TEPIAN Vol. 4 No. 3 (September 2023) p-ISSN 2721-5350 e-ISSN 2721-5369
doi.org/10.51967/tepian.v4i3.2623 © 2023 TEPIAN Agricultural Polytechnic of Samarinda
This work is licensed under a Creative Commons Attribution 4.0 License CC-BY

Development of Spatial Models in Making Decisions on Suitable Area for Smart Farming at Agriculture Polytechnic of Samarinda

F. V. Astrolabe Sian Prasetya *
Geomatics Technology, Agricultural Polytechnic of Samarinda, Samarinda, 75131, Indonesia
astrolabesp@politanisamarinda.ac.id
Corresponding author

Nia Kurniadin
Geomatics Technology, Agricultural Polytechnic of Samarinda, Samarinda, 75131, Indonesia
niakurniadin@politanisamarinda.ac.id

M. Faisal Abimanyu
Geomatics Technology, Agricultural Polytechnic of Samarinda, Samarinda, 75131, Indonesia
abimanyusanjaya27@gmail.com

Submitted: 2023-06-13; Accepted: 2023-08-21; Published: 2023-09-01

***Abstract*—**In the context of fulfilling food, especially for agricultural and plantation commodities in East Kalimantan and fulfilling the Agriculture Polytechnic of Samarinda research strategic plan on Strengthening the Application of GIS and Remote Sensing for Land Management in the Agro-Ecosystem Zone, it is necessary to conduct studies related to determining suitable locations for smart farming in the location of the Agriculture Polytechnic of Samarinda. The closest technique in this study is to make a land model that is suitable for smart farming. The model was created by utilizing spatial data derived from remote sensing data, and also analyzed using GIS techniques. Several agricultural and plantation commodities have criteria as conditions for growth that must be met for each commodity. These parameters are conditions of humidity, temperature, and intensity of sunlight, where these data can be extracted from remote sensing data. By utilizing the NDVI, NDMI, and LST algorithms, as well as shadow analysis at the time of irradiation, it will be possible to model an area suitable for smart farming. By using spatial data from sentinel 2 and applying the NDMI, NDVI, and LST algorithms, it can be determined specifically which areas are suitable for several agricultural and plantation commodities. From the results of this study, it was found that several commodities could grow optimally in almost every location at the Agriculture Polytechnic of Samarinda, such as for the commodities of strawberry, rubber crop and robusta coffee. As for the commodities of Mustard Greens, Pepper, Cocoa, and Arabica Coffee, they are not suitable for planting in the Agriculture Polytechnic of Samarinda.

***Keywords*—**Decision Making, Smart Farming, Humidity, Vegetation Index, Temperature, dan Sunlight Illumination Intensity.

I. INTRODUCTION

East Kalimantan has an area of 129,066.64 km^2 (Central Statistics Agency (BPS) East Kalimantan, 2019) with a population of 3.77 million (Central Statistics Agency (BPS) East Kalimantan, 2020). Very fast population growth in East Kalimantan, can cause real problems in fulfilling food for the whole community. The implementation of agricultural activities in East Kalimantan is considered relatively small when compared to the existing population, will have a negative impact on meeting the food needs of the people in East Kalimantan.

Population data from the East Kalimantan BPS concluded that there was an increase in the population of 1.93% or the equivalent of 71,763 people from 2019-2020 (Pictures 1). In addition, city/regency population data in East Kalimantan Province shows that the largest population is in Samarinda City, which is 0.887 million people. With this population, the community's need for food must be taken into consideration in the development of sustainable land use, so that it can meet the food needs of all cities/regencies in East Kalimantan.

Agriculture Polytechnic of Samarinda as one of the institutions providing Vocational Education in Samarinda, has a role to support the provision of food needs in East Kalimantan. This is in line with the formulation of the Research Strategic Plan by Agriculture Polytechnic of Samarinda. The Research Strategic Plan formulated several fields, especially in the field of Environmentally Friendly Agro-industry research (Pictures 3).

In the 2019-2023 Research Strategic Plan of the Agriculture Polytechnic of Samarinda, it was stated that the research topic that was in line with the problem of meeting the food needs of the people in East Kalimantan Province was "Strengthening the Application of GIS and Remote Sensing for Land Management in the Agroecosystem Zone" can be seen in Picture 4 (UPT. Research and Service to Society, 2019). Fulfilling people's food needs is inseparable from considerations of land utilization/use which must be appropriate in the East Kalimantan region, especially in the area of the Samarinda State Agricultural Polytechnic. By using the application of GIS technology and Remote Sensing, geospatial data will be obtained in order to determine the appropriate location for Smart Farming-based agricultural land.

