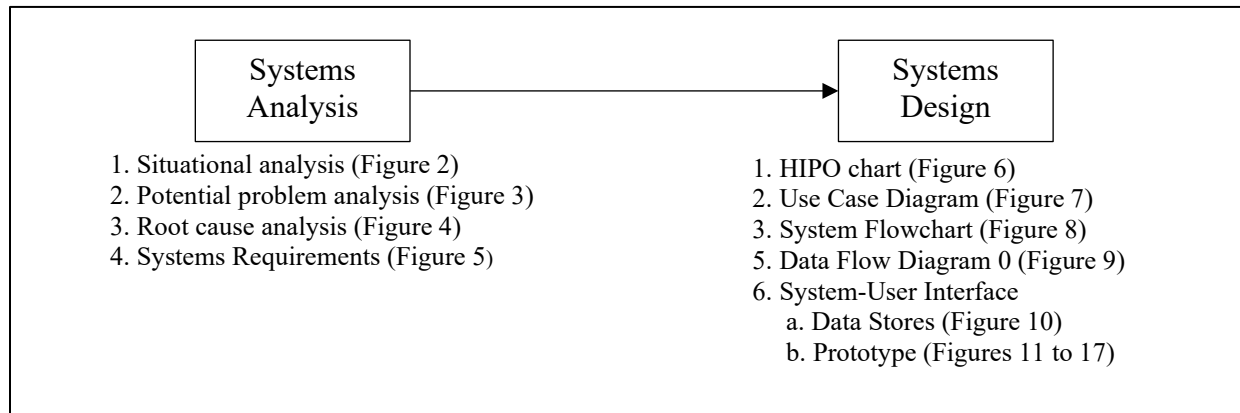


Figure 1. Prototyping for an In-month Seed Forecasting System

Systems analysis relied on personal observations and started with a situational and problem analysis to confirm and identify opportunities for a computer-based information system, culminating in a root cause analysis. This led to the determination of the (5) categories of systems requirements – input, output, processes, performance, and control.

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, and Data Flow Diagrams were developed to map the proposed processes. Microsoft Access was used to create and simulate the management of the database for the proposed new system. For the system/user interface, low fidelity prototyping was designed using Justinmind software. For the Systems Evaluation phase, the current and the proposed system were compared. The advantages of the proposed automated system were highlighted.

4. Data Collection

A systems analysis was conducted drawing from the author's experience and familiarity with the seed industry. Data collected were organized and presented in the form of a Situational Analysis, Potential Problem Analysis, and Root Cause Analysis.

Figure 2 shows a Situational Analysis highlighting the need for an improved forecasting system.

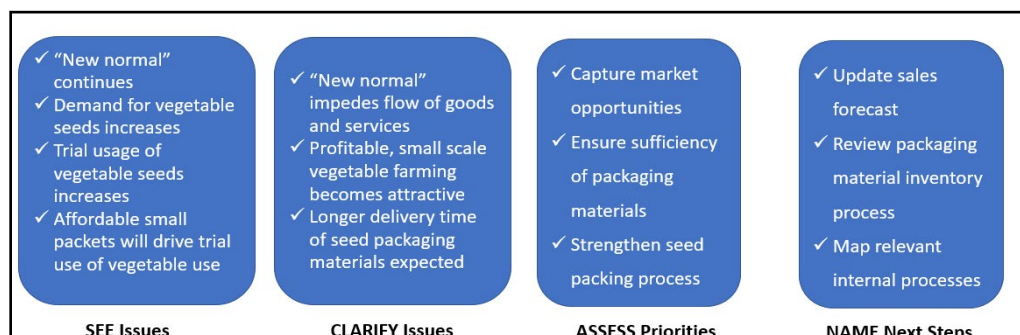


Figure 2. Situational Analysis

Using the See Issues-Clarify Issues -Assess Priorities – Name Next step framework as shown in Figure 2, an updated sales forecast is necessary to be able to address the indicated issues and priorities.

Given the uncertainties of the Covid pandemic and the continuation of operating under the "New Normal", seed distributors needed to anticipate potential issues in their bid to cope with the projected surge in demand for vegetable

seeds. The potential problem analysis in Figure 3 reiterates the need for the review and adaptation of the sales forecasting process to the pandemic conditions.

