BUKTI KORESPONDENSI ARTIKEL

Carrying capacity and food self-sufficiency of paddy field resources: NDVI analysis in Batang Regency, Central Java Province, Indonesia

Dimuat pada

Journal of Socioeconomics and Development Vol 4 No. 2 Tahun 2021

(Sinta 2)

No.	Tanggal	Keterangan
1.	03 Maret 2021	Submit Artikel
2.	25 Maret 2021	Peer review ke-1 (batas waktu 30 hari harus diperbaiki)
3.	11 Agustus 2021	Accepted Submission (submit artikel dianggap layak dan berlanjut ke proses berikutnya) Peer review ke-2
4.	03 September 2021	Peer review ke-3. Review lanjutan dalam bentuk coret-coret kuning pada naskah dan bila sudah diperbaiki, maka kalimat perbaikan dicetak biru muda. Diminta juga mengirim peta dengan resolusi lebih tinggi
5.	Oktober 2021	Published

[JSeD] Submission Acknowledgement

1 message

Prof. Iwan Nugroho <no-reply.ojs@widyagama.ac.id> Wed, Mar 3, 2021 at 12:56 PM
To: Dr Ananto Aji <ajiananto@mail.unnes.ac.id>

Dear Dr Ananto Aji:

Thank you for submitting the manuscript, "FOOD SELF-SUFFICIENCY ANALYSIS USING LAND CARRYING CAPACITY STATUS AND NDVI IN BATANG REGENCY, CENTRAL JAVA PROVINCE, INDONESIA" to Journal of Socioeconomics and Development. With the online journal management system that we are using, you will be able to track its progress through the editorial process by logging in to the journal web site:

Manuscript URL:
http://publishing-widyagama.ac.id/ejournal-v2/index.php/jsed/author/submission/2266
Username: anantoaji

If you have any questions, please contact me. Thank you for considering this journal as a venue for your work.

Prof. Iwan Nugroho
Journal of Socioeconomics and Development

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[JSeD] Editor Decision

1 message

Dr. Rita Hanafie <no-reply.ojs@widyagama.ac.id>
To: Dr Ananto Aji <ajiananto@mail.unnes.ac.id>
Cc: jsed@widyagama.ac.id

Thu, Mar 25, 2021 at 10:16 PM

Dear Dr Ananto Aji:

We have reached a decision regarding your submission to Journal of Socioeconomics and Development, "FOOD SELF-SUFFICIENCY ANALYSIS USING LAND CARRYING CAPACITY STATUS AND NDVI IN BATANG REGENCY, CENTRAL JAVA PROVINCE, INDONESIA".

Our decision is: Revisions Required

Revised manuscripts should be resubmitted within 30 days.

Your submission is required to meet Author Guidelines, pay attention to the suggestions and comments from reviewers and editor's notes. The author ensures that the authors and their affiliates do not show typos or changes until the manuscript is published.

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Dr. Rita Hanafie
Faculty of Agriculture, Widyagama University of Malang
ritahanafiesrdm@gmail.com

Editor's note:
-authors are required to adhere to author guideline
-add research implication
-use the scientific term in the respective study
-see instruction in the editor version file

Reviewer A:
The paper is good for such land use related topic as it combines spatial analysis with statistical data analysis. For being published, it needs some revisions, as follows:

1. Methodology should explained in more detail the role of remote sensing/NDVI and GIS for land carrying capacity analysis. It will be better if you put a flowchart to describe your whole methodology. I found the methodology is just explained the theory.
2. Please be more precisely explain which data is secondary from the literature/statistics and which one is your primary data from spatial analysis/formula calculation. Put the reference as required in your result and discussion.
3. I found several confusing number because of redundancy and mistype of point and comma, ad also miscalculation. Plese be revised.
4. Please add explanation about using α (alpha) for land carrying capacity in the methodology.
5. Because you put NDVI in your title, so please make comments in your discussion related to benefit of using NDVI/remote sensing. For example it ease the step to map and calculate the real area of paddy field, or to predict the land supply data, etc.

Ananto Aji <ajiananto@mail.unnes.ac.id>

[JSeD] Editor Decision

2 messages

Dr. Rita Hanafie <no-reply.ojs@widyagama.ac.id> Wed, Aug 11, 2021 at 3:25 PM
To: Dr Ananto Aji <ajiananto@mail.unnes.ac.id>
Cc: jsed@widyagama.ac.id

Dear Dr Ananto Aji:

We have reached a decision regarding your submission to Journal of Socioeconomics and Development, "FOOD SELF-SUFFICIENCY ANALYSIS USING LAND CARRYING CAPACITY STATUS AND NDVI IN BATANG REGENCY, CENTRAL JAVA PROVINCE, INDONESIA".

Our decision is to: Accept Submission

If necessary, the editor will confirm the authors of their work prior to the article published

Dr. Rita Hanafie
Faculty of Agriculture, Widyagama University of Malang
ritahanafiesrdm@gmail.com

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Dr. Rita Hanafie <no-reply.ojs@widyagama.ac.id> Wed, Aug 11, 2021 at 3:25 PM
To: Dr Ananto Aji <ajiananto@mail.unnes.ac.id>
Cc: jsed@widyagama.ac.id

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Perbaikan naskah

3 messages

JSED Editor <jsed@widyagama.ac.id> Fri, Sep 3, 2021 at 11:25 PM
To: Ananto Aji <ajiananto@mail.unnes.ac.id>

Dear Penulis

Redaksi telah melakukan editing naskah. Redaksi menemukan banyak grammatical errors sehingga tidak memenuhi kaidah penulisan akademik yang efektif. Editor berusaha memperbaiki, dengan merubah kata/kalimat/paragraf, termasuk menghapus kata-kalimat yang berulang/berlebihan; tanpa merubah arti. Ini adalah upaya redaksi agar artikel memenuhi kaidah dan standar mutu jurnal.
Namun demikian, Redaksi memerlukan kerjasama penulis untuk memperbaiki kembali naskahnya. Ikuti petunjuk perbaikan sesuai naskah terlampir.
Perlu diketahui artikel final adalah minimal 4500 kata (tidak termasuk Tabel dan Gambar). Penulis perlu mereview temuan, dengan mengelaborasi lebih dalam dan fokus pada introduction, method dan discussion (termasuk research implication). Sebagaimana saran perbaikan sebelumnya.
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Perbaikan naskah dikirim ke email ini

