# Decision support system as an element of web-based integrated pest control on cabbage plants

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**Abstract.** Cabbage leaves are consumed as a healthy vegetable but the plant is very susceptible to attack by leaf caterpillars (P. xylostella). The residue from the periodic use of insecticides is very dangerous to human health. Hence Decision Support System (DSS) was developed which can be used as a reference when spraying insecticides is carried out. The system is intended to estimate the cabbage leaf damage based on web-based photo imagery that is used for detecting the percentage of pest attacks so that pesticides are only applied if the damage to the cabbage leaves is detected to be rather severe. Users are required to upload photos of cabbage plants to be detected. This research is carried out through literature studies, theoretical studies, data collection and location surveys of cabbage plant centers, statistical modeling, making a cabbage leaf hole display detection system with photo images, and making packages or libraries for models that have been developed, adding features that make it easier for users to run it. This developed system after passing the development process carries out 100% black box testing works according to the desired requirements. The implementation of pest experts and testing of this system gets an accuracy of about 87%, so the implementation is carried out on users. This developed system after going through the development process is carried out 100% blackbox testing to function according to the desired needs. The implementation of pest experts and testing of this system gets an accuracy of about 87%, so the implementation is carried out by the user. The results of this study have an analysis that can be stored in a database so that the utilization of recording analysis results can be directly stored in the database, can be printed, and can issue results from the Decision Support System for spraying cabbage pests.

## 1 Introduction

Agriculture plays a crucial role in achieving the Sustainable Development Goals (SDGs) set by the United Nations (UN). One of the relevant SDGs is Goal 2, namely "End Hunger, Achieve Food Security, Improve Nutrition, and Promote Sustainable Agriculture." Sustainable and productive agriculture is essential to ensure adequate food availability for the entire world's population. Indonesia is one of the world's agrarian countries, but ironically

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in recent years Indonesia has imported foodstuffs from abroad [1]. However, the challenges faced in agriculture are pests and plant diseases that can threaten productivity and food security. One of the plants that are susceptible to this attack is the cabbage plant. Efforts to reduce the impact of pests and plant diseases on cabbage cultivation are a key aspect of achieving Goal 2 and several other goals, such as Goal 15 ("Living on the Land"). According to data from Statista [2], cabbage production in Indonesia experienced significant fluctuations. This happens because of the attack of cabbage pests and their management.

One approach that can be used to overcome this problem is to develop a Decision Support System (DSS) as a web-based Integrated Pest Control element. DSS is a tool that combines information from various sources to help farmers and agricultural managers make better decisions related to pest and plant disease control. A web-based DSS will give farmers easy and quick access to information on identifying pests and diseases, estimating the risk of infestation, and recommending appropriate controls. The use of this technology not only helps increase efficiency in decision-making, but also reduces the risk of crop loss due to pests and plant diseases. Research by Roche et al. [3], has researched decision support system based on Bayesian modeling for pests management: Application for wireworm risk assessment in corn fields, but still not publicly accessible. In the context of SDGs Goals 2 and 15, this approach supports productive sustainable agriculture, reduces potential losses, and contributes to global food security. Research by Subedi et al., [4] has found the Impact of climate change on the biology and ecology of insect pests: Implications for pest management strategies, crop production, and Food security.

This is the main part of controlling plant pests to achieve food security in accordance with the SDGs.The results of the study by Miluch et al. [5] showed that when monitoring with pheromones, the moths caught were not directly related to the density of the larvae. Therefore visual observations are better used to predict larval density. Most of the visual observations made in previous studies were observations of the number of larvae. However, observing the larvae is difficult because the size of the larvae is very small and tends to hide behind the leaves [6]. Visual observation of larvae to predict larval density can be replaced by observing the number of holes on the leaves [7]. Research on guidelines for the design of cabbage intercropping systems as a first step in a meta-analysis relay for vegetables becomes a benchmark in the development of an integrated system.

In this era, several combined methods to increase crop production are carried out on a large scale. The method used is not in the form of opening new agricultural land, but by applying multidisciplinary knowledge (intensification). One of them is the application to detect pests, plant diseases, or other plant growth disturbances. Research by Mahlein [8], explains that the trend in the detection of plant disturbances and diseases is using increasingly innovative information technology.