Potential Problems	Preventive Actions	Contingent Actions
Loss of sales opportunities	Review and adapt sales forecasting process to pandemic conditions	Increase level of buffer stocks for fast moving products
Delayed deliveries of packets packaging materials	More frequent inventory review period; review re-order quantity and reorder point	Explore alternative suppliers; reduce SKU count of packets
Bottlenecks in packing operation	Review packing process and identify bottlenecks	Improve skill level of packers

Figure 3. Potential Problem Analysis

The inability to timely serve customer orders for vegetable seeds hounded seed distributors during the pandemic. Using the Ishikawa Diagram for root cause analysis, errors related to sales forecasting and manual processes were highlighted under “Method” as shown in Figure 4.

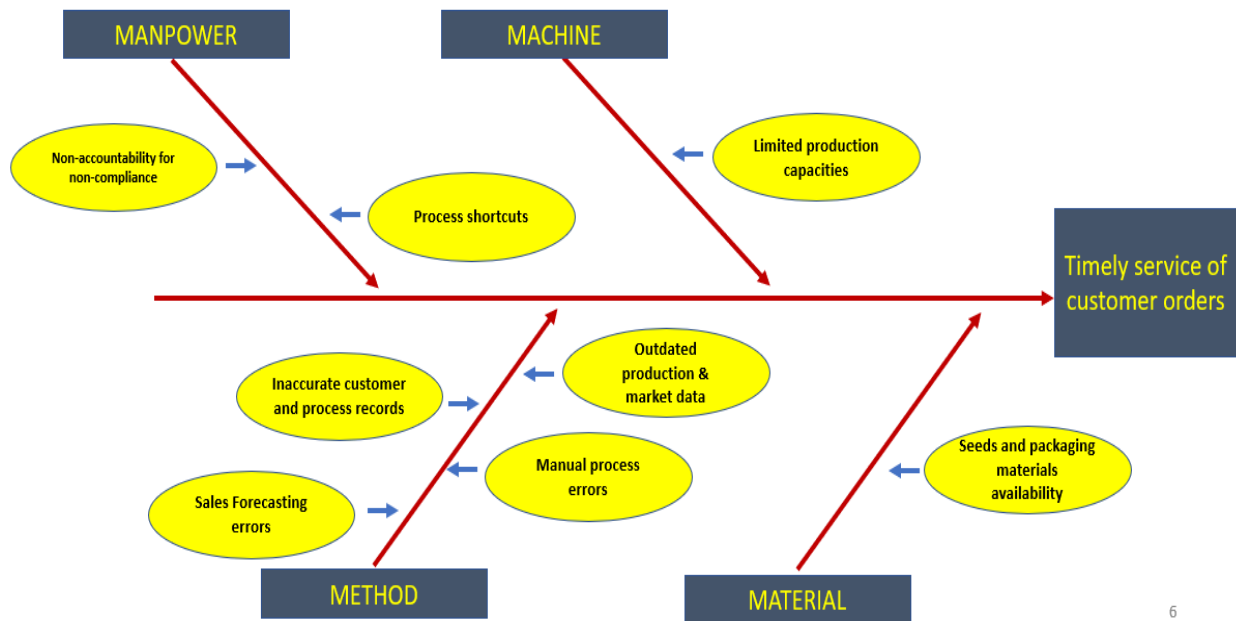


Figure 4. Root Cause Analysis using Ishikawa Diagram

5. Results and Discussion

5.1. Results

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 5.

