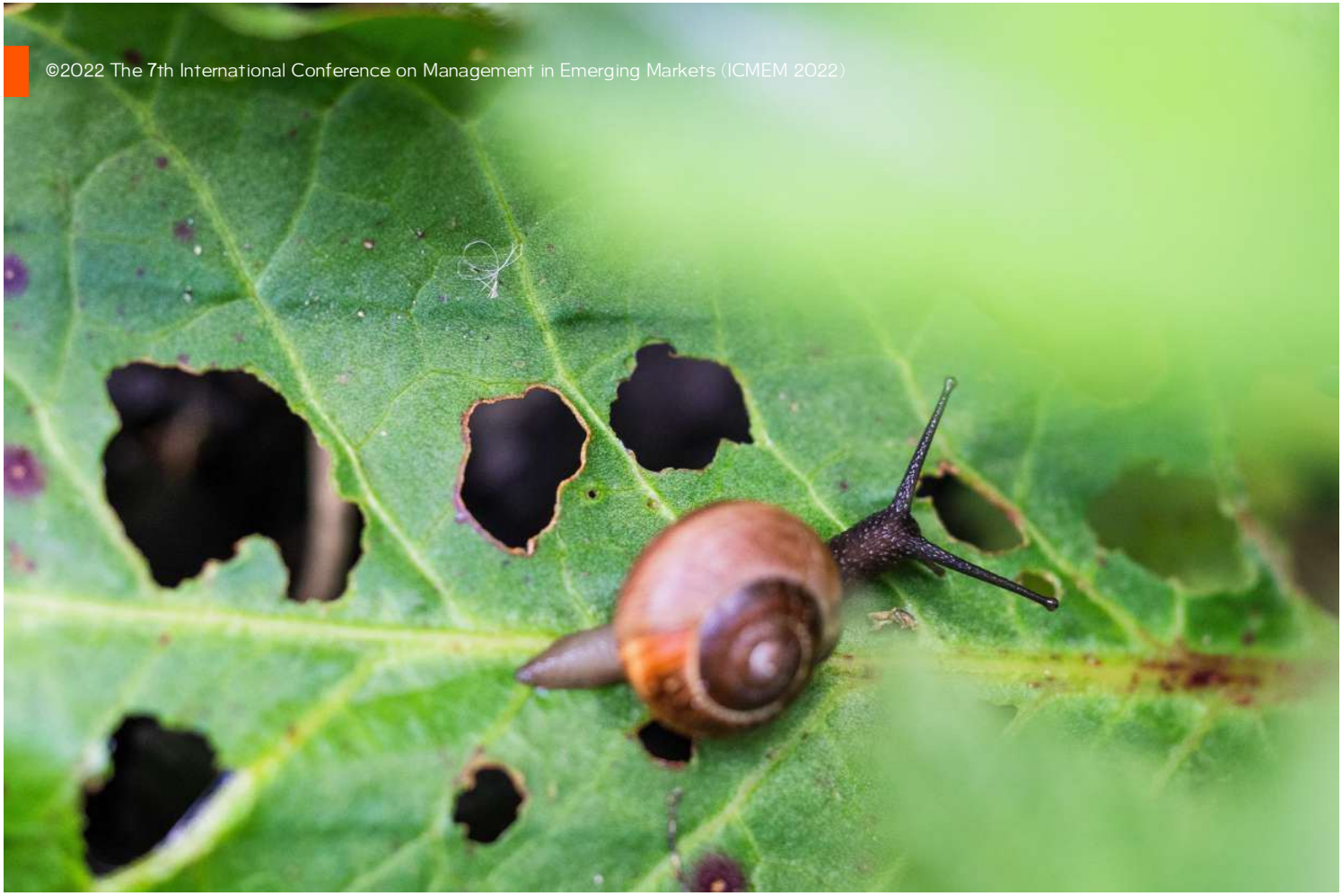

Paper 62

Design of Information System and Database Management for Pests and Diseases Management