The trend of knowing the nature of plant diseases now refers to the study of visual patterns in a particular plant. Research by Patil et al. [9], provides advances in various methods used to study plant diseases/traits using image processing. The method studied is to increase yield & reduce human subjectivity in detecting plant diseases. Furthermore, research by Dong et al. [10] created an Automatic System for Plant Pests and Diseases Dynamic Monitoring and Early Forecasting. This can be used as a basis for dynamic monitoring of pests but many must be adjusted to the plant growth and development requirements.

Research by Arnal Barbedo [11], uses digital image processing techniques to detect, measure, and classify plant diseases from digital images in the visible spectrum. Although disease symptoms can manifest in any part of the plant, the method explores the symptoms seen on leaves and stems only. In this study, three parts were involved, namely detection, quantification severity, and classification. Each class, in turn, is divided according to the main technical solution used in the algorithm

Research development by Raza et al. [12], combines visible thermal light image data with detailed information and develops a machine learning system for plants infected with powdered tomato dew fungus Oidium neolycopersici. The method is to extract a new feature set from the image data using local and global statistics showing that by combining the depth information, greatly improves the detection accuracy of diseased plants.

Research on the implementation of the image processing method was also carried out by Pujari et al. [13], to detect diseases caused by fungi that attack various plants. Another study by Holsteen et al. [14], has detected stem disease of the flax plant which is one of the most important plants in several Asian countries. An automated system based on an Android application has been implemented to capture images of the disease-infecting hemp stems and send them to a dedicated server for feature extraction. On the server side, the affected portion of the image will be segmented using a threshold formula that is adjusted based on hue-based segmentation. Consequential feature values will be extracted from the segmented portions for texture analysis using the color methodology. However, this research is still in the development process and has not yet been socialized to the public.

Based on the latest research by Saradhambal et al. [15], introduced a defined color-based segmentation model to segment infected areas and assign them to relevant classifications. Plant diseases can be detected by image processing techniques. Disease detection involves steps such as image acquisition, image pre-processing, image segmentation, feature extraction, and classification. It shows the affected leaf part in percentage. Our previous research has carried out an analysis of cabbage plants using a statistical approach with an uneven distribution of data to determine cabbage pest attacks. This research will be developed into a website so that it can be analyzed more quickly [16].

The horticulture subsector is very prospective for development, especially cabbage, where cabbage plays an important role because it contains many vitamins that are useful for human health, as well as a source of income for farmers. In order to identify the level of attack by plant pests through the number of holes on the leaves, not much has been explored before the application of pesticides. The main challenge is how to reduce the use of pesticides to increase the quality and quantity of production. Therefore, research is focused on pests that attack cabbage leaves to be identified so as to create a system where farmers can make the right decisions to take action. The results of this study are also used as a supporting element for the cabbage IPM database.

By integrating aspects of information and communication technology (ICT) with agriculture, the development of DSS as an element of Integrated Pest Management in Cabbage offers innovative solutions that can support the achievement of SDG goals related to sustainable agriculture, food availability, and protection of terrestrial ecosystems. Through easy and widespread access to information related to agriculture and pest control, farmers can increase productivity, reduce environmental impact, and support overall sustainability.

## 2 Methods

Data collection was carried out on cabbage planting areas in the Batu and Tumpang areas. This location was chosen because it has a suitable height for the cultivation of cabbage plants. The collected data is then processed in a statistical computing laboratory for modeling. In addition, from the data obtained, the development of Plutella xylostella pest detection software was also carried out in the information technology laboratory. The object of research is photos of cabbage plants that have various conditions, both attacked by pests and not attacked by pests. Photo data will be analyzed and the level of pest attack will be grouped.

