ISSN 2549-3922 EISSN 2549-3930

*Journal of Regional and Rural Development Planning*
(Jurnal Perencanaan Pembangunan Wilayah dan Perdesaan)
Februari 2025, 9 (1): 1-13
DOI: http://dx.doi.org/10.29244/jp2wd.2025.9.1.1-13

# The Evaluation of Suitability of Sustainable Food Agricultural Land to Land Use and Regional Spatial Plan of Boyolali Regency (Case Study: Boyolali and Mojosongo District)

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(Received: April 25th,2024; Accepted: Agustus 28th, 2024)

## ABSTRACT

Land Use Change occurred in many places in Boyolali Regency, including Boyolali and Mojosongo District. Some factors contributed to that thing, like residential and toll road development. There were some instruments to mitigate, such as Boyolali Regional Law Number 17/2016 and Boyolali Regional Law Number 8/2019. Despite being regulated, the enforcement of these regulations has been suboptimal, leading to changes in agricultural land use to non-agricultural purposes in several areas. Monitoring the law is important to see if it goes well or not. This can be utilized Geographic Information Systems (GIS) with overlay method and on-screen digitization of SPOT-6 imagery. Besides that, Remote Sensing analyzed land use trends using multi-temporal SPOT-6 images of 2018 and 2022. This study aims to determine the extent of land use in 2018 and 2022 as well as to determine the suitability of Sustainable Food Agricultural Land to land use and also evaluate the suitability of Sustainable Food Agricultural Land to the Regional Spatial Plan. Results showed that in 2018, the largest land use class was residential areas, covering 2,437.77 hectares, followed by rice fields and moorland, which covered 1,109.06 and 2,205.74 hectares, respectively. By 2022, residential areas had expanded to 2,625.57 hectares, while rice fields and moorland covered 1,130.54 and 2,145.07 hectares, respectively. Based on the overlay method, the suitability analysis revealed that Sustainable Food Agricultural Land matched 90.47% of land use in 2018 and 90.04% in 2022. Meanwhile, the suitability between the Sustainable Food Agriculture Land and Regional Spatial Plan amounted to 81.03%.

Keywords : Land Use, Overlay, Regional Spatial Plan, Suitability, Sustainable Food Agricultural Land

## INTRODUCTION

Changes in agricultural land use to non-agricultural land use have happened in many places in Indonesia. One of them is the Boyolali Regency in Central Java. Over the years, agricultural land use has changed in many areas in Boyolali Regency, including Boyolali and Mojosongo Districts (Saifuddin & Danardono, 2024). Boyolali District is the capital of Boyolali Regency, and Mojosongo District is the seat of the government (Rohmah & Setiawan, 2019). According to the Indonesia Statistics Agency, Boyolali District's agricultural land shrank from 290 hectares in 2015 to 285 hectares in 2018, and Mojosongo District's agricultural land decreased from 943 to 922 hectares over the same period.

Two dominant factors contributed to the agricultural land use change in Boyolali, as stated by Aryono (2016) in Solopos News. These factors were residential and toll road development. Many places in Boyolali Regency have experienced changes in the use of agricultural land for residential. Solopos News revealed that the average subsidized house in Boyolali was built on former moorlands (Malinda, 2022). Apart from that, the construction of toll roads in Boyolali Regency has also contributed to changes in land use in the area. Indrawati (2012) stated in a Solopos news report that the toll road project affected most of the agricultural land belonging to residents in Kragilan Village, Mojosongo District.

Realizing that changes in land use continue to occur, efforts are needed to protect this land use. The government of Boyolali Regency regulated the Regional Spatial Plan in Regional Law Number 8 / 2019. Besides that, there is also a regulation about Sustainable Food Agricultural Land in Regional Law Number 17 / 2016.

Monitoring of Sustainable Food Agricultural Land is essential. This monitoring can use various technologies, such as Geographic Information Systems (GIS) and Remote Sensing. Reja et al. (2020) and Rashwan et al. (2024) research used GIS to integrate many maps with overlay methods. Meanwhile, Remote Sensing Technologies can be utilized to assess the land conditions in Boyolali and Mojosongo Districts at certain times like research by Nampak et al. (2018). High-resolution satellite imagery is useful for monitoring land use from year to year.

This research emphasizes the need to evaluate the suitability of actual land use resulting from the imagery interpretation with land use designated by regulations and the coherence among land use designated by different regulations. The efforts to control land use are necessary for maintaining the suitability between Sustainable Food Agricultural Land and land use and the Spatial Regional Plan. Assessing the suitability of these parameters ensures that land use practices align with regulatory frameworks. This approach supports creating a balanced and sustainable land-use strategy that meets the needs of both current and future generations.

## METHODOLOGY

This research was conducted in Boyolali District and Mojosongo District, Boyolali Regency, Central Java. The data used in this research was secondary data obtained from various government agencies. There were Administration map and Regional Spatial Plan of Boyolali Regency Year 2011–2031 obtained from Regional Development Planning, Research, and Innovation Agency of Boyolali Regency; Sustainable Food Agricultural Land geospatial data obtained from Boyolali Office of Agriculture; and georeferenced SPOT-6 imagery year 2018 with cloud cover 1.08% and georeferenced SPOT-6 satellite imagery year 2022 with cloud cover 5.63% obtained from National Research and Innovation Agency.

The SPOT-6 satellite imagery was digitized to produce land use maps in Boyolali and Mojosongo Districts. This digitization refers to the Indonesian National Standards (SNI) 7645:2010 Land Cover Classification so that land use is classified into nine types according to needs, such as residential, rice fields, moorland, orchards, scrub, quarries, rivers, toll roads, and industry. After the digitization process, the topology was checked to find out whether there was overlap or not and whether there were gaps or not.