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Ananto Aji <ajiananto@mail.unnes.ac.id> Tue, Sep 14, 2021 at 10:05 PM
To: JSED Editor <jsed@widyagama.ac.id>

Dear Editor Journal of Socioeconomics and Development (JSeD)

Terimakasih telah memberikan masukan dari draft paper kami. Akan kami tindak lanjuti sesegera mungkin.
[Quoted text hidden]
--
Warm regards,

Dr. Ir. H. Ananto Aji, M.Si.
Head of Lab. Geography
Dept. of Geography
Universitas Negeri Semarang

Ananto Aji <ajiananto@mail.unnes.ac.id> Sun, Sep 19, 2021 at 9:02 AM
To: JSED Editor <jsed@widyagama.ac.id>

Dear Editor Team Jurnal of Socioeconomics and Dev (JSeD)

Bersamaan dengan email ini, kami mengirimkan revisi sebagaimana saran reviewer, diantaranya:

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Salam.
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Vol.4, No.2 (2021) published issue and DOI activated

1 message

JSED Editor <jsed@widyagama.ac.id> Sat, Nov 6, 2021 at 11:47 AM
To: Chusnul Faizah <chusnulfaizah@gmail.com>, Jumriani Jumriani <jumriani@ulm.ac.id>, Ananto Aji <ajiananto@mail.unnes.ac.id>, Choirul Okviyanto <choirul.ok@gmail.com>, Ismu Rini Dwi Ari <dwiari@ub.ac.id>, Shasa Chairunnisa <shasa.chairunnisa@gmail.com>, Alfiana Yuli Efiyanti <alfi_huda@pips.uin-malang.ac.id>, arifin.maros13@gmail.com, Aloysius Hari Kristianto <harialoysius@gmail.com>

Dear Author,

We would like to inform that Vol. 4, No. 2 (2021) has been fully published, also available at the following DOI address : https://doi.org/10.31328/jsed.v4i2

Thank you for the participation. We are waiting for your other manuscripts for the next issue.

Best Regard,

Hefifa Rhesa Yuniar
JSeD Editorial Assistant
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Submission

Authors Ananto Aji, Edy Trihatmoko, Sigit Bayhu Iryanthony (http://publishing-widyagama.ac.id/ejournal-v2/index.php/jsed/user/email?redirectUrl=http%3A%2F%2Fpublishing-widyagama.ac.id%2Fejournal-v2%2Findex.php%2Fjsed%2Fauthor%2FsubmissionReview%2F2266&to%5B%5D=%22Ananto%20Aji%22%20%3Canantoaji%40umm.ac.id%3E&subject=Carrying%20capacity%20and%20food%20self-sufficiency%20of%20paddy%20field%20resources%3A%20%20NDVI%20analysis%20in%20Batang%20Regency%2C%20Central%20Java%20Province%2C%20Indonesia)

Title Carrying capacity and food self-sufficiency of paddy field resources: NDVI analysis in Batang Regency, Central Java Province, Indonesia

Section Research Articles

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2021-03-25 02:16 PM

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Dear Dr Ananto Aji:

We have reached a decision regarding your submission to Journal of Socioeconomics and Development, "FOOD SELF-SUFFICIENCY ANALYSIS USING LAND CARRYING CAPACITY STATUS AND NDVI IN BATANG REGENCY, CENTRAL JAVA PROVINCE, INDONESIA".

Our decision is: Revisions Required

Revised manuscripts should be resubmitted within 30 days.

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Dr. Rita Hanafie
Faculty of Agriculture, Widyagama University of Malang
ritahanafiesrdm@gmail.com

Editor's note:
-authors are required to adhere to author guideline
-add research implication
-use the scientific term in the respective study
-see instruction in the editor version file

Reviewer A:
The paper is good for such land use related topic as it combines spatial analysis with statistical data analysis. For being published, it needs some revisions, as follows:
1. Methodology should explained in more detail the role of remote sensing/NDVI and GIS for land carrying capacity analysis. It will be better if you put a flowchart to describe your whole methodology. I found the methodology is just explained the theory.
2. Please be more precisely explain which data is secondary from the literature/statistics and which one is your primary data from spatial analysis/formula calculation. Put the reference as required in your result and discussion.
3. I found several confusing number because of redundancy and mistype of point and comma, ad also miscalculation. Plese be revised.
4. Please add explanation about using α (alpha) for land carrying capacity in the methodology.
5. Because you put NDVI in your title, so please make comments in your discussion related to benefit of using NDVI/remote sensing. For example it ease the step to map and calculate the real area of paddy field, or to predict the land supply data, etc.

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Our decision is to: Accept Submission

If necessary, the editor will confirm the authors of their work prior to the article published

Dr. Rita Hanafie
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Our decision is to: Accept Submission

If necessary, the editor will confirm the authors of their work prior to the article published

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Carrying Capacity and Food Self-Sufficiency of Paddy Field Resources: NDVI Analysis in Batang Regency, Central Java Province, Indonesia

Ananto Aji*, Edy Trihatmoko and Sigit Bayhu Iryanthony

Department of Geography, Universitas Negeri Semarang

*Correspondence email: ajiananto@mail.unnes.ac.id

Abstract. Monitoring of paddy field area using remote sensing and mapping techniques has been well recognized and efficient. This study aims to monitor paddy with NDVI analysis with extensive GIS calculations and integrated with the food self-sufficiency formulas. The research was conducted in Batang Regency, Central Java Province, Indonesia, that annually produces 104,211,080 kg on average. The results show that the production of lowland rice is sufficient to meet the daily rice needs of 897.19 g per capita. The region also shows a surplus of rice production of more than 342 g per capita above the daily needs, or categorized in the criteria of food self-sufficiency. Food self-sufficiency classification is related to carrying capacity (α) reaching ca. 4.179356 (α>1). This value shows that rice production can meet the needs of the population of Batang Regency.