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Abstract - **The agriculture industry in Indonesia will continue to be the country's economy in 2021. Agriculture became a priority in several countries and evolved into one of the businesses capable of supporting the economy. Pesticide is a vital component and has become extensively used in modern agriculture, but with pesticides, especially synthetic chemicals, one must have better control. Most farmers still don't have awareness of the dangers of overuse of pesticides on the environment which can cause greater problems. The farmers also have limitations to access information because there is no integrated information. The research was conducted with the System Development Life-Cycle (SDLC) method to come up with the solution, carried out up to the recommended system design stage. The solution provided recommendations for the use of pesticides that are by pests and diseases experienced. Based on this stage it is known that there are 13 databases needed in creating pest and disease management applications. The implication of this research is to help farmers by reducing costs through the control of pesticide usage and providing integrated information on pests and diseases through the development of new features in Agree Application.**

Keywords - **Agriculture, Pests and diseases management, Management Information System, System Development Life-Cycle, Database management**

I. INTRODUCTION

Agriculture became a priority in several countries, and it evolved into one of the businesses capable of supporting the economy[1]. Indonesia is one of the countries that continue to rely on agriculture to maintain its economy. The agriculture industry in Indonesia will continue to be the country's economic driver in 2020, and Indonesia's coordinating minister of economics hopes that agricultural performance would be even better in 2021[2]. The agriculture industry still faces significant challenges in attaining this pace of development[1]. According to the Coordinator Ministry of Economics, some of the global challenges for the agriculture sector in 2021 include the continued wave of pandemics in several countries, changes in consumption behavior from restaurants and similar places to households, and the disruption of financial technology and face-to-face technology[3]. Climate anomalies, application of technology, demographic bonuses, regeneration of Human Resources (HR), and food diversification are some of the national problems that Indonesia's agriculture industry should manage[4]. Another challenge that arises is the high operational costs in the planting phase. One of the costs in the very influential planting phase is the cost of pesticides.

Pesticides are synthetic chemicals or biochemicals that use to eliminate pests or diseases in plants[5]. Pesticides itself is including a wide range of substances used to control pests and diseases, it includes insecticides, herbicides, rodenticides, and fungicides[6]. Pesticide is a vital component and become extensively used in modern agriculture to add more protection to the plant, around 45% of annual food are lost due to pests' attack[7] This condition could be seen in the sample of farmers in this research, 100% of them are use pesticides to control and eliminate pests or diseases. Of the sample farmers in West Java – Indonesia, about 63% of respondents are still using chemical pesticides. Chemical pesticides are more effective to eliminate pests than using organic pesticides. But due to the high price of chemical pesticides, there is around 30% started to use combination pesticides between organic and chemical pesticides. The other 7% of respondents already use organic pesticides.

Since synthetic chemical pesticide is the most common pesticide to use on West Java's farms, the synthetic chemicals price becomes an issue for farmers. Due to the review of literature, farmers believe' that performance becomes the most important thing in choosing pesticides[5], [6], [8]. This makes farmers keep using the synthetic chemicals pesticide even the price is relatively higher than biochemical ones. Sample respondents cost at least 5% for pesticide of the total production expenses of they use organic pesticides, and 20% to 70% more of the total production costs if they use chemical pesticides. The other condition that becomes an issue for farmers in West Java, is most farmers still guess how much and when to apply pesticides to their crops, and do not follow the pesticide manufacturer's recommendations[7]–[9]. Farmers usually rely on their senses to determine how much pesticide to apply. Most farmers do not follow the pesticide manufacturer's recommendations. Even though there are explicit guidelines for using certain types of pesticides, farmers frequently have concerns that the pesticides they use are ineffective for their crops and that pests will attack them. Because of their concerns,

farmers frequently use pesticides over the recommended dosage. From the interview conducted there are 90% of the respondent still use their approximation on applying pesticides. Only 10% apply pesticides as its recommendation.

