DOST Form 2 (for Basic/Applied Research)

DETAILED RESEARCH & DEVELOPMENT PROJECT PROPOSAL

(1) PROJECT PROFILE

Program Title:

Project Title: Developing Decision Support System for Surveillance and Border Control of Swine Diseases

Project Leader/Sex: NATHALIE JOY CASILDO / FEMALE

Project Duration (number of months): 24 months

Project Start Date:

Project End Date:

Implementing Agency (Name of University-College-Institute, Department/Organization or Company): CENTRAL MINDANAO UNIVERSITY - COLLEGE OF INFORMATION SCIENCES AND COMPUTING

Address/Telephone/Fax/Email (Barangay, Municipality, District, Province, Region): UNIVERSITY TOWN, CENTRAL MINDANAO UNIVERSITY, MUSUAN, MARAMAG, BUKIDNON

(2) COOPERATING AGENCY/IES (Name/s and Address/es)

Northern Mindanao Hog Raisers Association, Pork Producers Federation of the Philippines and National Federation of Hog Farmers

(3) SITE(S) OF IMPLEMENTATION

IMPLEMENTATION SITES NO.	COUNTRY	REGION	PROVINCE	DISTRICT	MUNICIPALITY	BARANGAY
1.	Philippines	X	Bukidnon			
2.						
3.						
4.						
5.						

(4) TYPE OF RESEARCH

_____ Basic

(✓) Applied

(5) R&D PRIORITY AREA & PROGRAM (based on HNRDA 2017-2022)

(✓) Agriculture, Aquatic and Natural Resources
Commodity: Swine

_____ Health
Priority Topic: _____

_____ Industry, Energy and Emerging Technology
Sector: _____

_____ Disaster Risk Reduction and Climate Change Adaptation

_____ Basic Research
Sector: _____

Sustainable Development Goal (SDG) Addressed

Zero Hunger

(6) EXECUTIVE SUMMARY (not to exceed 200 words)

Swine diseases are a major concern for farmers and government agencies in the Philippines, with outbreaks leading to significant economic losses and potential public health risks. However, there is currently a lack of integrated computing solutions and machine learning approaches for animal border control of swine diseases in the region, making it difficult to develop effective control and prevention strategies.

This research project aims to develop an integrated computing solution and intelligent monitoring system for preventing and controlling African Swine Fever (ASF) and other swine diseases in the Philippines. The computing solutions include various applications such as document control and tracking, ticketing system, swine and support services profiling, and mobile-based applications for animal border control. The intelligent monitoring system includes AI-based computer vision applications and decision support systems for early detection and severity estimation of swine diseases and geographic information systems for mapping the distribution of swine diseases and other related information.

The outcomes of this project are expected to enhance border control by tracking and controlling the spread of swine diseases and other transboundary animal diseases, improve the livestock industry's productivity, enhance food security, and promote animal welfare in the Philippines.

(7) INTRODUCTION

Transboundary animal diseases (TADs) such as African Swine Fever (ASF) pose a significant threat to the livestock industry and food security in the Philippines. The country's swine industry is one of the largest in Southeast Asia, employing thousands of people and providing a significant source of protein for Filipinos. However, the emergence of ASF and other TADs has resulted in significant economic losses, reduced food supply, and increased prices for consumers. As such, ASF is a highly contagious viral disease that affects domestic and wild pigs. The disease causes high fever, loss of appetite, internal bleeding, and ultimately death in infected animals. Since the first outbreak was reported in the Philippines in September 2019, ASF has spread to multiple provinces, resulting in the culling of millions of pigs and significant disruptions to the swine industry.

The use of a Decision Support System can provide decision-makers with the necessary information to identify and respond to potential ASF outbreaks. A DSS can incorporate information from various sources, such as disease surveillance data to provide real-time risk assessment and recommendations for preventive actions. Similarly, the use of Data Science technologies can help in early detection of ASF by identifying sick animals and changes in their behavior, allowing for early intervention and control measures.

This research aims to develop and test an integrated IT solution for ASF prevention and control in the Region. The study will involve the development of the Information System and Data Science modules, incorporating input from stakeholders and subject matter experts. The effectiveness of the IT solution will be evaluated through simulation exercises and case studies, comparing the results to the current ASF prevention and control measures in place in the region.

The research findings will contribute to the development of evidence-based IT solutions for ASF prevention and control in the Philippines and other countries. The results of this study can inform policy decisions on improving ASF prevention and control measures, and support the implementation of a comprehensive and coordinated approach to prevent the spread of ASF and other TADs. Furthermore, the development and deployment of IT solutions can help enhance the capacity and resilience of the swine industry and food security in the Philippines.

(7.1) RATIONALE/SIGNIFICANCE (not to exceed 300 words)

The development of a decision support system for surveillance and border control of swine diseases can aid in identifying, tracking, and monitoring potential disease outbreaks in swine populations. It can help veterinarians and animal health workers detect disease outbreaks early, assess disease risk, and make informed decisions regarding the implementation of disease control measures. Furthermore, it can assist border control authorities in monitoring the movement of animals and animal products across borders to prevent the spread of diseases.

The decision support system for surveillance and border control of swine diseases can integrate data from various sources, including animal health records, environmental factors, and disease surveillance data. The integration of this data can help in identify infected swine and implementing preventive measures in a timely and efficient manner. The use of predictive analytics can enable decision-makers to take informed actions that can minimize the impact of swine diseases. For instance, the system can provide insights into the effectiveness of control measures, enabling authorities to make timely adjustments to improve the efficacy of interventions.

Several studies have demonstrated the potential of decision support systems in improving disease surveillance and control. For instance, a study by Willeberg et al. (2007) developed a decision support system for early detection and control of foot-and-mouth disease in Denmark, which improved the efficiency of disease surveillance and control measures. Similarly, a study by Brouwer et al. (2016) developed a decision support system for the control of African swine fever in the European Union, which aided in early detection and rapid response to disease outbreaks.

(7.2) SCIENTIFIC BASIS/THEORETICAL FRAMEWORK

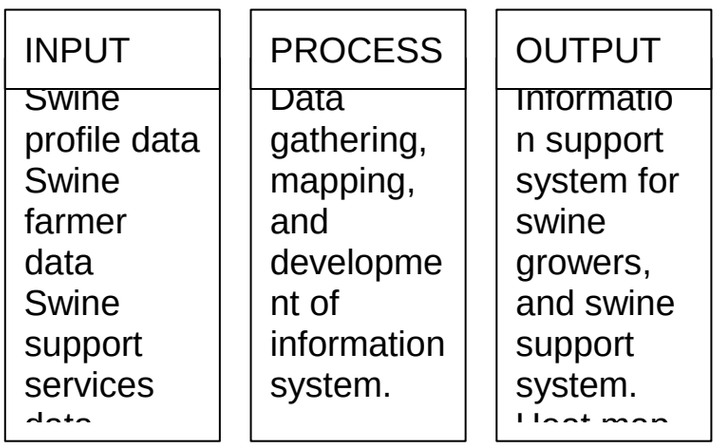
Surveillance is a critical component of disease prevention and control. The purpose of surveillance is to detect disease outbreaks early and to enable effective control measures to be implemented promptly. A Decision Support System (DSS) for swine disease surveillance can aid in the collection, analysis, and interpretation of disease-related data. It can integrate data from various sources, including laboratory testing, animal movement, and epidemiological investigations. The DSS can use advanced analytical techniques such as machine learning and artificial intelligence to identify patterns and trends in the data and to provide early warnings of potential disease outbreaks.

Border control is another crucial aspect of disease prevention and control. It involves monitoring the movement of animals and animal products across borders to prevent the spread of diseases. A DSS for

swine disease border control can aid in the monitoring of animal movement and the identification of high-risk animals and products. It can integrate data from various sources, including import/export records, animal health certificates, and border inspection reports. The DSS can use advanced analytical techniques to identify high-risk shipments and to provide recommendations for additional inspections and testing.

Once a disease outbreak has been detected, prompt implementation of control measures is critical to prevent the spread of the disease. A DSS can assist veterinarians and animal health workers in assessing disease risk and making informed decisions regarding the implementation of disease control measures. The DSS can provide real-time information on the spread of the disease, identify high-risk areas and populations, and provide recommendations for targeted disease control measures.

The following figure shows the Input-Process-Output (IPO) diagram of the proposed project. The first component of the system is the input, which includes swine profile data, swine farmer data, swine support services data, location information of swine support services, swine images with diseases, pork meat images with diseases, border control procedures and policies, and veterinarian control procedures. These inputs are based on research findings on the key factors that affect swine health and productivity, as well as regulations and policies that govern the swine industry. The second component of the system is the process, which includes data gathering, mapping, and development of the information system. The system utilizes machine learning techniques that are validated through research to train data models that help to develop a decision support system. The data is also processed to create a web-based and mobile-based border control checker, which is designed based on research findings on user needs and preferences. The final component of the system is the output, which includes the information support system for swine growers and the swine support system. The system produces heat maps and data visualizations based on research findings on swine disease outbreaks, computer-aided swine disease detection tools, and swine farms and border control. These tools are designed based on research findings on the most effective ways to monitor and manage swine diseases. The app-based checker for swine transport is designed based on research findings on regulatory compliance and user needs. An information system is developed based on research findings on swine movement patterns and risk factors.



IPO diagram of the proposed project

The project is composed of three major modules: Border Control with GIS mapping, Computer Vision to detect Swine disease, and Profiling Information System. The Border Control with GIS mapping module is composed of three research development modules that facilitate request and validation of swine transport across identified government borders. Farmers that will transport swine to locations are expected to apply for travel clearance using the information system. The border control then verifies the completeness of the application then issues the transport ticket. The ticket is used at the border control location wherein law enforcement scans it using a developed mobile application. This makes the process faster in validating and allowing swine transport at border facilities. The second module takes advantage of data science as aid in decision making. Using computer vision, a software will be developed that can scan swine and meat for possible diseases using images. This is useful in border control as suspected swine to be transported can be checked for possible diseases at the border using mobile devices. This feature can be used as an additional testing procedure to molecular testing from the other project of this program. The second module can be also used by swine growers to check possible swine diseases in the farm. The last module is focused on profiling and providing information for swine and support services. The data of this component can be used to database the swine growers in the vicinity.

