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Develop a method for utilizing remote sensing and GIS technology to manage wetland ecosystems — a study case in the Melaleuca forest ecosystem in U Minh Thuong Ramsar, Mekong Delta, Vietnam

Section B.2
Structure and contents of Detailed Project Proposal

A. Background and justification

According to Ramsar 4th Strategic Plan 2016 – 2024: "Wetlands are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters". The network of wetlands, comprising 2,208 Ramsar Sites covering 210.73 million hectares (2015) (Ramsar 4th Strategic Plan 2016 – 2024).

Information about the characteristics and changes of forest ecosystems is important in the management, conservation, and sustainable development of natural forest ecosystems. That is even more meaningful for ecosystems in wetlands, where investigation and surveying using traditional methods is difficult and costly. According to IUCN (2021), wetland ecosystems are gradually disappearing and it is estimated that about 35% of the world's wetlands have disappeared in the past 50 years, which is an alarming trend. Faced with urgent needs, the United Nations has called on all countries to take action to improve the effectiveness of management and restoration of ecosystems in degraded wetlands (IUCN, 2021).

The current problem is that wetlands lack data and lack regular updates, the data is also not standardized and unified and lacks data-building methods for support to monitoring and management. Therefore, it has caused difficulties in the management and other related conservation activities.

Through more than half a century of development, today satellite remote sensing technology has proven to play an important role in detecting, identifying, mapping, assessing, and monitoring changes in resources over time (Gue et al., 2017; Zu et al., 2018; Zhang et al., 2022). Large-scale, detailed, accurate, low-cost, time-based (historical, current) data corresponding to human activities from remote sensing satellite images have provided the scientific community with an excellent opportunity to explore the causes and consequences of changes in the objects on the earth's surface including wetland ecosystems.

Remote sensing and GIS technology are a range of modern tools that contribute to the efficient mapping and geographic analysis of the Earth and human society (Ruefenacht et al., 2008;

Riemann et al., 2010; Yeo et al., 2013; Breunig et al., 2020; Ettehadi et al., 2022). Today, satellite remote sensing technology has proven to play an important role in detecting, identifying, mapping, assessing, and monitoring changes in resources over time (Lu et al., 2006; Kuenzer et al., 2011; Camarretta et al., 2020). Large-scale, detailed, accurate, low-cost, time-based (historical, current) data corresponding to human activities from remote sensing satellite images have provided the scientific community with an excellent opportunity to explore the characteristics, causes, and consequences of changes in the objects on the earth's surface.

Typical earlier studies on the application of remote sensing satellites on wetlands include: Baker et al. (2007) used Landsat data for change detection of wetlands in Montana, United States with an overall accuracy of over 76%; Jamal et al., (2020) assessing land use/landcover dynamics of wetland ecosystem used Landsat satellite data in Kashmir Valley, India; Kaplan et al. (2017) use Sentinel 2 satellite data for mapping and monitoring wetlands in Eskisehir, Turkey. Luong et al. (2015) used SPOT data for analysis of the impact of succession in mangrove forest associations in southern Vietnam; Luong et al. (2019, 2021) used Landsat and ALOS-2 data for biomass estimation and mapping of mangrove forests-a wetland ecosystem in Vietnam. Li et al. (2021) use Sentinel 2 satellite imagery for estimating above-ground biomass in the Shengjin Lake Wetland, China; Sánchez et al. (2019) use Landsat 8 and Sentinel 2 for land/landcover mapping of wetlands in Andalucia, in south Spain; Slagter et al. (2020) use Sentinel 2 and Sentinel 1 data for mapping wetlands characteristics in the St. Lucia wetlands, South Africa. Vanderhoof et al. (2021) use Sentinel 2 for mapping wetlands burned areas in the Southeastern United States. Earlier studies have demonstrated and confirmed the important and irreplaceable roles of satellite image data in practical applications, related sectors, dynamics of change, and/or monitoring changes of ground cover objects over time, including wetland ecosystems.

Research reviews over the last few decades have shown that (i) Mapping wetlands are significant for management purposes and improve the quality of conservation missions; (ii) Remote sensing technology has many advantages in monitoring wetlands, inherently not easily accessible for survey using traditional methods; (iii) Despite the advantages of remote sensing data, there is an absence of studies monitoring changes in wetlands ecosystem cover over long periods, such as decades; (iv) Optical satellite and radar satellite image data are commonly used. However, until now, no research has thoroughly explained the methods of mapping wetlands using remote sensing methods; (v) The need for field data collection should be reduced by advanced remote sensing techniques that provide reasonable accuracy with some training samples in the first time.

Vietnam has an area of about 10 million hectares of wetlands, distributed across all 8 ecological regions, including 2 main groups (i) coastal and (ii) inland. Among them, two regions, the Mekong Delta and the Red River Delta, have the largest wetland area. By 2022, Vietnam has nine wetlands recognized as Ramsar sites - wetlands of international importance. These include Xuan Thuy National Park, Bau Sau Wetlands, Ba Be National Park, Tram Chim National Park, Mui Ca Mau National Park, Con Dao National Park, Lang Sen Wetlands Reserve, U Minh Thuong National Park, and Van Long Wetland Nature Reserve - this is not only a recognition at the national level but also at the regional and international levels. Wetland ecosystems with high biodiversity and conservation value also play an important role in the production and supply of food, food, and medicine. Wetland ecology is also a place to store and provide water resources, reduce floods, provide biodiversity, store carbon, and is a sustainable natural solution to mitigate vulnerability due to climate change (Huynh et al., 2012; Thang, 2015).