The validation test was done with Google Earth Pro. The use of Google Earth Pro in validation tests is because the images used are so far apart in time that they cannot be used for field tests. Therefore, a validation test was carried out with the help of Google Earth Pro to compare the imagery used with the field appearance in Google Earth Pro. The number of validation test points referred to SNI 8202:2019 with the following Formula 1.

$$n = \frac{N}{1+Ne^2} \quad (1)$$

n = Number of Objects Tested
N = Total Population
e = Error Tolerance

Based on the result of the calculation from Formula 1, the number of samples used was 41 points. This is also in line with SNI 8202-2019. Based on the law, it is stated that for an area ≤250 $km^2$ the minimum number of test points is 12 points. This has met the minimum limit because the research area is 74.72 $km^2$.

The samples were distributed using stratified random sampling, that is, sample points were determined randomly in each stratum and attempted to be evenly distributed throughout the research area (Wulansari, 2017). The validation test is performed to obtain general accuracy, measured using an error matrix on remote sensing classification data. The error matrix can be in the form of a table that shows the relationship between classification results based on interpretation and reference data samples obtained according to actual conditions in the field (Luthfina et al., 2019).

Table 1. Error Matrix

| Map Data | Field Data | | | Amount |
|---|---|---|---|---|
| | a | b | c | |
| A | $X_{11}$ | $X_{12}$ | $X_{13}$ | $X_{1+}$ |
| B | $X_{21}$ | $X_{22}$ | $X_{23}$ | $X_{2+}$ |
| C | $X_{31}$ | $X_{32}$ | $X_{33}$ | $X_{3+}$ |
| Amount | $X_{+1}$ | $X_{+2}$ | $X_{+3}$ | n |

Source: SNI 8202-2019

The acceptable accuracy used in this research was 85% referring to the Regulation of the Head of the Geospatial Information Agency Number 15 of 2014. After obtaining the results of the error matrix, the overall attribute accuracy test is calculated using the following Formula 2.

$$\textit{Overall Accuracy} = \left(\frac{\sum_{i=1}^{r} x_{ir}}{n}\right) \times 100\% \quad ....(2)$$

n = number of objects tested

$X_{ir}$ = number of objects on the map with attributes matching the field (diagonal values from the Accuracy Test Matrix)

After obtaining the Land Use Map, an overlay process is conducted for each instrument. First, an overlay is performed on the Sustainable Food Agricultural Land with the Land Use of Boyolali and Mojosongo Districts using the following scheme based on research by Muryono (2016) and Hambali et al. (2021). It could be explained as follows:

a. Developed a suitable matrix between Sustainable Food Agricultural Land and Land Use, with the following classification:
    1) Suitable, if Sustainable Food Agricultural Land matches the land use area. For example, if the land use area was rice fields, then the Sustainable Food Agricultural Land map, would indicate the location for Sustainable Food Agricultural Land.
    2) Unsuitable, if Sustainable Food Agricultural Land does not match the land use area. For example, if the land use area was residential in the Sustainable Food Agricultural Land map, it would indicate an unsuitable location for Sustainable Food Agricultural Land.
b. Carry out an overlay of the land use map with the Sustainable Food Agricultural Land Map using the Suitability Matrix as a reference. This will provide information regarding the suitability and unsuitability of the two maps.

Table 2. The Suitability Criteria Between Sustainable Food Agricultural Land to Land Use

| No | Sustainable Food Agricultural Land Area | Land Use | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Industry | Toll Road | Orchard | Residential | Rice Field | Scrub | River | Moorland | Sand Quarry |
| 1 | Rice Field | × | × | × | × | ✓ | × | × | × | × |
| 2 | Moorland | × | × | × | × | × | × | × | ✓ | × |

Information : ✓ = Suitable, × = Unsuitable

Second, the suitability between Sustainable Food Agricultural Land and Regional Spatial Plan was done with the overlay method. The process could be explained as follows:

a. Developed a suitable matrix between Sustainable Food Agricultural Land and Land Use, with the following classification:
    1) Suitable, if Sustainable Food Agricultural Land is suitable with a Regional Spatial Plan. For example, if the designated function of an area in the Regional Spatial Plan is for Wet Agricultural Land Area, then in the Sustainable Food Agricultural Land Map, it will also be designated as Sustainable Food Agricultural Land.
    2) Unsuitable, if Sustainable Food Agricultural Land is unsuitable for Regional Spatial Plan. For example, if the designated function of an area in the Regional Spatial Plan is for residential purposes, but in the Sustainable Food Agricultural Land Map it is designated as Sustainable Food Agricultural Land.
b. Next, carry out an overlay of the Regional Spatial Plan Map with the Sustainable Food Agricultural Land Map using the Suitability Matrix as a reference. This will provide information regarding the suitability and unsuitability of the two maps.

Table 3. The Suitability Criteria Between Sustainable Food Agricultural Land to Regional Spatial Plan (RTRW)

| **No** | **Sustainable Food Agricultural Land Area** | **Regional Spatial Plan** | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | **Industrial Designation Area** | **Plantation Area** | **Residential Area** | **Wet Agricultural Land Area** | **Dry Agricultural Land Area** | **River** | **Quarry** |
| 1 | Rice Field | × | × | × | ✓ | × | × | × |
| 2 | Moorland | × | × | × | × | ✓ | × | × |

Information : ✓ = Suitable, × = Unsuitable

## RESULTS AND DISCUSSION

### Accuration Test Result

The SPOT-6 satellite imagery was digitized based on interpretation. After all of the areas were digitized, the next step was to conduct validation tests. The accuracy test was carried out once on the digitization results for 2018 and 2022. This test was implemented on each element of the land cover group that had been digitized. The results of this accuracy test use field test tables and confusion matrix. The accuracy test used Google Earth because the images are taken so far apart in time that they cannot be used for field tests. After that, compile the result of the accuration test into a confusion matrix. The confusion matrix for SPOT 6 imagery 2018 is shown in Table 4 and the confusion matrix for SPOT 6 2022 can be seen in Table 5.