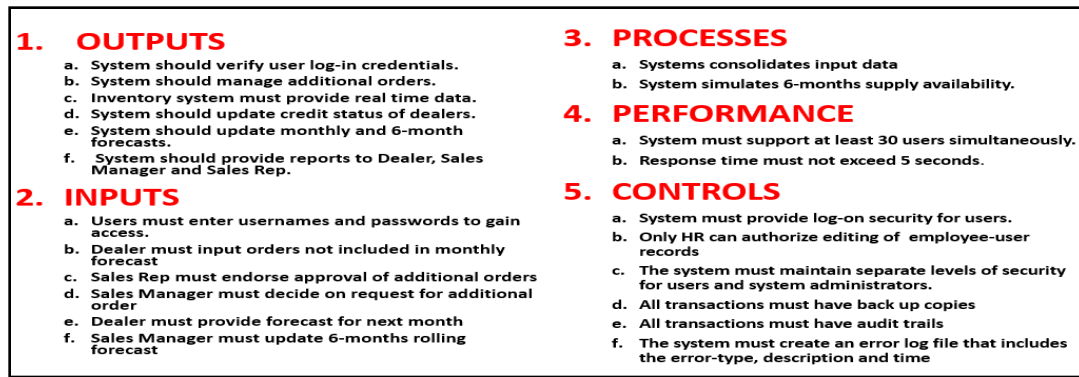


Figure 5. Systems Requirements

The scope of the proposed process is illustrated in the Hierarchical Input-Process-Output Chart as shown in Figure 6 below.

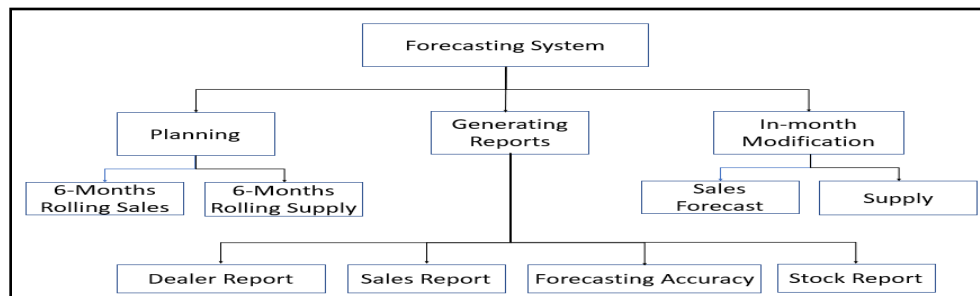


Figure 6. Hierarchical Input-Process-Output Chart

The proposed forecasting system is a planning tool, specifically to provide projections for a rolling period of six (6) months, for both sales and supply outlook. The proposed system should generate reports for the Dealer, Sales Manager, and Sales Rep. The most important feature of the proposed system is to provide flexibility and capability with regard to forecasting adjustments within the month. The new system proposed three (3) users – Dealer, Sales Representative (hereinafter referred to as Sales Rep), and Sales Manager. Figure 7 shows a Use Case Diagram, illustrating the interaction of these three (3) users with the proposed system, highlighting the different use cases in which the users are involved.

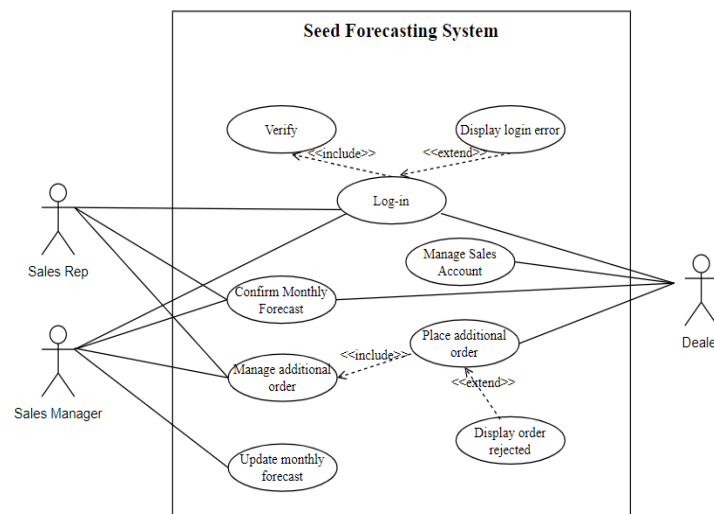


Figure 7. Use Case Diagram

To better understand the sequence of steps in the proposed system, Figure 8 provides a System Flowchart, illustrating how information is proposed to be moved in the new system.