Smart farming, also known as precision agriculture, is an innovative approach to agriculture that utilizes technology and data-driven techniques to optimize the

Prasetya, F. V. A. S. ., Kurniadin, N., & Abimanyu , M. F. . (2023). Development of Spatial Models in Making Decisions on Suitable Area for Smart Farming at Agriculture Polytechnic of Samarinda. TEPIAN, 4(3), 145–151. https://doi.org/10.51967/tepian.v4i3.2623

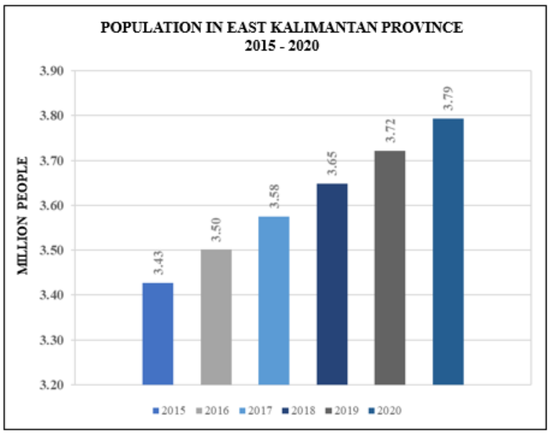
efficiency, productivity, and sustainability of farming practices. It involves the integration of various technologies such as sensors, satellite imagery, drones, GPS, and spatial models to make informed decisions about planting, irrigation, fertilization, pest management, and harvesting. The integration of spatial models is a crucial component of smart farming as it enables farmers to better understand the variability of their fields and make targeted management decisions.

Some of the geospatial data parameters used to determine a suitable location for the Smart Farming area are the Air Humidity Index, Temperature, and Sunlight Intensity. Next, the geospatial data is used to carry out analysis as a basis for decision making in determining the location of Smart Farming at the Agriculture Polytechnic of Samarinda. By modeling the environmental conditions of some of these parameters, it can be indicated specifically which locations are suitable for the cultivation of plantation crops and agriculture.

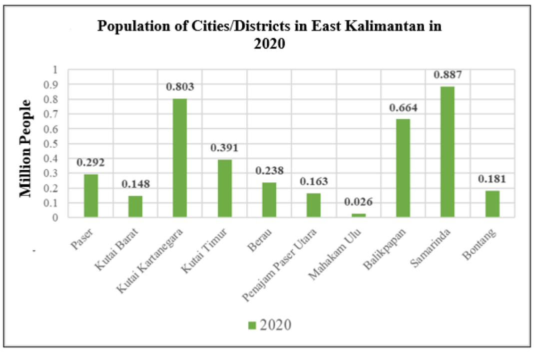
II. Literature Review

A. Population Conditions in East Kalimantan

Very fast population growth in East Kalimantan, can cause real problems in fulfilling food for the whole community. Population growth data in East Kalimantan can be seen from the following statistical data portrait.



Picture 1. Projection of Population in East Kalimantan in 2015-2020

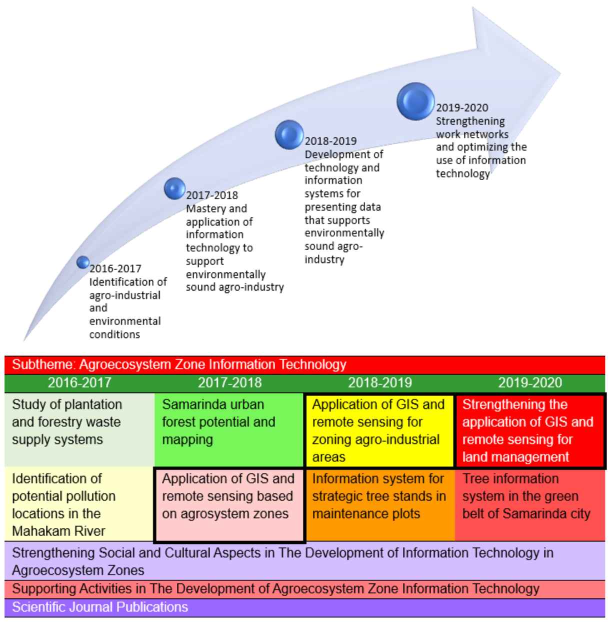


Picture 2. Projection of City/Regency Population in East Kalimantan in 2020
(Source: Population Census of East Kalimantan Province in 2020)

B. Strategic Plan and Roadmap Research Topic of the Agriculture Polytechnic of Samarinda

Seeing the condition of food needs that can be photographed from the growth rate of the population in the city of Samarinda, it can be seen that the strategic plan offered by the Samarinda State Agricultural Polytechnic can be very much in line in overcoming this problem. The following is a strategic plan and research roadmap from the Samarinda State Agricultural Polytechnic in 2019 – 2023.