According to Decision No. 287/QD-TTg, dated February 28, 2022, approving the "Mekong Delta region planning for the period 2021-2030, vision to 2050" of the Government of Vietnam, it has emphasized the importance of "wetlands ecosystems" and needs to be focused on conservation and development, contributing to the development of the Mekong Delta towards sustainable development, green growth, proactively preventing, avoiding and minimizing risks, natural disasters and adaptation to climate change.

The Melaleuca forest ecosystem is unique in the tropics. In Vietnam, the Melaleuca forest ecosystem is distributed in areas of the Mekong Delta, including the provinces of An Giang, Ca Mau, Dong Thap, Kien Giang, Long An, and Tien Giang (Trung, 1998; Bartolo, 2005). Among them, large inland wetlands such as U Minh with Melaleuca forest ecosystems are home to many endemic and rare species of animals and plants (Trung, 1998; Thang, 2017; The et al., 2020). Changes in biological indicators of Melaleuca forests have greatly influenced and impacted the wetland environment (Bell et al., 2001).

The basic and important characteristics of the forest ecosystem, including Melaleuca forests, are the coverage and structure. In particular, forest stand structure or forest structure refers to the horizontal and vertical arrangement of forests. This is important information to help make the right decisions in choosing measures to manage, restore, preserve, and develop forest ecosystems in a specific area. Thus, there is a need to have a tool and method to investigate and evaluate the vegetation characteristics of wetlands ecosystems with the requirements of fast, accurate, low-cost, and wide-scale coverage.

Based on the above analysis, we have proposed this research, with the title: "Develop a method for utilizing remote sensing and GIS technology to manage wetland ecosystems —a study case in the Melaleuca forest ecosystem in U Minh Thuong Ramsar, Mekong Delta, Vietnam".

The research will explore and apply the advantages of remote sensing data (optical and radar) in detecting and evaluating the structural characteristics of the forest (Melaleuca forest)- one typical wetland ecosystem in the U Minh region, Mekong Delta, Vietnam by exploring the effectiveness of spectrum channels, polarizations, thresholds, combinations, indexes, combining from multiple sources of satellite image data (optical and radar), field survey data. The new techniques in satellite image analysis and modeling are also applied such as Google Earth Engine (GEE), and machine learning techniques (AI) in detecting and evaluating the structural characteristics of forests (Melaleuca forest). It can be explained by automatically modeling and then building thematic maps of structural vegetation in the study area. At other times or in the future, apply the methods and models developed in this study without needing costly and difficult field surveys in wetland areas. The study aims to propose solutions for managing, rehabilitating, and wise use of wetland ecosystem services with effective support from remote sensing and GIS technology.

Study area

U Minh Thuong National Park, Kien Giang province, Mekong Delta, Vietnam.

- Site number: 2228
- Area: 8,038 ha.
- Ramsar designation date: 30-04-2015.
- Coordinates: 09°35'N 105°05'E.

U Minh Thuong National Park is one of the last remnants of climax peat swamp forest in the biogeographic region, dominated by mixed forests and Melaleuca forests on peat that covers around 3,000 ha (approximately 37%) of the Park. The Site is recognized as one of the three highest-priority sites for wetland conservation in the Mekong Delta. It is home to distinctive flora and fauna including 32 mammal species, 187 bird species, 34 reptile and amphibian species, 37 fish species, and 203 insect species. Many of these are globally threatened, including the endangered yellow-breasted bunting (*Emberiza aureola*), yellow-headed temple turtle (*Heosemys annandalii*), Sunda pangolin (*Manis javanica*), and fishing cat (*Prionailurus viverrinus*). It is also one of the only three sites in the world known to support a population of the endangered hairy-nosed otter (*Lutra sumatrana*). The Site regularly hosts more than 20,000 waterbirds. Most of the fish species observed are native and the distribution of eight of these is restricted to the lower Mekong Basin. U Minh Thuong National Park supports large areas of peat layers and a complex system of canals that can store a large volume of water. It functions as a sponge that maintains the groundwater level and releases surface water to the surrounding areas and supports the production and daily activities of the local communities surrounding the Park. In addition, the Site is of significant spiritual, historical, archaeological, educational, and scientific value (Ramsar Sites Information Service, 2015). The location of the study area is shown in Figure 1 below.