(7.3) OBJECTIVES

Project : Developing Decision Support System for Surveillance and Border Control of Swine Diseases

General: This project aims to create a Decision Support System for Surveillance and Border Control of Swine Diseases in Northern Mindanao. The system will include various tools and technologies to enhance the monitoring and control of animal movements across borders. These tools will include a Document Control and Tracking System for Animal Border Control using QR codes, a Mobile-Based Application: Document Verifier for Animal Border Control, livestock profiling, and its swine support services, computer vision applications for animal border control, and a visualization tool using an integrated web application for geographic information systems. By developing these tools and technologies, the project seeks to improve border control measures, enhance disease surveillance, and ensure the safety of swine and other livestock animals in Northern Mindanao.

The project specifically aims to:
1. develop a document Control and Tracking System for Animal Border Control using QR codes;
2. develop a Mobile-Based Application: Document Verifier for Animal Border Control
3. develop a geographic Information System for animal border control;
4. develop a decision support system on image-based classification of swine diseases using deep convolutional neural networks
5. develop a decision support system to localize and estimate the severity of swine diseases using object detection and instance segmentation;
6. develop a swine Profiling Information System;
7. develop a swine Support Services Profiling Information System

Component 1: Development of a Document Control and Tracking System for Animal Border Control using QR codes

General: Animal border control is a crucial process to prevent the spread of diseases and ensure the safety of animals in a country. The main goal of this project is to create a web-based document control and tracking system for animal border control especially to the swine industry in order to track and verify the requirements and papers that have been submitted. This study proposes that all animal transportation should submit a comprehensive set of documents before crossing a particular border. The system will provide a simple, efficient and secure way to track the movement of animals especially those swine infected with African Swine Fever (ASF) in order to control the dissemination of such disease. The system will be used by government agencies responsible for monitoring animal movements and enforcing animal health regulations..

Specific:
In order to attain the general objective, the system should have:
1. document submission and application features;
2. document QR codes generation for the swine transport application;
3. document validity check feature;
4. document management features;
5. an account management features;
6. document control and tracking features;
7. document submission expiry feature;
8. document submission renewal feature;and
9. logs, reports and printing features;

Study 2: Development of a Mobile-Based Application: Document Verifier for Animal Border Control

General: The main objective of this study is to develop a verifier for document issued permits and ticketing systems for border control. This system will be responsible for verifying a travel permit document issued through the use of QR code security.

Specific:
Specifically this system should be able to:
1. verify issued QR code as pass ticket
2. have a ticketing dashboard;
3. send QR code ticket to livestock owner’s mobile account;
4. search and view livestock owner registration status and profiling status;and
5. print ticket pass.

Study 3: Geographic Information System (GIS) for Animal Border Control, Swine Farms, and Swine Support Services

General: The main objective of this study is to develop a geographic Information System for Animal Diseases Border Control

Specific:
Specifically, this study aims to:
1. collect and record animal diseases information in region 10;

(8) REVIEW OF LITERATURE

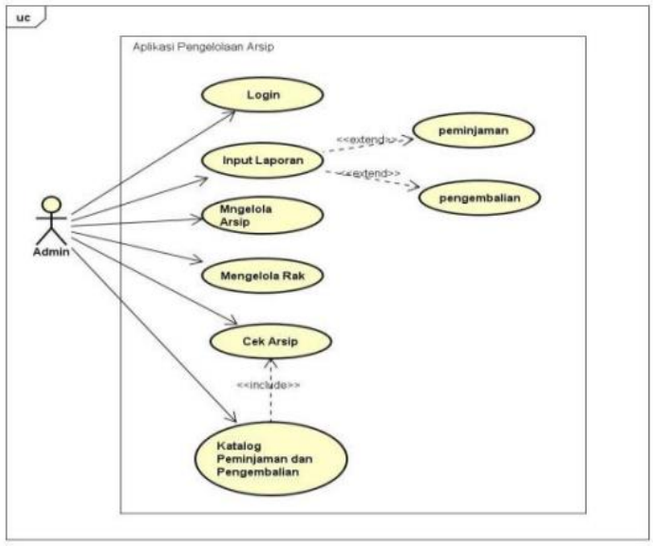
Component 1: Development a document Control and Tracking System for Animal Border Control using QR codes

Document Control Tracking System

Document Tracking System is very much useful in the productivity of work. To increase the effectiveness of document retrieval online at any time and trace the movement of documents in and out, the Electronic Document Tracking System (EDTS) has been developed [1]. In Indonesia the Electronic-Based Government System is being implemented that provides fast and unlimited services by distance, space and time [2] . Another tracking application which serves the government was developed through a web based application [4].It is an application for electronically tracking the report provides an online loss reporting function and the results of the development of the loss, the first follow-up from the police to the community is the ease of managing loss reports, and facilitating notification of developments in reporting to the public [4]. Aside from giving an ease to the process in the government and community, the document tracking system is surprisingly beneficial to tracking the building performance [3], medical establishments [5][8], academic sector [6], Book tracking [7] and etc. A study [3] about building a Life-Cycle Information System for tracking building performance metrics designed to manage a wide range of building related information across the life cycle of a building project. [3] The study developed a tool for tracking performance metrics called metracker, which focuses the attention on the specification, tracking, and visualization of performance metrics [3]. A document tracking and identification system was developed for patients and medical staff in Romania [5]. It has been proven in this study[5] that the identification and tracking system reduce medical mistakes, improve patient safety and enhance the quality of medical service in hospitals. Moreover, the Information system for patient tracking examines nurses' attitudes and reflection on the transformation of their work practices after the implementation of an Emergency Department Information System (EDIS)[8].

Archives Feature

The development of an archives management information system using visual basic has a design at West Java province has a system design with the steps of Planning, System Design, Database, Visual Basic 6.0, Crystal Report 8.5 [9]. Moreover, this study [9] also developed a use case for archives management.



[9] Use Case Diagram for Archive Management Applications

The only actor in the use case for this archive management tool is admin [9]. The Administrators can enter inactive archive data and access the archive application[9]. Additionally, the administrator can manage shelves, examine archives, and record loan and return reports[9]. The archive check includes a borrowing and returning catalog [9].

QR Code Feature

Quick response (QR) codes provide a rapid, easy, convenient, accurate, and automatic data collection method [21]. As responsive as it is, this technology has been successful in the medical field [21], electronic payment [22], transportation [23],[24] and etc. The QR code is structured in number mode, alphanumeric mode, 8-bit byte mode, and kanji and kana characters mode[22].Creating a regular QR code is not difficult, as there are currently a large number of services for creating it [25].

Submission Feature

Submission of documents or design models and assignment of attributes to documents (e.g. creation and due dates, phase, etc.) are common features of an electronic document management system [10].Users of this feature can also give the submitted documents different attributes, such as assigning a document filter based on the relevant division or office (for example, planning, design, or construction), type (for example, contract documents, shop drawings, or requests for information), subtype, phase, event date, and due date, etc., so that the documents can be quickly searched for and arranged in accordance with the designated properties [10].

Scalability Features

Scalability refers to the system's portability and ability to be used at any time or place. A web-based and mobile-based feature of the system must be integrated. In a developed electronic document management[10] mobile-based gives safety, productivity, error detection, and communication to the user. Mobile application is very handy as it was made for healthcare [16], construction [17], teachers and students [18], waste management [19] and etc.

The data in a web-based information system stored in the repository helps in taking intelligent decisions by the management [11]. As handy as it is, a web-based information system attracts users because it is very portable, multiple devices can productively participate in the functionality and the features can be customized based on what is needed. Certain applications, construction projects [12], Tourism [13] , education [11], workplace [14] , risk reduction [15] and etc.

Methodology

- Define the requirements and scope of the system:
  - Identify the necessary document types and their corresponding information that need to be tracked and controlled.
  - Determine the stakeholders involved in the document control process and their respective roles.
  - Determine the timeline and budget for the development and implementation of the system.

- Design the user interface and workflow:
  - Develop a user-friendly interface for document submission, generation, tracking, and renewal using QR codes.
  - Create a workflow that clearly outlines the steps involved in document submission, review, approval, and renewal.

- Develop the technical components of the system:
  - Generate QR codes for each document type using a QR code generator library or API.
  - Develop a document management system that allows for document upload, storage, and retrieval.
  - Implement a validity check feature to ensure that the documents submitted are valid and up-to-date.
  - Develop an account management system that allows for user registration, login, and profile management.

- Implement document control and tracking features:
  - Develop a document control system that tracks the status of each document (e.g., submitted, approved, expired, and renewed).
  - Implement a document tracking system that allows for the tracking of documents using QR codes.
  - Develop a document submission expiry feature that sends notifications to users when their documents are about to expire.
  - Implement a document submission renewal feature that allows users to renew their documents.

- Implement logging, reporting, and printing features:
  - Develop a logging system that logs all activities related to document submission, review, approval, and renewal.
  - Implement a reporting system that generates reports on document status, user activity, and other relevant metrics.
  - Develop a printing feature that allows users to print their documents.

- Test and deploy the system:
  - Test the system thoroughly to ensure that all features are working as expected.
  - Deploy the system to the target environment (e.g., a web server, cloud platform, or local network).
  - Provide training and support to users to ensure that they can use the system effectively.

- Maintain and update the system:
  - Monitor the system regularly to ensure that it is running smoothly and efficiently.
  - Address any issues or bugs that arise in a timely manner.
  - Update the system as needed to accommodate changes in document types, workflows, or user requirements.