Picture 3. The theme of the Environmental Agro-industry Sector in the Strategic Plan of the Agriculture Polytechnic of Samarinda in 2019 – 2023



Picture 4. Roadmap and Milestones as well as Research Topics for the Information Technology Sub-theme of the Agro-ecosystem Zone

C. Normalized DifferenceMoisture Index (NDMI)

The Normalized Difference Moisture Index (NDMI) is an index used to detect the humidity of a land surface. Moisture, in particular, the water content plays an important role in the functioning of a vegetation. This is because the leaves where photosynthesis generally occurs, most of it is water (Bell, 2011). NDMI has the middle value of the spectral obtained from NIR / Near Infrared (band 5) and Shortwave Infrared (band 6) electromagnetic waves. In this study, the humidity index value was obtained by processing using the Raster Calculator with the following equation (1)

$$\boldsymbol{NDMI = \frac{Band\ 5 - Band\ 6}{Band\ 6 - Band\ 5}} \qquad (1)$$

NDMI values range from -1 to +1. A low NDMI value indicates a low humidity level and a high NDMI value indicates a high humidity level.

D. Land Surface Temperature (LST)

Land Surface Temperature (LST) is a condition that is controlled by the balance of surface energy, atmosphere, thermal properties of the surface, and the subsurface media (Becker and Li, 1990 in Utomo, et al, 2017). LST is an important phenomenon in global climate change. As the content of greenhouse gases in the atmosphere increases, the LST will also increase. (Rajeshwari and Mani, 2014 in Guntara, 2016). LST can be interpreted as the average surface temperature of a surface which is described in the range of a pixel with a variety of different surface types (Faridah and Krisbiantoro, 2014 in Guntara, 2016).

In this calculation to find out the brightness temperature brightness value (Wiweka, 2014). Brightness Temperature (TB) produces two values, namely TB10 (band 10). Band 10 which is the TOA Spectral Radiance value is then converted to the Brightness Temperature value using the thermal constant provided in the Landsat 8 metadata file with the following formula (2) (USGS, 2013 in Wiweka, 2014):

$$\boldsymbol{TB = \frac{K2}{ln(\frac{K1}{L\lambda}+1)}} \qquad (2)$$

Where:

TB : At-satellite brightness temperature (K)
Lλ : TOA spectral radiance (Watts / (m2*srad*µm))
K1 : *Band-specific thermal conversion constant from the metadata (K1_CONSTANT_BAND_x, where x is the band number)*
K2 : *Band-specific thermal conversion constant from the metadata (K2_CONSTANT_BAND_x, where x is the band number)*

Table 1. Band Constant Value on Landsat 8

Note	Band 10
K1	774,89
K2	1321,08

LST calculations are carried out using the Land Surface Temperature (LST) algorithm can be seen in Equation (3), (Sobrino et al, 2004 in Fadlin et al, 2020).

$$\boldsymbol{LST = \frac{TB}{1+(w*\frac{TB}{\rho})ln(e)}} \qquad (3)$$

Where:

LST = Land Surface Temperature (celcius),
TB = Temperature Brightness
W = wavelength of emitted radiance (11.5 µm)
ρ = h * c / σ (1,438 * 10-2 mK)
h = Planck's constant (6.626 *10-34 Js)
c = speed of light (2,998 * 108 m/s)
σ = Boltzman's constant (1.38 * 10-23 J/K)
E =Built-up emissivity (0,937)

E. Normalized Difference Vegetation Index (NDVI)

NDVI is one of the parameters used to analyze the vegetation condition of an area. The NDVI calculation adheres to the principle that green plants grow very effectively by absorbing radiation in the visible light spectrum (PAR or Photosynthetically Active Radiation) region, then green plants reflect radiation from the near infrared region. The NDVI calculation is as follows in Equation (4) (Darlina, Sasmito, & Yuwono, 2018; Muzaky & Jaelani, 2019; Putra, Sukmono, & Sasmito, 2018; Zhang, Estoque, & Murayama, 2017).

$$\boldsymbol{NDVI = \frac{NIR - Red}{NIR - Red}} \qquad (4)$$

In this equation (4), NIR is the near infrared radiation from the pixel and Red is the red-light radiation from the pixel. NDVI values themselves range from -1 (which is usually water) to +1 (dense vegetation).