Table 4. Research's Confusion Matrix of SPOT 6 Imagery Year 2018

| | | Digitization Results | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Industry | Toll Road | Orchards | Residential | Rice Field | Moorland | River | Sand Quarry | Scrub | Total |
| Field Appearance Results | Industry | 2 | - | - | - | - | - | - | - | - | 2 |
| | Toll Road | - | 1 | - | - | - | - | - | - | - | 1 |
| | Orchards | - | - | 11 | - | - | - | - | - | - | 11 |
| | Residential | - | - | - | 15 | - | - | - | - | - | 15 |

| | | Digitization Results | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Industry | Toll Road | Orchards | Residential | Rice Field | Moorland | River | Sand Quarry | Scrub | Total |
| | Rice Field | - | - | - | - | 5 | - | - | - | - | 5 |
| | Moorland | - | - | - | - | - | 4 | - | - | 1 | 5 |
| | River | - | - | - | - | - | - | 1 | - | - | 1 |
| | Sand Quarry | - | - | - | - | - | - | - | 1 | - | 1 |
| | Scrub | - | - | - | - | - | - | - | - | - | 0 |
| Total | | 2 | 1 | 11 | 15 | 5 | 4 | 1 | 1 | 1 | 41 |

Table 5. Research's Confusion Matrix of SPOT 6 Imagery Year 2022

| | | Digitization Results | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Industry | Toll Road | Orchards | Residential | Rice Field | Moorland | River | Sand Quarry | Scrub | Total |
| Field Appearance Results | Industry | 2 | - | - | - | - | - | - | - | - | 2 |
| | Toll Road | - | 1 | - | - | - | - | - | - | - | 1 |
| | Orchards | - | - | 11 | - | - | - | - | - | - | 11 |
| | Residential | - | - | - | 15 | - | - | - | - | - | 15 |
| | Rice Field | - | - | - | - | 5 | - | - | - | - | 5 |
| | Moorland | - | - | - | - | - | 4 | - | - | 1 | 5 |
| | River | - | - | - | - | - | - | 1 | - | - | 1 |
| | Sand Quarry | - | - | - | - | - | - | - | 1 | - | 1 |
| | Scrub | - | - | - | - | - | - | - | - | - | 0 |
| Total | | 2 | 1 | 11 | 15 | 5 | 4 | 1 | 1 | 1 | 41 |

According to Tables 4 and 5, both tables have the same values, it happens because of the ability and experience in interpreting and digitizing images. The calculation of the overall accuracy can be done with Formula 2.

$$\textit{Overall Accuracy} = \left(\frac{\sum_{i=1}^{r} x_{ir}}{n}\right) \times 100\%$$
$$= \left(\frac{40}{41}\right) \times 100\%$$
$$= 97.5\%$$

These results show that accuracy meets the requirements of the accuracy test, namely ≥ 85%.

## Land Use Map

Based on the Land-Use Map, the total area of the Boyolali District and Mojosongo District is 7,471.5868 hectares. In 2018, the land use that has the largest area of residential land use with an area of 2,437.7682 hectares. Agricultural land use, namely rice fields and moorland, had an area of 1,109.0614 hectares and 2,205.7383 hectares, respectively. Meanwhile, non-agricultural land use amounted to 4,156.7871 hectares with an industry of 65.4346 hectares; toll road of 32.3807 hectares; orchards of 1,534.9495 hectares; Residential of 2,437.7682 hectares; scrub of 41.9555 hectares; river of 42.6088 hectares; and sand quarry of 1.6899 hectares. Land-use Map in 2018 can be seen in Figure 1.