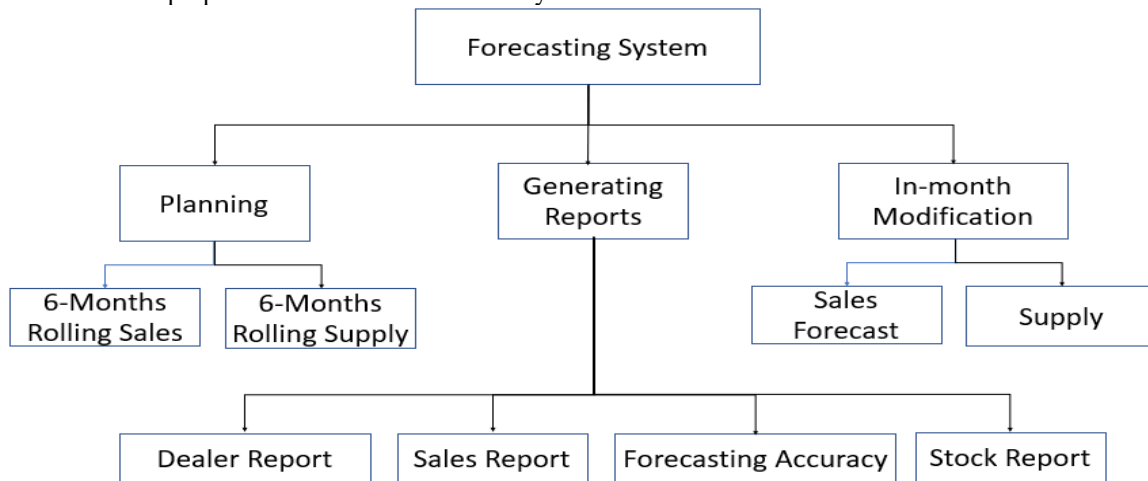


Figure 8. System Flowchart

The system starts with a request from the Dealer for an order which was not part of the monthly forecasting process. The request is subject to endorsement by the Sales Rep and the eventual approval or disapproval by the Sales Manager.

Data Flow Diagrams further clarify how the new system works, showing the flow of data through the system. Figure 9 presents a Context Diagram, summarizing all processing activities and showing the system boundaries.

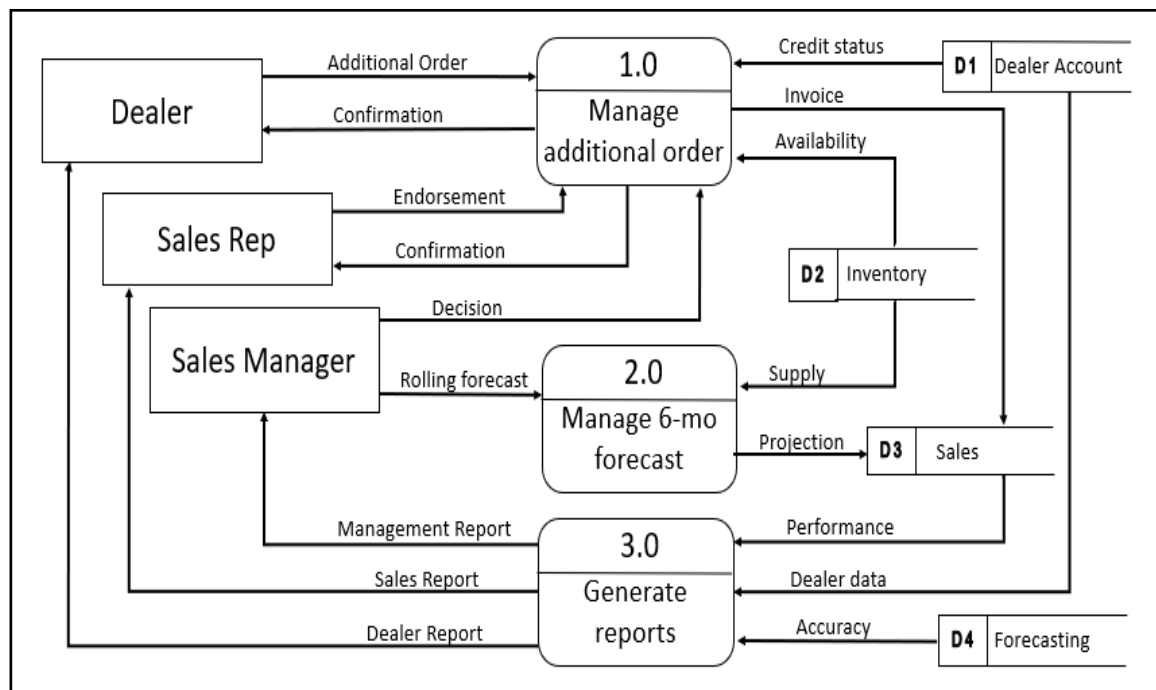


Figure 9. Data Flow Diagram

The Forecasting system needs to manage the additional orders, manage the six-month rolling forecast and generate the relevant reports to be used by the three (3) actors. The lower-level Data Flow Diagram 0 also introduces the four (4) data stores – Dealer account, Inventory, Sales, and Forecasting.

