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DESIGN AND DEVELOPMENT OF A DECISION SUPPORT SYSTEM (DSS) FOR RICE INSECT PEST INFESTATION IN BUTUAN CITY, PHILIPPINES

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ABSTRACT: The Agricultural Comprehensive Assessment of Landscape and Modeling for Sustainability Analysis and Forecasting Events Program (CALM-SAFE Agriculture) program devise methods on modeling infestation on various crops. This program aims to develop a comprehensive assessment for agricultural sustainability and forecasting such events like pest infestation and disaster risk in crop insect pest infestation. The program's web mapping facility provides the functionalities that can use as a decision support system for resource management and other sustainability and monitoring. To develop a Decision Support System (DSS), the researchers will develop a stationary insect pest detector for gathering data of insect pests in an area and Geographic Information system (GIS) for data management, spatial analysis, and visualization. This paper focuses only on the design and the development of the web platform and sensor data retrieval of the CALM-SAFE Program. This program plays a significant role in assessing the agricultural areas in the Caraga region, especially in Butuan City. Outputs of the program find valuable in mitigation, prevention, planning, decision-making, and management of the resources, most importantly, in the agricultural sector.

KEYWORDS:*Risk Management;Insect Monitoring;Monitoring System;Insect Infestation, Decision Support System.*

1.0 INTRODUCTION

Rice is an essential crop in the world, feeds most people than any other crop. In 2012, almost 50% of the world's total population (around 3 million) depended on rice. Rice

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is one of a kind since it can develop in damp situations that distinctive crops cannot survive in. The cultivation of rice plants is one of the standout developments in history, and now a vast number of rice varieties are cultivated in every country[1].

It is the staple food for about 80% of Filipinos inthe Philippines. The rice production in the Philippines has expanded from 5.32 million to 16.82 million metric tons from 1970 to 2008, a staple food for about 80% of the Filipinos. Due to natural disasters (such as typhoons), rice production in 2010declined to 15.77 million metric tons[2]. Another reason that affects the downturn of rice production in the Philippines is the rice insect pest infestation. Rice insect pests assault all parts of the rice plant with regards to itsgrowth stage, that is why it is one of the reasons for low rice productivity. The rice plant is a favorite host of many insects, such as pests-root feeders, stems borers, leaf feeders, and grain feeders [3][11].Grain insects remove milk from developing grains, defoliators feed on the leaves, sucking insects feed on the leaves and stem, stem borers feed within the stem, and some species feed on the roots. According to a Manila Bulletin report in the year 2018 of February, an emerging rice pest named Rice Grain Bug continues to infest more areasin Negros Occidentaland resulted to P2.4 million worth of damage in two municipalities according to the Office of the Provincial Agriculturist (OPA). Pontevedra town and Himamaylan City lost P2,445,536 worth of loss due to an infestation in January. Pontevedra’s 59 hectares alone, lost the value of P2,053,760 and affecting 33 farmers. OPA noted that last year, the rice production yield in the province reach 7.1 tons per hectare. The pest has a dirty-brown color and is half the size of the Rice Black Bug(RGB). In the second half of 2017, cases of RGB infestation reported with damage of P8.4 million in Southern Negros [4].

A very efficient method for managing insect pest species is employingIntegrated Pest Management (IPM) [5][12][13]. According to UN's Food and Agriculture Organization (UNFAO), IPM is the consideration of all pest control techniques available. It subsequently integrates appropriate measures that lessen the insect pest population and keep pesticides and other interventions to certain levels that are acceptable and minimize the risks to human health and the environment [6]. IPM highlights the healthy crop growth with the least disruption to agroecosystems and encourages natural pest control mechanisms [7].

