Geospatial analysis for developing agriculture of marshlands to support regional food security in the era of pandemic Covid-19 in HST Regency, Kalimantan Selatan

S Sutisna¹, Sa’dianoor², S Maarif³ and J A Bohari¹

¹ Disaster Management Study Programme, Faculty of National Security of the Indonesian Defense University, Kawasan IPSC Sentul, Desa Tangkil, Kecamatan Citeureup, Bogor 16810, Indonesia.
² Doctoral Programme, Faculty of Technology of the Indonesian Defense University, Kawasan IPSC Sentul, Desa Tangkil, Kecamatan Citeureup, Bogor 16810, Indonesia.

Corresponding author: jazmi.bohari@idu.ac.id

Abstract. Hulu Sungai Tengah (HST) Regency has a very large marshland in the South Kalimantan Province. Since 2019 HST is promoted to be a model for Indonesian local foods and agricultural development program, known as SERASI Program. SERASI stands for “Selamatkan Rawa dan Sejahterakan Petani” (or in English “save marshland and bring prosperity to farmers”) that aimed to exploit marshland which was not productive yet. The SERASI will convert a non-productive caved swamp areas to a productive rice fields which able to support regional food security sustainably. In order to able define the suitable marshland area for SERASI Program in HST Regency precisely in the era of pandemic Covid-19, this research had been carried out by applying geospatial analyses method using Sentinel Satellite Imagery acquisitioned from two different epochs, i.e. of 20th February 2019 and of 20th February 2020. GPS coordinates collected from the field were used for ground truthing imagery data. The results of geospatial analysis have provided evident that paddy fields in caved marshland area is increased that means the SERASI Program is successful. From interviews’ data collected from 14 villages shows that the program of SERASI is accepted by local farmers and also local government. From image combination analysis concluded that the area of caved rice fields is suitable for developing agriculture in marshlands.

1. Introduction
Currently, the whole world is facing the same disaster, pandemic Covid-19. The outbreak of Covid-19 has caused economic crisis world widely. To anticipate the spread of the virus by staying at home raises its own problems. Staying at home for some informal workers means reduced income. The reduced income will result in households being unable to meet their clothing and food needs. Furthermore, failed to provide needed foods will cause famines.

Referred to a Greek proverb "Primum manducare, deinde philosophare" that mean “eating first, then philosophizing” that illustrates how vital foods is to humans. [1]. Difficulties in meeting food needs contribute to safety risks. [2]. When inequality rises, social capital deteriorates, leaving people vulnerable to riots and conflict. Conflicts in various parts of the world are always related to meeting economic needs, especially food, which is increasingly difficult.

The adequacy of food, water and shelter is the basis for human survival. [3]. Fulfillment of food, water and shelter is part of the Sustainable Development Goals (SDGs). For the Indonesian nation, the
fulfillment of staple foods is the same as the availability of rice. Rice as a staple food for most of Indonesia's population has strategic value, both from the economic, environmental, social and political aspects. [4].

In agriculture development, Indonesia has to learn from Japan's ruined country after World War II. The most important thing for Japanese agricultural policy after World War II is the reform of agricultural land use. [5]. The Japanese government is trying hard to solve the problem of rural poverty, which has been considered as a background of war. And another goal is to increase agricultural productivity, which had fallen during the war, and thus save the Japanese people from hunger. It is estimated that by building many owner farmers, this goal will be realized. [6].

Agriculture development shall be a main task in Indonesian because the agricultural sector is the spearhead of the progress of the Indonesian nation in determining the level of welfare of its people [7]. The Ministry of Agriculture the leading sector in order to reach the ideals condition of the World Food Barn with the target of realization reached in 2045. The goal is opened through the use of hundreds of thousands of hectares of marshland spread across six provinces, i.e. in South Sumatra, South Kalimantan, Jambi, Lampung, South Sulawesi and Central Kalimantan. Later, the land will be used as productive agricultural land to encourage the welfare of cooperative-based farmers that are coordinated through the Save Peasant Welfare Peasant (SERASI) program. [7].