Component 2: Development of a Mobile-Based Application: Document Verifier for Animal Border Control

The 'Quick Response' (QR) code was first developed in 1994 by Masahiro Hara from the Japanese company Denso Wave [1][2][3] , subsidiary of the Toyota, intended to keep track of automated parts manufactured, to a replacement of the overwhelmed bar codes, each of which had to be scan separately [4]. The development of marking components accelerates logistics processes for automobile production. QR (quick response) codes are two dimensional images that when scanned by a smart phone's camera, prompt the smartphone to open a web-page or display an image, video, or text. QR codes are, therefore, essentially pictographic hyperlinks that can be embedded in the physical environment. This technology has the potential to revolutionize the way businesses deliver instructions, connect patrons to information about product materials, and market their services.

The Adoption
Quick Response code is now used in a much broader context, which include both commercial tracking application convenience-oriented applications aimed at mobile-phone users. It is used to display text to the user, to access a webpage on the user's device, to add a vCard contact to the user's device, to access a Uniform Resource Identifier (URI), to connect to a wireless network, or to compose an email or text message. The QR code becomes one of the most-used types of two-dimensional code as of today [5].

A QR code is the abbreviation for quick response code, which is a machine-readable optical label with information on the associated item or product. In barcodes, information is coded in one direction or one dimension only. On the other hand, in a two-dimensional code, which the QR code is, information is coded in two directions: horizontally and vertically. It can be read easily and is capable of holding a great deal of information. Although Denso Wave could choose to retain the patent rights to the QR code, the company declared that it would not exercise them, with the aim that QR codes be used by as many people as possible. Thus QR codes can be used at no cost and without worrying about patent problems. They are becoming a public code used worldwide [6].

High Capacity Encoding of Data
Several QR code features are worth examining in more detail. The QR code's most important characteristic is the encoding of enormous quantities of data. Conventional bar codes can store up to 20 digits. On the other hand, QR codes can provide up to a hundred times more information than barcodes. QR codes can manage all types of data, for example, letters, numbers, graphics, and audio or video files. One QR code can encode up to just over 7,000 characters [7].

Document Validation Using QR Code
Businesses face a lot of risks every single day, some of them are document-related such as lack of document control and document fraud [9]. Document verification aims to stop these issues from arising. By scanning the QR code in the document, it's now possible to

ensure that your copy of the document is the same as the one in your official database, and have the peace of mind that it is not tampered with.

This technology is being used by companies and government agencies like the US Food and Drug Administration (FDA) for “Certificate to a Foreign Government” and “Certificate of Exportability” for human food products for easy verification of the authenticity of these certificates.

The document management system provided by the Department of Budget and Management Regional Office VI a server that would secure the circulars and memorandum documents which accepts an official document sent by the Central Office to be scan into the system thru a scanning module using an Optical Character Recognition (OCR). The captured image of the scan document is converted to text and clustered in to supervise keywords to facilitate searching. To ensure authenticity, the scan document will undergo authentication by imprinting a watermark image and a QR code using the watermarking algorithm using Text Brush Embedding and a QR Code Model 2 matrix code [10]. The features of the system were able to generate a scan document with watermark and QR code imprint which were used to verify the acceptability, authenticity of the secured copy document generated by the system.

Component 3: Geographic Information System for Animal Border Control, Swine Farms, and Swine Support Services

Geographic Information System
Geographic Information System (GIS) can be very useful for mapping specific dataset, it is seen to be useful in flash floods[45], mapping of mosquitos [46], groundwater [47], public transportation [48] and etc. If GIS will be implemented in the animal border control, specifically in the classification of animal diseases, it could be a very big help in the community. [49] Fish farming was closely monitored using the GIS technology, giving the benefit to the department of fisheries. Moreover the GIS was very much helpful in the border control during covid 19 pandemic [50]. A Prototype of Mobile Application for Monitoring the Global COVID-19 Epidemiological Situation was made in a study [52] .

Component 4: Developing a decision support system on image-based classification of swine diseases using deep convolutional neural networks

The identification of livestock has been practiced for several centuries, and although it was a means of claiming ownership in the early days, it later played a significant role in the detection and control of veterinary infections in the herd for welfare, behavior detection, and activity management of livestock [65]. Current best practice involves the use of RFID tags which are time-consuming for the farmer and distressing for the animal to fit. They also have a limited range at which they can be activated and read successfully, and multiple tags cannot be read concurrently [66]. An alternative approach to this problem is the use of cameras, which are able to identify images due to astounding advances in technology that may also provide an opportunity for automated and smart livestock farming.

The research of face detection has important research value due to the variability of facial expression, skin color, and illumination [67]. By adapting the algorithms that produce promising human facial recognition outcomes, successful pig facial identification has been demonstrated in previous studies. For instance, [66] showed that it is possible to accurately recognise individual pigs non-invasively from a relatively unconstrained scene. Subsequently, [68] implemented an automated pig face recognition framework on images captured under farm condition with the use of deep convolutional neural networks. In another study, [73] proposed an improved ResNet pig face recognition method, using ResNam to extract deep pig face features. By using CNN, [69] was able to reliably distinguish whether a pig is stressed or unstressed in unseen animals using features extracted from a front view of the animal. Thus, this work has the potential for the non-invasive monitoring of individuals, whereby farmers might be quickly alerted if an individual animal is showing signs of stress.

The application of computer vision has also shown great promise in improving the management of swine diseases and livestock in general, particularly in the areas of disease detection, behavior monitoring, and growth tracking. Swine diseases pose a significant threat to the global swine industry, with far-reaching impacts on animal welfare, economic sustainability, and public health. One of the most significant threats to swine production is the African swine fever virus (ASFV), which can cause acute hemorrhagic fever in pigs and has a mortality rate of up to 100%. The virus is highly contagious and spreads rapidly, making it difficult to control. Other major swine diseases include porcine reproductive and respiratory syndrome, swine influenza, porcine epidemic diarrhea virus, classical swine fever, foot-and-mouth disease, and transmissible gastroenteritis virus, among others. These diseases can have significant economic impacts on the swine industry, resulting in production losses, trade restrictions, and increased costs of disease control and prevention. One example of study which employed computer vision was done by [70], where a deep convolutional neural network (CNN) was trained to quantify pneumonia-like lesions in slaughtered pigs from 5,902 images of pigs in both controlled and uncontrolled environments, achieving an overall accuracy of 85.5%.

Although deep CNNs have shown great potential for image-based disease classification, the following are some of the research gaps that need to be addressed:

- Limited availability of annotated datasets: Deep CNNs require large annotated datasets to be trained effectively. However, there is a limited availability of annotated datasets for swine diseases, which can limit the performance of the model.
- Lack of standardized diagnostic criteria: There is a lack of standardized diagnostic criteria for swine diseases, which can lead to variability in disease diagnosis across different border checkpoints and laboratories.
- Limited evaluation of real-world performance: Deep CNNs have shown great performance in controlled settings, but their real-world performance is not well understood. Therefore, there is a need for comprehensive evaluations of deep CNNs in real-world scenarios to determine their feasibility and accuracy for disease diagnosis in swine.

Addressing these research gaps can help improve the performance and applicability of deep CNNs for image-based classification of swine diseases, which can contribute to effective disease control and prevention in the swine industry.

Component 5: Developing a decision support system to localize and estimate the severity of swine diseases using object detection and instance segmentation

Swine diseases are a major concern in the global pig farming industry due to their economic impact on the production and welfare of pigs. Timely detection and accurate estimation of the severity of swine diseases are critical for effective disease management and control. Traditional methods of disease diagnosis and severity estimation involve visual inspection by veterinarians, which is time-consuming, subjective, and prone to error. The application of computer vision and deep learning algorithms can provide a more efficient and objective approach to disease detection and severity estimation in swine.

Studies have shown the potential of object detection and deep learning algorithms in improving livestock management and welfare, enabling farmers to monitor individual animal behavior and health more accurately and efficiently, which can lead to improved production and reduced disease spread. For instance, [71] showed the potential of object detection and 3D depth cameras in detecting and tracking individual livestock, which will enable farms to detect the signs and symptoms of ASF as early as possible in a contact-free and automatic way. In the context of pig behavior, an object detection method such as YOLO and semantic segmentation such as DeepLab achieved an accuracy of 92.45% on 800 images for classifying pig postures [72]. Similarly, [75] adopted YOLO to monitor drinking and feed intake of pigs, achieving a mAP of above 90%. Relatedly, [76] leveraged object detection methods such as Faster R-CNN, R-FCN, and SSD to detect lying and standing postures of pigs, achieving a mAP of more than 93%.

Object detection and instance segmentation techniques [74] have the potential to provide more detailed and accurate information on the location and severity of swine diseases in images. However, they also require more computational resources and specialized expertise for their implementation and optimization. Therefore, this research component will work towards improving the effectiveness of using object detection and instance segmentation techniques for swine disease detection and severity estimation using images or videos, which can ultimately improve animal welfare and benefit the swine industry as a whole.

Component 6: Livestock Profiling Information System

The profiling system is very much common to students [27], [28],[29] and governance [31],[32],[33]. Profiling Information systems can also be integrated in employment [30], medical [35], agriculture [36], and etc. A patented system [34] attempts to describe a novel and comprehensive method for providing a secure electronic identification and management system for individual livestock. A Livestock Disease Management System was also developed where animal disease is recorded through an application called vetlink app [37]. Some VetLink features, such as user registration, account administration, standard website search, a help page, and others, are quite comparable in design and implementation to those in conventional database management systems[37]. A project developed an Android application related to livestock profiling which displays the results using mobile application [38]. This study [38] also uses RFID in creating profiles for livestock and parties involved in the livestock industry such as farmers and veterinarians,share information about the livestock through electronic storage like servers and cloud storage platforms.Utilizing new ICTs also makes it easier to track vaccination and medicine supplies, as well as to map and monitor the spread of infectious illnesses and their coordination across sectors[41].