Filipino’s primary solution when it comes to pest control is by using pesticides, and its usage remains to increase regardless of the implementation and promotion of the Integrated Pest Management (IPM) Program. The usage of Insecticides in any variety of crops, approximately 55%, around 22% for fungicide, and 16% for herbicide[8]. The widespread use of pesticides and the risks to human health and the environment are now a significant concern. Environmental problems caused by pesticidesare: (a) ground and surface water pollution: (b)resistance of insect pests to pesticides; and (c)

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impact on non-target organisms (reduction of beneficial insects, soil micro and macro organisms, biomagnification, and pesticide residue transmittal within the food web). The Government exertsits efforts to reduce hazards from pesticides, including pesticide regulation and monitoring, continuous development and research, and improvement in the information delivery system [9].

Insect pest damage can result in yield loss annually, and it is essential to study the seasonal behavior of the insect pests towards rice to come up a control measures.The over usage of pesticides will not only harm the pest and humans but will also destroy the soil paddy field. The solution to this problem is not only achieved by using pesticides but, more importantly, the perfect time to use pesticides. The farmers need a tool that they can monitor the insect pest. For example, the farmers must know the population of the insect pest in the area and determine what kind of insect pests are present in the rice fields so they can act accordingly and analyze what pesticides only to use to avoid further damage to the soil.

About the general issue, the main goal of the program is to help the farmers and agriculturists in monitoring their rice fields through the online DSS platform when there is a pest infestation. This system will display the data acquired by the sensors (insect information, sample population, or count and showing the location of the predicted outbreak using a Geographic Information System). Lastly, the program aims to aid the farmers on how much pesticides to apply for the pest infestation. This study will support the Department of Agriculture in extending their help to rice field owners. The study is most significant to farmers; this will allow them to improve their way of monitoring with the use of technology tailored CALM-SAFE program.

2.0 METHODOLOGY

Figure 1 shows the interactions of entities within the application. As shown, the sensor will detect the insect pests in the area and send the observations to the cloud and performing calculations to builda result and presented it to the user. The user needs an account to play with the system. The processed (calculated/analyzed) data will then shown to the users through the platform and also give decisions to the user base on the results provided by the Predictive Data Analytics module. Table 1 shows the hardware and software requirements for the development of the website.

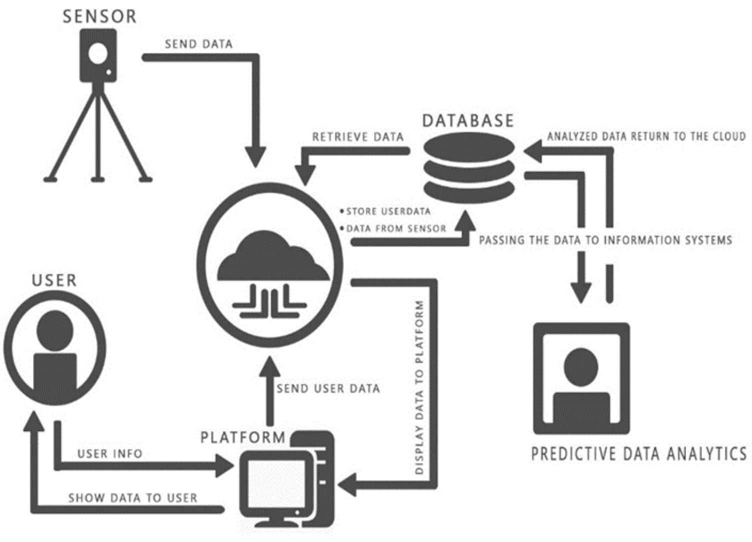

Figure 1: Conceptual Framework

2.1 Display Module Design

Figure 2 shows the transmission and receiving files using FileZilla. For saving the data from the sensor, the platform will submit a request to the Raspberry Pi to send the data to the cloud for analysis and store it in the database.