Keywords: carrying capacity; land use; NDVI; rice; self-sufficiency

JEL Classification: 013; Q00; R11

INTRODUCTION (tambahkan hingga 1000 kata)

The increasing of population has resulted in increased development activities in various fields to meet the needs of the community (Li et al., 2017). It is associated with the construction of settlement facilities, infrastructure networks, commercial facilities, or social facilities. The increase in development activities will undoubtedly be accompanied by the rise in land requirements to accommodate these development activities (Trihatmoko, 2020). It means that the higher activities in the development led to lack land availability.

Since the enactment of regional autonomy in 2001, local governments in Indonesia have broader authority in determining the best development policies and programs for improving

the welfare of the people and the progress of their respective regions. The management of natural, human, and other resources requires development priorities by paying attention to regional excellence (Mawardi, 2007). The balancing of the potential local excellence with emphasis on the carrying capacity of the environment will be able to create efficiency and effectiveness in regions. The condition relates to the use and management of development resources can improve community welfare and regional development.

The concept of land carrying capacity is widely applied to animal studies, especially to measure the amount of environmental capacity to support animal life expressed per unit in certain area. Then the carrying capacity of the environment is applied to the human population. Another carrying capacity analysis is also based on plant biomass (rice) produced by rice fields in a certain area and time. Thus, the carrying capacity is the ability of the environment to be able to support human life (Li et al., 2017).

The development of regional potentials such as the agricultural sector refer to the Law No. 41/2009 concerning Protection of Sustainable Food Agricultural Land (PLP2B). The PLP2B program protects the agricultural sector in each region so that both quantity and quality of corresponding resources are maintained. One of the implementations of this program is based on productive land in Indonesia that meets the requirements for the carrying capacity of agricultural land. However, the fact is that agricultural land in many regions in Indonesia is decreasing both in quantity and quality (Asmuti & Tjandra, 2020).

As known, most of the population in Batang Regency are farmers who highly depend on the availability of the land to meet their needs. Besides, Batang Regency is well known as the agriculture area (Keris-Jateng, 2017). On the other hand, Batang Regency also displays very dynamic economic development in its coastal areas, along the Java Sea coast (Marfai et al., 2019). Unfortunately, Batang Regency is also a area target for the development of an industrial area which is very attractive for investment (KFMAP, 2021). In this regard, it is necessary to research the environmental carrying capacity of Batang Regency based on land availability and needs for agricultural sector, precisely on rice field availability.

Introduction terlalu singkat, Sebaiknya ditambahkan paragraf untuk memberi fokus dan penajaman

This research is aimed to reveal the carrying capacity using geographic information system (GIS) by Normalized Difference Vegetation Index (NDVI) analysis from the series of Sentinel-2 satellite imagery. The research is also related to how paddy field resources in Batang Regency, Central Java Province, Indonesia indicate the carrying capacity of food self-sufficiency, especially rice production.

RESEARCH METHOD

This research was conducted in Batang Regency, Central Java, Indonesia, including geographical location between 6°51'46" S to 7°11'47" S and 109°40'19" E to 110°03'06" E. Area sampling selection comprises all districts or about 15 districts. The object of research was all paddy fields, i.e. technical irrigation paddy fields, simple irrigation, and rainfed paddy fields.

Primary data is the latest cross-check data on changes in land use in the field and data on agricultural commodity productivity. Secondary data includes statistical data and satellite image data (geographical information system data). Geographic information system data were taken from the website of the Geospatial Information Agency (BIG), as well as satellite imagery data from the United States Geological Survey (USGS).

The Sentinel-2 satellite imagery relies on multispectral high-resolution optical observations over the global terrestrial surface, including land change monitoring, emergency response and security services activitiesThe use of Sentinel 2A Satellite imagery emphasizes the design of a reliable multispectral land observation system by featuring a Multi-Spectral Instrument (MSI) with 13 spectral bands ranging from visible and near-infrared to shortwave infrared. Spatial resolution varies from 10 m to 60 m, depending on the spectral band, with a field of view of 290 km. The combination of high spatial resolution, wide field of view, and broad-spectrum coverage shows an advantage over other multispectral images.

NDVI (Normalized Difference Vegetation Index) Analysis

Vegetation index is analyzed based on digital brightness values as a result of the near-infrared and red band reflectance and absorption from vegetation (Campbell, 1987; Zhou et al., 2020). This analysis conducted for experiments measuring biomass or vegetative level. NDVI measures flourishing green vegetation and also investigates changes in the ecological environment (Li et al., 2017). The combination of the different formulation of normalization and the use of the highest absorption and reflection of the chlorophyll makes it durable under various conditions (Syamsia et al., 2018). The index value ranges from -1 to 1. The general range for green vegetation is 0.2-0.8 (*NASA Technical Reports Server (NTRS)*, n.d.), use equation as follows:

$$NDVI = \frac{(NIR - Red)}{(NIR + Red)}$$

Tolong didefinisikan persamaan tersebut

GIS (Geographic Information System)

GIS is a computer-based system (CBIS) to store and manipulate geographical information. GIS is designed to collect, store, and analyze objects and phenomena where geographical location is an essential or critical characteristic to be analyzed. GIS works in handling geographic reference data: (a) input, (b) data management (data storage and recall), (c) data analysis and manipulation, and (d) output (Aronoff, 1989). Paragraf ini tidak perlu membuat definisi, diganti dengan bagaimana cara metode analisis Carrying Capacity of the Land (cantumkan referensinya)

Carrying Capacity of the Land

Food self-sufficiency is an attempt to meet their own food needs by cultivating food crops such as cereal (rice and the like), secondary plants, cassava, and others. Another researcher suggested that land capability implies land carrying capacity (Notohadiprawiro, 1987). Previous research said that the land carrying capacity degradation is influenced by an increasing population and a low percentage of farmers (Mantra, 1986; Trihatmoko, 2020) . Paragraf ini tidak perlu membuat definisi, diganti dengan bagaimana cara metode analisis Carrying Capacity of the Land (cantumkan referensinya)