Some concepts need to be done in building an analysis system. Hartono (2004) states that there are seven important parts that must be considered:

a. Planning, the first step in building an information system is to make a plan (planning), namely making all plans related to the information system project;
b. Analysis, the intended analysis is an analysis of the information system workflow that is currently running and identifies whether the workflow is efficient and according to certain standards. The analysis is carried out by a Business Process Analyst (BPA) who has experience and/or understands the management system workflow in the area being analyzed;
c. Design is a very important step in the SDLC cycle because it defines the foundation of the information system. Errors in design can cause obstacles and even project failure. There are 2 types of designs made in this step, namely business process designs and programming designs. The programming design is carried out by the System Analyst (SA), namely making the necessary designs for programming based on the business process designs that have been made by the BPA. This design will be a guideline for programmers to write source code. Programming design includes database design, screen layout design, process diagram design, report layout design, and development;
d. Development, the development carried out is programming, namely the work of writing computer programs in a programming language based on certain algorithms and logic;
e. Testing, this process is to test the quality of information systems, to identify discrepancies in the results of an information system with the expected results;
f. Implementation, this process is to implement an information system that has been created so that users use it to replace the old information system. Implementation process includes notifying the user, training user, installing system, data entry/conversion, prepare user ID;
g. Operation and Maintenance, there are several routine procedures performed on the information system, namely system maintenance, backup and recovery, and data archive.

The stages of system development can be seen in the figure 1.

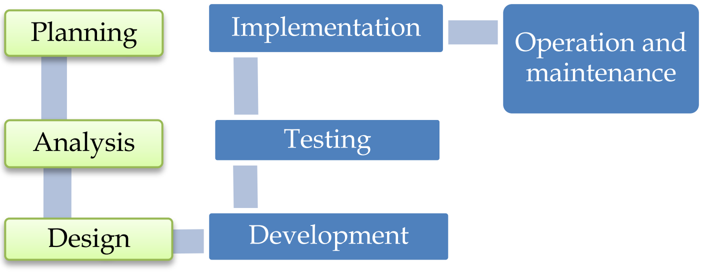


**Fig. 1.** System Development Stages Flowchart

The development offered is a website-based information system and open access for the user community. This can be done with website-based development and a user-friendly design. Need development for a fast process. Algorithms and databases must be the basis for the development of this system. The development activities carried out are in the form of website design development (Front End), Database Development (Back End), Domain and Hosting Creation, Integration, and Local Migration to Open Access Websites. The research stages are divided into 3 stages, namely testing, implementation, and operation and maintenance.

Basically, system testing aims to ensure that the system created can run well as expected. There are two methods for testing that are often carried out by developers, namely the Black box or Black box Testing method, and the White box or White box Testing method. At this stage, it consists of system testing activities, system whitebox testing, system blackbox testing, testing by IT experts, and repair and finishing. The main implementation of this system is for cabbage farmers to find out the level of pest attack quickly with photo images of cabbage. For this stage, besides cabbage farmers, it is also implemented in the biostatistics laboratory for input on the implementation of an open-access website-based information system. This stage consists of implementing the system as a whole, implementing the system for farmers, and implementing the system for experts. The operation of the system is an important part of the website-based information system that is launched. Apart from that, it analyzes bugs/errors from the user so that it can operate properly. As for maintenance, there needs to be periodic maintenance of the information system.

The research utilizes the Gray Level Co-occurrence Matrix (GLCM) method as an extraction method. Research by Zhang et al. [17] has provided evidence of results using GLCM provides good results and can be applied to plant types. Gray Level Co-occurrence Matrix (GLCM) is used for texture analysis/ feature extraction. Moreover, GLCM will describe the frequency of the appearance of pairs of two pixels with an intensity is in a certain distance and direction from the image [18]. The coordinates of a pair of pixels have a distance d and an angle orientation θ. Distance is represented in pixels, while angle in degrees. Angle orientation is formed based on four corner directions, namely, 0°, 45°, 90° and 135°, and the distance between pixels is 1 pixel [19]. The steps in the GLCM calculation are presented as follows: (i) Formation of the initial GLCM matrix from pairs of two pixels aligned in the direction 0°, 45°, 90° or 135°; (ii) Form a symmetrical matrix by adding the initial GLCM matrix with its transpose value; (iii) Normalize the GLCM matrix by dividing each matrix element by the number of pixel pairs.