Figure 2: Sending and Receiving of Data

To save the data to the database, the researchers used the following text file format:

1: sensor4
2: 2019-05-28
3: 8.967 125.604
4: 1300
5: stemborer:12,blackbug:8,green-hornedcaterpillar:15,
6: zigzag-leafhopper:6,rice-thrips:23,mealy-bug:14,cutworm:7

The text file consist of sensor name, the date on when the pest is detected, the geo-

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location (latitude, longitude) of the sensor, followed by the area covered of the sensor, and lastly are the insects identified in the area along with the count of each insect discovered.

Table 1. Hardware and Software Requirements

Software	MINIMUM RECOMMENDED REQUIREMENTS
OS	Windows 7 or Higher
IDE	Sublime/ VSCode
Framework	Laravel Framework
Server	XAMPP
Database	MySQL
Hardware	
Processor	Pentium Dual-Core CPU E5200 @2.5 GHz or Higher *AMD A6-7310
Hard drive	500 GB at least *1TB
Memory	4GB or Higher *8GB

The code snippet of the reading of data from the source file using PHP. The code will read the source file and save itto the database if the sensor name is not existing along withthe area, location of the sensor, and pest detected. However, ifthe sensor name is already in the database, it will loop to thepest detected, and date identified of that sensor and save it to thedatabase.

```
public function load(){
$sensor_name = array();
$file = fopen('input.txt','r');
while(!feof($file)){
$content = fgets($file);
array_push($sensor_name,$content);
}
$name = strtolower(trim($sensor_name[0]));
$petsa = strlower(trim($sensor_name[1]));
$sensor_id ='';
$date_id ='';
$lat ='';
$lng ='';
$location = $sensor_name[2];
$area = trim($sensor_name[3]);
$loc = explode( ' ',&location);
$lat = trim($loc[0]);
```

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```
$lng = trim($loc[1]);
$newString = strtolower(trim($sensor_name[4]));
}
```

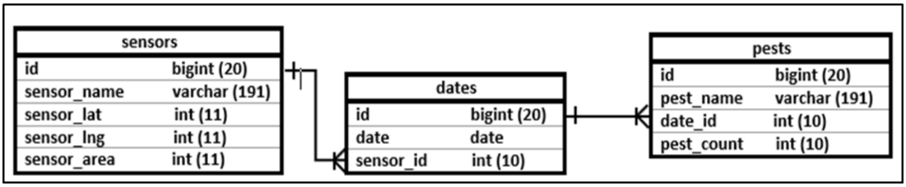

Figure 3: Pest Detected ERD

Figure 3shows the Entity-Relationship Diagram. The data is a textfile, originally from the Raspberry pi. The sensors tablewill act as the storage of the sensor name, location, and areacovered of the sensor. The dates table contains the sensor's timestamp of the pest detection, while the peststable acts as a storage for the pest name and its pest count. Figure 4 shows the data flow diagram for storing pest data.

Figure 4: Data Flow Diagram of Storing the Detected pest.

2.2 Methods for Calculating the liters of Pesticides to be used.

The formula used by the researchers shown in Equation 1 in achieving of how much liters the farmers would apply for their rice fields:

$$\boldsymbol{Pesticide_{in\ liters} = \frac{4\ liters\ x\ Farm\ area\ in\ meters}{100\ meters}} \qquad (1)$$

The code snippet for the computation on how much liters toapply in the rice fields using the formula at Equation 1:

```
$count = 0;
$area = $sensor → sensor_area;
$count = 4 * $area;
```

```
4: $liters = $count/100;
```

Another thing to consider before spraying is to check if thepest count for a date is higher than 100. Below is the script forthe recommendation liter based on pest count. If the total pestcount is higher than 100, the system will recommend howmuch liters the farmers may apply else, and it will say that the pestis manageable in the area.