Land Availability Analysis

Land availability is determined based on the total of local actual production data of each commodity in a particular area adding up by the products of all commodities. The commodities such as agriculture, land availability analysis is carried out by calculating land availability. The formula for land availability used the equation below (Ministry of Environment, 2009)

$$SL = \frac{\sum(Pi \times Hi)}{Hb} \times \frac{1}{Ptv\mathfrak{b}}$$

On this equation SL is land availability (ha), then Pi is the actual production of each type of commodity (the unit depends on the type of product), including agriculture, plantation, forestry, and animal husbandry. Hi is the unit price for each type of commodity (Rp/unit) at the producer level. Hb represents the unit price of rice (Rp/kg) at the producer level. Pt is Rice productivity (kg/ha). (ini contoh bagus untuk mendefinisikan formula, dan disertai satuan; bisa dicontoh untuk formula lainnya)

The Needs of Land Analysis

Population pressure on the carrying capacity of land can be determined based on the value of the ratio between the population and the percentage of farmers with a minimum area of land to live properly. The land requirement formula used in research is shown in equation below (Ministry of Environment, 2009).

$$D_L = N \times KHL_L$$

DL is the needs of land in total equal to rice (ha). N represents population and KHLL is the needs of land to live properly.

Determination of Land Carrying Capacity Status

The carrying capacity of the land is obtained from a comparison between the availability of land (SL) and land requirements (DL) (Ministry of Environment, 2009):

$$Cc = \frac{S_L}{D_L}$$

If $s_L > D_L$, a surplus of land carrying capacity. If $s_L < D_L$, a deficit of land carrying capacity. To get the precise carrying capacity of the land (α) the calculation is continued as follows:

$$\alpha = \frac{X}{K}$$

Where X is the available area on site location. The formula as follows:

$$X = \frac{Total\ Area\ of\ Harvest}{Population}$$

On the other hand, K is the area needed for food self-sufficiency. The formula as follows:

$$K = \frac{minimum\ rice\ consumpsion}{Average\ rice\ production\ -\ average\ in\ Ha}$$

The surplus of land carrying capacity is emphasizes to the rice production analysis by using formula:

$$Rice\ production\ in\ Total = Total\ area\ of\ paddy\ field\ (Ha) * IP * productivity\ (tons/ha)$$

The total rice production was assumed as the conversion value of milled unhusked rice (GKG) then the value of rice obtained is as follows:

$$Rice = Index\ GKG * total\ harvest$$

The level of productivity of paddy fields in meeting the needs of the population of rice in Batang was calculated based on the following formula:

$$Supply = \frac{Rice\ production\ in\ 1\ year}{Population\ in\ one\ regency}$$

RESULT AND DISCUSSION

(terlalu singkat, Sebaiknya ditambahkan paragraf untuk menemukan kedalaman dan perspektif lebih luas, tambahkan hingga 3500 kata)

Carrying Capacity of the Land

Batang Regency has very abundant natural resource potential in agriculture, especially the availability of paddy fields. The area of rice fields reaches 24,081.4 ha or equivalent to 28.0% of the total area of Batang Regency. The land does not include rainfed rice fields which reach 3,134.4 ha or the equivalent of 3.6% of the total land area. This condition indicates that Batang Regency has a very significant carrying capacity of agricultural land as stated in the Central Statistics Agency (BPS, 2016) (Table 1).

Kalau bisa ditambahkan pembahasan lagi dari setiap Tabel

Table 1. Land Carrying Capacity Status of Batang Regency in 2017

District	Land Availability	Land Required	Carrying Capacity of the Land	Status
Wonotunggal	3,523.65	218.25	32.66	Surplus
Bandar	3,299.83	409.60	16.54	Surplus
Blado	1,570.51	539.15	6.48	Surplus
Reban	1,241.75	624.59	4.58	Surplus
Bawang	1,828.26	540.98	7.82	Surplus
Tersono	4,855.25	167.85	60.74	Surplus
Gringsing	5,132.30	247.64	41.90	Surplus
Limpung	3,411.77	210.02	33.43	Surplus
Banyuputih	1,567.76	565.71	5.97	Surplus
Subah	3,278.63	319.41	23.11	Surplus
Pecalungan	2,203.62	367.13	13.50	Surplus

Tulis	3,801.68	197.82	50.18	Surplus
Kandeman	3,173.66	306.32	20.95	Surplus
Batang	1,340.23	808.28	13.32	Surplus
Warungasem	4,665.30	325.50	28.83	Surplus

Spatial Pattern of Batang Regency

Batang Regency is a hilly area, both in the north and in the southern region bordering Banjarnegara Regency. The south part of Batang is dominated by tea plantations, which are located in a cold area because it is a plateau area. Most of the Batang Regency area (30.2%) is a plantation area situated in the southern part. Batang Regency forest area is in the north, which is a teak forest or tree plantations. The industrial sector in Batang Regency is centred on Batang Regency mostly spread along the north coast road as the densest road in Indonesia (Hartatik, 2016), i.e. Kandeman, Tulis, Subah, and Banyuputih Districts. This condition is considering that the industry requires adequate accessibility. For the detail, land uses, as shown in Table 2.

Batang Regency has many hilly areas that spread in the north and the south of region. The southern region which borders Banjarnegara Regency, is dominated by tea plantations which are cultivated in upland areas with cool temperatures. Most of Batang Regency (30.2%) is a plantation area located in the southern part. The forest area to the north is found in large areas of teak forest or tree plantations. The industrial sector in Batang Regency is mostly spread along the north coast road as the busiest traffic road in Indonesia (Hartatik, 2016), through the route along the Kandeman, Tulis, Subah, and Banyuputih districts. The industry requires adequate accessibility to connect to the supply chain and distribution channels. Land use in Batang Regency is presented in Table 2.

Table 2. Land use distribution in Batang Regency, 2016.

Land use type	Area (ha)	%
Forest	13,309.4	15.5
Industry and Tourism	141.9	0.2
Water body	1,275.6	1.5
Grassfield	615.1	0.7
Dry field	3,134.4	3.6
Mix garden	6,158.5	7.2
Settlement	11,209.4	13.0
Garden	25,980.7	30.2
Paddy Field	24,081.4	28.0
Total	85,906.4	100.0

Source: Spatial Plan (RTRW) data analysis of Batang Regency.