The use of pesticides especially for synthetic chemicals must have better controlled since the pollutants from pesticides can be harmful to the environment and all associated organisms[7], [10], [11]. In the current condition, most farmers still don't have awareness of the dangers of the overuse of pesticides on the environment, which can cause greater problems[9], [11]. The overuse of pesticides could also lead to resistance to pests and diseases[9]–[11]. The pests and diseases were resistant to pesticide drugs and antibiotics due to the adaptation condition, which is the implication of over pesticide usage[5].

The development of pests and diseases management information systems could help farmers reduce the cost of pests and diseases elimination by controlling pesticide usage[9]. Management information systems could benefit agriculture by giving data from a centralized computer database that is constantly updated[12]. Information systems are also useful in gaining a better understanding of an agricultural issue and determining the viability of adopting improvements [13]. Therefore, this research is aimed to help farmers by reducing costs through the control of pesticide usage and by providing integrated information on pests and diseases[12]. To achieve this goal, this research sets the following questions: (i) How to minimize the cost of pests and diseases management? (ii) How is database management developed for pest and diseases management? Apart from helping farmers to reduce costs and control pesticide usage, this research also aims to the development of new feature in Agree Application of Telkom Indonesia, which could give an integrated recommendation for pesticide usage to eliminate specific pests or diseases

II. METHODS

This research uses qualitative methodology by performing a qualitative interview. Qualitative interviews are similar to conversational interviews in that each question is an open-ended question. In this interview, the researcher allowed the participant to explain the situation in the field in their own words [14], [15]. There are two types of data used in this research:

1. Primary data in this research are the result of the qualitative interview involving farmers, agriculture field officers, and other people involved in agriculture. These interview results are the basic benchmark for this research. Particularly to get the outlook of agriculture in West Java
2. Secondary data was obtained by doing the process of compiling and accumulating objects from various sources about this study topic is referred to as collecting. Documents gathered might be tangible or represent a point of view on the environment. Data collected in this research are data about agriculture in Indonesia, agriculture in West Java, and data about pesticides and the management of pesticides from electronic sources and any library sources. These data are collected to support system design for pesticide management.

Through the qualitative interview, the data collected could be used to define the current condition and also issue in agriculture. After the current condition and the issues define, then the next step is to define an information system by doing the analysis based on the System Development Life-Cycle (SDLC).

The System Development Life-Cycle (SDLC) is a phased approach to making an analysis and design that holds systems that are best developed by using the specific cycle of an analyst and user activities[13], [16]. The SDLC done in this research are included in four four-steps define in the figure below:

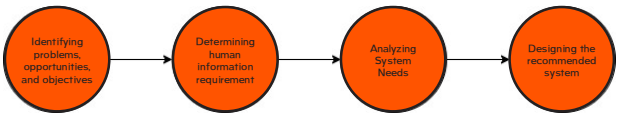

Fig 1. Research Methodology

Adopted from SDLC Method (Kendall & Kendall, 2011)

III. RESULTS AND DISCUSSION

Identifying problems, opportunities, and objectives

Identifying problems can be done by using gap analysis and root cause analysis. Through the gap analysis, it could be seen that there are still some gaps between the current condition and the ideal condition. In the current condition farmers only use their experience and knowledge to eliminate pests and diseases. Farmers use their observations to determine pesticide dosage; farmers are dependent on a specific brand of pesticide, and farmers use the pesticide depending on the brand; farmers are unconcerned about the active chemicals in the pesticide. The ideal condition Farmers in ideal conditions should be looking for pest and disease recommendations. Farmers can also easily obtain information on the types of pests or illnesses, pesticides to be used to treat them, and pesticide dosage recommendations. To use the pesticide properly, farmers must follow the prescribed dosage instructions on the label, and they must also comprehend or be aware of the active components in the pesticide, which vary based on the brand. According to

the findings above, the gap between them is a limitation of knowledge for pests and diseases management, access to recommendation channels, and integrated pests and disease management information system.