III. Research Methods

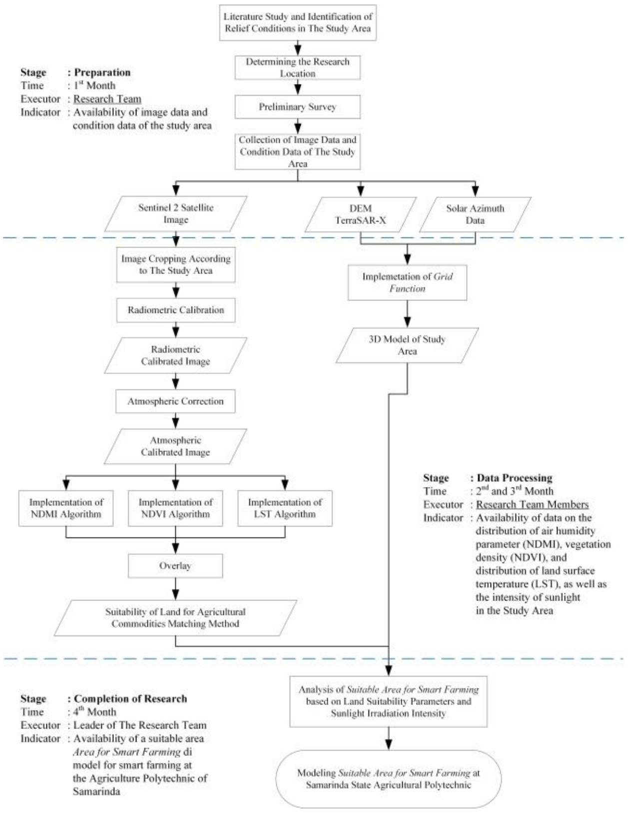
A. Selection of Satellite Image Data

Before carrying out the process of modeling areas suitable for plantation land, it is necessary to analyze the availability of data that has excellent quality. These conditions are needed to improve the quality of the output from the model area suitable for smart farming at Agriculture Polytechnic of Samarinda.

B. Data Analysis Flow Diagram

1. Preparation of Remote Sensing spatial data (Image Sentinel 2) and aerial photo images at the study location.
2. Preparation of solar azimuth data (input parameters: location and date, at the website address : https://gml.noaa.gov/grad/solcalc/)
3. Radiometric and atmospheric corrections on Sentinel 2 Image
4. Application of NDMI, NDVI, and LST algorithms to corrected Sentinel Imagery.
5. Applying the grid function to DEM aerial data and also solar azimuth data so that sunlight irradiation conditions at the study location can be extracted.
6. Application of regional analysis suitable for agricultural land at Agriculture Polytechnic of Samarinda.

A full flowchart related to the process of making land suitability models for agricultural and plantation commodities can be seen in Picture 4.



Picture. 4. Data Analysis Flow Diagram

IV. Result And Discussion

A. *Sentinel 2 Satellite Image Data Selection*

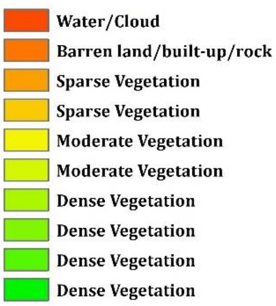
From the results of the selection of sentinel 2 imagery data, the following is sentinel 2 satellite imagery data which has the best conditions with cloud cover at the study location of less than 40%.

Table 2. Pemilihan Data Citra Satelit Sentinel 2 berdasarkan Tutupan Awan (Cloud Cover)

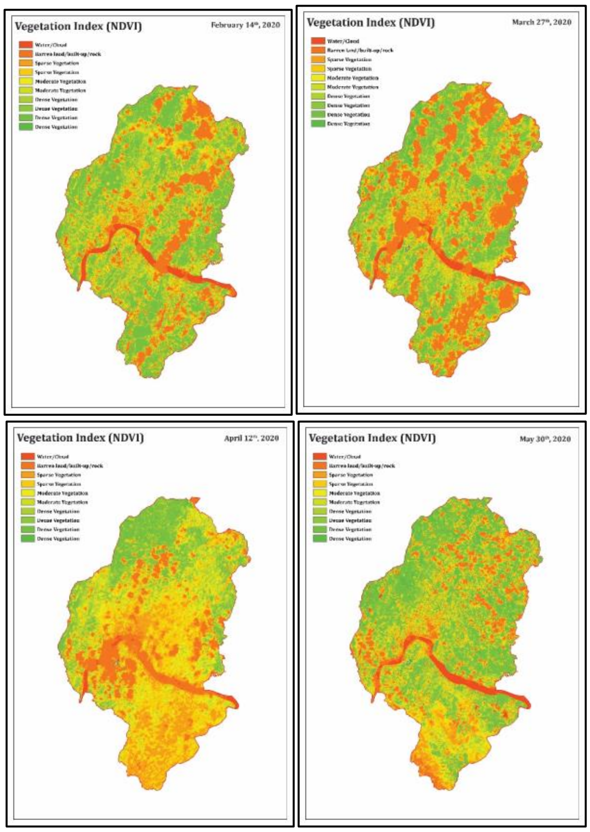
No	Acquisition Date	ID File	Cloud Cover
1.	24-02-2020	LC08_L1TP_116060_20200224_20200313_01_T1	18.60%
2.	27-03-2020	LC08_L1TP_116060_20200327_20200409_01_T1	34.74%
3.	12-04-2020	LC08_L1TP_116060_20200412_20200422_01_T1	28.16%
4.	30-05-2020	LC08_L1TP_116060_20200530_20200608_01_T1	28.66%