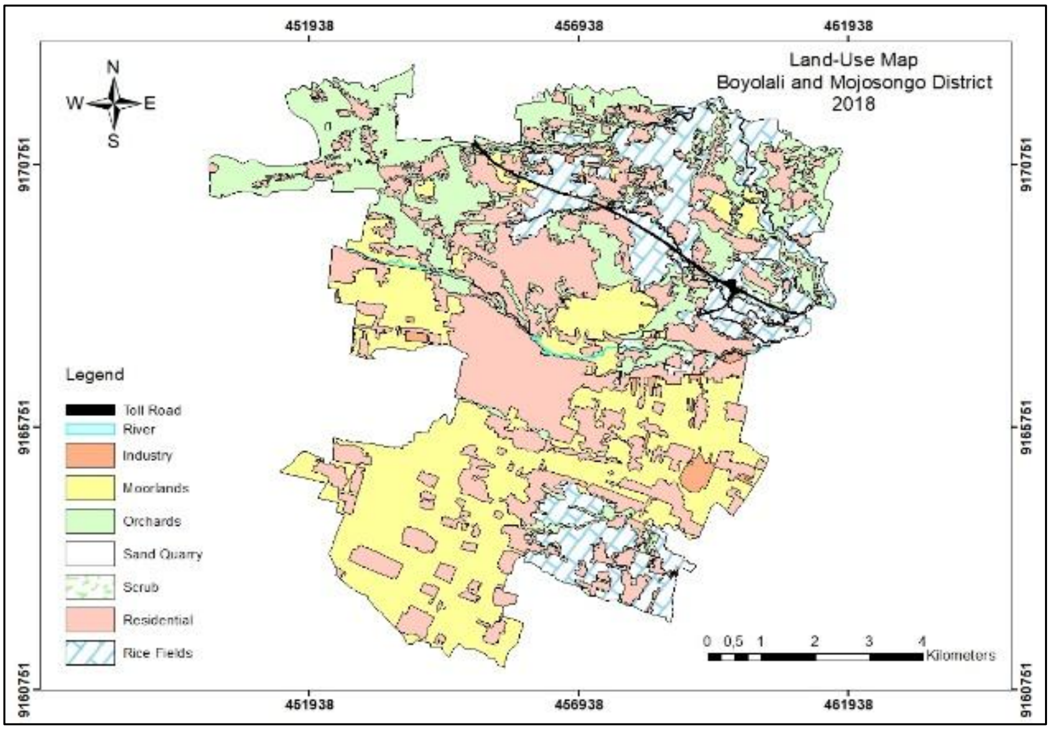


Figure 1. Land-Use Map Boyolali and Mojosongo District in 2018
Source: Research Analysis, 2024

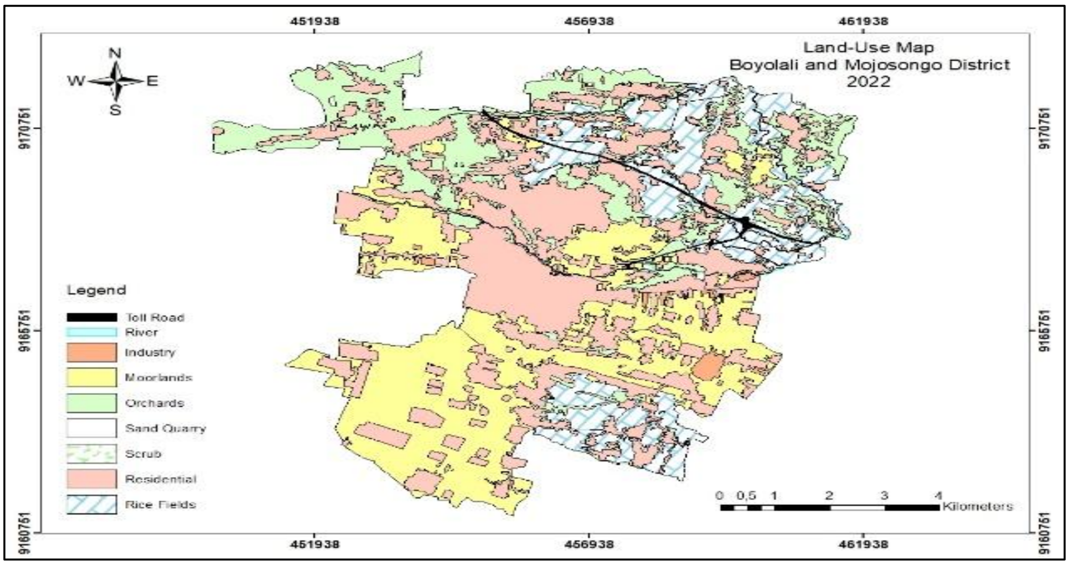


Figure 2. Land-Use Map Boyolali and Mojosongo District in 2022
Source: Research Analysis, 2024

In 2022, the land use with the largest area was still Residentials with an increase in area to 2,625.5650 hectares. Agricultural land, namely rice fields covering 1,130.5402 hectares and moorland covering 2,145.0745 hectares. Non-agricultural land was 41,95.9721 hectares with industry of 63.7779 hectares; toll road of 37.4194 hectares; orchards of 7,404.7284 hectares; Residential of 2,625.5650 hectares; Scrub of 16.0866 hectares; river of 42.6083 hectares; and sand quarry of 5.7865 hectares. Land-use Map in 2022 can be seen in Figure 2. Comparison Between Land-Use Area in 2018 and 2022 can be seen in Table 6.

Table 6. Comparison Between Land-Use Area

| No | Land Use | 2018 | 2022 |
|---|---|---|---|
| 1 | Industry | 65.4346 | 63.7779 |
| 2 | Toll Road | 32.3807 | 37.4194 |
| 3 | Orchards | 1,534.9495 | 1,404.7284 |
| 4 | Residential | 2,437.7682 | 2,625.5650 |
| 5 | Rice Field | 1,109.0614 | 1,130.5402 |
| 6 | Scrub | 41.9555 | 16.0866 |
| 7 | River | 42.6087 | 42.6083 |
| 8 | Sand Quarry | 1.6899 | 5.7865 |
| 9 | Moorland | 2,205.7383 | 2,145.0745 |
| | Total | 7.471,5868 | 7.471,5868 |

## Suitability between Sustainable Food Agricultural Land and Land Use

According to the overlay data processing, there were unsuitable areas in both 2018 and 2022. The result of the map overlay of Sustainable Food Agricultural Land is shown in Figure 3 and Figure 4. The suitable area is shown in Table 7. Meanwhile, the unsuitable area is shown in Table 8 and Table 9.

Table 7. The Suitable Area for Sustainable Food Agricultural Land Area

| No | Sustainable Food Agricultural Land Area | Area | | |
|---|---|---|---|---|
| | | 2018 | 2022 | Regional Spatial Plan |
| 1 | Rice Field | 980.9105 | 992.2985 | 997.1820 |
| 2 | Moorland | 1,593.8816 | 1,570.1073 | 1,308.8276 |
| | Total | 2,574.7921 | 2,562.4059 | 2,306.0096 |

Source: Research Analysis, 2024

The suitable area in 2018 was 2,574.7921 hectares or 90.47% of the area designated for Sustainable Food Agricultural Land and in 2022 was 2,562.4059 hectares or 90.04% of the area designated for Sustainable Food Agricultural Land. The use of land that is currently in the form of rice fields must be maintained, while the use of land that is not yet in the form of rice fields needs to be considered to change to the use of rice fields so that it is in accordance with the directions in Sustainable Food Agricultural Land (Muryono, 2016). The Map of Suitability Food Agricultural Land for Land Use in 2018 is shown in Figure 3 and the Map of Suitability Food Agricultural Land for Land Use in 2022 can be seen in Figure 4.