Food problems faced are increasing severely and complex amid increasing population and land conversion and production disruptions. Since 2018 the Ministry of Agriculture has sought to increase food production, especially rice nationally through the UPSUS PAJALE Program (Special Efforts for Rice, Corn and Soybean) and the SERASI Program (Save the Peasants and Welfare of Farmers). Out of an area of 34.12 million hectares of marshland, 14.18 million hectares are potential sources of rice production, including 2.80 million hectares of tidal marshland. [8].

SERASI is an acronym for the phrase "save marshland for prosperity". The SERASI program is implemented based on Permentan Number: 40.1 / Permentan / RC.010 / 10/2018. The purpose of this program is to increase production and improve the welfare of farmers while still caring about the environment. In line with the objectives of SERASI, the development of agricultural technology in the swamp is supposed to adjust to environmental conditions. [9].

So important is food that the United States issued the Homeland Security Presidential Directive HSPD-9 on January 30, 2014. In the HSPD-9 one of them contained the Defense of the United States Agriculture and Food Purpose. Defense not only anticipates terrorist attacks as the main goal, but also anticipates against natural disasters and other emergencies such as poverty and hunger. Homeland Security Presidential Directive / HSPD-9 "Defense of the United States Agriculture and Food" (January 30, 2003). HSPD-9 established a national policy to defend the agriculture and food system against terrorist attacks, major disasters, and other emergencies. [10].

National defense policy in accordance with the Minister of Defense Decreec on National Defense Policy Year 2020 Number: KEP / 104 / M / 1 / 2020 requires the management of a national defense system that is no longer Java centric, but leads to Indonesia centric. So it is necessary to develop regional logistics in some areas to become a logistics buffer for the new National Capital. But the condition of soil fertility on other islands in Indonesia is not as good as on the island of Java, so it requires more handling.

To that end, the Ministry of Agriculture of the Republic of Indonesia cooperates with the Ministry of Defense of the Republic of Indonesia which has a territorial network to the District. With the assistance of the Village Trustees Petty Officers (Babinsa) who were given the task of monitoring and evaluating SERASI activities in the program location village.

The Indonesian National Army (TNI) was born from the people, so that it has its own uniqueness in carrying out its organization. The TNI was born during the struggle to defend Indonesian independence so that it was known as the "universal struggle". The struggle of the universe puts the army and the people in bond that cannot be separated from one another. Fighting together against the invaders who tried to usurp the new independence in the Proclamation in 1945. In the struggle of the universe for a long time all the food needs of the fighters were provided in mutual cooperation by the community throughout the struggle location. Fighters and the people eat the same food. War with the people or known as guerrilla war inspired the birth of a universal defense system, which involved all
citizens in the country's defense efforts. The universal defense system applies the totality of mobilizing all components of the nation in taking part in the defense of the State.

In his research, Maarif found that as many as 59.3% of the 1,072 community respondents still wanted the importance of the Territorial Command (Koter) to exist. Koter must be maintained to carry out territorial functions in the region (community development, illiteracy operations, development of food insecure areas, etc.). [11].

This study aims to analyze the impact of the SERASI Program implemented by the Ministry of Agriculture in collaboration with the TNI in developing marshland swamp land. The combination of direct surveys to the field and spatial data analysis is expected to provide a clearer picture regarding the SERASI Program.

2. Data and methodology

The study area is located in Hulu Sungai Tengah (HST) Regency of South Kalimantan Province, Indonesia. Being in geographical position 115° 12' 45.836" - 115° 22' 22.148" East Longitude, and of 2° 29' 31.169" - 2° 41' 23.431" South Latitude. The location is in the marshland area. The type of swamp itself according to [12] there are two types, namely tidal marshland, and monotonous marshland. The tidal swamp is a swamp where the water surface is influenced by water movement of regular fluctuation caused by tidal movement. In South Kalimantan, it can be found in the coastal and river basin area of Banjar Regency and Barito Kuala Regency. Monotonous swamp (locally known as rawa lebak) is swamp formed in the inland valley where the water comes from upstream river or rain. It is commonly found in the inland area of the northern part, like the Hulu Sungai Utara Regency and Hulu Sungai Tengah Regency.