Microsoft Access was used to create and simulate these four (4) data stores. Figure 10 shows Microsoft Access screenshots of the sample tables representing Dealer Account, Inventory, Sales, and Forecasting data stores.

D1-Dealer Acct									
Customer ID	Dealer	First name	Last Name	Email Address	Phone	Address	City	Credit Limit	
1	Warriors	Steph	Curry	steph@mail.com	111-111-0000	123 Main St	Laoag	1,000,000	
2	Chiefs	Patrick	Pat	pat@mail.com	222-222-0000	234 Main St	San Fernando	1,000,000	
3	Lakers	Bron	James	bron@mail.com	333-333-0000	345 Main St	Olongapo	1,000,000	
4	Bengals	Joe	Burrow	joe@mail.com	444-444-0000	456 Main St	Cebu	1,000,000	
5	Rams	Mat	Stafford	mat@mail.com	555-555-0000	567 Main St	Davao	1,000,000	
(New)									

D2-Inventory									
Record ID	Record Date	Record Month	Product ID	Product	Units	Price	Starting Inven	Received	
1	01/01/2022	Jan	1	Veg A	Packs	50	10000	0	
2	01/05/2022	Jan	1	Veg A	Packs	50	10000	0	
3	01/06/2022	Jan	1	Veg A	Packs	50	9000	0	
4	01/07/2022	Jan	1	Veg A	Packs	50	7000	0	
5	31/01/2022	Jan	1	Veg A	Packs	50	4000	6000	
(New)			0			0	0	0	

D3-Sales										
Order ID	Custom	Order Month	Order Date	Product	Order Qty	Price	Order Filled	Order Amount	Inv Month	Allocated this M
1	1	Jan	01/05/2022	1	1000	50	☒	50,000	Jan	☒
2	2	Jan	01/06/2022	1	2000	50	☒	100,000	Jan	☒
3	3	Jan	01/07/2022	1	3000	50	☒	150,000	Jan	☒
4	4	Feb	02/05/2022	1	1000	50	☐	50,000		☐
5	5	Feb	02/06/2022	1	3000	50	☐	150,000		☐
6	1	Feb	02/07/2022	1	4000	50	☐	200,000		☐
7	2	Feb	02/08/2022	1	6000	50	☐	300,000		☐
0	0			0	0	0	☐			☐

D4-Forecasting										
Forecast ID	Customer ID	Product ID	Entry Date	Forecast Mo	Forecast Qty	Actual Sales	Accuracy	Mo+1 Forecast	Mo+2 Forecast	
1	1	1	01/01/2022	Jan	1000	1000	100%	0		
2	2	1	01/01/2022	Jan	2000	2000	100%	0		
3	3	1	01/01/2022	Jan	3000	3000	100%	0		
4	4	1	01/01/2022	Jan	100	0	0%	0		
5	5	1	01/01/2022	Jan	100	0	0%	0		
6	1	1	02/01/2022	Feb	100	0	0%	0		
7	2	1	02/01/2022	Feb	100	0	0%	0		
8	3	1	02/01/2022	Feb	1000	0	0%	0		
9	4	1	02/02/2022	Feb	2000	0	0%	0		
10	5	1	02/01/2022	Feb	3000	0	0%	0		
(New)	0	0			0	0		0		

Figure 10. Data Stores (from Microsoft Access)

These four (4) data stores were used by the proposed system in its interaction with the identified actors. Queries, Reports, and Forms were also generated from MS Access using sample databases as shown in the Figure 10 screenshots. The Justinmind software was used to simulate the system/user interface. A low-fidelity prototype was developed. Figure 11 shows the boundaries of the system/user interface represented by Frame A and Frame X.

In-Month Forecasting System

Username

Password

DEALER

Sales Rep

Sales Mgr

Thank you for visiting.

For other concerns, please leave your message in the box below.

