I. INTRODUCTION

1.1. Background

Rice (*Oryza sativa* L.) is one of the main commodities in Indonesia's agricultural sector and plays an important role in supporting national food security. According to data from the Central Statistics Agency (2024), rice accounts for more than 90% of the carbohydrate consumption of the Indonesian population, making rice a strategic crop in meeting food needs. The importance of rice is also evident in its contribution to the rural economy. Most people in agricultural areas rely on rice cultivation as their primary source of income. Therefore, disruptions to rice production, such as diseases and pests, can directly impact the well-being of farmers. Additionally, the increasing demand for rice due to population growth necessitates a sustainable increase in rice productivity. However, efforts to increase rice productivity are not without challenges, one of which is plant disease outbreaks that can significantly hinder growth and harvest yields. One of the main diseases threatening rice plants is bacterial leaf blight.

Bacterial leaf blight (BLB) caused by the bacterium *Xanthomonas* sp. is one of the most damaging diseases affecting rice plants. This disease can reduce crop yields by up to 50% or even result in crop failure under severe conditions (Bande *et al*., 2022). The spread of this disease is greatly influenced by the warm and humid tropical climate. The initial symptoms of bacterial leaf blight are typically marked by the appearance of wet spots along the edges of leaves or on damaged leaf areas. Over time, these spots spread and change color to a grayish-green hue, eventually causing the leaves to dry out and appear as though they have been scalded by hot water. In more severe cases, infected plants may wilt and rot, causing significant losses for farmers. The spread of *Xanthomonas* sp. is particularly rapid in areas with high humidity, making the disease difficult to control if not detected early. In addition to economic losses, bacterial leaf blight also contributes to instability in the local food supply. One of the main challenges in controlling bacterial leaf blight is the conventional disease monitoring system.

Farmers and agricultural extension workers currently rely on direct visual inspections in the field to identify infected plants. This method is not only timeconsuming and labor-intensive but also inefficient, especially for large agricultural areas. In addition, subjectivity in observation can lead to errors in determining the severity of the disease, resulting in interventions that are often late or misdirected. Therefore, innovative solutions are needed to improve the effectiveness and efficiency of detecting and classifying plant diseases. With the development of technology, the use of camera drones has become an alternative to improve the effectiveness of rice plant health monitoring.

Drones or Unmanned Aerial Vehicles (UAVs) have the ability to cover large agricultural areas in a short time and produce high-resolution aerial images. The use of drones offers flexibility in monitoring agricultural land and also reduces dependence on manual inspections that require a lot of labor and time. In a short time, drones can collect data from large areas, even in locations that are difficult for humans to reach. In Southeast Asia, drones are widely used for rice field monitoring, providing efficiency in disease detection and land management (Gupta *et al.*, 2021). This drone (sky) technology is an innovation that aligns with Allah's words in Q.S. Ar-Rahman verse 33, which states, "...if you are able to penetrate (cross) the corners of the sky and the earth, then cross them. You cannot penetrate them except with knowledge." This information inspires the use of knowledge and technology as a force to overcome various challenges on Earth, including in the field of agriculture. With the help of digital image processing technology, drones can be used to detect early signs of plant diseases such as bacterial leaf blight, enabling farmers to take preventive actions more quickly. Image processing plays a crucial role in extracting information from aerial imagery.

The use of image processing technology has become crucial in various fields, including agriculture. Image processing is the process of manipulating and analyzing digital images to improve image quality and extract important features that can be used in decision making. This technology involves a series of methods and algorithms applied to image data to alter or enhance image visualization, extract useful information, and provide a deeper interpretation of the visual data presented in the form of images. With this technique, images obtained from drones can be analyzed more accurately, enabling faster and more accurate disease detection compared to conventional methods. This aligns with research conducted by Harisca

(2020), who states that the use of image processing in the context of agriculture offers great potential for improving efficiency, productivity, and sustainability in agriculture. One of its main applications is in the early detection of rice plant diseases.

In plant health monitoring, drones are usually equipped with multispectral cameras that can calculate the Normalized Difference Vegetation Index (NDVI) to measure vegetation health. In recent years, the use of image-based technologies such as NDVI generated by drones has developed as an effective method for identifying plant stress due to disease (Yang *et al*., 2017). NDVI enables the detection of changes in plant physiological conditions, including the presence of disease infection, before visual symptoms are visible to the human eye. The advantage of NDVI lies in its sensitivity to small changes in plant health. Through spectral analysis, NDVI can detect changes in leaf color and density that are not directly detectable by the human eye. However, the use of multispectral cameras has a major drawback: their relatively high cost, meaning not all farmers or researchers have access to this technology. Therefore, an alternative method that is more economical yet still accurate in detecting plant conditions is needed. One approach that can be used is the Visible Atmospherically Resistant Index (VARI), which can be calculated using a standard RGB camera.

VARI is a vegetation index that uses the visible light spectrum (red, green, and blue) to assess plant health. Compared to NDVI, which requires near-infrared (NIR) sensors, VARI is more affordable because it only uses RGB cameras commonly found on commercial drones. The advantage of VARI lies in its wider accessibility and its ability to provide basic information about plant conditions without requiring special sensors. However, its weakness is its sensitivity to lighting and atmospheric conditions, which can affect the accuracy of analysis results compared to NDVI. Nevertheless, VARI remains an attractive solution in supporting more affordable precision agriculture systems. Several previous studies have examined the effectiveness of VARI in monitoring plant health.

Research conducted by Al Fanshuri (2023) examined various vegetation indices, including NDVI and VARI, to estimate chlorophyll content, plant height, canopy area, and fruit yield in lemon trees. The results of this study indicate that NDVI has a strong correlation with chlorophyll content, while VARI also provides reliable estimates of other agronomic variables. The use of NDVI and VARI in crop monitoring offers an efficient non-destructive approach. NDVI, which utilizes the difference in red and near-infrared light reflection, has long been used to assess vegetation health. On the other hand, VARI, which uses the visible light spectrum, offers an alternative, especially when near-infrared data is unavailable. Another study conducted by Ramadhani (2024) showed that a VARI-based leaf disease classification model combined with the Random Forest algorithm achieved up to 85% accuracy in classifying diseases in mango plants. These results highlight the potential of VARI in visually detecting plant diseases through leaf color and texture analysis. Based on this, the question arises: can VARI be used as an effective method for early detection and classification of the severity of HDB disease in rice plants? If proven effective, this approach could serve as an alternative solution for farmers to enhance the efficiency of rice plant health management and reduce the risk of crop yield losses due to disease outbreaks.

1.2. Problem Formulation

Based on the above background, the following problems can be formulated:

1. How to determine the severity classification of bacterial leaf blight (*Xanthomonas* sp.) in rice plants based on VARI Image Processing using drone images?
2. What is the accuracy level of the VARI Image Processing method using drone images to classify the severity of the disease compared to conventional monitoring methods?

1.3. Purpose

The objectives of this study are:

1. Classify the severity of bacterial leaf blight (*Xanthomonas* sp.) in rice plants by utilizing VARI Image Processing drone imaging technology..
2. Determine the accuracy of the VARI Image Processing method using drone imagery to classify the severity of the disease using conventional monitoring methods.

1.4. Benefit

This study is expected to enrich the literature on the application of remote sensing technology and image analysis in agriculture, particularly in the management of bacterial leaf blight disease in rice crops. It aims to provide practical solutions for farmers in detecting and managing bacterial leaf blight early on, thereby increasing crop productivity. Additionally, it will provide data and recommendations that local governments and relevant agencies can use to design technology-based intervention and extension programs for farmers.