The total area of marshland in Indonesia is estimated at 33.40 million ha, consisting of 20 million ha of tidal marshland and 13.40 million ha of marshland marshland. [13]. Lebak Swamp is an ecosystem that is flooded with river water or rain throughout the year. The length of standing water in this marshland swamp depends on its typology. Lebak in general is inundated for most of the year (October to July), midwife floods are inundated from November to June, and shallow or shallow dikes are flooded from November to April. This specific typology causes local farmers to adapt to these conditions by cultivating adaptive commodities in the ecosystem. Local farmers are generally still conventional in rice cultivation. [9].

South Kalimantan Province is considered potential because it has a swamp area of almost 80% of the existing land. Based on data from the Office of Food Crops and Horticulture in South Kalimantan Province, the implementation of the SERASI program reached 250,000 hectares spread across Regencies / Cities. [14]. The government continues to strive to increase rice production, especially in marshland. In fact, at the end of 2018, through the Ministry of Agriculture the "Save the Peasant Welfare Farmers (SERASI)" program was initiated. [15]. The distribution of paddy fields in South Kalimantan Province can be seen in Figure 1.

The area of paddy fields in the province is still able to be increased because it has lebak land that has not been used intensively. By combining modern technology and local wisdom, it is expected to be able to make food defense areas.

In this study using primary data derived from irregular interviews with farmers in the SERASI Program. Spatial data were obtained from a field survey using the Montana 650 Navigation GPS Type. While checking the SERASI results used comparison of Citra Sentinel 2 data in 2019 and 2020 photography.

Sentinel 2 imagery is used because it has a better resolution than MODIS and Landsat. [16]. Sentinel 2 imagery can also be downloaded for free through the USGS website.

The method used in this study is spatial analysis, field surveys and interviews. To get the SERASI program location through the Agriculture Department of Hulu Sungai Tengah Regency. Whereas spatial data in the form of Sentinel-2 Satellite Imagery can be downloaded from the USGS website.
Figure 1. Paddy fields in South Kalimantan Province, Indonesia and surrounding areas (processed from http://sig.pertanian.go.id:8080/portalsig/)

Figure 2. Research Framework

To obtain an appropriate location for the implementation of SERASI Program through relevant agencies, the Agriculture Service of HST Regency is consulted. The given shp data is then overlaid
with the reference satellite imagery. The distribution of the location for SERASI program is plotted on shp data as shown in Figure 3.

The photograph data of SERASI activities was collected from ‘penyuluh’ Field Extension Officers (PPL) of the HST Regency’s Agriculture Department in the fostered area of Jatuh Village and of the Association of Farmers Group (Gapoktan) Mahang Sungai Hanyar Village of HST Regency (Figure 4).

From the data obtained as a reference for conducting field surveys. The field survey was conducted in 14 villages. Taking the coordinates using the Montana 650 Navigation GPS. While taking pictures using a mobile phone that has a Timestamp Camera application.

The methodology and procedure employed in the LULC study included interpretation and analysis of recent and middle-aged satellite images, normalized difference vegetation index (NDVI) and NDVI differencing (DNDVI) analysis, preliminary land use and land cover classification and mapping, field and signature data collection and verification, and post land cover mapping. [17].

![Figure 3. Distribution of SERASI Program locations](image)

![Figure 4. Photographs series at the distributed SERASI program locations in HST Regency (source: Gapoktan Administrator Mahang Sungai Hanyar Village and PPL Desa Jatuh, 2019)](image)
NDVI and NDWI: Index-based classification requires NDVI and NDWI as features; consequently, they were first calculated in SNAP. As mentioned in Section II, Band 4, Band 8A and Band 11 are chosen as RED, NIR and SWIR band, respectively. NDVI and NDWI can be calculated by GIS’s softwares. [18], [19].