Back

Exit

Figure 11. System Boundaries of the Proposed In-month Forecasting System

As shown in Figure 11, 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 making an exit. The user interface starts at the Log-in page (Frame A). The Log-in page welcomes three (3) users – a Dealer, the Sales Representative (or the Sales Rep), and the Sales Manager (or Sales Mgr). Figure 12 shows the login page and underneath, three (3) windows, for each of the three users. The user inputs his username and password and confirms his user classification – Dealer, Sales Rep, or Sales Manager. Once credentials are verified, the user is directed to any of the three (3) windows – Dealer Module, Sales Rep Module, and Sales Manager Module. A Dealer will be directed to the Dealer Module (Frame B). Figure 12 shows the Dealer Module which provides a menu with three (3) options – “View my statement of accounts”, “Place additional order this month”, or “Submit my forecast for next month”.

Figure 12. Dealer Module

The Dealer can perform any or all three tasks by going “Back to previous page” after completion of a task. When the In “View my statement of account”, the Dealer can view invoice details, past payments, and account balance while confirming whether the additional and unforecasted sales order requested can still be accommodated. The Dealer can make an outright exit (Frame X), or can perform other tasks through the “Back” button. In “Place additional order this month”, the Dealer places the details of an additional order within the current month. Since this order was not part of the regular forecast submitted the previous month, the Dealer is required to justify it under “Comments re Order”. A third option for the Dealer is to “Submit my forecast for next month”. For the next month, any order that the Dealer did not include in this submission will be considered as additional order, which needs prior endorsement and approval from the Sales Representative and Sales Manager, respectively. Figure 13 below shows the Dealer Sub-module featuring the three options – “View my statement of account” (Frame B.1), “Place additional order this month” (Frame B.2), and “Submit my forecast for next month” (Frame B.3).

Figure 13. Dealer Sub-modules

As the second user in the system, the Sales Rep logs in with his credentials. Once verified, the Sales Rep is directed to the Sales Representative Module (Frame C) with two options – “Justify additional order this month” or “View performance”, as shown in Figure 14.

Figure 14. Sales Representative Module

Figure 15 shows the Sales Representative sub-modules, composed of two options – “Endorse additional orders” (Frame C1) and “View my performance” (Frame C2).

Figure 15. Sales Representative Sub-Modules

As shown in Figure 15, The Sales Rep needs to review and endorse (Frame C1), as applicable, the request by the Dealer for order on top of what was included in the current month’s order. A second option for the Sales Rep is to view his performance (Frame C2). Similarly, the Sales Rep can perform both tasks, one after the other. As the third user of the system, the Sales Manager is directed to the Sales Manager Module (Frame D) as shown in Figure 16. In the case of the Sales Manager, there will be three (3) tasks – “Approve additional order”, “Manage 6-month forecast”, and “View performance.”

Figure 16. Sales Manager Module

Figure 17 shows the Sales Manager Sub-modules featuring three options for the Sales Manager - “Decide on additional order”, “Manage 6-month rolling forecast”, and “View performance”.

Decide on additional order

D1

I am _____ the request of (Dealer) for the approval of the additional sales order below:

<u>Products</u>	<u>Units</u>	<u>Quantity</u>	<u>Approve/Disapprove</u>

Back

Submit

Manage 6-month rolling forecast

D2

<u>Dealer</u>	<u>Next Month</u>	<u>Month+2</u>	<u>Month+3</u>	<u>Month+4</u>	<u>Month+5</u>

Back

Submit

View Performance

D3

	<u>THIS MONTH</u>			<u>YEAR-TO-DATE</u>		
<u>Dealer</u>	<u>Forecast</u>	<u>Actual</u>	<u>%</u>	<u>Forecast</u>	<u>Actual</u>	<u>%</u>

Back

Submit

Figure 17. Sales Manager Sub-modules

In “Decide on additional order” (Frame D1), the Sales Manager reviews the endorsement of the Sales Rep and decides whether to approve the additional sales requested and endorsed. He submits his decision which is communicated to both the Dealer and Sales Representative. Another option available to the Sales Manager is “Manage 6-month rolling forecast” (Frame D2). Here, the Sales Manager incorporates recent market developments which were not considered in the formulation of the six-month forecast currently in the system. A third option for the Sales Manager is to “View Performance” (Frame D3), where real-time month-to-date and year-to-date sales performance are available on a national scale.