```
1: if($total > 100)
2: <h1 class='lead'><b> Recommendation:
3: <span class='text-danger> {{$liters}}
4: liters of pesticides due to high number of pest present
5: in your area </span></b></h1>
6: else
7: <h1 class='lead'><b> Pest is manageable in
8: your area </b></h1>
```

3.0 EXPERIMENTAL RESULTS AND DISCUSSIONS

Design and Development of an Agricultural CALM-SAFE Decision Support System (DSS) Platform is a system where the main reason is to help the farmers in checking their rice fields about the pest infestations without leaving their homes. Moreover, this application will also display insect information for additional knowledge of farmers about insects and their damages.

3.1 The Display Module Interface

Figure 5 shows the sample data of detected insects from the sensors where the data has been acquired and stored at the database. A bar chart and pie graph represents the visualization of the data.It displays the total number for all insects present in the areaand the overall pests or insect count found in the rice fields. Farmers will then find out what insects are present in the area, and they can also compare the given data from the current date to the previous periods and see what the insects are mostly present every day.

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Figure 5: Data Analytics per Day

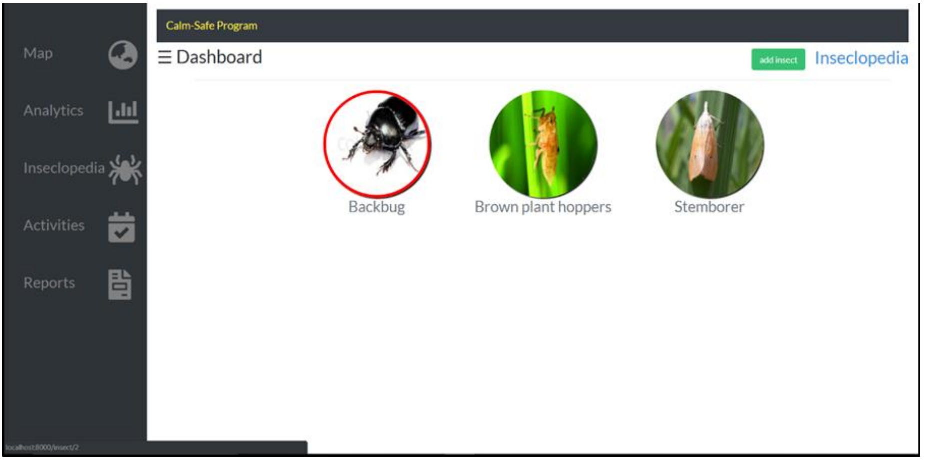
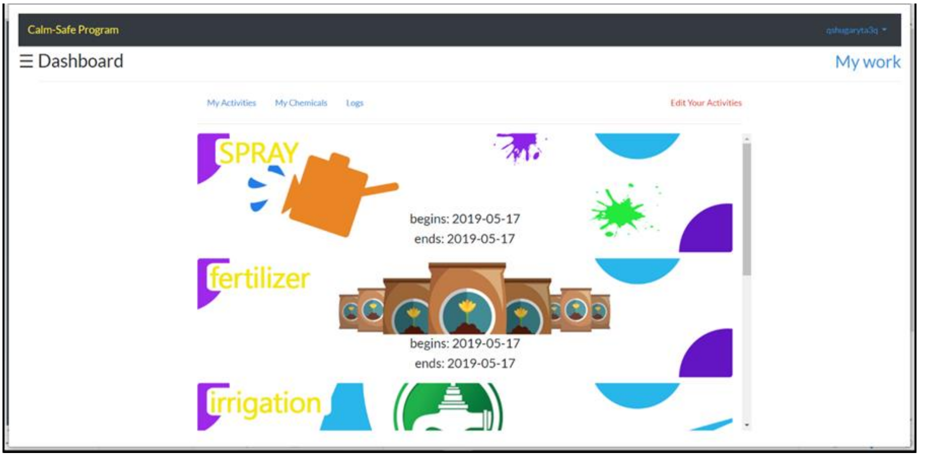


Figure 6: Displaying the Insect Information