The root cause of the issue of today's agriculture in West Java that has high costs during the planting phase is the farmers still have limitations to access the information, and there are no integrated platforms or applications that could give diseases and pests information and specific volume recommendation of pesticide dosage to use. Based on the root cause analysis that has been done, there is an opportunity for companies to develop an application using a database system. The database system in this application serves to bring together data on diseases, pests, and pesticide use from various sources. Due to the root cause analysis result, the objectives of this research are to determine the management information system database to develop for pests and diseases management. The result of the database will give specific insight into the data needed to develop an agriculture application. Before we identify the system for pests and disease management, first we need to identify the user of this system. Since this research is focused on the agriculture sector, and the issue that occurs is the high costs in the planting phase, then this system is made for farmers. But not only the farmers who will involve but also farm equipment sellers, and also farm support staff in this case field assistants.

In this step, it also could be concluded what kind of system is needed in the planting process of the agriculture sector. This research defines farmers' system needs fully through the interview process directly with the farmers.

Determining Human Information Requirements

The difference between the proposed business process and the current business process is that in the current business process, all of the processes were done by the farmer and were done based on the farmer's experience and knowledge, whereas in the proposed business process diagram, Agree Application will assist the farmer by recommending pest and disease management. Farmers must enter data required by Agree as the initial step in the planned business process. Farmers must enter data into the Agree Application during this business procedure. Following the input of the signing-in data, the farmer should enter the data of their farm controlling process, which includes farm conditions and the pests and diseases that occur on the farmer's farm.

The farmer enters this data into the Agree Application, and Agree receives and analyzes the farmer's data. Agree's analysis focuses on the pests and diseases discovered on the farm, as well as the strategy for eliminating these pests and diseases. All of the analysis data were given to the farmer as well as the field officers who worked with him. Agree's recommendation is for an appropriate pesticide's active component that can eliminate pests and diseases and a dosage recommendation based on the pests and diseases attacks experienced.

Referring to the Agree's suggestion, farmers purchase the pesticide as directed. The farmer might purchase pesticides based on the active components or any available brand. Following the purchase, the farmer might spray their farm under the supervision of field officers. Field officers are advised to provide supervision in the suggested business process to reduce errors in the pesticide spraying procedure.

Analyzing System Needs

In this research, analyzing the system requirements is a stage in which a business process is decomposed, a context diagram is created, and a data flow diagram is created. Before creating the data flow diagram, first, it needs to know how the big process of the system until the system could give results to the farmers. In this research, the big depiction of the process is defined below.

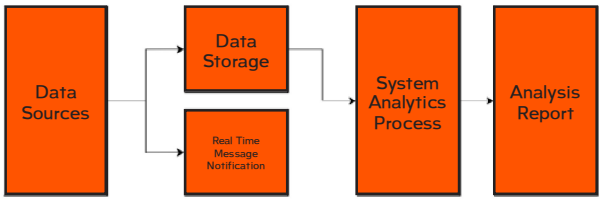

Fig 2. Data Architecture

After the data architecture of the system defined, the system need context diagram to get a more detail depiction of the system. The context diagram is used to see the entire picture of the system's input and output. Following the completion of the context diagram, the data flow diagrams are depicted, beginning with the highest level, level 0, and progressing to the smallest level. Simply said, context diagrams and DFDs are used to visualize problems in the system under consideration from the input, process, and output sides.

The current business process must be decomposed before creating a context diagram and DFD. Processes are decomposed by defining the function into more detailed processes and sub-processes

Table 1 - Business Process Decomposition

Process		
Planting Phase	Pests and Diseases Management System	**1. Sign-in into Application**
		1.1 Input Farmer's Identity Data
		1.2 Input Farm Identity Data
		2. Pests and Diseases Detection
		2.1 Farm Controlling
		2.2 Input Data Farm's Pests / Diseases Found
		3. Looking for Recommendation Pests and Diseases Solution
		3.1 Input Data Required
		3.2 Analyzing Farm Condition
		4. Pests and Diseases Recommendation Solution
		4.1 Make Recommendation
		4.2 Give Recommendation
		5. Spraying Pesticide
		5.1 Receive Recommendation
		5.2 Buy Pesticide as Recommended
		5.3 Spray Pesticide
		5.3.1 Looking for Weather Recommendation
		5.3.2 Decide time to Spray
		5.3.3 Make Pesticide Mixture
		5.3.4 Decide the best way to apply pesticie