5.2. Discussion

For the systems evaluation phase, the prototype will be presented to three (3) dealers, the Sales Manager, and three (3) Sales Representatives. The Justinmind file will be simulated for each of the selected users to gather important and timely feedback on the proposed new system. Feedback from the users will also be generated for the data stores in MS Access for their comments.

The current sales forecasting process observed from typical seed distributors relied heavily on Microsoft Excel spreadsheets maintained by the Sales Manager and consolidated from the submissions by the Sales Representatives. These existing systems were observed to rely mainly on historical demand, making them merely reactive and unable to adjust to uncertainties in the market. As mentioned in the root cause analysis, this type of system results in the inability of seed distributors to cope with the surging market demand for vegetable seeds in this pandemic. Seeds forecasts are typically set for at least six (6) months with very little flexibility to react to sudden market developments. The proposed new forecasting system provides several advantages over the current system. There will be ownership of results from the users. The Sales Manager and the Sales Representatives will be regularly apprised of their performance. A six-month scenario for sales and supply is always updated as additional in-month orders are placed by the Dealer. But the biggest difference will be the active role of the dealer, particularly with regards to managing the forecasting process. The proposed system takes advantage of the market proximity and expertise of the Dealer to provide information impacting sales forecast in a timely manner. The submission of the forecast for the following month becomes institutionalized with stronger ownership of numbers from the Dealer. The additional orders, although not eliminated, will be minimized. In the end, seed distributors become more responsive to the needs of the dealers, notwithstanding the uncertainties that come with the current pandemic.

6. Conclusion

The ongoing pandemic required the availability of an improved seed forecasting system for seed distributors in the Philippines. Systems analysis of the typical practices of seed distributors presented opportunities for a computer-based in-month seed forecasting system. Process maps such as Use Case Diagrams, System Flowcharts, and Data Flow facilitated the systems design process. Diagrams helped clarify information flow, users, and data requirements. A simulation of databases, forms, queries, and reports using Microsoft Access was very instrumental. As a result, a low-fidelity prototype using Justinmind was effectively developed. Compared to the current process, the new system provided several advantages. None bigger was the flexibility and capability afforded by the new system to a seed distributor, in strengthening the forecasting process to cope with the growing demand for vegetable seeds amidst the uncertainties brought about by the pandemic.

Most forecasting methods used in the vegetable seed industry focused on market historical demand, i.e., a reactive approach. This prototype provided a more proactive approach. While considering historical demand, the in-month feature provides real-time information from the dealer and allows the adjustment of the six-month rolling forecast as necessary. The sales forecasting process is unique for each organization and varies across industries. This proposed in-month forecasting system represents an enhancement to existing systems by the incorporation of real-time inputs from the Dealer within the current month. The in-month inputs and information captured by the system as provided by the Dealer are captured both in the current month's forecast and in the next month's forecast. As a result, the Sales Manager can incorporate such developments into the six-month rolling forecast as these market developments happen. This adds the proactive approach to the current sales forecasting processes observed.

The simple low-fidelity prototype developed for three (3) users in an in-month seed forecasting system present several opportunities for the development of other computer-based information systems in the seed industry. Such opportunities may include, but are not limited to the following: (a) a Business-to-Business (or B2B) tool to manage the relationship between a seed producer and seed distributor, particularly in the areas of forecasting, sales, and credit management; and (b) a Business-to-Consumer (or B2C) tool to manage the relationship between a seed distributor and a farmer, particularly in the areas of demand planning and other relevant farmer feedback; and (d) a component of a coexistence system to sustainably manage the production of GM crops such as Golden Rice and Bt eggplant in the Philippines.

The new forecasting system represented by the prototype likewise finds application in industries with operations like the seed industry. Equivalent users in similar industries working with crop protection, feeds, animal health, and animal nutrition, among others, should find this improved forecasting system useful. Industry. Another exciting opportunity is the instructional value available in this study. Highlighted was the process of systems analysis and design and the emphasis on the concept of prototyping, as applied to agriculture. The detailed steps involving the selected tools represent a simple and effective example 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 bioscience engineering field. Innovation of agricultural systems becomes mandatory as the world struggles with a growing population against the backdrop of limited, if not dwindling natural resources. The benefits which can be derived from the prototyping process, as part of these innovation projects, can certainly help.

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Biography

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