In Figure 6, shows the pest information when a user clicks anypest from the choices. Farmers can gain knowledge from this module if ever they do not know why and where this insect occurs, and this module will give instructions to the users on how to identify such insects if the insects are not familiar with them.

Figure 7: User Activities



In Figure 7, shows the activities or work of the users. They can check from the module when to plant, harvest, and other activities they want to do. Users can update their actions by clicking the "Edit Your Activities" button. They can add their work, such as the starting date of spraying, harvesting, fertilization of the rice crops, and planting. They can also add the time of when they aregoing to end such work. By this module, users can check the system if ever they forgot the exact date of planting, harvesting, and other tasks. Figure 8 shows the geographic location of the users. They can check the sensor that is near to their farm about the pest infestations. First, users will have to register their farm location and area. Figure 9 shows the GUI for the registration of farm location by the users and its area. Lastly, Figure 10 shows the report generated per sensors. If farmers or other concerned want to have a hard copy of the detected pest results for every sensor, users can use this.

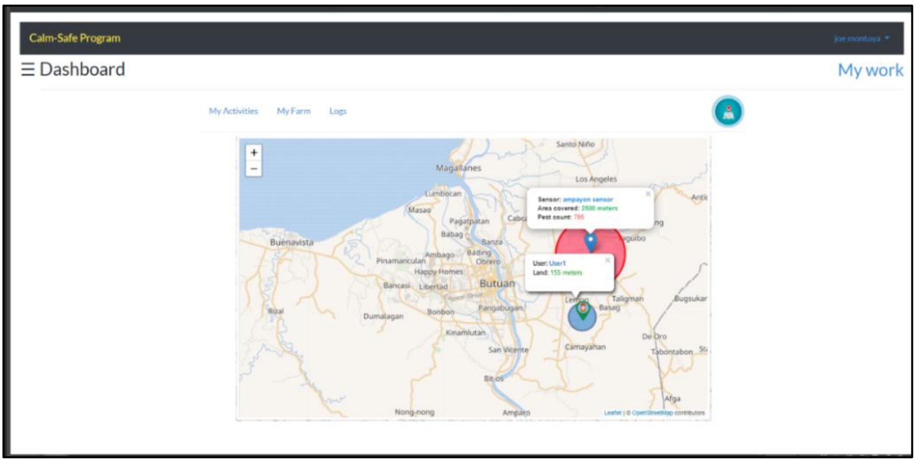


Figure 8: Geographic Information System of the User Location

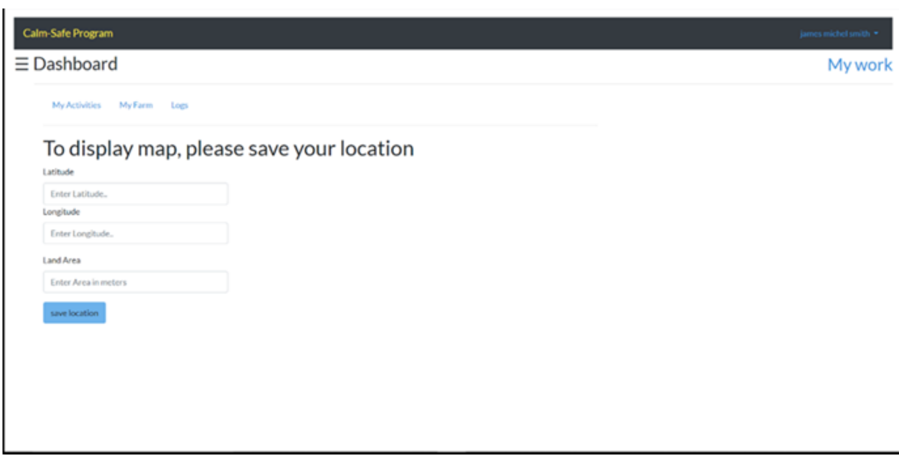


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Figure 9: User Registration Form for their farm location

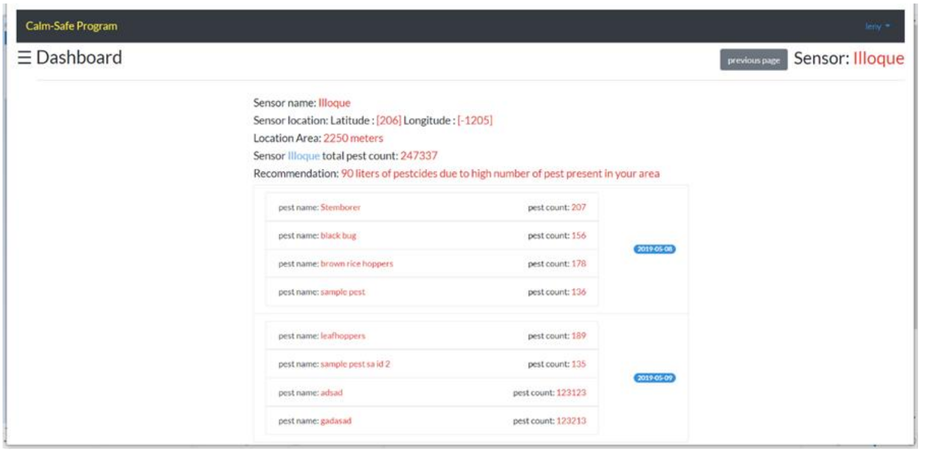