Account Registration

Since the student information system and the profiling information system share many similarities, an integrated student management information system [39] can be used to compare features in the account registration process. This module includes all administrative, registrar/assistant, and registration-related processes. [39] The system's administrator, known as Admin, has the power to add or delete other people and objects to and from the system, respectively. To build their accounts in the system,client users and employees (Register/assistant) must register themselves [39].

Livestock vaccine and health monitoring

A paper [40] described a monitoring and surveillance system of small ruminant health in The Netherlands and gives a general overview and some elaborated examples of findings since this additional voluntary system started in 2003. [40] This technique has proven to be quite effective at identifying both new and (re)emerging illnesses. Annual checks on representativeness and effectiveness are conducted because, in a world that is constantly changing, regular attention is required for potential system modifications and improvements.The need for animal health monitoring and surveillance is an adaptable strategy that can keep up with changes and advancements in the field[40] . As a result, monitoring and surveillance systems should be regularly modified and enhanced using new methods and insights[40].The application of Digital Technologies in Livestock Systems will help to investigate thoroughly and fully understand the dynamics and impact of climate change on farm animal ecology[42].

Submission of documents

Submission of documents or design models and assignment of attributes to documents (e.g. creation and due dates, phase, etc.) are common features of an electronic document management system [10].Users of this feature can also give the submitted documents different attributes, such as assigning a document filter based on the relevant division or office (for example, planning, design, or construction), type (for example, contract documents, shop drawings, or requests for information), subtype, phase, event date, and due date, etc., so that the documents can be quickly searched for and arranged in accordance with the designated properties [10].

Component 7: Swine Support Services Profiling Information System -

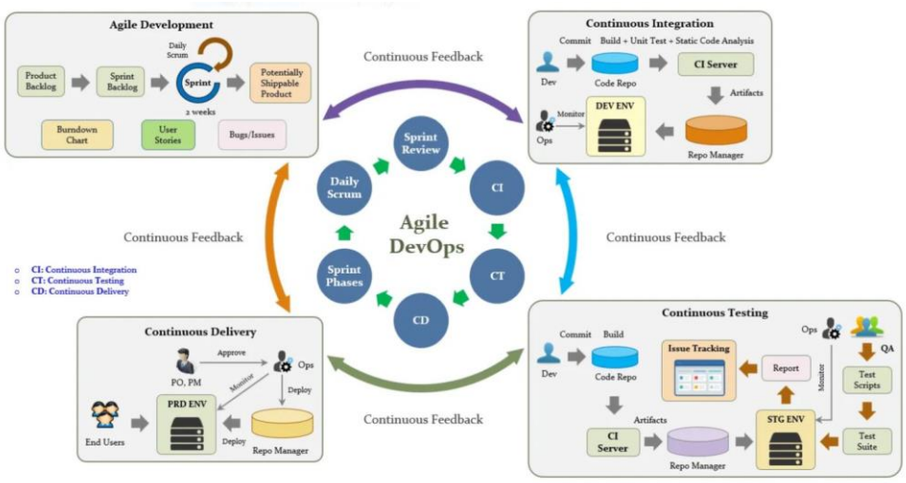
This profiling information system of the support services resources of swine production could technologically empower the swine farmers in the Philippines especially in region 10. Farmers in the Philippines who were technologically empowered with simple mobile phones gets better deals with traders. The finding supports the notion that farmers receive a higher proportion of the surplus according to the study [63] .Although the study was not geared towards swine production, it exhibits the role of information on farmer's consumption. This means that the impact that access to information can have on the farmer makes them lead to informed decisions about farming practices efficiently. An access to support services profiling system would eventually be significant in improving swine farmers and its stakeholders improve the swine production in general.

There are numerous studies for swine and swine production in the Philippines, however based on review, there has been less to no study regarding a development of an information system for profiling of swine production support services resources. With such profiling system, this could address the lack of comprehensive and accurate information systems for swine production stakeholders. Digital technologies are widely being used in most industries but is limited towards support to swine production. The study would be able to promote understanding of the potential benefits of implementing a profiling system for swine production support services. In addition, such profiling would also promote the efficiency and profitability of swine production.

Development of such profiling system needs to consider also the security as it is an increasing issue. It is important that software development activities would include methods for specifying security. A study [64] introduces a mechanism to consider accommodating and assimilating new information system methodologies by providing a framework of flexibility for handling the raise of new development methodologies. This profiling system can adopt a framework which considers and promotes information security along its development.

(9) METHODOLOGY

Component 1: Develop a document Control and Tracking System for Animal Border Control using QR codes



Agile DevOps Process (Source: https://medium.com/@raycad.seedotech/devops-methodology-and-process-dde388eb65bd)

Agile DevOps is an approach to software development that combines the Agile methodology with DevOps practices to enable teams to deliver software more quickly and efficiently. The Agile methodology emphasizes iterative development, collaboration, and rapid feedback, while DevOps focuses on automation, continuous integration and delivery, and collaboration between development and operations teams.

The Agile DevOps process involves the following key stages:

- Planning: The team plans out the project and breaks it down into small, manageable pieces. This helps to ensure that everyone is on the same page and that the project is moving forward as expected.
- Development: The team develops the software using an iterative approach, continuously testing and delivering small pieces of functionality. This allows for rapid feedback and course corrections, as needed.
- Testing: The team performs extensive testing to ensure that the software is working as expected and is of high quality. This includes automated testing as well as manual testing.
- Deployment: The team deploys the software to the production environment using automated tools and processes. This allows for rapid deployment and reduces the risk of errors or downtime.
- Monitoring: The team monitors the software in production to ensure that it is performing as expected and to quickly identify and fix any issues that arise.

The Agile DevOps process emphasizes collaboration, communication, and continuous improvement, with the goal of delivering high-quality software more quickly and efficiently.

Methodology

Define the requirements and scope of the system:
- Identify the necessary document types and their corresponding information that need to be tracked and controlled.
- Determine the stakeholders involved in the document control process and their respective roles.
- Determine the timeline and budget for the development and implementation of the system.

Design the user interface and workflow:
- Develop a user-friendly interface for document submission, generation, tracking, and renewal using QR codes.
- Create a workflow that clearly outlines the steps involved in document submission, review, approval, and renewal.

Develop the technical components of the system:
- Generate QR codes for each document type using a QR code generator library or API.
- Develop a document management system that allows for document upload, storage, and retrieval.
- Implement a validity check feature to ensure that the documents submitted are valid and up-to-date.
- Develop an account management system that allows for user registration, login, and profile management.

Implement document control and tracking features:
- Develop a document control system that tracks the status of each document (e.g., submitted, approved, expired, and renewed).
- Implement a document tracking system that allows for the tracking of documents using QR codes.
- Develop a document submission expiry feature that sends notifications to users when their documents are about to expire.
- Implement a document submission renewal feature that allows users to renew their documents.

Implement logging, reporting, and printing features:
- Develop a logging system that logs all activities related to document submission, review, approval, and renewal.
- Implement a reporting system that generates reports on document status, user activity, and other relevant metrics.
- Develop a printing feature that allows users to print their documents.

Test and deploy the system:
- Test the system thoroughly to ensure that all features are working as expected.
- Deploy the system to the target environment (e.g., a web server, cloud platform, or local network).
- Provide training and support to users to ensure that they can use the system effectively.

Maintain and update the system:

- Monitor the system regularly to ensure that it is running smoothly and efficiently.
- Address any issues or bugs that arise in a timely manner.
- Update the system as needed to accommodate changes in document types, workflows, or user requirements.

Component 2: Development of a Mobile-Based Application: Document Verifier for Animal Border Control

DevOps methodology is a software engineering methodology that aims to integrate the work of software development and software operations teams by fostering a collaborative and shared responsibility culture. It involves communication, collaboration and integration between software developers and IT operations professionals. DevOps methodology of software development is all about automating the software development process to speed up delivery and make it more efficient.

The DevOps lifecycle optimizes development processes from start to end and engages the organization in continuous development, resulting in faster delivery times. This process mainly consists of the following seven stages.

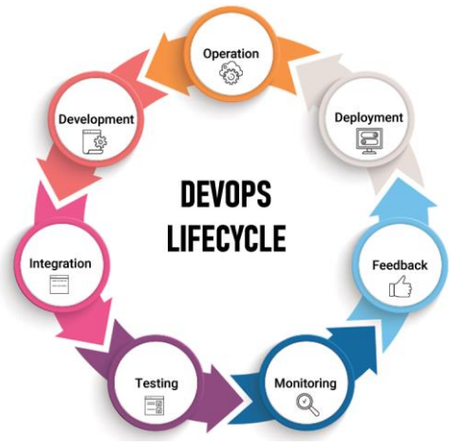


Figure 1. Software application pass through seven different stages in a DevOps pipeline: (https://www.spiceworks.com/tech/devops/articles/what-is-devops-lifecycle/)

Continuous development
The first step involves planning and coding the software. Here, the entire development process gets broken down into smaller development cycles if necessary. This process makes it easier for the DevOps team to accelerate the overall software development process. This phase is instrumental in mapping the vision for the entire development cycle, enabling developers to fully understand project expectations. Through this, the team starts visualizing its end goal as well.

Continuous Integration
It includes different steps related to the execution of the test process. Along with this, stakeholders also provide information to be incorporated for adding new features to the application. Most changes happen in the source code during this phase. Building code is a combination of unit and integration testing, code review, and packaging. Since developers make frequent changes, they can quickly spot problems (if any) and resolve them at an early stage.

Continuous Testing
In the testing phase, wherein the developed code is tested for bugs and errors that may have made their way into the code. This is where quality analysis (QA) plays a major role in checking the usability of the developed software. Successful completion of the QA process is crucial in determining whether the software meets the client's specifications.

Continuous Deployment
To ensure hassle-free product deployment without affecting the application's performance. It is necessary to ensure that the code is deployed precisely on all available servers during this phase. This process will eliminate the need for scheduled releases and accelerate the feedback mechanism, allowing developers to address issues more quickly and with greater accuracy.