According to Table 8, the unsuitable area in 2018 was 271.1329 hectares or 9.53% of the designated area. Meanwhile, the unsuitable area in 2022 which can be seen in Table 9 was 283,5191 hectares or 9.96% of the designated area. The biggest incompatibility between Sustainable Food Agricultural Land and Land Use in Boyolali & Mojosongo Districts is the overlap between Sustainable Food Agricultural Land and residential land use with an area of 117,1976 hectares in 2018 and increasing to 144,0539 hectares in 2022. This is in line with research by Khoirunnisa et al. (2023) which said that land changes in Mojosongo District from 2018 to 2022 were dominated by changes from moorland to residential areas.

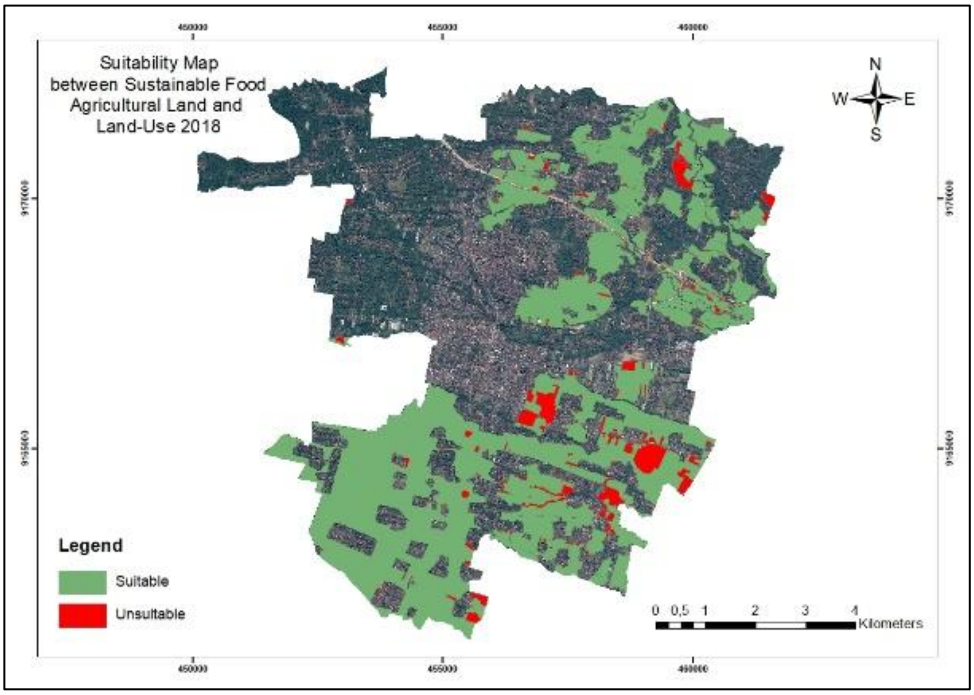


Figure 3. Suitability Map between Sustainable Food Agricultural Land and Land Use in 2018
Source: Research Analysis, 2024

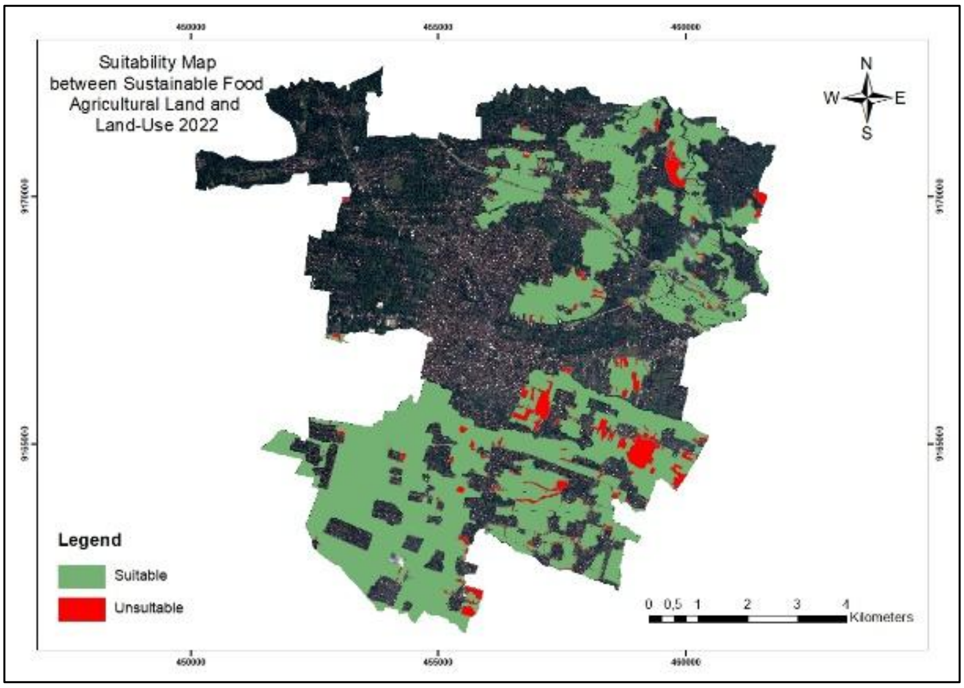


Figure 4. Suitability Map between Sustainable Food Agricultural Land and Land Use in 2022
Source: Research Analysis, 2024

Based on Figure 3 and 4, land use was still in line with the area of Sustainable Land Agricultural Land. Therefore, the unsuitable data might be used as material for government evaluation at least once every five years under applicable regulations. The analysis of unsuitable areas between Sustainable Food Agricultural Land Area and Land Use.