Paddy Field Area in Batang Regency

Batang Regency has favorable and reliable natural resource potential for food crop agriculture (paddy) on condition that meets proper resource management support. In the region, the area of irrigated paddy fields reaches 28% of the district's area (Table 2) and is spread over all sub-districts (Table 3).

Table 3. Paddy fields distribution in 2017 of Batang Regency.

District	Area size	
	%	ha
Bandar	10.2	…
Banyuputih	5.1	…
Batang	7.6	…
Bawang	7.4	…
Blado	5.9	…
Gringsing	8.9	…
Kandeman	6.5	…
Limpung	5.5	…
Pecalungan	3.6	…
Reban	7.0	…
Subah	8.3	…
Tersono	7.8	…
Tulis	4.1	…
Warung Asem	5.2	…
Wonotunggal	6.9	…

Most of the rice fields are located in the northern and southern areas of Batang Regency (Figure 1). The central area is dominated by teak forest. Besides, the central area is also used for residential and industrial areas. The districts with the small size area of paddy fields are found in Warung Asem, Limpung, Pecalungan, and Tulis districts. The area is mostly hilly and some areas are indicated to have developed rapidly.

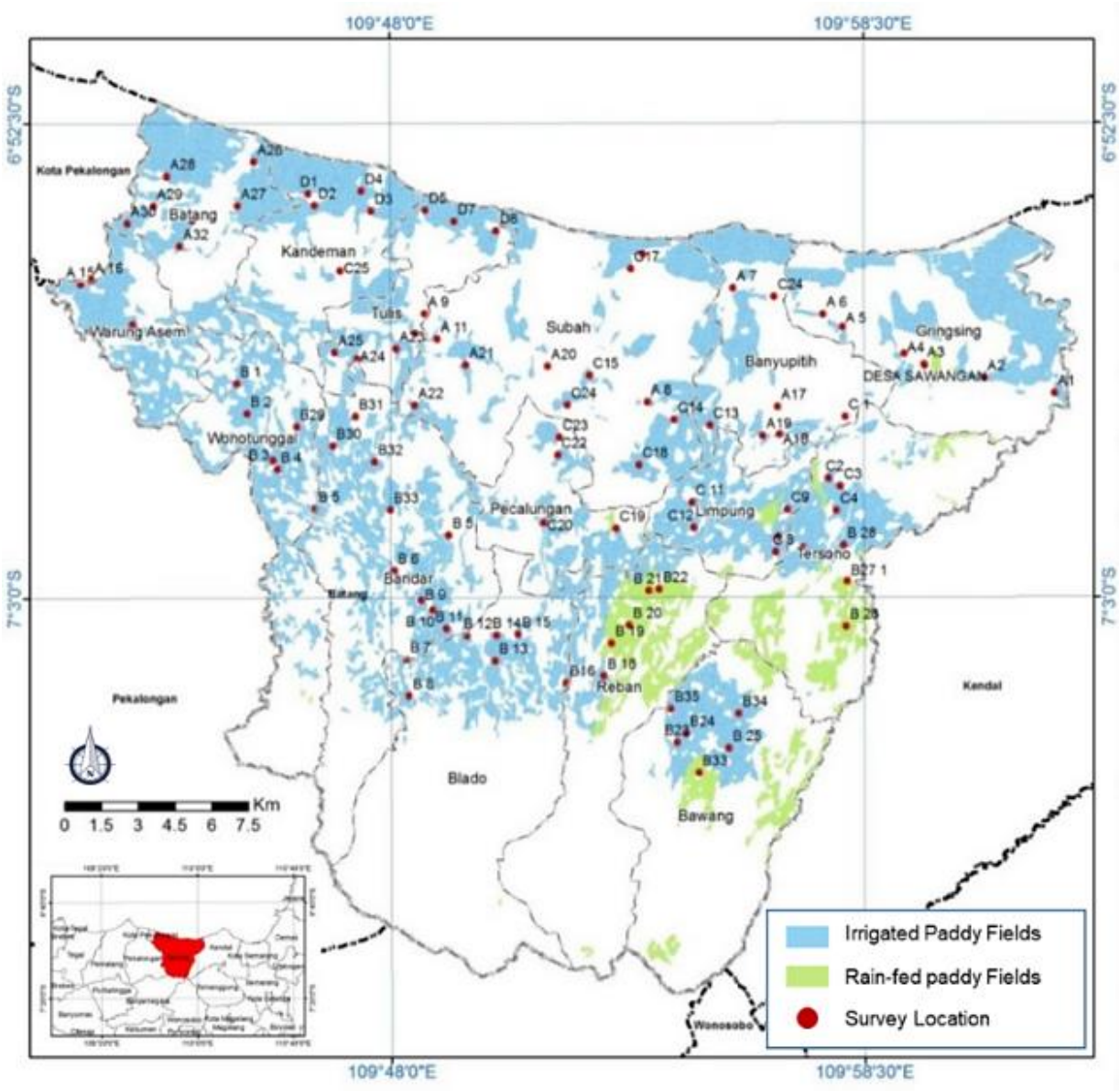

Figure 1. Paddy field area in each district.

The NDVI analysis identifiy rice field from of the amount of chlorophyll that reached its maximum point in its growth phase. NDVI analysis was able to estimate the area of rice field to reach 6,967.5 ha. The mature rice plants are visually recorded from the spectral reflection which is very bright compared to other plants. NDVI can identify high brightness sensitivity even though it is lower than the brightness of water bodies (Figures 2 – 4). In panchromatic satellite image analysis, the amount of cloud cover will cover or reduce the accuracy of image classification.