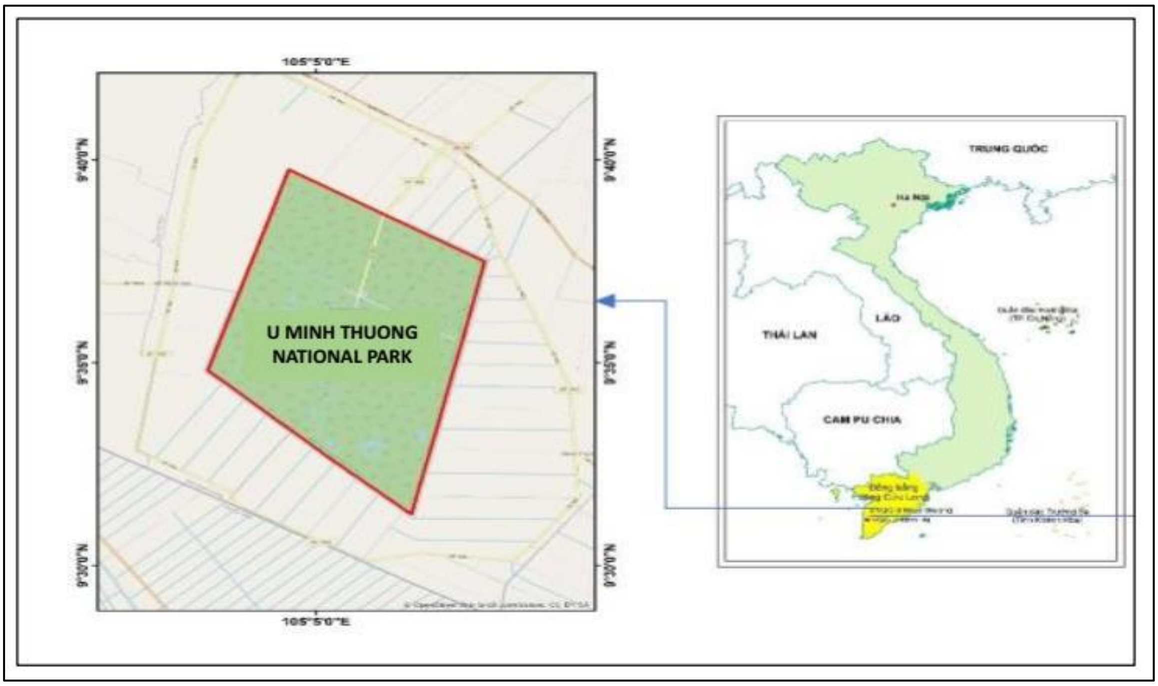


Figure 1. Study area

About the preparation of the project: The project will use optical images from Landsat 1- Landsat 9 data and Sentinel-2 and radar images from ALOS-2 PALSAR-2, and Sentinel-1. Free satellite image data such as from Landsat (1-9), Sentinel-1, and Sentinel-2 has been regularly checked and updated by us. So far, these data sources ensure the quality and quantity of the research content of the proposed project. The ALOS-2 PALSAR-2 data must be purchased. However, we have been provided by Japan Aerospace Exploration Agency (JAXA) for the free use of this satellite image data source in another collaborative research programme between the two parties with "PI No. ER3A2N520 and effective term from April 8, 2022, to March 31, 2025" (please see at Appendix 1). This type of radar satellite data is beneficial and important in estimating forest volume and carbon storage by tropical forests. If the project proposal is approved, we will certainly have the full data source for the research.

B. The problem(s) to be addressed

Remote sensing and GIS technology have many advantages and can support better management and monitoring of wetland ecosystems, thereby indirectly improving the effectiveness of conservation.

C. Objective(s)

General Objective(s):

Develop a method for utilizing remote sensing and GIS technology to assess values, monitor, wise use and manage wetland ecosystems.

Specific Objective(s):

OB1: Using multi-satellite data to build models to estimate forest structural parameters including the Melaleuca forest ecosystem's diameter, height, forest volume, and biomass/carbon stocks/CO_2 sequestration.

OB2: Using remote sensing data, assessing changes in the Melaleuca forest ecosystem covered over 50-year periods (1975-2025) with steps of a decade and evaluating the causes of change, and challenges.

OB3: Development of methodology and procedures for monitoring, managing, and assessing the value and role of wetland vegetation using remote sensing and GIS technology.

OB4: Propose solutions for management, restoration, and wise use of wetland ecosystem services in the study area.

OB5: Improving the capacity to use remote sensing and GIS technology for officers and rangers in the study area through short-term courses.

D. Outputs

The outputs (OPs) of the project are as follows:

OP1: Models to estimate vegetation structural parameters include diameter, height, forest volume, and biomass/carbon/CO_2 sequestration by satellite data.

OP2: Maps of changes of Melaleuca forest cover over 5 decades (1975-1985, 1985-1995, 1995-2005, 2005-2015, 2015-2020, 2020-2025) using remote sensing data with a scale 1: 50.0000 by satellite data.

OP3: Methodology and procedures for monitoring, managing, and assessing the value and role of wetland vegetation using remote sensing and GIS technology.

OP4: Proposed solutions for management, restoration, and wise use of wetland ecosystem services in the study area.

OP5: Organize one short-term training course on using Remote sensing and GIS technology for officers and rangers in the study area.

E. Activities

The project activities are as follows:

ACT1. Collection of satellite data and other related documents, pre-processing of satellite images for field work: The research will utilize optical satellite image data such as Sentinel-2 and Landsat, as well as radar satellite image data including Sentinel-1, ALOS 1/2 PALSAR 1/2. Subsequently, we will preprocess the satellite images and conduct a preliminary classification of the current vegetation status in the study area to support field planning. Additionally, we will refer to other relevant documents such as biodiversity reports and related maps.

ACT2: Fieldwork: (establish sample plots network, at each sample point, the circumference at breast height (cbh) of all tree species is recorded (the individual woody tree with diameter > 5 cm, and shrub with height > 1m). The plot for woody forest is 25 m x 20 m (500 m^2). For poor forest and shrubs, a plot is 10 m x 10 m.

ACT3: Field data processing: The statistics data from the sample plots description, determine the structure of the vegetation forest (diameter, height, density, timber volume, biomass) in the study area.

ACT4: The analysis and processing of satellite images, and extracting parameters from satellite images.

From the Landsat/Sentinel-2 image, Normalized Difference Vegetation Index (NDVI) will be calculated. The NDVI (Equation (1) is calculated using the surface reflectance value of the near infrared (R_N) and red (R_R) bands:

$$\text{NDVI} = \frac{R_N - R_R}{R_N + R_R} \quad (1)$$

From ALOS-2 PALSAR-2, the digital number (DN) values of the images in both the HH and HV polarizations will be calibrated by calculating the backscattering intensity using Equation (2):

$$\sigma° = 10 \times \log10\ (DN^2) + C. \quad (2)$$

In Equation (2), σ° is the sigma naught backscattering intensity and CF is the calibration factor, which is currently set as −83 (JAXA, 2014).

Research will also use eight texture values from ALOS-2 PALSAR-2 image including, Contrast, Correlation, Dissimilarity, Entropy, Homogeneity, Mean, Second Moment, and Variance.

For each plot, the mean backscattering intensity, and mean texture values of HV, HH polarization from ALOS-2 PALSAR-2 data, mean NDVI values from Landsat/Sentinel-2 data and NDVI data will be calculated.