## 3 Result and discussion

Website-based information system and open access for the user community. This can be done with website-based development and a user-friendly design. Need development for a fast process. Algorithms and databases must be the basis for the development of this system. Making the application that has been done is making an analysis of pest attacks on cabbage plants. The application work process is shown in Figure 2.

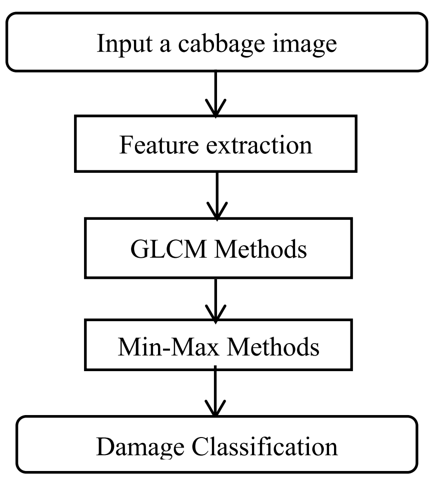


**Fig. 2.** Application work process

The initial appearance of the system is like this, Analysis is on the left while the right side is used to issue analysis results. Input the image for the extraction analysis of cabbage damage. The initial appearance of the system can be seen in Figure 3.

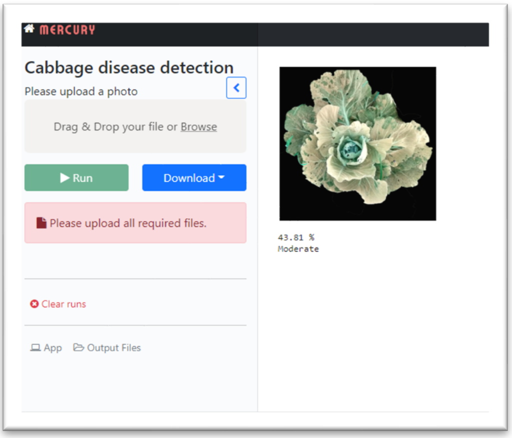


**Fig. 3.** Initial display of the system

After inputting the system, a display will appear as shown in Figure 4. This indicates that the input image is received.

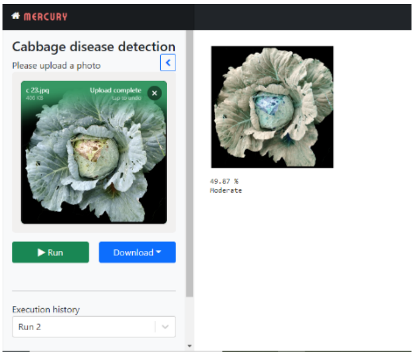


**Fig. 4.** Input image is received

To be able to perform an analysis, click the run button as shown in Figure 4. Aplikasi akan mulai menganalisis. Proses analisis ditampilkan pada gambar 5.

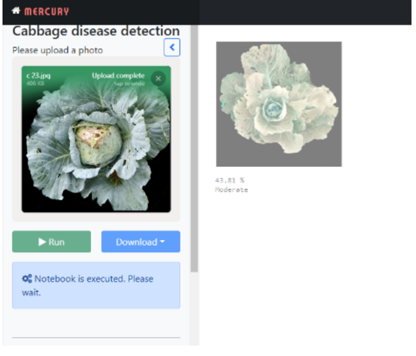


**Fig. 5**. analysis process

The results of the analysis process are shown in Figure 6.

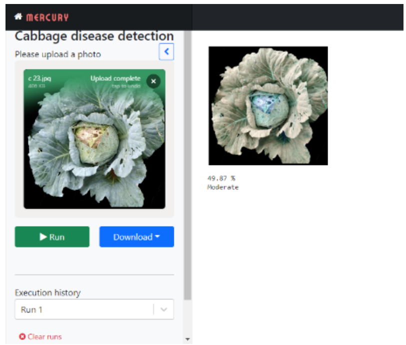


**Fig. 6.** Results of the analysis carried out

The next stage is testing, system testing aims to ensure that the system created can run as well as expected. There are two methods for testing that are often carried out by developers, namely the Black box or Black box Testing method, and the White box or White box Testing method.