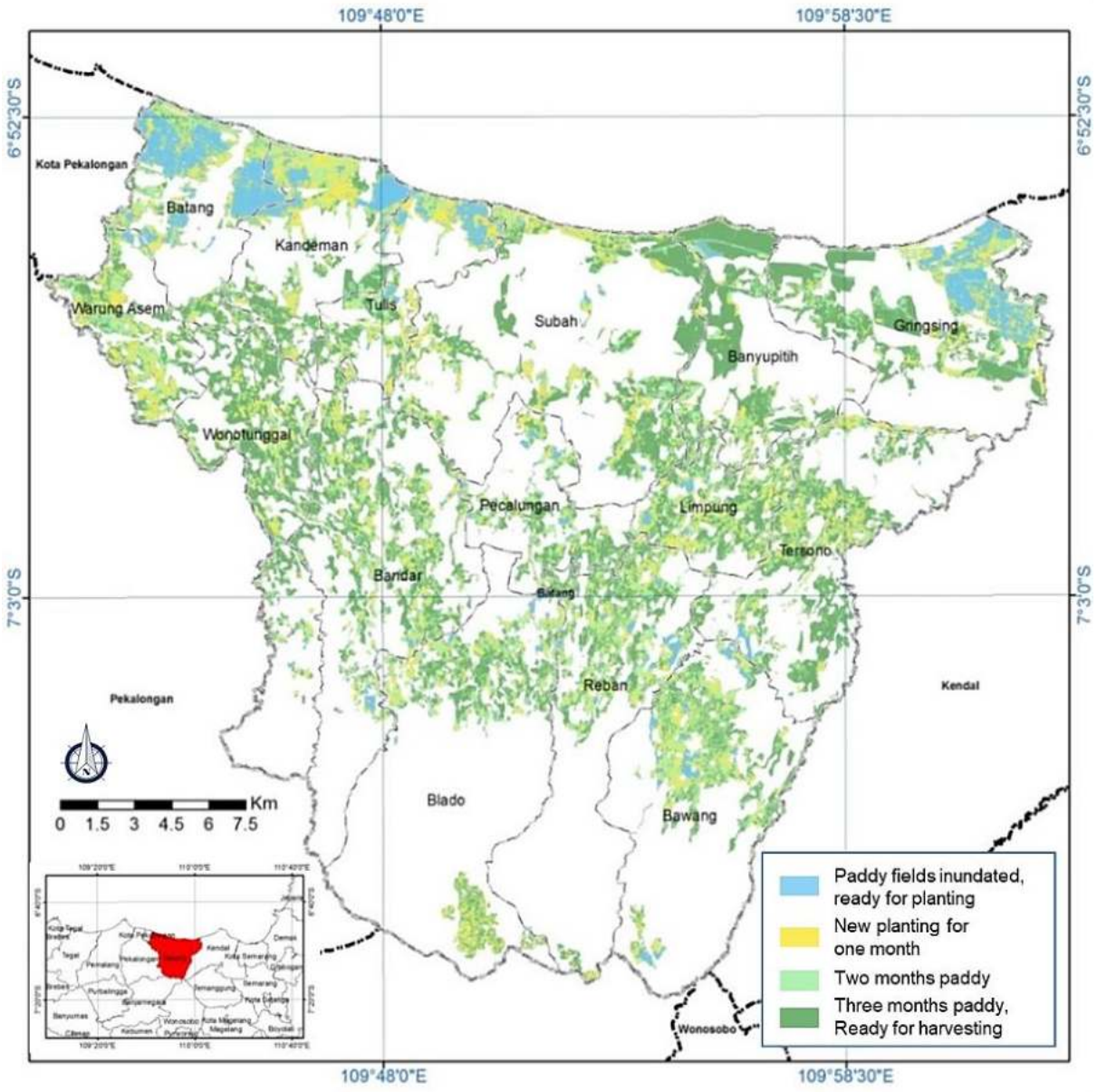

Figure 2. The paddy filed identification in February year??.