ACT5: Build models including training and validation models to estimate forest structural parameters such as diameter, height, timber volume, and biomass. The sensitivity of the different parameters from satellite data to the diameter, height, density of tree, and biomass/timber volume will be statistically analyzed by using simple linear regression and multiple linear regression analysis. The coefficient of determination (R^2) and root mean square error (RMSE) are used as the metrics for evaluating the relationships.

ACT6: Build change maps of the Melaleuca forest ecosystem cover over 50-year periods (1975-1985, 1985-1995, 1995-2005, 2005-2015, 2015-2020, 2020-2025) in the study area by satellite data with scale 1: 50.0000 and accuracy assessment of the maps. In this study, we utilized the supervised classification technique. We employed the post-classification assessment method for change evaluation. For example, to obtain the product of the land cover change map of 1975-1985, which uses satellite images. That is, we will classify the forest cover status of 1975 and 1985 using satellite imagery data and then build a change map product of 1975-1985. More detailed and specific tasks for this output are interpreting and classifying forest cover status using satellite images; processing, analyzing, assessing accuracy, designing, editing, adding attributes, refining, and extracting data.

In this study, we have applied "*Criteria for forest classification in Vietnam*" from Circular No. 33/2018/TT-BNNPTNT (MARD, 2018) from the Ministry of Agriculture and Development of Vietnam. It has adopted the classification criteria of UNESCO (1973) and Thai Van Trung (1998). The classes that will be classified and shown on the map include: Class 1 - Rich forest; Class 2 - Medium forest; Class 3 - Poor forest; Class 4 - Other land; Class 5 - Water body.

In this study, we utilized the supervised classification technique. We employed the post-classification assessment method for change evaluation. For example, to obtain the product of the land cover change map of the period 1975-1985, which uses satellite images. Here we use the post-classification evaluation method, that is, we will classify the forest cover status of 1975 and 1985 using satellite imagery data and then build of change map product of the period 1975-1985. More detailed and specific tasks for this output are interpreting and classifying forest cover status using satellite images; processing, analyzing, assessing accuracy, designing, editing, adding attributes, refining, and extracting data.

In this study, we have applied Circular No. 33/2018/TT-BNNPTNT (MARD, 2018) from the Ministry of Agriculture and Development of Vietnam. It has adopted the classification criteria of UNESCO (1973) and Thai Van Trung (1998). The classes will be classified and shown on the map including: Class 1 - Rich forest; Class 2 - Medium forest; Class 3 - Poor forest; Class 4 - Other land; Class 5 - Water body.

ACT7: Build on method and procedure for estimating forest structures using remote sensing and GIS. Based on the research results, this activity will be summarized into methods and procedures for application. Based on experimental research results in this study (Output 1, and Output 2) and will also reference previous studies on the application of remote sensing and GIS technology in the management and monitoring of wetland ecosystems in other parts of the world, this study will analyze, synthesize, and then carefully propose a method and procedure for wetland ecosystems management in which remote sensing and GIS technology. The method and procedure should be easy to use, convenient, practical, and highly reproducible. This method and procedure can be roughly outlined as follows:

- Phase I: Preparation (*includes specific steps*).
- Phase II: Processing satellite images and field data (*includes specific steps*).
- Phase III: Building and editing maps from satellite images (*includes specific steps*).
- Phase IV: Building technical reports.

However, more details in the Phases (by steps) will be clearly stated, and completed based on the scientific basis when this study is carried out. This is the main and important content of the report. We believe that the methodology and procedures of this study will bring many benefits (such as reducing costs, time, and labour) in the management and monitoring of wetland ecosystems.

ACT8: Research for proposed solutions for management, restoration, and wise use of wetland ecosystem services in the study area. The method used in this activity is to evaluate and analyze synthesis and then propose solutions, which means: (i) Based on the comprehensive results of the study on the assessment of land cover change over 5 decades, from 1975 to 2025 (historical to present), data on increase/decrease area, discover the dynamics and speed of change of forest cover in the study area as well as data on the estimation of current parameters of the current structure of the land cover including diameter, height, timber volume, biomass. An optimal solution using remote sensing and GIS technology will be outlined such as the type of satellite image data corresponding to each specific task as well as the frequency (monthly, quarterly, yearly) of using satellite image data in the management and monitoring of wetlands ecosystems; (ii) Assessment of carbon stock/CO_2 sequestration capacity by forest vegetation as well as the role of climate change adaptation will be focused on analysis and evaluation; (iii) Inheriting previous research documents and results will also be collected, analyzed, and evaluated such as evaluation of the role and value of biodiversity and landscape; (iv) The research will also focus on analyzing and evaluating the subjective and objective causes (natural, socio-economic and/or second Indochina War), interactions, impacts, and challenges to quality of wetland ecosystems in the study area; (v) Another important thing is that the proposed solution must be based on international conventions and strategies on Ramsar. Vietnam's international commitments on Ramsar. Vietnam's current laws, regulations, and policies on Ramsar. Based on the above scientific data and documents, this project will propose good solutions for management, restoration, and wise use of the ecosystem here, for example: the total area that can be restored, areas (specific locations) that can be replanted, areas for thinning, forest cleaning, forest fire prevention measures, etc. by appropriate silvicultural techniques. Development potential, and participation in the carbon credit market, etc.

ACT9: Prepare documents and lectures including theory and data practices data and conduct short courses training on using RS and GIS technology for officers and rangers in the study area (5-10 person practice). The short course is organized by experts from STI and/or CRES, and at the same time as the project's field implementation time. Class location (expected) at U Minh Thuong National Park, Kien Giang province.

ACT10: Writing the final report.