| Table 1. Bands for Sentinel-2A [20] [21]. |
|------------------------------------------|
| Sentinel-2 Bands | Central Wavelength (µm) | Resolution |
|------------------|--------------------------|-------------|
| Band1 – Coastal Aerosol | 0.433 | 60 |
| Band2 – Blue | 0.490 | 10 |
| Band3 – Green | 0.560 | 10 |
| Band4 – Red | 0.665 | 10 |
| Band5 – Near Infrared | 0.705 | 20 |
| Band6 – Near Infrared | 0.740 | 20 |
| Band7 – Near Infrared | 0.783 | 20 |
| Band8 – Near Infrared | 0.842 | 10 |
| Band8A – Near Infrared | 0.865 | 20 |
| Band9 – Water Vapour | 0.945 | 60 |
| Band10 – Shortwave Infrared (Cirrus) | 1.375 | 60 |
| Band11 – Shortwave Infrared | 1.610 | 20 |
| Band12 – Shortwave Infrared | 2.190 | 20 |

In order to obtain land in 2019 and 2020 in the SERASI Program area, Sentinel-2 Satellite image processing was performed. In making land cover, the classification must be done. In this study Guided Classification was carried out with the help of Satellite Imagery from the Geospatial Information Agency and the results of taking GPS coordinates in the field. Guided classification can be done by using the Semi-Automatic Classification plugin, which is one of the plugins in the Quantum GIS (QGIS) application. Described in [22] that SCP is a free and open-source plugin developed by Luca Congedo allowing the implementation of Semi-Automatic Classification based on a variety of satellite images such as MODIS, Landsat or S2.

The NDVI is based on the reflectance in the red and the near-infrared whose difference increases with the density of green leaves and therefore with the chlorophyll concentration of the canopy. It is therefore a good indicator of the amount of green vegetation. [22]. NDVI (Normalized Difference Vegetation Index) was computed with the temporal data for land cover analysis. NDVI is based on the principle of spectral difference based on strong vegetation absorbance in the red and strong reflectance in the near-infrared part of the spectrum. [23].

\[ \text{NDVI} = \frac{NIR - Red}{NIR + Red} \quad \text{for Sentinel-2} \]

\[ \text{NDVI} = \frac{B08 - B04}{B08 + B04} \] .............................. (1)

Normalized Difference Water Index (NDWI) is a construction similar to that of the NDVI but using a short wave infrared wavelength (water absorption peak) instead of a red band. [22].

\[ \text{NDWI} = \frac{NIR - SWIR}{NIR + SWIR} \quad \text{for Sentinel-2} \]

\[ \text{NDWI} = \frac{B08 - B11}{B08 + B11} \] .............................. (2)

Particularly for areas characterized by dense vegetation cover, the SAVI (Soil-Adjusted Vegetation Index has been developed by modifying the NDVI. The SAVI is structured similarly to the NDVI but with the addition of a correction factor, noted L, considering the soil–vegetation interactions. [22].

\[ \text{SAVI} = \frac{NIR - Red}{(NIR + Red + 0.5)} \times (1 + 0.5) \quad \text{for Sentinel-2} \]

\[ \text{SAVI} = \frac{B08 - B04}{(B08 + B04 + 0.5)} \times (1 + 0.5) \] ............ (3)

Normalized Difference Red-Edge Index (NDRI) is similar to NDVI but uses red-edge reflectance instead of the red reflectance. [22].

\[ \text{NDRI} = \frac{RE (780) - RE (730)}{RE (780) + RE (730)} \quad \text{for Sentinel-2} \]

\[ \text{NDRI} = \frac{B07 - B06}{B07 + B06} \] .............................. (4)
It is hoped that direct interviews in the field can obtain correct information on the results of SERASI Program activities. The farmers who were used as the resource persons were the sharecroppers who were at the location. It is expected that the direct interview at the location of the explanation from the farmer will be more complete and the field will be immediately shown at that time.

3. Result and discussion

By comparing the results of the Sentinel 2 Guided Image Imagery Classification recording 20 April 2019 and 20 April 2020, the difference in data is obtained. To be able to make guided classification done in two ways, namely by using high-resolution imagery and data collection in the field.

![Figure 5. Sentinel-2 Satellite Imagery, recording date: a) 20th April 2019 and b) 20th April 2020](image)

Then the processing is done with the application QGIS versions 3.12.2-București and Semi-Automatic Classification Plugin version 3. Cropping is done according to the area of SERASI Program. Data was overayed by GPS pick-up points and rice field deliniation by the Ministry of Agrarian Affairs and Spatial Planning in 2018.