From the process decomposition table above, 5 main processes are Sign-in into the application, pests and diseases detection, looking recommendation pests and diseases solution, pests and diseases solution recommendation, and spraying pesticide. Every step is divided into other subprocesses to make the process clear. After the process of decomposition from the pests and diseases management system, the next step is to make the context diagram from the system.

The making of diagram context is to get a picture of a system environment that would be included in the research. As can be seen in Figure 5, external entities are involved in the pests and diseases management system from Agree, namely Farmers, Field Officers, Vendors, Saprotan (Means of Agricultural Products) Providers, and Weather Forecast

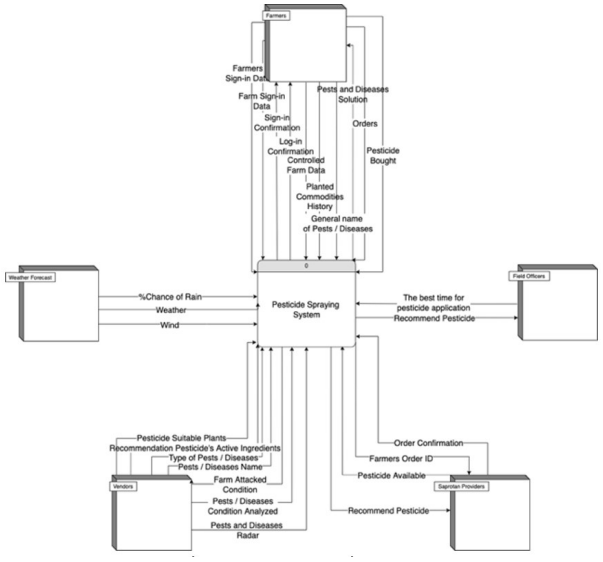

Fig. 3. Context Diagram

As can be seen in figure 4 above, Farmers will give data of farmer's sign-in data, farm sign-in data, farm controlling data, planted commodities history, a general name of pests/diseases (if only farmer know) and pesticide bought. These data will be helpful in the making of the pests and diseases solution recommendation which will be detailed in the DFD section.

The next process is the data will be processed on the system and given to vendors. Vendors will receive the data about attacked farm conditions, then the vendors will give data to the system about the type of pests and diseases, pests/diseases names, pests/diseases condition analyzed, pests/diseases radar, pesticide suitable plants, recommendation pesticide's active ingredients.

The recommendation pesticide's active ingredients will be processed in the system and given to the saprotan providers. Saprotan providers will give the data about pesticides that are available with that kind of active ingredients. This information will also process in the system then it will give the pests and diseases solution to the farmers which inclusive of the pests/diseases analyzed data and its pesticide available solution. The pests and diseases solution is used by the farmers to buy pesticides in the application or manually in the saprotan providers. The recommended pesticide data will also be given to field officers, then field officers will process the data to give the data about the best time for pesticide application. To support the recommendation solution for pests and diseases, there is one external entity of weather forecast that supports the data of forecast weather. The data that will be provided by the weather forecast entity is the data about the %chance of rain, weather, and wind.

Pests and Diseases Spraying Management System consists of several processes and several subprocesses as can be seen in table 1 DFD depiction is useful to get a more detailed picture of the process carried out and the flow of data in each process on the system.

The first process is a sign-in into the application process, this becomes important because it is the first process for farmers to be able to use pests and diseases spraying management system services. In this process, farmers provide farmer sign-in data as well as farm sign-in data, which will then be stored in a farmer's identity database and farm's identity data store. Farmer's identity datastore will contain the username, name, ID number, email address, and address. While Farm's Identity data store will contain about regular commodities planted by the farmer, location, altitude, land area, and average soil condition. After this process, the system will confirm with farmers the results of the sign-in, and confirmation regarding logging in to the Agree application.