Continuous Monitoring
Monitoring the performance of a software product is essential to determine the overall efficacy of the product output. This phase processes important information about the developed app. Through continuous monitoring, developers can identify general patterns and gray areas in the app where more effort is required. Continuous monitoring is an operational phase where the objective is to enhance the overall efficiency of the software application.Different system errors such as 'server not reachable', 'low memory', etc., are resolved in the continuous monitoring phase. It also maintains the availability and security of the services. Network issues and other problems are automatically fixed during this phase at the time of their detection. Proactive checking improves the reliability and productivity of the system and also reduces maintenance costs. Moreover, important and major issues are directly reported to the development team to be corrected in the initial stages. This leads to faster resolution of issues.

Continuous Feedback
It is essential to ascertain and analyze the final outcome of the application. It sets the tone for improving the current version and releasing a new version based on stakeholder feedback. The overall process of app development can only be improved by analyzing the results of the software operations. Feedback is nothing but information gathered from the client's end. Here, information is significant, as it carries all the data about the performance of the software and its related issues. It also contains suggestions given by end users of the software.

Operational Continuity
Continuity operations that help automate release processes, allows developers to detect issues quickly, and build better versions of software products. Continuation is key to eliminating diversions and other extra steps that hinder development. It is crucial for reducing planned downtime, such as scheduled maintenance. Generally, developers are required to take the server offline to make the updates, which increases the downtime and might even cost a significant loss. Eventually, continuous operation automates the process of

launching the app and its updates. It uses container management systems to eliminate downtime. These container management tools help simplify the process of building, testing, and deploying the application on multiple environments. The key objective of this phase is to boost the application's uptime to ensure uninterrupted services. Through continuous operations, developers save time that can be used to accelerate the application's time-to-market.

Component 3: Geographic Information System for Animal Border Control, Swine Farms, and Swine Support Services

Key Features:

The proposed GIS system will include the following key features:

- Animal tracking: The system will track the movement of animals across borders and within the country, including the origin and destination of the animals.
- Disease outbreak tracking: The system will track disease outbreaks in real-time, including the location of the outbreak, the type of disease, and the number of animals affected.
- Data analytics: The system will provide data analytics tools to analyze the movement of animals and the incidence of disease outbreaks over time.
- Risk assessment: The system will provide risk assessment tools to assess the potential risk of disease outbreaks based on the movement of animals and other relevant factors.
- Alert system: The system will provide an alert system to notify animal border control, swine farms, and swine support services of potential disease outbreaks or other relevant information.
- Reporting: The system will provide reporting tools to generate customized reports on animal movement and disease outbreaks for animal border control, swine farms, and swine support services.
- Mobile application: The system will provide a mobile application to allow animal border control, swine farms, and swine support services to access real-time information on the movement of animals and potential disease outbreaks.

Methodology

- Define the scope and requirements: The first step is to define the scope and requirements of the system, including the specific objectives of collecting and recording animal diseases information in region 10, integrating the data of swine profiling including the swine support services data, integrating Philippine Map Feature, developing an account management feature, mapping out the animal diseases information per area, adding a heat map showing where diseases are most prevalent, displaying a summary of data when hovered to specific area, and exporting and printing reports, logs, and location details.
- Identify data sources: The next step is to identify the data sources for animal diseases information, swine profiling data, swine support services data, and Philippine Map Feature. The data sources can include government agencies, private companies, and research institutions.
- Develop data collection and recording system: Based on the data sources, the system should be developed to collect and record the animal diseases information, swine profiling data, and swine support services data. The system should allow for easy input of data and should have validation rules to ensure data accuracy.
- Integrate Philippine Map Feature: The Philippine Map Feature should be integrated into the system to enable visualization of the animal diseases information and swine profiling data. The map should be interactive and allow for zooming in and out to view specific areas.
- Develop account management feature: The system should have an account management feature to enable users to log in and access the system. The account management feature should have different levels of access to ensure data security and privacy.
- Map out animal diseases information per area: Using the Philippine Map Feature, the animal diseases information should be mapped out per area. The map should enable users to view the number of cases per area and the types of diseases that are prevalent.
- Add heat map showing where diseases are most prevalent: The system should have a heat map feature that shows where diseases are most prevalent. The heat map should use color coding to indicate the level of disease prevalence.
- Display summary of data when hovered to specific area: When the user hovers over a specific area on the map, the system should display a summary of data, including the number of cases, the types of diseases, and the swine profiling data for that area.
- Export and print reports, logs, and location details: The system should have a feature that allows users to export and print reports, logs, and location details. The reports should be customizable and should include relevant information, such as the number of cases per disease type, the swine profiling data per area, and the heat map of disease prevalence.

Component 4: Vision-based classification of swine diseases using Deep Convolutional Neural Networks

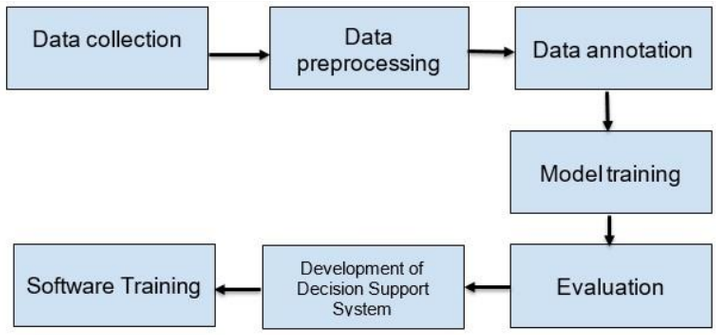


Figure 1. Overall Research Framework of Component 4. The method consists of data collection, data preprocessing, data annotation, model training, evaluation, development of decision support system, and software training.

Figure 1 shows the overall research framework that will be employed by Research Component 4. The first stage of the research process is data collection, followed by data preprocessing and data annotation. Once the data will be preprocessed, model training will follow which includes selecting appropriate machine learning algorithms and evaluating its accuracy and effectiveness. Finally,a decision support system will be developed and user training will be done to ensure the effectiveness of the proposed system. The details of the major phases of our research framework are as follows:

A. Data collection

The study will collect a dataset of images of swine with different diseases. This dataset will serve as the training data for the deep learning models. The dataset will be collected from various sources, including veterinary clinics, farms, and research centers. The images will be captured using high-resolution cameras, and the diseases will be identified and verified by veterinarians. The dataset will consist of images of swine with different diseases, including but not limited to African swine fever, porcine epidemic diarrhea, swine influenza, and porcine reproductive and respiratory syndrome, among others.

B. Data preprocessing

After collecting the dataset, the next step is to preprocess the images. The images will be preprocessed to remove noise and standardize the image size. The images will be resized to a fixed size to ensure that all images have the same dimensions, which is necessary for training the deep learning models. Image augmentation techniques will also be applied to increase the size of the dataset and improve the robustness of the models. Some of the augmentation techniques that will be used include rotation, flipping, and scaling, shear, and other image transformation techniques. The study will also explore training generative adversarial networks for data augmentation.

C. Data annotation

Data annotation is a crucial step in the process of developing a deep learning model for swine disease detection. During the annotation process, each image in the dataset is labeled with the corresponding disease that is present in the image. The labeled data is then used to train the deep learning model to recognize different diseases. Manual annotation involves the use of human annotators to label the images manually. In this research, manual annotation will be used as it is more accurate and reliable, especially for complex datasets such as swine disease images. The annotation will be performed by veterinary professionals who have experience in identifying swine diseases. The annotators will be provided with clear annotation guidelines to ensure consistency in the labeling process. The annotated dataset will be used to train and evaluate the deep learning models. The quality of the annotations will be checked by randomly selecting a subset of the images and verifying their labels manually. This process will help to ensure the accuracy and reliability of the annotated dataset and the deep learning models.

D. Training image classifiers

Several deep learning models will be developed to classify swine diseases. Convolutional Neural Networks (CNNs) will be the primary deep learning architecture used in this research, as they have been shown to be effective in image classification tasks. The deep learning models will be implemented using popular deep learning frameworks such as TensorFlow. The models will be trained on the preprocessed dataset using a suitable loss function and optimizer. The hyperparameters of the models, including the learning rate, batch size, and number of epochs, will be tuned to achieve optimal performance.

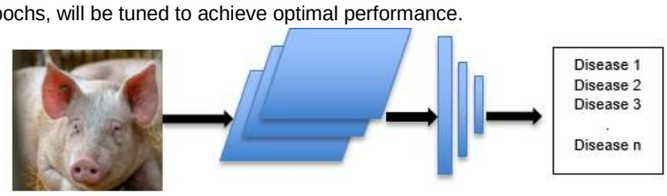


Figure 2. Framework for training swine disease image classifier

As shown in Figure 2, training image classifiers will include 2 phases: transfer learning and classification. In the transfer learning phase, a pre-trained neural network model is imported and fine-tuned on the swine disease dataset. The pre-trained model serves as a starting point and has already learned to extract useful features from images, which saves time and computational resources. Fine-tuning the final layers of the model on the new data makes it more suitable for the swine disease classification task. In the classification phase, the input image is fed into the trained model, which extracts features and predicts its class label. Using transfer learning, we will train several CNN models on our own swine disease image dataset. The models will include DenseNet, Inception, InceptionResNet, MobileNet, ResNet50, ResNet101, ResNet152, VGG16, VGG19 and Xception. These network architectures are considered as state-of-the-art models for image classification.

E. Evaluation

The developed models will be evaluated using various metrics, including accuracy, precision, recall, and F1 score. The evaluation metrics will be calculated on a separate validation dataset to assess the generalization performance of the models. Precision measures the proportion of true positive predictions among all the positive predictions made by the model. Recall measures the proportion of true positive predictions among all the actual positive cases in the dataset. F1 score is the harmonic mean of recall and precision. Accuracy measures the proportion of correct predictions among all the predictions made by the model. The confusion matrix will also be generated to visualize the classification results and identify any misclassifications. The evaluation metrics will be used to select the best-performing model for further. After selecting the best-performing model, further optimization will be performed to improve its performance. Several optimization techniques will be used, including regularization, dropout, and fine-tuning. Regularization techniques such as L1 and L2 regularization will be used to prevent overfitting of the model. Dropout will be used to reduce the sensitivity of the model to specific features, improving its robustness. Fine-tuning will be used to improve the performance of the model on specific diseases.