![Figure 6. Delineation of rice fields using GPS technique by the ministry of Agriculture Spatial Planning, 2018](image)
Using the guided classification a data grouping reference is made with three criteria, namely: (1) Agricultural Areas; (2) Urban Areas; and Water Bodies. Then in Criteria (1) divided into sub criteria, namely: Swamp Paddy Field and Rainfed Paddy Field.

![Guided Classification Diagram]

**Figure 7.** Criteria and Sub Criteria in Guided Classification

Retrieval of coordinates with GPS Navigation is done at the same time by conducting unstructured interviews with smallholder farmers. The results of the interview focused on three questions: (1) Did the TNI and the Agriculture Service Officers actively go to the field; (2) Are there additional areas of paddy fields; and (3) Do farmers feel the benefits of the SERASI program.

![Collection of GPS Coordinates]

**Figure 8.** Collection of GPS coordinates and interviewing local people in Jatuh Village
Interviews were conducted in 14 villages directly in the field. Farmers are given questions that are not structured but contain three main points.

**Figure 9.** GPS coordinate collection and interview location in Mahang Matang Landung Village

**Figure 10.** Direct interview with sharecroppers
By looking directly at the field conditions, it can be seen that the TNI, Field Agricultural Officers and Farmer Groups work together. They work together to open lebak land that is still not fully utilized. The TNI has proven that they are indeed part of the community in accordance with the motto "TNI from the people and for the people".

Figure 11. Expropriation of the scanty land resulting from the SERASI Program

4. Conclusion
The SERASI program activities have been able to increase the value of land which was originally only in the form of abandoned land. Land that could not be cultivated at first because of an unregulated water system was able to produce land that was ready for planting. Drainage canals can be used by residents for irrigation and fisheries. Dredging of canals and rivers makes the area that is always flooded can be managed irrigation. Geospatial analysis was carried out successfully using Sentinel satellite imageries and ground checked by GPS data to define the appropriate location of SERASI Program in HST Regency.

This research wished to suggest that in agriculture development planning, one need to integrate the delineation of administrative boundaries digitally and precisely. When one using a map derived from satellite imageries, the imagery map has to be registered by GPS coordinates collected from the field survey.

The role of local community and land owners’ involvement at the site of SERASI program is urgent, they must fully involve in the SERASI activities as target group for the realization of “Selamatkan Rawa dan Sejahterakan Petani” (save marshland and bring prosper to farmers).

References
[1] B. H. Sunarminto, Ed 2010, Integrated Agriculture to Support National Food Sovereignty. BPFE - YOGYAKARTA. (In Bahasa)
[2] M. W. Byrd 2018, “Economic gap increasingly contributes to risks of security,” Indo-Pacific Defense Forum, 43, Hawaii, pp. 41–45. (In Bahasa)
[3] D. Pimentel and M. H. Pimentel 2008, Food, Energy, and Society, Third. Boca Raton: Taylor & Francis Group.
[4] S. Hermanto 2017, “Rice price policy in terms of price determining dimensions,” Forum Penelit. Agro Ekon., 35, no. 1, pp. 31–43. (In Bahasa)

[5] C. Ortiz 2010, Private armed forces and global security: A guide to the issues. California: Praeger.

[6] T. Hashiguchi 2014, “Social ecological restoration in paddy dominated landscapes,” in Ecological Research Monographs, N. Usio and T. Miyashita, Eds. Tokyo: Springer.

[7] W. F. Wardhiani 2019, “Agricultural Political Role in Agricultural Development in the Face of the Industrial Revolution 4.0 Era in the Agricultural Sector,” JISIPOL | J. Ilmu Sos. dan Ilmu Polit., 3, no. 2, pp. 83–94. (In Bahasa)

[8] M. H. S. M. Noor 2019, “Sustainability of tidal swamp land technology innovation: Prospects, Constraints and implementation,” J. Sumberd. Lahan, 12, no. 2, pp. 117–131. (In Bahasa)

[9] S. Hermanto 2017, “Rice price policy in terms of price determining dimensions,” Forum Penelit. Agro Ekon., 35, no. 1, pp. 31–43. (In Bahasa)
Acknowledgments
The author would like to thank for the support from the HST Regency Government and the Indonesia Defense University.