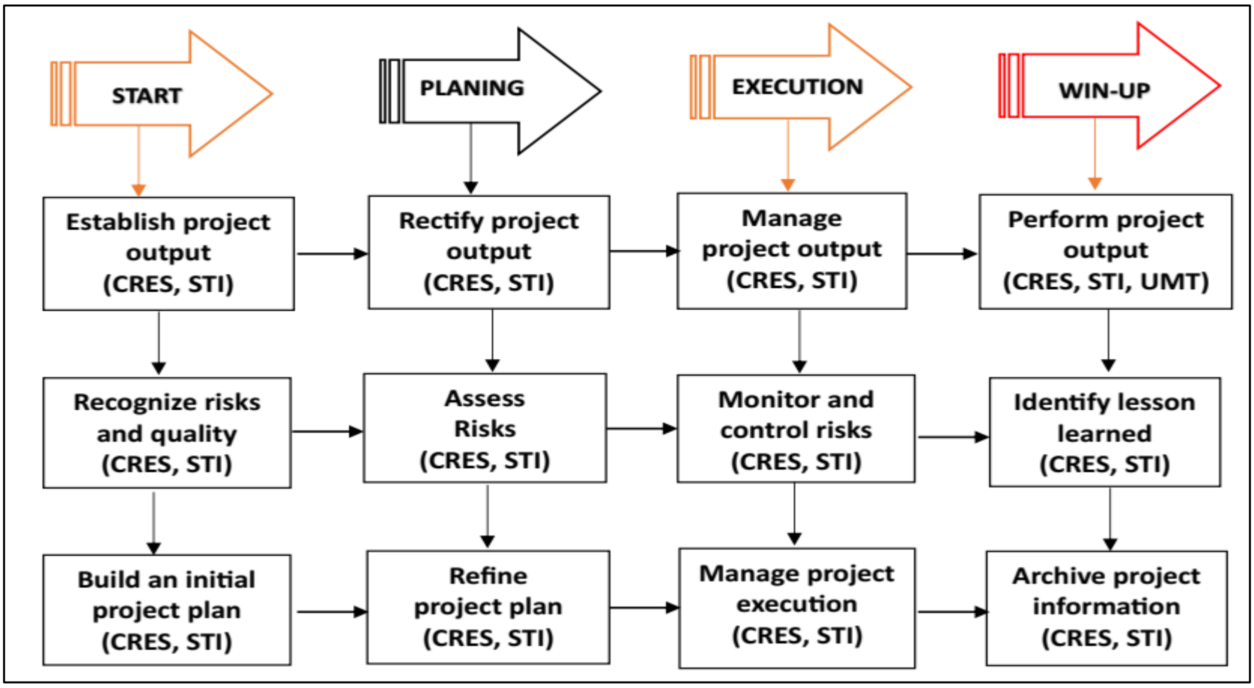
F. Logical frame of the project

Use the table below to summarize the activities undertaken to produce each output and to reach each objective. This table should be consistent with the paragraphs B, C, D and E above. It will be used to assess the project's progress.

Problems	Objectives	Outputs	Activities
There is no information on the vegetation cover structure of the wetland ecosystem	*1. Using multi-satellite data to build models to estimate forest structural parameters including the Melaleuca forest ecosystem's diameter, height, forest volume, and biomass/carbon stocks/CO_2 sequestration.*	*1. Models to estimate vegetation structural parameters include diameter, height, forest volume, and biomass/carbon/CO_2 sequestration by satellite data.*	*1. Collection of satellite data and other related documents, pre-processing of satellite images for field work.* *2. Field work.* *3. Field data processing. The statistics data from the sample plots such description, determine the structure of forest ($D_{1.3m}$, H, density) in the study area.* *4. The analysis, processing, and extraction of parameters from satellite images.* *5. Build models including training and validation models to estimate forest structural parameters such as diameter, height, timber volume, and biomass.*
There are no thematic maps such as forest vegetation cover; forest tree density distribution, forest vegetation cover, and forest biomass/carbon/CO_2 sequestration maps to support the management of wetland ecosystems	*2. Using remote sensing data, assessing changes in the Melaleuca forest ecosystem covered over 50-year periods (1975-2025) with steps of a decade or more.*	*2. Maps of changes of Melaleuca forest cover over 5 decades (1975-1985, 1985-1995, 1995-2005, 2005-2015, 2015-2020, 2020-2025) using remote sensing data with a scale of 1: 50.0000.*	*6. Build change maps of the Melaleuca forest ecosystem cover over 50-year periods (1975-1985, 1985-1995, 1995-2005, 2005-2015, 2015-2020, 2020-2025) by satellite data with a scale 1: 50.0000 and accuracy assessment of the maps.* *6.1. Build a set of interpretation keys for the land cover objects of the research area using satellite images.* *6.2. Build a map of vegetation change for the period (1975-1985).* *6.3. Build a vegetation change map for the period (1985-1995)* *6.3. Build a vegetation change map for the period (1995-2005).* *6.4. Build a vegetation change map for the period (2005-2015).* *6.5. Build a vegetation change map for the period (2015-2020).* *6.6 Build a vegetation change map for the period (2020-2025).*
There are no methodology and procedures for monitoring, managing, and assessing the value and role of wetland vegetation using remote sensing and GIS technology.	*3. Development of methodology and procedures for monitoring, managing, and assessing the value and role of wetland vegetation using remote sensing and GIS technology.*	*3. Methodology and procedures for monitoring, managing, and assessing the value and role of wetland vegetation using remote sensing and GIS technology.*	*7. Build on methodology and procedures for monitoring, managing, and assessing the value and role of wetland vegetation using remote sensing and GIS technology.* *7.1. Analysis and evaluation of advantages, disadvantages, and application trends of remote sensing and GIS technology in wetland ecosystem management.* *7.2. Build methodology and procedures for monitoring, managing, and assessing the value and role of wetland vegetation using remote sensing and GIS technology.*