Table 8. The Unsuitable Area between Sustainable Food Agricultural Land and Land Use in 2018

| No | Sustainable Food Agricultural Land Area | Unsuitable with Land Use Area in 2018 (hectares) | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Industry** | **Toll Road** | **Orchard** | **Residential** | **Rice Field** | **Scrub** | **River** | **Moorland** | **Sand Quarry** | |
| 1 | Rice Field | 2.2227 | 2.8234 | 56.6591 | 15.6375 | 0 | 3.1855 | 0.4267 | 27.8374 | 0 | 108.7923 |
| 2 | Moorland | 34.8782 | 0 | 25.6591 | 101.5601 | 0.4929 | 0.0625 | 0.0106 | 0 | 0 | 162.3406 |
| | Total | 37.1009 | 2.8234 | 82.3182 | 117.1976 | 0.4929 | 3.2480 | 0.4372 | 27.8376 | 0 | 271.1329 |

Source: Research Analysis, 2024

Table 9. The Unsuitable Area between Sustainable Food Agricultural Land and Land Use in 2022

| No | Sustainable Food Agricultural Land Area | Unsuitable with Land Use Area in 2022 (hectares) | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Industry** | **Toll Road** | **Orchard** | **Residential** | **Rice Field** | **Scrub** | **River** | **Moorland** | **Sand Quarry** | |
| 1 | Rice Field | 2.4713 | 3.5709 | 54.8159 | 19.4055 | 0 | 0.0513 | 0.4236 | 16.1005 | 0.5417 | 97.3807 |
| 2 | Moorland | 33.2219 | 0 | 26.6006 | 124.6484 | 1.6600 | 0 | 0.0075 | 0 | 0 | 186.1384 |
| | Total | 35.6932 | 3.5709 | 81.4165 | 144.0539 | 1.6600 | 0.0513 | 0.4311 | 16.1005 | 0.5417 | 283.5191 |

Source: Research Analysis, 2024

## Suitability between Sustainable Food Agricultural Land and Regional Spatial Plan

According to the overlay process, there was an unsuitable and suitable area between Sustainable Food Agricultural Land and Regional Spatial Plan. The unsuitability area was 539.9154 hectares or 18.97%. Meanwhile, the suitability area was 2306.0096 hectares or 81.03%. This indicates that most of the directives for Sustainable Food Agricultural Land are already in accordance with the designated land use specified in the Regional Spatial Plan.

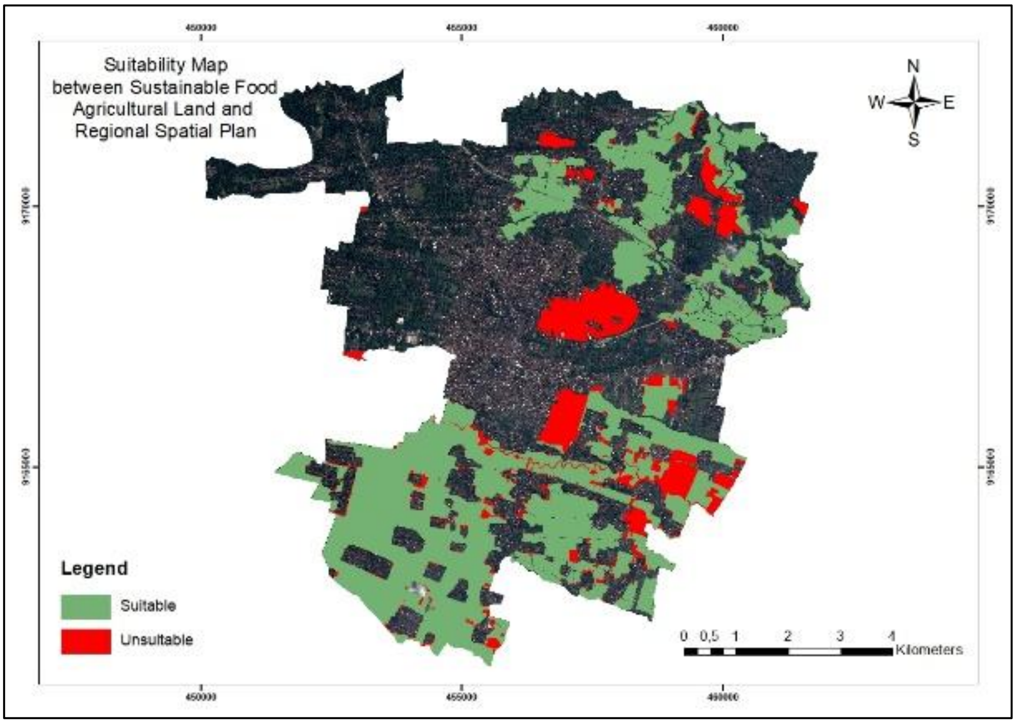


Figure 5. Suitability Map between of Sustainable Food Agricultural Land and Regional Spatial Plan
Source: Research Analysis, 2024

Based on Table 7, the suitable area for Sustainable Food Agricultural Land and the Regional Spatial Plan on rice fields is 997.1820 hectares, and for moorlands, it is 1308.8276 hectares. Additionally, the unsuitable areas are detailed in Table 10. In terms of the discrepancy between the regional spatial plan's functional direction and the sustainable food agricultural land area, the most unsuitable area is for the Residential function, covering 222.8538 hectares.