B. *Normalized Difference Vegetation Index (NDVI)*

Following are the results of applying the NDVI algorithm to corrected Sentinel 2 satellite images (Picture 6). The legend of the NDVI value results is as follows.



Picture 5. Map legend for NDVI results

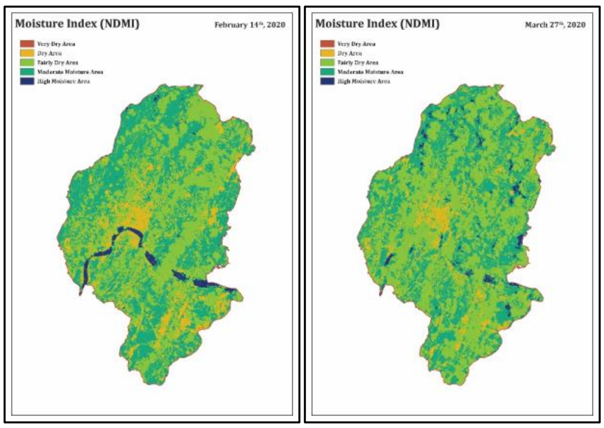


Picture 6. NDVI Distribution in the Samarinda City

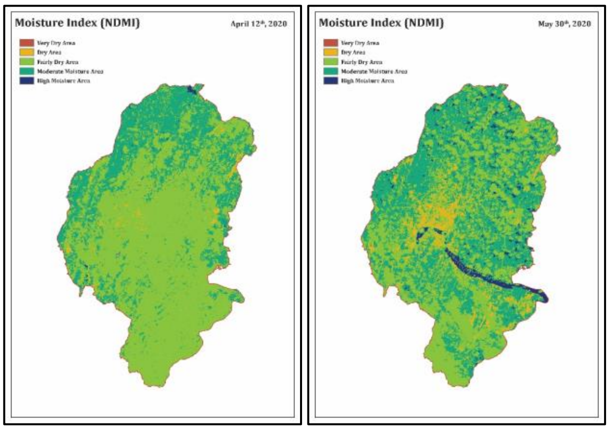
C. *Normalized Difference Moisture Index (NDMI)*

Following are the results of applying the NDMI algorithm to the corrected Sentinel 2 satellite images (Picture 8). The legend of the NDMI value results is as follows.

Picture 7. Map legend for NDMI results



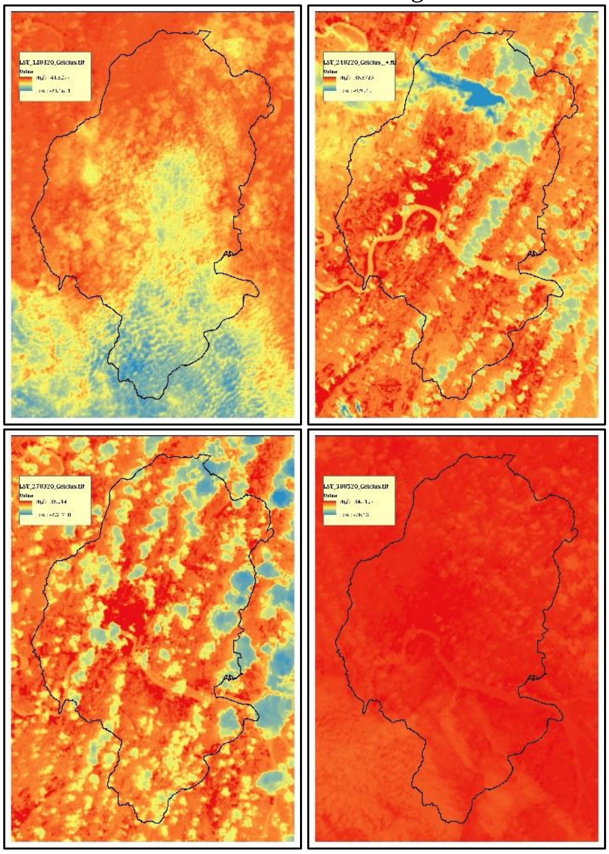
Prasetya, F. V. A. S. ., Kurniadin, N., & Abimanyu , M. F. . (2023). Development of Spatial Models in Making Decisions on Suitable Area for Smart Farming at Agriculture Polytechnic of Samarinda. TEPIAN, 4(3), 145–151. https://doi.org/10.51967/tepian.v4i3.2623



Picture 8. NDMI Distribution in the Samarinda City

D. *Land Surface Temperature (LST)*

Following are the results of applying the LST algorithm to the corrected Sentinel 2 satellite images.