Problems	Objectives	Outputs	Activities
There is no specific solution for the management, restoration, and wise use of wetland ecosystem services in the study area.	*4. Propose solutions for management, restoration, and wise use of wetland ecosystem services in the study area*	*4. Proposed solutions for management, restoration, and wise use of wetland ecosystem services in the study area.*	*8. Research and propose solutions for management, restoration, and wise use of wetland ecosystem services in the study area.* *8.1. Assessment of the current status of biodiversity and landscape (include: role, value), CO_2 sequestration capacity, and impacts on biodiversity of the study area.* *8.2. Analyzing and evaluating the subjective and objective causes (natural, socio-economic, second Indochina War), policies, interactions, impacts, and challenges to wetland ecosystem quality in the entire study area.*
The officers and rangers who directly manage the study area have not been trained in remote sensing and GIS technology.	*5. Improving the capacity to use remote sensing and GIS technology for officers and rangers in the study area through short-term courses.*	*5. Organize one short-term training course on using remote sensing and GIS technology for officers and rangers in the study area.*	*9. Prepare documents and lectures including theory and data practices data and conduct short courses training on using Remote sensing and GIS technology for officers and rangers in the study area.*

G. Project management arrangements and stakeholders



- Host agency: Central Institute for Natural Resources and Environmental Studies (CRES).
- Coordinating agency: Space Technology Institute (STI), Vietnam Academy of Science and Technology.
- Coordinating agency: U Minh Thuong National Park Management Board (UMT), Kien Giang province, Vietnam.

H. Work Plan

A schedule should be presented for the production of all the outputs of the proposed project during the life of the project. This work plan should indicate the order in which activities will be undertaken so as to show the sequence and relationship between activities.

	Month											
Outputs & Key Activities	1	2	3	4	5	6	7	8	9	10	11	12
Output 1: Models to estimate vegetation structural parameters include diameter, height, forest volume, and biomass/carbon/CO_2 sequestration by satellite data.												
Activity 1: Collection of satellite data and other related documents, pre-processing of satellite images for field work.												
Activity 2: Field work.												
Activity 3: Field data processing. The statistics data from the sample plots such description, determine the structure of the forest ($D_{1.3m}$, H, density) in the study area.												
Activity 4: The analysis, processing, and extraction of parameters from satellite images.												
Activity 5: Build models including training and validation models to estimate forest structural parameters such as diameter, height, biomass, and/or forest volume.												
Output 2: Maps of changes of Melaleuca forest cover over 5 decades (1975-1985, 1985-1995, 1995-2005, 2005-2015, 2015-2020, 2020-2025) using remote sensing data with a scale 1: 50.0000.												

	Month											
Outputs & Key Activities	1	2	3	4	5	6	7	8	9	10	11	12
Activity 6: Build change maps of the Melaleuca forest ecosystem cover over 50-year periods (1975-2025) by satellite data with a scale 1: 50.0000 and accuracy assessment of the maps.												
6.1 Building a set of interpretation keys for the land cover objects of the research area using satellite images.												
6.2 Periods (1975-1985)												
6.3 Periods (1985-1995)												
6.4 Periods (1995-2005)												
6.5 Periods (2005-2015)												
6.6 Periods (2015-2020)												
6.7 Periods (2020-2025)												
Output 3: Methodology and procedures for monitoring, managing, and assessing the value and role of wetland vegetation using remote sensing and GIS technology.												
Activity 7: Development of methodology and procedures.												
7.1 Analysis and evaluation of advantages, disadvantages, and application trends of remote sensing and GIS technology in wetland ecosystem management.												
7.2 Build methodology and procedures for monitoring, managing, and assessing the value and role of wetland vegetation using Rremote sensing and GIS technology.												
Output 4: Proposed solutions for management, restoration, and wise use of wetland ecosystem services in the study area.												

	Month											
Outputs & Key Activities	1	2	3	4	5	6	7	8	9	10	11	12
Activity 8: Research and proposed solutions for management, restoration, and wise use of wetland ecosystem services in the study area.												
8.1 Assessment of the current status of biodiversity and landscape (include: role, value), CO_2 sequestration capacity, and impacts on biodiversity of the study area.												
8.2 Analyzing and evaluating the subjective and objective causes (natural, socio-economic), policies, interactions, impacts, and challenges to wetland ecosystem quality in the entire study area.												
Output 5: Organize one short-term training course on using RS and GIS technology for officers and rangers in the study area.												
Activity 9: Prepare documents and lectures including theory and data practices data and conduct short courses training on using Remote sensing and GIS technology for officers and rangers in the study area.												
Activity 9: Short course training.												
Activity 10: Writing the final report.												

I. Budget

The budget summary and itemized budget of this project are described below.

i) *Budget summary*

The exchange rate applied: 1 US dollar (USD) = 25,458 Vietnam Dong (VND) (update on 30 May, 2024).

Funding Source	**Total funds** (Vietnam Dong)	**Total funds** (US dollars)
NWF	740,142,809	29,073.09
Implementing Organization	0	0
Other sources of funding	0	0
TOTAL	**740,142,809**	**29,073.09**

ii) *Overall itemized budget*

The exchange rate applied: 1 US dollar (USD) = 25,458 Vietnam Dong (VND) (update on 30 May 2024).