F. Development of decision support system

After selecting the best model, the next phase of the research methodology is to deploy the selected and optimized model as a swine disease detection system. The system will take input images of swine and output the classification of the disease. The system will be implemented using a suitable programming language and framework and deployed on a suitable platform such as a web application or mobile application. The system's performance will be evaluated using real-world data, and any necessary improvements will be made to ensure its effectiveness and efficiency.

G. Training and evaluation of the end users

The final stage of this study is to conduct software training to the users. This activity includes identifying the users, developing a training plan, preparing training materials, conducting training sessions, evaluating the usability and effectiveness of the software.

Component 5: Developing a decision support system to localize and estimate the severity of swine diseases using object detection and instance segmentation

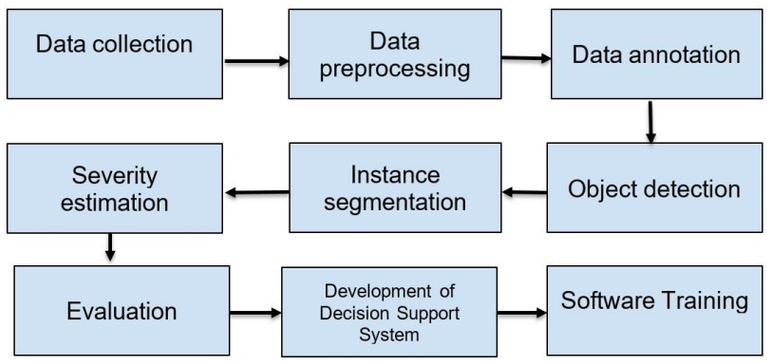


Figure 3. Overall Research Framework of Component 5. The method consists of data collection, data preprocessing, data annotation, object detection, instance segmentation, severity estimation, evaluation, development of decision support system and software training

Method:

Figure 3 shows the overall research framework that will be employed by Research Component 5. The first stage of the research process is data collection, followed by data preprocessing and data annotation. Once the data will be preprocessed, training various object detection models and instance segmentation models will be exhaustively done by leveraging transfer learning. Object detection stage involves identifying and localizing objects within an image while instance segmentation segments or separates the object from the background. Once the object has been detected and segmented, severity estimation will be performed to determine the severity of the object. The evaluation stage will follow to assess the accuracy and effectiveness of the models. Finally,a decision support system will be developed and user training will be done to ensure the effectiveness of the proposed system. The details of the major phases of our research framework are as follows:

A. Data collection

The study will collect a large dataset of swine images with various diseases and their corresponding labels. The dataset can be obtained from different sources such as public datasets, animal hospitals, or farms. The images will be captured under different conditions (e.g., lighting, angles, etc.) to increase the variability of the data.

B. Data preprocessing and data augmentation

The collected images will be preprocessed to ensure that they are properly formatted and annotated. The preprocessing techniques may include resizing, cropping, gray-scaling, histogram equalization, and contrast stretching. The images will be augmented in order to add additional images using techniques such as flipping, rotating, scaling, and color jittering to increase the diversity of the data. The study will also explore training generative adversarial networks to generate synthetic data to increase diversity to the training data. The augmented dataset should be balanced across different classes of objects to avoid bias in the model.

C. Data annotation

Data annotation involves manually labeling the regions of interest (ROIs) in the swine images, such as the presence of lesions, inflammation, or other disease symptoms. Data annotation is necessary because it provides the ground truth information needed to train and evaluate the deep learning models accurately. Manual annotation involves annotating the images by hand, which can be time-consuming and labor-intensive but provides the highest accuracy. In this study, data annotation will be performed manually to ensure the highest level of accuracy. The collected images will be annotated with bounding boxes and masks for the objects of interest

(e.g., lesions, ulcers, etc.) to be used in training the object detection and instance segmentation models. The annotations can be done manually or using automated tools such as Labelbox, VGG Image Annotator (VIA), or RectLabel. The annotators will be trained to identify the different types of ROIs accurately and consistently, and the annotation process will be validated through a quality control process to ensure the accuracy and consistency of the annotations. The annotated data will be split into training, validation, and test sets, with the training set used to train the deep learning models, the validation set used to tune the hyperparameters of the models, and the test set used to evaluate the performance of the models. The annotated data will be an essential component of the research methodology, as it provides the ground truth information needed to develop accurate and effective deep learning models for swine disease severity estimation.

D. Object detection
The study will train an object detection model to detect the object classes of interest in the swine images. The object detection model takes an image as input and outputs the bounding boxes and object class probabilities of the detected objects. The model can be trained using transfer learning, where a pre-trained model is fine-tuned on the swine images dataset. Object detection algorithms, such as Faster R-CNN, SSD, YOLO, or RetinaNet, etc., will be employed to detect the ROIs in the swine images. These algorithms will be trained using the annotated images to recognize the ROIs and predict their location in new images.

E. Instance segmentation
After detecting the ROIs, instance segmentation algorithms (e.g., Mask R-CNN, U-Net, etc.), will be used to segment the ROIs and identify their boundaries more precisely. Instance segmentation algorithms can identify individual instances of objects within an image and segment them more accurately than traditional object detection algorithms. The instance segmentation model takes an image as input and outputs the binary masks of the segmented objects. The model can be trained using transfer learning, where a pre-trained model is fine-tuned on the swine images dataset.

F. Severity estimation
Once the ROIs are detected and segmented, a severity estimation model will be developed using deep learning algorithms, such as CNNs, to estimate the severity of the disease based on the ROIs' characteristics. The model will be trained using the segmented images and their corresponding severity scores.

G. Evaluation
The developed models will be evaluated on a separate test dataset to assess their accuracy in detecting and segmenting ROIs and estimating the severity of swine diseases. Metrics such as precision, recall, F1 score, intersection of threshold, and mean average precision score will be used to evaluate the models' performance. The study will also involve validating the developed models on a separate dataset from a different pig farm to ensure that the models can generalize to new and unseen data. The selection of the best model will be done based on the quantitative performance metrics and qualitative visualization techniques.

H. Development of decision support system
Once the model is trained and tested, it will be deployed into a suitable platform for real-time disease detection and severity estimation. This can be a mobile application or a web-based service, depending on the end-users' requirements. The decision support system should provide an intuitive and user-friendly interface for end-users to upload images or videos and view the results.

I. Training to end users
The final stage of the methodology is to provide training to end-users on how to use the software effectively. This can be done through online tutorials, webinars, or in-person training sessions. The training will cover the following topics: how to use the software interface, how to upload images or videos for analysis, how to interpret the results and understand the severity of the detected diseases, and how to troubleshoot any issues that may arise during the analysis process. Furthermore, the study will also conduct evaluations with end-users to gather feedback on the software's usability, functionality, and accuracy. This feedback will be used to improve the software's performance and user experience.

Component 6: Swine Profiling Information System

Methodology

This study can achieve the mentioned objectives given the following methodology:

Literature review: Conduct a comprehensive review of relevant literature, including studies on swine production, support services, and profiling information systems. This will help identify existing data and information needs, frameworks, and protocols for information systems in profiling support services.

Stakeholder consultation: Engage with stakeholders such as swine producers, support service providers, industry experts, and regulatory bodies to understand their data and information needs, and to identify potential benefits and challenges of an information system for profiling support services.

Data and information identification: Based on the literature review and stakeholder consultation, identify the key data and information needs for each of the support services, including veterinary, nutrition and feeds, breeding, equipment and technology, marketing and sales, transportation and logistics, and financial and business management services.

Framework development: Develop a framework for capturing and analyzing the identified data and information by determining the key attributes and relationships of the swine production support services resources. This may involve defining data elements, establishing data relationships, and developing data classification and coding schemes.

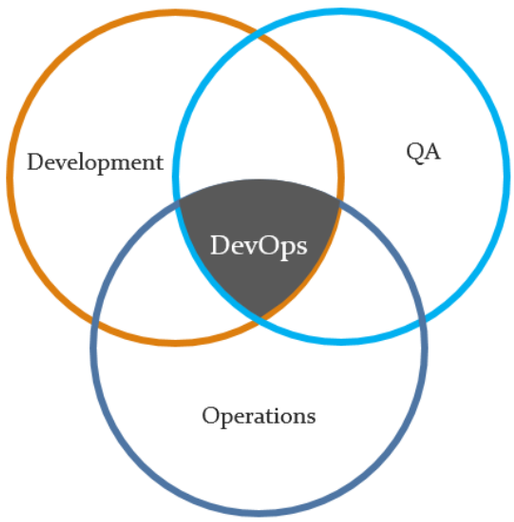
Data quality and security protocols: Develop data quality and security protocols for the information system, including measures to protect the privacy of individuals and organizations involved. This may involve developing data collection and validation procedures, data storage and retrieval protocols, and access control measures.

Information system implementation: Implement the information system, including data collection, storage, retrieval, and analysis components, in accordance with the developed protocols. Ensure that the system is user-friendly and accessible to stakeholders.

Benefits and challenges assessment: Evaluate the potential benefits and challenges of using the information system in profiling swine production support services resources. This may involve conducting a cost-benefit analysis, identifying potential risks and benefits, and assessing the system's effectiveness in meeting the identified data and information needs.

System refinement: Based on the evaluation, refine the information system and associated protocols as necessary to improve its effectiveness and efficiency.

The work plan would involve a comprehensive and iterative process that considers the needs and perspectives of stakeholders, while ensuring the quality and security of the data and information being collected and analyzed.