In line with research by Hambali et al. (2021), the Sustainable Food Agricultural Land Area is still in line with the Regional Spatial Plan. However, discrepancies in the Regional Spatial Plan designation still overlap with the Sustainable Food Agricultural Land designation. This would have happened because the Regional Spatial Plan was first regulated in 2011 and was revised in 2019. Meanwhile, the Boyolali Regency Sustainable Food Agricultural Land was determined in 2016. Therefore, it is hoped that there will be further clarification between the directions of Sustainable Food Agricultural Land and Regional Spatial Plan to prevent future land use changes from agricultural to non-agricultural. Additionally, it is hoped that the Sustainable Food Agricultural Land area and Regional Spatial Plan area can sync with each other.

Table 10. The Unsuitable Area between Sustainable Food Agricultural Land and Regional Spatial Plan

| No | Sustainable Food Agricultural Land Area | Unsuitable with Regional Spatial Plan (hectares) | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | | Industrial Designation Area | Plantation Area | Residential Area | Wet Agricultural Land Area | Dry Agricultural Land Area | River | Quarry | |
| 1 | Rice Field | 0.4616 | 24.8118 | 36.6901 | 0 | 30.0357 | 0.5007 | 0 | 92.4999 |
| 2 | Moorland | 50.9578 | 184.8909 | 186.1639 | 5.4466 | 0 | 18.9308 | 1.0255 | 447.4155 |
| | Total | 51.4194 | 209.7027 | 222.8540 | 5.4466 | 30.0357 | 19.4315 | 1.0255 | 539.9154 |

Source: Research Analysis, 2024

## Suitability between Sustainable Food Farming Land and Land Use and Regional Spatial Plan by Villages

Next, an analysis was carried out to find out which villages had discrepancies. This analysis is referred to as Graha et al. (2023) and Andriawan et al. (2020) research. They divided into districts because their research was city level. Based on data processing, the village with the widest unsuitable area was the Kemiri Village in Mojosongo District. That happened because the area designated as Sustainable Food Agricultural Land has changed a lot into new land uses. The most changed land use area was the moorlands. The area where the discrepancy occurred was as much as 51.9927 hectares or 15,21% in 2018 and 49.9485 hectares or 14,61% in 2022. There were wide differences in 2018 and 2022 because the land uses changed into different land uses.

Table 11**.** The Suitable & Unsuitable Area between Sustainable Agricultural Land and Land Use by Village

| Districts | Villages | 2018 | | | | 2022 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Suitable | | Unsuitable | | Suitable | | Unsuitable | |
| | | (hectares) | (%) | (hectares) | (%) | (hectares) | (%) | (hectares) | (%) |
| Boyolali | Karanggeneng | 72.2464 | 95.63 | 3.2983 | 4.37 | 72.6184 | 96.13 | 2.9232 | 3.87 |
| | Kebonbimo | 11.4239 | 83.16 | 2.3135 | 16.84 | 11.7847 | 85.79 | 1.9514 | 14.21 |
| | Kiringan | 34.6952 | 96.25 | 1.3524 | 3.75 | 34.3056 | 95.17 | 1.7397 | 4.83 |
| | Mudal | 177.7951 | 93.37 | 12.6300 | 6.63 | 176.2370 | 92.55 | 14.1855 | 7.45 |
| | Penggung | 0.0000 | 0.00 | 0.4597 | 100.00 | 0.0000 | 0.00 | 0.4588 | 100.00 |
| | Pulisen | 0.0000 | 0.00 | 0.0581 | 100.00 | 0.0381 | 66.61 | 0.0191 | 33.39 |
| | Siswodipuran | 0.0009 | 0.00 | 0.0024 | 0.00 | 0.0012 | 0.00 | 0.0007 | 36.84 |
| | Winong | 3.6604 | 54.52 | 3.0538 | 45.48 | 3.7272 | 55.50 | 2.9886 | 44.50 |

| Districts | Villages | 2018 | | | | 2022 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Suitable | | Unsuitable | | Suitable | | Unsuitable | |
| | | (hectares) | (%) | (hectares) | (%) | (hectares) | (%) | (hectares) | (%) |
| Mojosongo | Brajan | 113.9200 | 89.33 | 13.6002 | 10.67 | 115.3755 | 90.48 | 12.1411 | 9.52 |
| | Butuh | 106.7194 | 68.94 | 48.0875 | 31.06 | 105.5285 | 68.17 | 49.2771 | 31.83 |
| | Dlingo | 111.8118 | 77.45 | 32.5580 | 22.55 | 111.6599 | 77.35 | 32.7037 | 22.65 |
| | Jurug | 102.9655 | 75.30 | 33.7689 | 24.70 | 116.5645 | 85.25 | 20.1668 | 14.75 |
| | Karangnongko | 266.8983 | 96.77 | 8.9064 | 3.23 | 262.8175 | 95.29 | 12.9864 | 4.71 |
| | Kemiri | 289.8462 | 84.79 | 51.9927 | 15.21 | 291.8886 | 85.39 | 49.9485 | 14.61 |
| | Mojosongo | 44.8907 | 81.96 | 9.8820 | 18.04 | 40.0612 | 73.14 | 14.7098 | 26.86 |
| | Kragilan | 181.6374 | 95.16 | 9.2402 | 4.84 | 176.2774 | 92.35 | 14.5962 | 7.65 |
| | Madu | 175.0890 | 99.19 | 1.4212 | 0.81 | 172.9852 | 98.00 | 3.5311 | 2.00 |
| | Manggis | 176.6713 | 93.04 | 13.2109 | 6.96 | 173.8595 | 91.56 | 16.0207 | 8.44 |
| | Metuk | 174.1121 | 96.50 | 6.3219 | 3.50 | 171.3797 | 94.98 | 9.0488 | 5.02 |
| | Singosari | 248.4443 | 98.75 | 3.1465 | 1.25 | 247.3721 | 98.31 | 4.2420 | 1.69 |
| | Tambak | 281.9640 | 94.68 | 15.8283 | 5.32 | 277.9241 | 93.32 | 19.8800 | 6.68 |
| | TOTAL | 2,574.7921 | 90.47 | 271.1329 | 9.53 | 2,562.4059 | 90.04 | 283.5191 | 9.96 |