Description of budget item (include unit costs where appropriate)	**Unit Cost (VND)**	**Number of Unit (day)**	**NWF (VND)**	**Quantifier**	**Total** (VND)	**Total** (USD)
1. SALARIES / WAGES / CONSULTANCY COSTS						
1.1 Supervisory Staff						
No. of persons & duration of employment on this project:						
1.2 Consultants / Experts						
No. of persons & duration of employment on this project:						
1.3 Field Staff / Equipment operators						
No. of persons & duration of employment on this project: 3 local persons or rangers from the study area-Field survey support.	600,000	45	27,000,000	day	27,000,000	1,103.93
1.4 Office Staff						
No. of persons & duration of employment on this project						
1.5 Daily workers						
No. of persons & duration of employment on this project						
SUB-TOTAL:			**28,103,933**		**28,103,933**	**1,103.93**
2. TRAVEL & ACCOMMODATION COSTS						
2.1 Air fares: 3 persons (return air ticket)-from Hanoi to Ho Chi Minh city	5,000,000	3	15,000,000	ticket	15,000,000	589.21
2.2 Other travel costs: car/moto/boat rental*15 days	2,500,000	15	37,500,000	day	37,500,000	1,473.01
2.3 Accommodation: 14 night*3 staff	500,000	42	21,000,000	night	21,000,000	824.89
2.4 Meals: 14 days*6 persons (03 staff+03 local persons)	900,000	210	189,000,000	day	189,000,000	7,423.99
SUB-TOTAL:	**8,900,000**	**270**	**262,500,000**		**262,500,000**	**10,311.10**
3. OFFICE RUNNING COSTS						
3.1 Computer costs						
3.2 Telephone & fax	2,500,000	1	2,500,000		2,500,000	98.20

Description of budget item (include unit costs where appropriate)	**Unit Cost (VND)**	**Number of Unit (day)**	**NWF (VND)**	**Quantifier**	**Total** (VND)	**Total** (USD)
3.3 Photocopies	2,500,000	1	2,500,000		2,500,000	98.20
3.4 Office supplies						
3.5 Other (please specify):						
SUB-TOTAL:	**5,000,000**	**2**	**5,000,000**		**5,000,000**	**196.40**
Costs of planned activities:						
1. Output 1: Models to estimate vegetation structural parameters include diameter, height, forest volume, and biomass/carbon/CO_2 sequestration by satellite data.						
1.1 Collection of satellite data and other related documents, pre-processing of satellite images for field work.	1,000,000	25	25,000,000	day	25,000,000	982.01
1.2 Field data processing. Field data processing. The statistics data from the sample plots such description, determine the structure of the forest ($D_{1.3m}$, H, density) in the study area.	1,000,000	45	45,000,000	day	45,000,000	1,767.62
1.3 The analysis, processing, and extraction of parameters from satellite images.	1,000,000	75	75,000,000	day	75,000,000	2,946.03
1.4 Build models including training and validation models to estimate forest structural parameters such as diameter, height, biomass, and forest volume.	1,500,000	75	112,500,000	day	112,500,000	4,419.04
SUB-TOTAL:		**220**	**257,500,000**		**257,500,000**	**10,114.70**
2. Output 2: Maps of changes of Melaleuca forest cover over 5 decades (1975-2025) in the study area using remote sensing data with a scale 1: 50.0000 by satellite data.						
2.1. Building a set of interpretation keys for the land cover objects of the research area using satellite images	1,500,000	15	22,500,000	day	22,500,000	883.81
2.2 Period: 1975-1985		16	24,000,000		24,000,000	942.73
2.2.1 Forest cover classification using satellite imagery in 1975.	1,500,000	5	7,500,000	day	7,500,000	294.60
2.2.2 Forest cover classification using satellite imagery in 1985	1,500,000	5	7,500,000	day	7,500,000	294.60
2.2.3 Build of forest cover change map for the period 1975-1985	1,500,000	6	9,000,000	day	9,000,000	353.52
2.3 Period: 1985-1995		11	16,500,000		16,500,000	648.13
2.3.1 Forest cover classification using satellite imagery in 1995	1,500,000	5	7,500,000	day	7,500,000	294.60
2.3.2 Build of forest cover change map for the period 1985-1995	1,500,000	6	9,000,000	day	9,000,000	353.52
2.4 Period: 1995-2005		11	16,500,000		16,500,000	648.13
2.4.1 Forest cover classification using satellite imagery in 2005	1,500,000	5	7,500,000	day	7,500,000	294.60
2.4.2 Build of forest cover change map for the period 1995-2005	1,500,000	6	9,000,000	day	9,000,000	353.52
2.5 Period: 2005-2015		11	16,500,000		16,500,000	648.13