Picture 9. Distribution of LST in the Samarinda City

E. *Land Suitability Parameters for Agricultural and Plantation Commodities*

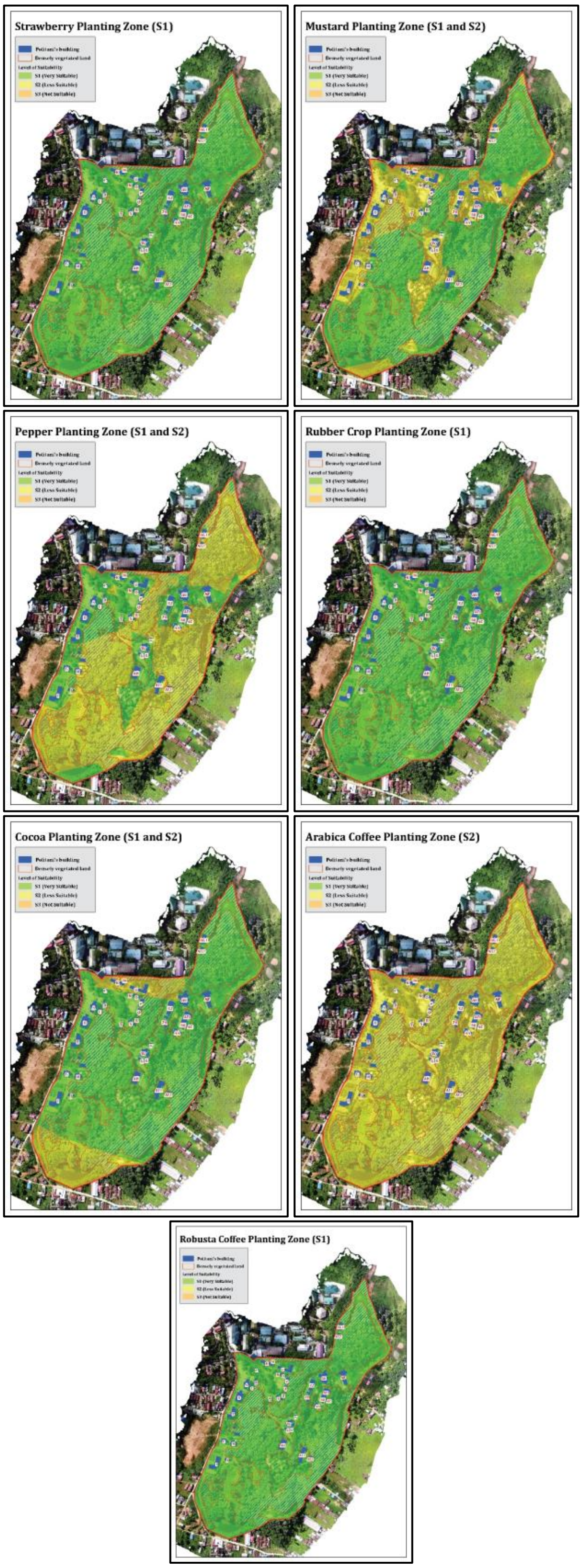
Furthermore, to determine land suitability for several commodities, land capability is needed based on its suitability for several commodities.

Table 3. Land Suitability Parameters for Agricultural and Plantation Commodities

Commodity	S1	S2	S3	N
Strawberry				
Temperature (°C)	17-20	20-30 or 15-17	30-35 or 10-15	>35 or <10
Humidity (%)	>42	36-42	30-36	<30
Exposure time (hour)		8-10		
Mustard				
Temperature (°C)	16-22	>22 -28 or 13 - <16	>28 – 35 or 4 - <13	>35 or <4
Humidity (%)	80-90			
Exposure time (hour)		10-13		
Pepper				
Temperature (°C)	23-32	20-23 or 32-34		>34 or <20
Humidity (%)	60-80	-	-	<60 or >80
Exposure time (hour)		10		
Rubber Crop				
Temperature (°C)	26-30	30-34 or 24-26	22-24	>34 or <22
Humidity (%)	>42	36-42	30-36	<30
Exposure time (hour)	5-7			
Cocoa				
Temperature (°C)	25-28	20-25 or 28-32	32-35	<20 or >35
Humidity (%)	40-65	65-75 or 35-40	75-85 or 30-35	>85 or <30
Exposure time (hour)		Need shelter		
Planting height (m)	0-500	until 800		
Arabica Coffee				
Temperature (°C)	16-20	15-16 or 20-22	14-15 or 22-24	<20 or >35
Humidity (%)	40-65	65-75 or 35-40	75-85 or 30-35	>24 or <14
Exposure time (hour)		Need shelter		
Planting height (m)	300-700	900		
Robusta Coffee				
Temperature (°C)	20-24	24-28	18-20 or 28-32	<18 or >32
Humidity (%)	70-85			
Exposure time (Hour)		Need shelter		
Planting height (m)	300-700	900		