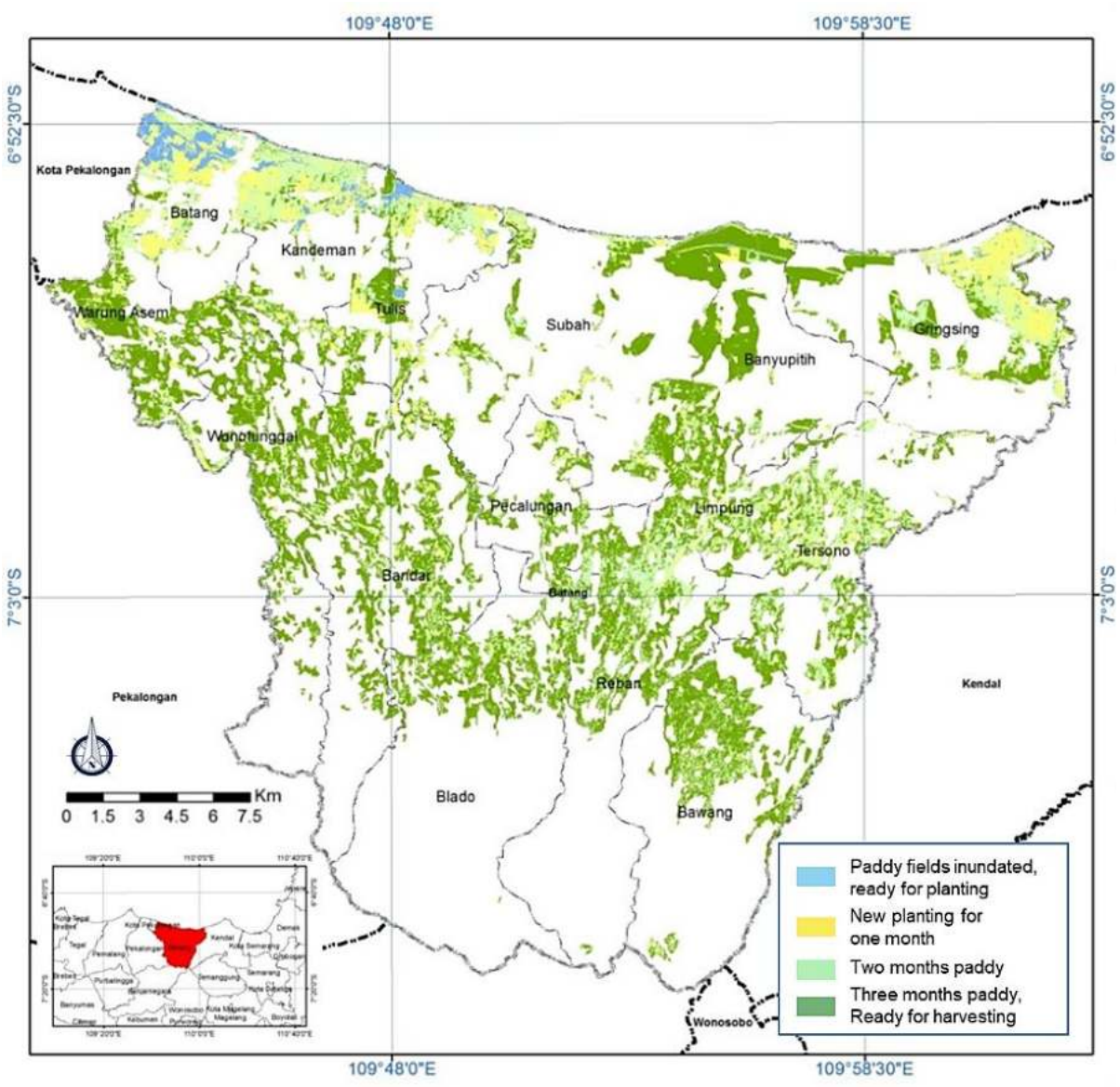

Figure 3. The paddy filed identification in August year??..

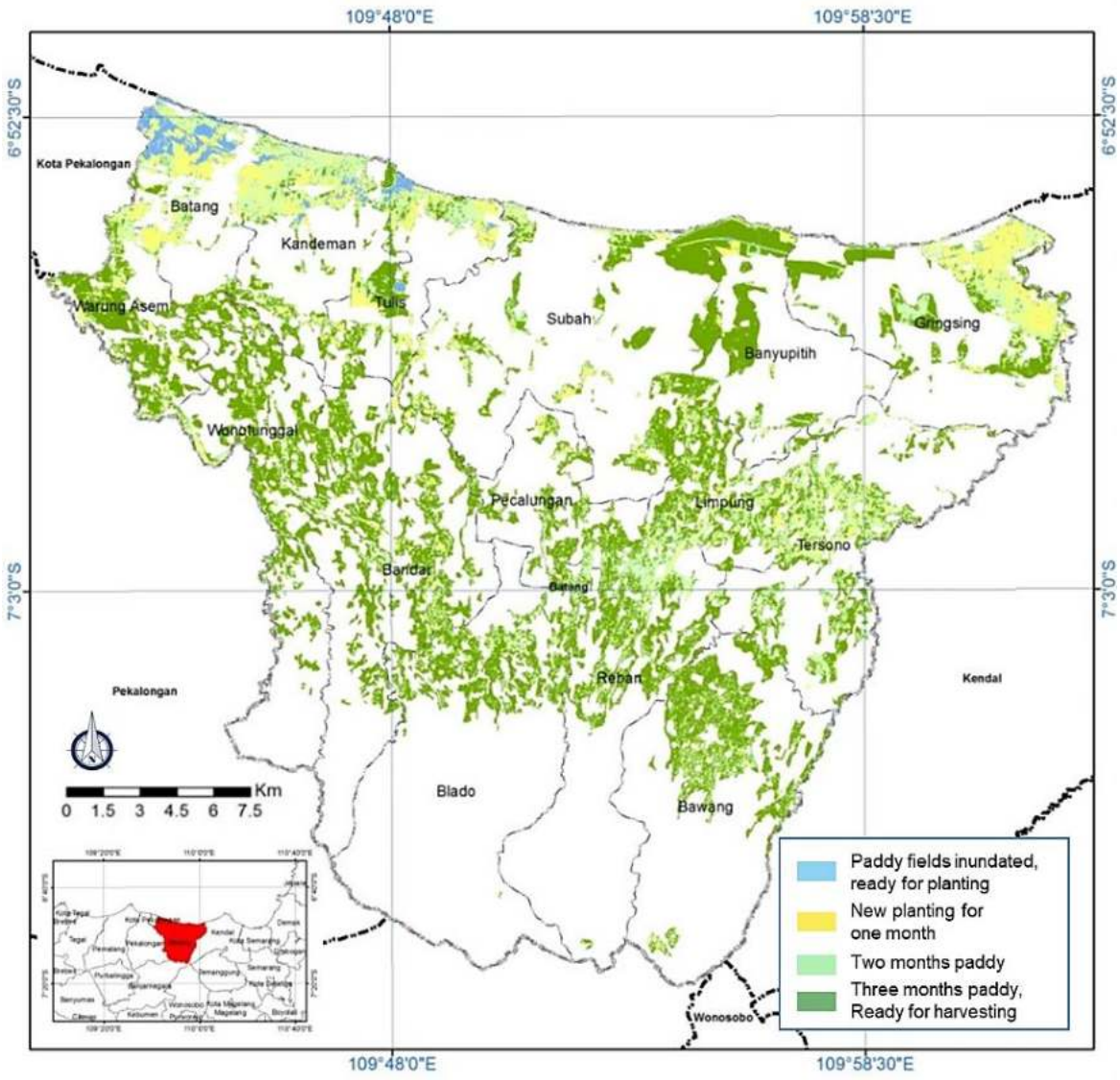

Figure 4. The paddy filed identification in October year??.

Overall, observations of the Sentinel 2A Satellite imagery (Figure 5) indicate that Batang Regency has a very suitable planting area. This means that paddy fields can be cultivated throughout the year, both in the rainy and dry seasons. This can be justified by observing the imagery of rice planted land that does not show extreme differences between the northern and southern parts of Batang Regency (Figure 6), represented by survey locations A2 and B8, respectively, as shown in Figure 2. Meanwhile, areas with simple to technical irrigation show relatively productive farming management. Indeed, NDVI analysis has proven to be able to provide an accurate assessment of the observation of paddy fields, and allows for the development of other environmental analyzes (Zhou et al., 2020).