The second process is pests and disease detection. This process requires farm-controlled data derived from farmers, log-in confirmation data, and agricultural location data. Then the data will be processed in the pests and diseases spraying management system and become the following data, planted commodities data, plant condition, plant characteristics, and plants age. This data will be stored in the farm's current condition data store. In addition to the data, the results of data processing on the system will also produce data commodities attacked, location of ion pests/diseases found, and characteristics of pests/diseases found. These data will be stored in plant attacked datastore, this data will be present when pests or diseases are found in data from farmers. The system will also issue a data farm's condition result that contains conclusions from the agricultural condition

The context diagram above is a depiction of data input and output from the entities and also from the systems. After done the context diagram, the next step is to define each process with a data flow diagram. The data flow diagram will detail every data input and the data output from the process of table 1 (decomposition of a business process).

After the DFD of each process is created, then the final step of this research using SDLC is designing the recommended system. The next step is database design, which depicted the Entity-Relationship Diagram (ERD) and normalization database.

Table 2 - Database Design

Farmers Sign-in	Farm Sign-in	Pests/Diseases Solutions
Username	**Location**	**Suitable Pesticide**
Email Address	Username	Recommendation pesticide's active ingredients
Name	Altitude	Pesticide Code
Address	Land Area	Type of pesticide
	Regular Commodities	Dosage Recommend
	Soil Condition	Pesticide function
		Price
		Producers
		Pesticide Application
		Usage Guidance

The ERD show relationship from each database in the pests and diseases management system. The proposed pests and diseases management system has 13 Databases in total, each database has a relation one to one or one to many to another database.

To identify whether this information system is appropriate for users, the researcher did an interview process with the doer in this case farmers, and a direct field assistant. To ensure all of the information systems are usable and could support the agriculture sector.

IV. CONCLUSION

Through the analysis in this research, and root cause analysis done with the 5whys root cause analysis tool, the root cause in the pests and disease management is The farmers still have limitations to access the information, and there is no integrated platform that could give diseases and pests information and exact volume recommendation of pesticide dosage to use. The available resources of information in the current environment are still independent or separated from one another. It makes farmers have an unclear solution, for specific pests or diseases experienced. The implication of this research is to help farmers reduce the operationalist for pests and disease management. With the technology in the agricultural sector, it hopes could improve the welfare of farmers and increase production efficiency. The benefit of implementing a management information system is it could help the farmer by providing accurate recommendations and information.

The Pests and Diseases Management Information system analyzes the data and recommends pesticide usage for specific pests and diseases experienced by farmers. The recommendation on what type of pesticide, how much the pesticide is to be applied, and when to apply it. This feature can also provide information on pests or diseases that are attacking the area around farmers, as a measure to prevent farmers from getting pests and diseases that are rife in the surrounding area

The findings of this research are 13 databases on database management for pests and diseases management in this research. The development of these databases is based on previously generated data flow dofAllms. All data that enters, processes, and outputs at every action in the pest and disease control system may be observed using a data flow diagram. This information may be seen in the data flow diagram, which begins with the highest level, namely level 0, and progresses through sub-processes for data flow diagrams with lower levels, namely levels 1 and 2. An entity-relationship diagram is developed to guarantee that every data entered, processed, and output from the system has a relationship with one another. After the entity-relationship diagram has been finished, the next step is to ensure that there is no data repetition and that a database already fulfills the standard. This could be done by doing the normalization database for each entity.

The recommendation for future research continues to the next step which is developing and documenting software, testing and maintaining the system, and implementing and evaluating the system. To make the database management and farmers could use the feature. in the agriculture application, and continuing to develop pests and diseases management features from developing

software until implementing and evaluating the system.

The implication of this research is to make costs for the planting phase effective, the decreasing volume of using pesticides, and makes it easier for farmers to determine the right type of pesticide so that the use of time is more efficient in the planting phase.

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