Description of budget item (include unit costs where appropriate)	**Unit Cost (VND)**	**Number of Unit (day)**	**NWF (VND)**	**Quantifier**	**Total** (VND)	**Total** (USD)
2.5.1 Forest cover classification using satellite imagery in 2015	1,500,000	5	7,500,000	day	7,500,000	294.60
2.4.2 Build of forest cover change map for the period 2005-2015	1,500,000	6	9,000,000	day	9,000,000	353.52
2.6 Period: 2015-2020		11	16,500,000		16,500,000	648.13
2.6.1 Forest cover classification using satellite imagery in 2020	1,500,000	5	7,500,000	day	7,500,000	294.60
2.6.2 Build of forest cover change map for the period 2015-2020	1,500,000	6	9,000,000	day	9,000,000	353.52
2.7 Period: 2020-2025		11	16,500,000		16,500,000	648.13
2.7.1 Forest cover classification using satellite imagery in 2025	1,500,000	5	7,500,000	day	7,500,000	294.60
2.7.2 Build of forest cover change map for the period 2020-2025	1,500,000	6	9,000,000	day	9,000,000	353.52
SUB-TOTAL:		**86**	**129,000,000**		**129,000,000**	**5,067.17**
3. Output 3: Methodology and procedures for monitoring, managing, and assessing the value and role of wetland vegetation using remote sensing and GIS technology.						
7.1 Analysis and evaluation of advantages, disadvantages, and application trends of remote sensing and GIS technology in wetland ecosystem management.	1,500,000	3	4,500,000	day	4,500,000	176.76
7.2 Build methodology and procedures for monitoring, managing, and assessing the value and role of wetland vegetation using remote sensing and GIS technology.	1,500,000	5	7,500,000	day	7,500,000	294.60
SUB-TOTAL:		**8**	**12,000,000**		**12,000,000**	**471**
4. Output 4: Propose solutions for management, restoration, and wise use of wetland ecosystem services in the study area.						
8.1 Assessment of the current status of biodiversity and landscape (include: role, value), CO_2 sequestration capacity, and impacts on biodiversity of the study area.	1,500,000	5	7,500,000	day	7,500,000	294.29
8.2 Analyzing and evaluating the subjective and objective causes (natural, socio-economic), policies, interactions, impacts, and challenges to wetland ecosystem quality in the entire study area.	1,500,000	2	3,000,000	day	3,000,000	117.72
SUB-TOTAL:		**7**	**10,500,000**		**10,500,000**	**412.01**
5. Output 5 For example COST OF TRAINING COURSE						
Dates of workshop(s)/course(s):						
No. of persons attending: 5-10 persons						
5.1 Transportation	500,000	10	5,000,000		5,000,000	196.40
5.2 Per diems	1,000,000	10	10,000,000	day	10,000,000	392.80
5.3 Rental of Facilities (Meeting room/lecture)	2,000,000	1	2,000,000	room	2,000,000	78.56
5.4 Lecturer' fees (Prepare lectures and documents including theory and	2,500,000	1	2,500,000		2,500,000	98.20

Description of budget item (include unit costs where appropriate)	**Unit Cost (VND)**	**Number of Unit (day)**	**NWF (VND)**	**Quantifier**	**Total** (VND)	**Total** (USD)
data practices data and conduct short courses training)						
SUB-TOTAL:		**22**	**19,500,000**		**19,500,000**	**765.97**
6. MISCELLANEOUS						
6.1 Tape measure (02 units)	150,000	2	300,000	unit	300,000	11.78
6.2 Gloves (03 pairs)	50,000	3	150,000	pairs	150,000	5.89
6.3 Protective boots (03 pairs)	500,000	3	1,500,000	pairs	1,500,000	58.92
6.4 Hats (03 units)	50,000	3	150,000	unit	150,000	5.89
6.5 Backpacks (03 units)	550,000	3	1,650,000	unit	1,650,000	64.81
6.6 Medicine (Protected by mosquitoes, leeches attack) (01 spray bottle)	300,000	1	300,000	bottle	300,000	11.78
SUB-TOTAL:			**1,950,000**		**1,950,000**	**159.09**
TOTAL:			**740,142,809**		**740,142,809**	**29,073.09**

J. Follow Up

The research results are expected to be developed and applied to other important wetland ecosystems in Vietnam as well as around the world. Additionally, the methods and results of the project will serve as the scientific and data foundation to improve publications and to train students at all levels, from university to PhD.

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Appendix 1:

21/JAXA/S1ER/No._1215002
December 15, 2021

Subject: Notification on the Evaluation Results of the Research Proposals for the 3rd Research Announcement on the Earth Observations (EO-RA3)

Dear Applicants,

As the result of our evaluations of your research proposal, I would hereby like to notify you that your proposal has been successfully accepted as a non-funded proposal. Please contact the JAXA point of contact listed in Appendix by **January 25, 2022** regarding whether or not to accept the adoption.

Implementation details will be adjusted based on the research plan upon your notification of acceptance.
If your initial plan needs to be revised, or if it is difficult for you to accept the result, please contact your point of contact.

- Due Date: January 25, 2022
- Response to: JAXA Point of Contact listed in Appendix
- How to respond:
  - ✓ If you accept the result, please submit the application form and collaboration research plan in the PDF file and also in the Word file. As for the collaboration research plan, you may need the coordination with JAXA.

    * Please send the original documents after the coordination. If the documents are mailed after the due date, please submit PDF files by e-mail as well.
  - ✓ If you do not accept the result, please let us know by e-mail.

To start your research as a Principal Investigator (PI), the research agreement between JAXA and your organization must be formally concluded beforehand. The detailed information of the procedures for the agreement will be announced later by the responsible division.

Please note that a PI number is assigned to each PI for our procedural reasons. Your PI number is listed in the attached appendix. Hereafter, please let us know your PI number when you contact us in the future.

I appreciate your cooperation and hope for your success in your research.

Sincerely,

Riko Oki

OKI, Riko
Director
Japan Aerospace Exploration Agency (JAXA)
Earth Observation Research Center (EORC)

Japan Aerospace Exploration Agency
Tsukuba Space Center, 2-1-1, Sengen, Tsukuba-shi, Ibaraki 305-8505 Japan
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[**APPENDIX**]

Information for the Research Agreement of the JAXA EO-RA3

PI Name: Nguyen Viet Luong

Research Organization: Space Technology Institute, Vietnam Academy of Science and Technology Remote Sensing Application

PI No.: ER3A2N520

Research Title: Research on using Japanese remotely sensed multi-sensor data and other data by artificial intelligence (AI) approach to forest classification, estimate carbon stock and CO2 sequestration by Vietnamese forests

Type of research agreement: Collaborative Research Agreement (Non-Funded)

ALOS-2 Request satellite data (scene/year) : 40
ALOS-3 Request satellite data (km2/year) : 9,800

JAXA Point of Contact:

Earth Observation RA Office for ALOS project
Earth Observation Research Center (EORC)
Tsukuba Space Center
Japan Aerospace Exploration Agency
2-1-1 Sengen, Tsukuba, Ibaraki, 305-8505, Japan
E-mail address: APROJECT@jaxa.jp