Source: Research Analysis, 2024

Table 12. The Suitable & Unsuitable Area between Sustainable Agricultural Land and Regional Spatial Plan by Village

| Districts | Villages | Regional Spatial Plan | | | |
|---|---|---|---|---|---|
| | | Suitable | | Unsuitable | |
| | | (hectares) | (%) | (hectares) | (%) |
| Boyolali | Karanggeneng | 32.7349 | 43.33 | 42.8070 | 56.67 |
| | Kebonbimo | 0.0000 | 0.00 | 13.7362 | 100.00 |
| | Kiringan | 35.1522 | 97.52 | 0.8932 | 2.48 |
| | Mudal | 174.8808 | 91.84 | 15.5419 | 8.16 |
| | Penggung | 0.0064 | 1.39 | 0.4525 | 98.61 |
| | Pulisen | 0.0050 | 8.73 | 0.0523 | 91.27 |
| | Siswodipuran | 0.0000 | 0.00 | 0.0020 | 0.00 |
| | Winong | 0.5248 | 7.81 | 6.1911 | 92.19 |
| Mojosongo | Brajan | 124.4024 | 97.56 | 3.1145 | 2.44 |
| | Butuh | 85.5378 | 55.25 | 69.2680 | 44.75 |
| | Dlingo | 107.1252 | 74.20 | 37.2391 | 25.80 |
| | Jurug | 111.7996 | 81.77 | 24.9322 | 18.23 |
| | Karangnongko | 256.6393 | 93.05 | 19.1647 | 6.95 |
| | Kemiri | 233.4493 | 68.29 | 108.3880 | 31.71 |
| | Mojosongo | 37.5308 | 68.52 | 17.2404 | 31.48 |
| | Kragilan | 92.7232 | 48.58 | 98.1508 | 51.42 |
| | Madu | 170.9318 | 96.84 | 5.5847 | 3.16 |
| | Manggis | 172.7663 | 90.99 | 17.1136 | 9.01 |
| | Metuk | 142.1957 | 78.81 | 38.2332 | 21.19 |
| | Singosari | 244.0445 | 96.99 | 7.5654 | 3.01 |
| | Tambak | 283.5597 | 95.22 | 14.2446 | 4.78 |
| | TOTAL | 2,306.0096 | 81.03 | 539.9154 | 18.97 |

Source: Research Analysis, 2024

As stated as Khoirunnisa et al. (2023) land use change in Mojosongo District, Boyolali Regency was dominated by Rice fields and Moorlands to Residential and Toll Road. The villages that experienced land use change were predominantly those not passed by the Toll Road. Not all villages in Mojosongo District that are passed by the toll road have experienced an increase in the area of Residential land use, like Kragilan Village.

Meanwhile, the villages that experienced unsuitable areas with 100% percentage were Penggung and Pulisen Village in Boyolali District. This occurred because there were differences between the designated area and the land use area. In those villages, the designated area was moorland, and it is different from actual land use areas like Orchards and Residentials. Information about unsuitable areas for each village is shown in the following Tables 11 and 12.

The unsuitable Sustainable Food Agricultural Land and Regional Spatial Plan area was bigger than the unsuitability between Sustainable Food Agricultural Land and land use. The most unsuitable area in this section was Kemiri Village in Mojosongo District too, which is the same as the unsuitability in land use. The unsuitable area in Kemiri Village was 108.3880 hectares or 31,71%. That happened because the designated area in the Regional Spatial Plan was unsynchronized with the designated area in Sustainable Food Agricultural Land, as noted in research by Hambali et al. (2021) in Sumenep Regency. The designated area in the Regional Spatial Plan was Residentials and it is different from the designated area in Sustainable Food Agricultural Land which is Moorlands.

Kemiri village was included in the Boyolali urban area as regulated in Boyolali Regency Regional Regulation Number 8 of 2019. They were designated as Residentials and industry areas. So, there were many land use changes in that area.

## CONCLUSIONS

In brief, this study aimed to analyze the suitability of Sustainable Food Agricultural Land in Boyolali and Mojosongo District, Boyolali Regency. The findings revealed that there were significant areas of unsuitability between Sustainable Food Agricultural Land and Land Use in both 2018 and 2022, with 271.1329 hectares (9.53% of the designated area) in 2018 and 283.5191 hectares (9.96% of the designated area) in 2022. Furthermore, a notable mismatch between Sustainable Food Agricultural Land and the Boyolali Regency Regional Spatial Plan, with 539.9154 hectares (18.97% of the designated area) not conforming to the plan. These results underscore the importance of aligning agricultural land planning with regional spatial plans to ensure sustainable land use. The discrepancies identified highlight areas that require policy intervention and better land management practices.

Recommendations to the local government are that areas that have experienced Sustainable Food Agricultural Land non-conformity as a result of changes in land use must be more closely guarded so that changes in land use do not occur more massively. The use of agricultural land that has undergone land use change to non-agricultural must be provided with replacement land so that the food supply remains sustainable. The recommendation for this research is that the accuracy test should ideally be conducted directly in the field. If this is not feasible due to different years, then maps with better accuracy from the same year can be used.

## ACKNOWLEDGEMENT

The authors would like to thank to government of Boyolali especially Badan Perencanaan Pembangunan, Riset, dan Inovasi Daerah (BAPPERIDA) and Dinas Pertanian; and also Badan Riset dan Inovasi Nasional who provided data in this research.

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