Figure 10: Report Generated

3.2Interface for Pesticide Usage

The result of the computed formula (refer to Equation 1)depends on the extent of the area. The recommended liters can be viewed through the Analytics page using per sensor view and also, in the Reports Page (refer to Figure 10). The platform willhelp the farmers to control the usage of pesticides to their ricefields, and this will also lessen the damage to the nearby water networks and the environment.Figure 11 shows the recommended liter of pesticides to usefor spraying and the detected insects per sensor. The graph's behavior changes all the time through the on the fly features of this system.

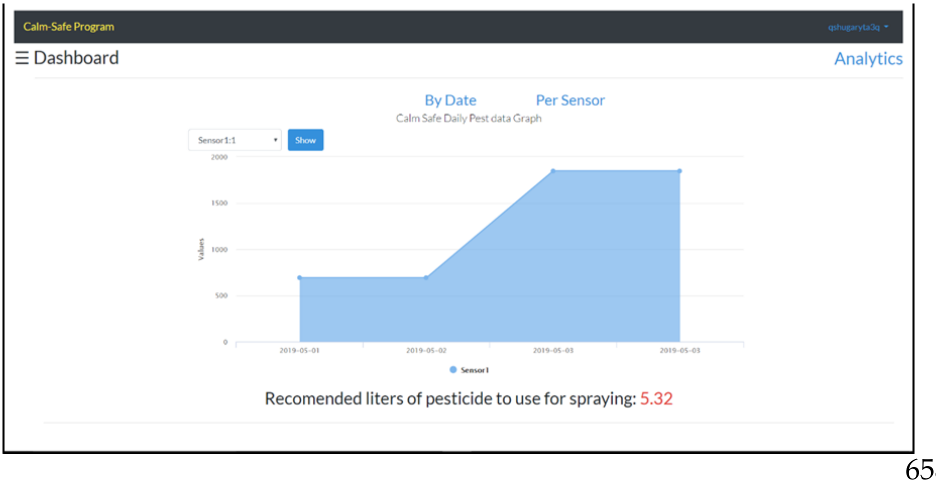

Figure 11 Recommended Liters

4.0 CONCLUSION

The system developed using the Laravel Framework as front end and MySQL as the database. It was to adopt web applications and to enable farmers and other stakeholders to access and check their crops, especially rice, without the hassle in leaving their homes. The primary function of the system was to display the detected pest data provided by the sensors. The platform will be a handy tool for the concerned farmers and stakeholders in checking or monitoring the rice fields about the possibility of an insect pest infestation. However, the system still lacks functional modules like Predictive data analytics, wherein the program needs many sensors to have valid and accurate forecasting of possible insect infestation.

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