F. *Suitable Area Model for Smart Farming in Agriculture Polytechnic of Samarinda*

Furthermore, from the land suitability parameters used as a reference, then the modeling of suitable land for the following agricultural and plantation commodities is carried out. So that the results of the analysis model for land suitable for these commodities are produced, as follows:



Picture 10. Land suitability for several agricultural and plantation commodities (the colors Green, Yellow and Orange indicate suitability conditions sequentially: Highly Suitable, Less Suitable, and Not Suitable) (from: up to down, left to right; Strawberry, Mustard, Pepper, Rubber Crop, Cocoa, Arabica Coffee, Robusta Coffee)

V. CONCLUSION

From this model it can be concluded that Strawberry, Rubber Crop and Robusta Coffee plants are very suitable in almost all open areas within the Agriculture Polytechnic of Samarinda. As for the commodities of Mustard Greens, Pepper, Cocoa, and Arabica Coffee, they are not suitable for planting in the Agriculture Polytechnic of Samarinda. For further model development, it is possible to modify the irradiation duration parameters for the suitability of agricultural land and plantations, in which the maximum area that gets sunlight (above buildings) is determined and also areas that get shading conditions from sunlight. With these parameters from the condition of the roof of the building in the polytechnic environment which can be used for smart farming locations with hydroponic techniques. From the existing findings, where there are several varieties of plantation crops that are suitable for environmental conditions at the Agriculture Polytechnic of Samarinda, then plant monitoring techniques based on Remote Sensing, Aerial Photography and Deep Learning can be developed. With spatial monitoring techniques and monitoring with deep learning techniques, it will be able to increase the productivity of smart farming at the Agriculture Polytechnic of Samarinda in the future.

VI. REFERENCES

Achmad, Eva, dkk. (2018). Indeks Kelembaban Taman Nasional Bukit Tiga Puluh Menggunakan Citra Satelit Landsat 8. Seminar Nasional Geomatika 2018: Penggunaan dan Pengembangan Produk Informasi Geospasial Mendukung Daya Saing Nasional.

Badan Pusat Statistik Provinsi Kalimantan Timur. (2020). Potret Sensus Penduduk 2020 Provinsi Kalimantan Timur. Kalimantan Timur: BPS Provinsi Kalimantan Timur.

Darlina, S. P., Sasmito, B., & Yuwono, B. D. (2018). Analisis Fenomena Urban Heat Island Serta Mitigasinya (Studi Kasus : Kota Semarang). Jurnal Geodesi Undip, 7(3), 77–87.

Dede, M., Pramulatsih, G. P., Widiawaty, M. A., Ramadhan, Y. R. R., & Ati, A. (2019). Dinamika Suhu Permukaan Dan Kerapatan Vegetasi Di Kota Cirebon. Jurnal Meteorologi Klimatologi Dan Geofisika, 6(1), 23–31.

Fadlin. F, Kurniadin. N, Prasetya. F. V. A. S. (2020). Analisis Indeks Kekritisan Lingkungan Di Kota Makassar Menggunakan Citra Satelit Landsat 8 OLI/TIRS. Semarang: Jurnal Elipsoida Vol 03 No 01., Universitas Diponegoro.

Guntara, I. (2016). Analisis Urban Heat Island Untuk Pengendalian Pemanasan Global Di Kota Yogyakarta Menggunakan Citra Penginderaan Jauh. Surakarta: Fakultas Geografi, Universitas Muhammadiyah Surakarta.

Hadi, Yowargana, P., Zulkarnain, M.T. et al. (2022). A national-scale land cover reference dataset from local crowdsourcing initiatives in Indonesia. Sci

Data 9, 574. https://doi.org/10.1038/s41597-022-01689-5

Insan, A. F. N., and Prasetya, F. V. A. S. (2021). Sebaran Land Surface Temperature Dan Indeks Vegetasi Di Wilayah Kota Semarang Pada Bulan Oktober 2019. Samarinda: Buletin Potanesa, Vol. 22, No. 01.