Component 7: Swine Support Services Profiling Information System

Methodology

This study can achieve the mentioned objectives given the following methodology:

- Literature review: Conduct a comprehensive review of relevant literature, including studies on swine production, support services, and profiling information systems. This will help identify existing data and information needs, frameworks, and protocols for information systems in profiling support services.
- Stakeholder consultation: Engage with stakeholders such as swine producers, support service providers, industry experts, and regulatory bodies to understand their data and information needs, and to identify potential benefits and challenges of an information system for profiling support services.
- Data and information identification: Based on the literature review and stakeholder consultation, identify the key data and information needs for each of the support services, including veterinary, nutrition and feeds, breeding, equipment and technology, marketing and sales, transportation and logistics, and financial and business management services.
- Framework development: Develop a framework for capturing and analyzing the identified data and information by determining the key attributes and relationships of the swine production support services resources. This may involve defining data elements, establishing data relationships, and developing data classification and coding schemes.
- Data quality and security protocols: Develop data quality and security protocols for the information system, including measures to protect the privacy of individuals and organizations involved. This may involve developing data collection and validation procedures, data storage and retrieval protocols, and access control measures.
- Information system implementation: Implement the information system, including data collection, storage, retrieval, and analysis components, in accordance with the developed protocols. Ensure that the system is user-friendly and accessible to stakeholders.
- Benefits and challenges assessment: Evaluate the potential benefits and challenges of using the information system in profiling swine production support services resources. This may involve conducting a cost-benefit analysis, identifying potential risks and benefits, and assessing the system's effectiveness in meeting the identified data and information needs.
- System refinement: Based on the evaluation, refine the information system and associated protocols as necessary to improve its effectiveness and efficiency.

The work plan would involve a comprehensive and iterative process that considers the needs and perspectives of stakeholders, while ensuring the quality and security of the data and information being collected and analyzed.

(10) TECHNOLOGY ROADMAP (if applicable) (use the attached sheet)

(11) EXPECTED OUTPUTS (6Ps)

6Ps	Expected	Year 1	Year 2

	Outputs		
Products	Border Control: Document Tracking Module	1	
	Border Control: Mobile base QR codes Scanner ticketing module	1	
	GIS Animal Border Control, Swine Farms, and Swine Support Services Mapping Module	1	
	Vision-based detection and severity estimation of swine diseases using deep learning	1	
	Swine Profiling Information Module	1	
	Swine Support Services Profiling Information Module	1	
	Updated /Optimized Decision Support System for Surveillance and Border Control of Swine		1

	Diseases System (DSSSBCSDS)		
People and Services	People trained on the use of the proposed system	50	150
Publications	Research Papers per study		7
	Proposed System Manual/ User Guide		3
Patents	Patent/UM for the proposed system modules		7
	Copyright for the proposed system modules		7
	Copyright for the proposed system software		1
Places and Partnerships	Agreement with swine industry key players on the use of the proposed system system		4
Policies	The proposed system policy		5

(12) POTENTIAL OUTCOMES

(13) POTENTIAL IMPACTS (2Is)

Social Impact:

Suggestion Nathalie Joy Casildo

Computer-based swine disease detection tools can have a significant social impact. They can help farmers detect diseases early, which can prevent the spread of diseases and reduce the number of animals that need to be culled. This can help farmers save money and reduce the risk of disease transmission to humans. In addition, early detection can help prevent the spread of diseases to other farms, which can help protect the health of the entire swine population. Thus, this project can increased social awareness about the severity of diseases like ASF can encourage swine growers to seek assistance through this swine support mapping technology. Moreover, the proposed software solutions can act as a bridge for farmers to access vital swine support services.

Economic Impact:

The Cooperating Agency is expected to utilize and conduct rigorous testing of the model and software developed under this project. The objective is to obtain valuable feedback to enhance the product and facilitate its adoption and implementation by other Local Government Units (LGUs) in the Philippines. The successful application of the model could lead to its commercialization and promotion, resulting in improved risk management practices and reduced financial risks related to pandemics. The adoption of this technology will enhance the collective response to future crises and safeguard the welfare of communities.

(14) TARGET BENEFICIARIES

- Northern Mindanao Hog Raisers Association, Pork Producers Federation of the Philippines and National Federation of Hog Farmers
- Swine growers
- Swine grower-support services in the government and private sectors such as *Abattoir, Meat Processing, Veterinary Clinics, Feed Manufacturers, etc.*
- Local Government and Law Enforcement offices

(15) SUSTAINABILITY PLAN (if applicable)

- Stakeholder engagement: Engage stakeholders, including government agencies, local communities, and private organizations, in the dissemination of the research findings. This will ensure that the findings are shared with relevant parties who can implement the recommendations and solutions proposed in the research and development.

- Capacity building: Develop training programs and workshops to build the capacity of stakeholders on ASF prevention and control measures. This will ensure that stakeholders are equipped with the necessary knowledge and skills to implement the IT solutions.

- Policy advocacy: Advocate for policy changes based on the research findings to improve diseases like ASF prevention and control measures. This can include lobbying government agencies and policymakers to adopt the recommendations and solutions.

- Sustainability funding: Seek funding sources to sustain the implementation of the IT solutions. This can include seeking funding from government agencies, international organizations, and private donors.

- Monitoring and evaluation: Establish a monitoring and evaluation system to assess the effectiveness of the IT solutions. This will ensure that the solutions are working as intended and can be adjusted as needed to improve their impact.

(16) GENDER AND DEVELOPMENT (GAD) SCORE (refer to the attached GAD checklist)

(17) LIMITATIONS OF THE PROJECT

(18) LIST OF RISKS AND ASSUMPTIONS RISK MANAGEMENT PLAN (List possible risks and assumptions in attaining target outputs or objectives.)

RISK	RISK LEVEL	PERSONS INVOLVED	SOLUTION
Data problems	HIGH	Project Member, Research Assista	Close coordination with stakeholders

		nts	is a must.
Restriction to Travel	HIGH	Project Leader	Close coordination with stakeholders online meeting,or online data gathering
Staff Hiring Problems	HIGH	Project Leader	Advance Job Posting and Job Hiring Interview
Data processing problems		Project Team Members,	Prior to collecting data, the research team must first determine the pertinent data and models. Training for the team in data management and processing skills.
Machine Learning, Tools Acquisition	HIGH	Project Leader	Follow up of documents and proper coordination

			with BAC
Human Error	HIGH	Project Team Members	Consistent Team meeting

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(20) PERSONNEL REQUIREMENT

Position	Percent Time Devoted to the Project	Responsibilities
Project Staff Level III (7 personnel, one per project component)	100%	Project component supervision, project manager, developed technology tester, and support personnel to the project leader and the project needs.
Project Staff Level I (2 personnel)	100%	Project collaborators
Programmer I (3 software developers)	100%	Software development, database designer, mapping, technology developers.
Research Assistant (1 personnel)	100%	Support personnel to the project leader and the project needs.

(21) BUDGET BY IMPLEMENTING AGENCY

IMPLEMENTING AGENCY	PS	MOOE	EO	Total
Year 1	1,931,916.00	297,500.00	290,000.00	2,519,416.00
Year 2	1,931,916.00	297,500.00		2,229,416.00
Year n				
TOTAL	3,863,832.00	595,000.00	290,000.00	4,748,832.00

(22) OTHER ONGOING PROJECTS BEING HANDLED BY THE PROJECT LEADER: 1 (number)

Title of the Project	Funding Agency	Involvement in the Project
Information and Computing Assessment and Solutions	Central Mindanao University	Project Leader

(23) OTHER SUPPORTING DOCUMENTS (Please refer to page 2 for the additional necessary documents.)

I hereby certify the truth of the foregoing and have no pending financial and/or technical obligations from the DOST and its attached Agencies. I further certify that the programs/projects being handled are within the prescribed number as stipulated in the DOST-GIA Guidelines. Any willful omission/false statement shall be a basis of disapproval and cancellation of the project.

	SUBMITTED BY (Project Leader)	ENDORSED BY (Head of the Agency)
Signature		
Printed Name		
Designation/Title		

Date		

Note: See guidelines/definitions at the back.

DOST Form 2 (for Basic/Applied Research)
DETAILED R & D PROJECT PROPOSAL

I. General Instruction: Submit through the DOST Project Management Information System (DPMIS), http://dpmis.dost.gov.ph, the detailed R&D proposal for the component project together with the detailed proposal of the whole Program, project workplan, line-item budget (LIB), 1-page curriculum vitae of the Project Leader, and Certificate of Incorporation or DTI Registration (if applicable) and other applicable supporting documents required under item II.23 below. Also, submit four (4) copies of the proposal together with its supporting documents. Use Arial font, 11 font size.

II. Operational Definition of Terms:
1. Title- the identification of the Program and the component projects.

Project- refers to the basic unit in the investigation of specific S&T problem/s with predetermined objective/s to be accomplished within a specific time frame.

Project Leader- refers to a project's principal researcher/implementer.

Project Duration- refers to the grant period or timeframe that covers the approved start and completion dates of the project, and the number of months the project will be implemented.

Implementing Agency- the primary organization involved in the execution of a program/project which can be a public or private entity

2. Cooperating Agency/ies- refers to the agency/ies that support/s the project by participating in its implementation as collaborator, co-grantor, committed adopter of resulting technology, or potential investor in technology development or through other similar means.

3. Site/s of Implementation- location/s where the project will be conducted. Indicate the barangay, municipality, district, province, region, and country.

4. Type of Research- indicates whether the project is basic or applied.
Basic research- is an experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular or specific application or use in view.
Applied research- is an investigation undertaken in order to utilize data/information gathered from fundamental/basic researches or to acquire new knowledge directed primarily towards a specific practical aim or objective with direct benefit to society.