**Table 1.** Test results for IT expert systems

| Test Scenario | Test Case | Test Step | Result |
|---|---|---|---|
| User uploads files | Users upload files in jpeg, png, jpg or other image formats. | The user is on a web page. The user enters an image via the browse/drag button and places the file in the available field. | File is uploaded and ready to be executed. |
| | files in formats other than jpeg, png, jpg or other image formats. | The user is on a web page. The user enters an image via the browse/drag button and places the file in the available field. | The file remains uploaded and ready to be executed. |
| Classification process | Process of classifying files in jpeg, png, jpg or other image formats that have been uploaded. | 1. The user is on a web page.<br>2. The user presses the run button for the classification process.<br>3. Users are waiting for the results of clarification | The web page will display the results of the classification as well as the files that have been uploaded. |
| | the process of classifying files in jpeg, png, jpg or other formats other than uploaded images | 1. The user is on a web page.<br>2. The user presses the run button for the classification process.<br>3. Users are waiting for the results of clarification | The web page does not display any results. |

Furthermore, the main implementation stage of this system is for cabbage farmers to find out the level of pest attack quickly with photo images of cabbage. For this stage, apart from cabbage farmers, it is also implemented in the biostatistics laboratory for input on the implementation of an open-access website-based information system.

The next stage is operation and maintenance. The operation of the system is an important part after the website-based information system that is launched. Apart from that, it analyzes bugs/errors from the user so that it can operate properly. As for maintenance, there needs to be periodic maintenance of the information system. After analyzing as many as 225 images were taken twice the analysis. The first uses this system and the other uses experts to determine the accuracy of this system. Of the 225 experiments carried out, 182 trials were the same between the expert and this system. So the accuracy of this system is above 80%.

Previous research conducted by Wardhani, et. al. [16], shows the lack of comprehensive evaluation metrics to measure classification performance on imbalanced data. The authors mention that imbalanced data is a common problem in classification, especially in image classification tasks such as medical or agricultural fields. However, they highlight that commonly used metrics such as accuracy, F1 score, and g-mean may not accurately reflect the performance of classifiers on imbalanced data. The because accurate evaluation metrics are critical for assessing classifier performance on imbalanced data. Without robust metrics, determining the effectiveness of various classification techniques and making informed decisions in real-world applications will be challenging. Therefore, further research is needed to explore and compare the performance of different metrics in the context of imbalanced data classification.

In research conducted by Dong, et. al. [10], a system is needed that can provide timely and spatially sustainable information regarding the occurrence and development of pests and diseases in a wide area. Current ground monitoring and meteorological-based forecasting methods are insufficient to meet these requirements. Additionally, this research highlights the need for improved database construction and the incorporation of communication technologies, deep learning, and artificial intelligence to efficiently extract and mine information from massive multi-source data. Additionally, there is a need to optimize system automation and intelligence to support green crop protection in China.

Research conducted by Carillo-Reche, et. al. [7] has limited understanding and utilization of competition control strategies, such as root pruning, in intercropping systems. The authors question whether this strategy is fully utilized to increase productivity and product quality in intercropping systems. This indicates the need for further investigation and exploration of competition control strategies to optimize the benefits of intercropping in agricultural systems.

Based on research conducted by Roche et. al. [3], concrete means are needed to protect maize field plants from wireworms. Although there are several data-driven models used to evaluate wireworm infestation risk, such as the VFF-QC web application developed and used in Quebec, there is no widely available DSS for wireworm infestation risk assessment yet.

## 4 Conclusion

From these results, it can be concluded that by using the feature extraction method from the analysis carried out in photo images taken to detect pest attacks by observing the number of holes in cabbage leaves can be applied in mathematical and statistical system modeling. Mathematical and statistical modeling can be used as a basis for classifying the distribution of P. xylotella pests in a cabbage field using the Bagging and Boosting methods. The development of a photo-image-based system application can be used as data to support decision-making for the use of pesticides in tackling P. xylotella pests.

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