Insanu, R. K., & Prasetya, F. A. S. (2021). Pemetaan Sebaran Suhu Permukaan Laut (SPL) sebagai Parameter Penentuan Potensi Perikanan dan Budidaya di Pesisir Perairan Delta Mahakam, Kalimantan Timur. Elipsoida : Jurnal Geodesi dan Geomatika, 4(01), 1-8.

Julianto, F. D., Putri, D. P. D., & Safi'i, H. H. (2020). Analisis Perubahan Vegetasi dengan Data Sentinel-2 Menggunakan Google Earth Engine. Jurnal Penginderaan Jauh Indonesia, 02(02), 13–18. Retrieved from http://jurnal.mapin.or.id/index.php/jpji/article/view/29

Kurniadin, N., Yani, M., Nurgiantoro, N., Annafiyah, A., Prasetya, F., Insanu, R., Wumu, R., & Suryalfihra, S. (2022). Deteksi Perubahan Suhu Permukaan Tanah dan Hubungannya dengan Pengaruh Albedo dan NDVI Menggunakan Data Satelit Landsat-8 Multitemporal di Kota Palu Tahun 2013 - 2020. Geoid, 18(1), 82 - 98. doi:10.12962/j24423998.v18i1.13157

Mabrur, A. F., Setiawan, N. A., & Ardiyanto, I. (2019). Remote Sensing Technology for Land Farm Mapping Based on NDMI, NDVI, and LST Feature. Yogyakarta: Universitas Gajah Mada.

Muzaky, H., & Jaelani, L. M. (2019). Analisis Pengaruh Tutupan Lahan Terhadap Distribusi Suhu Permukaan : Kajian Urban Heat Island (Uhi) Di Lima. Penginderaan Jauh Indonesia, 01(02), 45–51.

Octavianti, A., Muliadi, & Apriansyah. (2018). Estimasi Intensitas Radiasi Matahari di Wilayah Kota Makassar. Universitas Tanjung Pura: Prisma Fisika, Vol. 6, No. 3.

Prasetya, A. S., & Rajab, A. (2018). Analisis Distribusi Parameter Fisika dan Kimia pada Kawasan Budidaya Rumput Laut di Provinsi Jawa Timur Dengan Menggunakan Citra Satelit Terra MODIS. Elipsoida : Jurnal Geodesi dan Geomatika, 1(02), 56-63. https://doi.org/10.14710/elipsoida.2018.3467

Previansari, D., Sukmono, A., Firdaus, H.. S. (2020). Analisis Pengaruh Relief dan Arah Sinar Matahari Terhadap Kesesuaian Lahan Tembakau Berbasis Pemodelan Geospasial 3-Dimensi di Gunung Sindoro. Semarang: Jurnal Geodesi Undip.

Putra, A. K., Sukmono, A., & Sasmito, B. (2018). Analisis Hubungan Perubahan Tutupan Lahan Terhadap Suhu Permukaan Terkait Fenomena Urban Heat Island Menggunakan Citra Landsat (Studi Kasus: Kota Surakarta). Jurnal Geodesi Undip, 7(3), 22–31.

UPT Penelitian dan Pengabdian Pada Masyarakat. (2019). Rencana Strategis Penelitian Politeknik Pertanian Negeri Samarinda 2019 – 2023. Samarinda: Politeknik Pertanian Negeri Samarinda.

Utomo, W. A., Suprayogi, A., & Sasmito, B. (2017). Analisis Hubungan Variasi Land Surface Temperature Dengan Kelas Tutupan Lahan Menggunakan Data Citra Satelit Landsat (Studi Kasus: Kabupaten Pati). Semarang: Jurnal Geodesi Undip.

Wiweka. (2014). Pola Suhu Permukaan dan Udara Menggunakan Citra Satelit Landsat Multitemporal. Banten: Jurnal Ecolab. Vol 8. No 1., Pusat Penelitian dan Pengembangan Kualitas dan Laboratorium Lingkungan, Badan Litbang dan Inovasi KLHK.

Yanti, D., Megantara, I., Akbar, M., Melwanda, S., Izzul, S., Sugandi, D., & Ridwana, R. (2020). Analisis Kerapatan Vegetasi di Kecamatan Pangandaran Melalui Citra Landsat 8. Jakarta: Universitas Muhammadiyah Prof. Dr. Hamka.

Zulfa, V. Z. (2017). Optimasi Persebaran Suhu dan Kelembaban Pada Iklim Mikro Greenhouse Untuk Pertumbuhan Tanaman. Surabaya: Fakultas Matematika dan Ilmu Pengetahuan Alam, Institut Teknologi Sepuluh Nopember.