5. R&D Priority Area and Program- based on the Harmonized National R&D Agenda 2017-2022, indicates which R&D agenda the project can be categorized in: Agriculture, Aquaculture and Natural Resources; Health; Industry, Energy, and Emerging Technology; Disaster Risk Reduction and Climate Change Adaptation; and Basic Research. Indicate also the specific Commodity/Sector, whether crops, livestock, forestry, agricultural resources or socio-economics; fisheries or aquatic resources; biotechnical, pharmaceutical, or health services; biotechnology, information technology, material science, photonics or space technology; industry, energy, utilities or infrastructure.

Sustainable Development Goal (SDG) Addressed- indicates which among the 17 SDGs adopted by the United Nations Members States are addressed by the project

6. Executive Summary- briefly discusses what the whole proposal is about

7. Introduction- a formally written declaration of the project and its idea and context to explain the goals and objectives to be reached and other relevant information that explains the need for the project and aims to describe the amount of work planned for implementation; refers to a simple explanation or depiction of the project that can be used as communication material.

7.1. Rationale- brief analysis of the problems identified related to the project
Significance- refers to the alignment to national S&T priorities, strategic relevance to national development and sensitivity to Philippine political context, culture, tradition and gender and development.

7.2. Scientific Basis- other scientific findings, conclusions or assumptions used as justification for the research
Theoretical Framework- the structure that summarizes concepts and theories that serve as basis for the data analysis and interpretation of the research data.

7.3. Objectives- statements of the general and specific purposes to address the problem areas of the project.

8. Review of Literature- refers to the following: (a) related researches that have been conducted, state-of-the-art or current technologies from which the project will take off; (b) scientific/technical merit; (c) results of related research conducted by the same Project Leader, if any; (d) Prior Art Search, and; (e) other relevant materials.

9. Methodology- discusses the following: (a) variables or parameters to be measured and evaluated or analyzed; (b) treatments to be used and their layout; (c) experimental procedures and design; (d) statistical analysis; (e) evaluation method and observations to be made, strategies for implementation (Conceptual/Analytical framework).

10. Technology Roadmap (if applicable)**-** a visual document that communicates the plan for technology. It is a flexible planning technique to support strategic and long-range planning by matching short- and long-term goals to specific technology solutions.

11. Expected Outputs (6Ps)- deliverables of the project based on the 6Ps metrics (Publication, Patent/Intellectual Property, Product, People Service, Place and Partnership, and Policy).

Publication- published aspect of the research, or the whole of it, in a scientific journal or conference proceeding for peer review, or in a popular form.

Patent/Intellectual Property- proprietary invention or scientific process for potential future profit.

Product- invention with a potential for commercialization.

People Service- people or groups of people, who receive technical knowledge and training.

Place and Partnership- linkage forged because of the study.

Policy- science-based policy crafted and adopted by the government or academe as a result of the study.

12. Potential Outcomes- refer to the result that the proponent hopes to deliver three (3) years after the successful completion of the project.

13. Potential Impacts

Social Impact- refers to the effect or influence of the project to the reinforcement of social ties and building of local communities.

Economic Impact- refers to the effect or influence of the project to the commercialization of its products and services, improvement of the competitiveness of the private sector, and local, regional, and national economic development.

14. Target Beneficiaries- refers to groups/persons who will be positively affected by the conduct of the project.

15. Sustainability plan- refers to the continuity of the project or how it shall be operated amidst financial, social, and environmental risks.

16. Gender and Development (GAD) Score- refers to the result of accomplishing GAD checklists (for project monitoring and evaluation/project management and implementation) to highlight the contribution of the project in the achievement of the objectives of Republic Act 7192, “Women in Development and Nation Building Act,” interpreted as gender-responsive, gender-sensitive, has promising GAD concepts, or GAD is invisible.

17. Limitations of the Project- refer to restrictions or constraints in the conduct of the project.

18. Risk- refers to an uncertain event or condition that its occurrence has a negative effect on the project.

Assumption- refers to an event or circumstance that its occurrence will lead to the success of the project.

19. Literature Cited- an alphabetical list of reference materials (books, journals and others) reviewed. Use standard system for citation.

20. Personnel Requirement- details on the position of personnel to be involved in the project, percent time devoted to the project, and responsibilities.

21. Budget By Implementing Agency- personnel services (PS), maintenance and other operating expenses (MOOE), and equipment outlay (EO) requirement of the project by implementing agency for Year

1 and for the whole duration of the project. Please refer to the DOST-GIA Guidelines for the details (Section IX.B of DOST Administrative Order (A.O.) 011, s. 2020).

a. **PS**- total requirement for wages, salaries, honoraria, additional hire and other personnel benefits.

b. **MOOE**- total requirement for supplies and materials, travel expenses, communication, and other services.

c. **EO**- total requirement for facilities and equipment needed by the Program.

22. Other Ongoing Projects Being Handled By the Project Leader- list of ongoing projects being handled by the Project Leader funded by the DOST-GIA Program and other sources, and the accompanying responsibilities relevant to the project.

23. Other supporting documents required- as stated in Section VII of DOST A.O. No. 011, Series of 2020 – Revised Guidelines for the Grants-in-Aid Program:

a. Detailed breakdown of the required fund assistance to indicate the counterpart of the proponent and other fund sources including letter/s of commitment from the implementing, collaborating and coordinating agency/entity/ies;[1]

b. A counterpart fund, in kind and/or in cash, shall be required from the implementing agency/entity as one of the application requirements. All projects must have a minimum of 15% counterpart contribution except for projects involving public good;[1]

c. Curriculum Vitae or Personal Data Sheet (PDS) of Project Leader and other co-researchers/implementers. The service record may be requested if needed;[1]

d. Clearance from the DOST or the Funding Agency (e.g., DOST Councils) on previously funded completed projects handled by the Project Leader;[1]

e. Approval from the institution's ethics review board for research involving human subjects or in the case of animal subjects, approval from the Bureau of Animal Industry (BAI) (for PCAARRD- and PCHRD-monitored projects);

f. Clearance from the DOST Biosafety Committee (DOST-BC) shall be required for research proposals involving the use of GMOs under contained use (i.e., experiments done in laboratories, screen house, green house). For projects other than contained use, they shall be referred to the appropriate agency. The DOST Sectoral Councils, after determination as to whether or not the proposal has biosafety implications, shall endorse the same to the DOST-BC in accordance with the prescribed format under Annex 3 of the Philippine Biosafety Guidelines for Contained Use of Genetically Modified Organisms (series of 2014) (if applicable); and

g. For the private non-profit/non-government/people's organizations and startups:

i. Up-to-date Securities and Exchange Commission (SEC) registration, or Department of Trade and Industry (DTI) registration, or Cooperative Development Authority (CDA) registration certificate, or other authenticated copy of latest Articles of Cooperation and other related legal documents;
ii. Co-signers Statement (if applicable);
iii. Copy of latest Income Tax Return;
iv. Mayor's permit where the business is located;
v. Audited Financial Statements for the past three (3) years preceding the date of project implementation or in case of those with operation of less than 3 years, for the years in operation and proof of previous implementation of similar projects (or in the case of startups, at least for one (1) year);
vi. Document showing that NGO/PO has equity to 20 percent of the total project cost, which shall be in the form of labor, land for the project site, facilities, equipment and the like, to be used in the project;
vii. Disclosure of other related business, if any;
viii. List and/or photographs of similar projects previously completed, if any, indicating the source of funds for implementation;
ix. Sworn affidavit of secretary of the NGO/PO that none of its incorporators, organizers, directors or officers is an agent of or related by consanguinity or affinity up to the fourth civil degree to the official of the agency authorized to process and/or approved the proposed MOA, and release of funds;

h. For CSOs, compliance to regulations as required by the General Appropriations Act (GAA) pertaining to fund transfers to Civil Society Organizations (CSOs); and

i. For foundations, DOST certification as accredited by the Science and Technology Foundation Unit

[1] *required of all proposals*

III. Criteria for Evaluation:

A. **Criteria for Evaluating Proposals**

Criterion	Definition

Relevance or Significance	Aligned to national S&T priorities, strategic relevance to national development and sensitivity to Philippine political context, culture, tradition and gender and development
Technical / Scientific Merit	Sound scientific basis to generate new knowledge or apply existing knowledge in an innovative manner
Budget Appropriateness	The proposed budget is commensurate to the proposed work plan and deliverables.
Competence of Proponent	Proponent's expertise is relevant to the proposal and with proven competence to implement, manage and complete R&D programs/projects within the approved duration and budget.

B. **Governing Council / Board and EXECOM's Evaluation Criteria**

Criteria	Indicators	Raw Score
A. Soundness of Proposal (20%)	R&D addresses relevant sectoral need (applicable to pressing concern)	5
	Solution provided is most effective (compared to other proposed solutions)	5
	Proposed budget is reasonable (project is not expensive vis-a-vis output)	5
	Work plan is doable in a given timeframe	5
B. Suitability of Output (30%)	R&D output is cost-effective (cost is competitive in relation to new or existing products or process)	5
	Has identified partners to adopt the technology (with letter of support from the head of the company)	5
	Output can be commercialized (through an existing manufacturer, spin-off or start-up company)	5
	R&D utilization is timely (output should not be overtaken by other solutions)	5
C. Significance of Outcome (30%)	Economic: increase in productivity, increase in income, new jobs generated, high return of investment (ROI)	5
	Social: working partnerships established, training opportunities provided, policies adopted, increased access to basic services (i.e., food, health, education); political, cultural, gender sensitivity and inclusivity	5
	Environment: enhanced environmental health standards, no adverse effect to the environment	5
	Sustainability: sustainability mechanisms established in terms of institutional, financial and human resources capability (submission of a new proposal to sustain a completed or ongoing proposal does not constitute sustainability of the project)	5
D. Competence of Proponent (20%)	Proponent's expertise aligned with the proposal	5
	Collaboration with relevant agencies and/or industry partners	5
	Thorough understanding of the proposal's deliverables	5
	DOST has good experience with the proponent	5

C. **Additional Criteria on Gender and Development (GAD)**