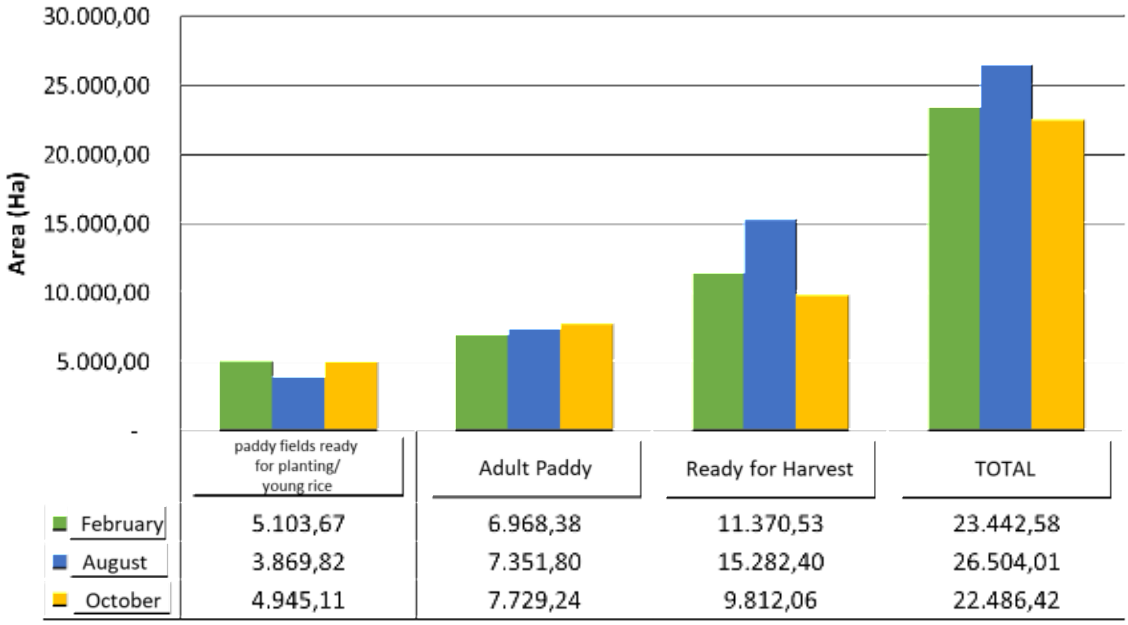

Figure 5. Paddy observations from Sentinel 2A in 2017.

Figure 6. Paddy filed survey from A2 location, the south region (left), and B8 location, the north region (right).

Batang Regency Rice Needs

The total demand for rice in Batang district is 104,211,080 kg per year. The amount of production must be met to achieve food self-sufficiency. These results can be achieved, thus placing Batang Regency as a mainstay agricultural area (Keris-Jateng, 2017), instead the government needs to consider the allocation of industrial areas in this district (KFMAP, 2021).

On the other hand, Batang Regency was asked to contribute to the rice needs of other regencies in Central Java, because this province was not self-sufficient in food in the 2014-2018 period (Pratiwi et al., 2020). Planning for rice production needs estimate without considering the main potential of land resources can lead to degradation (Wilis et al., 2020).

Sebaiknya ditambah diskusi

Rice Production Calculation in Batang Regency

The area of paddy fields with irrigation systems is 24,081.4 ha (28% of the total area in Batang Regency), which is very likely to result in significant deep rice production. In addition, the planting intensity (planting index) in several locations also reached three planting seasons in a year. The results of the study show that the average planting index reaches five harvests in 2 years or the equivalent of 2.5 times a year, with an average productivity of 6.5 tons/ha. Thus, the total rice production in all Batang Regency is calculated as ca. 391,322.75 tons per year or 245,515.89 tons per year in milled grain conversion (GKG) (62.74 percent conversion). The production is higher than the demand for one year (104,211,080 tons per year), which shows an indication of a production surplus. Furthermore, the calculation of food needs (Wilis et al., 2020) found a annual production of 327.476 kg per capita or equivalent to 897.19 g per capita.

Sebaiknya ditambah diskusi

Carrying Capacity Calculation of Paddy Field in Batang Regency

Daily rice consumption needs are 342 g/capita or equivalent to 124.89 kg. Meanwhile, the average productivity of rice is 6.5 tons/ha, so that the K value is 0.0192138. With the values of X and K, the carrying capacity of the land (α) is 4.179356. Average rice production per Ha is converted from paddy to rice (62.74%). The value α is used as an indicator of the ability of paddy fields to the population in one region. The evaluation standard as $\alpha>1$ means that the area has a functional carrying capacity so that it is capable of food self-sufficiency (the population is below the optimal community). $\alpha<1$, the region has inadequate carrying capacity so that food self-sufficiency is unable to exceed the optimal population. $\alpha = 1$, the area has an optimal carrying capacity, the availability of food can support the people within regency or even broader out of the regency.

Value of α is used as an indicator of the capacity of paddy fields relative to the population number in an area. The α more than 1.0 means that the area has a functional carrying capacity so that it indicates food self-sufficiency. On the other hand, α value less than 1.0 indicates that the area does not have the carrying capacity so that food self-sufficiency is not met. While α value equals to 1.0 , the region has an optimal carrying capacity, the availability of food can support the community needs in or outside the region.

Research Implication

This research can be used as an evaluation guide in the management of the PLP2B program in each regency, especially to support agricultural development. As discussed earlier, this research is also related to regional development, as well as development planning especially for Batang Regency. Also, the results of this study can be used as evaluation material for the government in importing rice policy which is still being carried out nowdays (Widarjono, 2018). The implementation of the PLP2B program to maintain agricultural land in Batang Regency needs attention, to consider the proposed allocation of industrial estates because Batang Regency has the potential to become a rice barn in Central Java and even at the national level (KFMAP, 2021).

The potential of rice farming by considering the carrying capacity of land, land availability, and population should provide incentives for farmers' livelihoods. The farmers of Batang Regency can carry out rice farming activities and have an interest in supplying outside the region or export, where the value of a reaches 4.179356. This means that the achievement of a surplus occurs up to more than four times the threshold. This can be a source of pride for farmers because it produces high production for Batang Regency.

This research led to multidisciplinary studies approach in which involve many field of GIS, regional planning, and environmental science as part of the geographical analysis. It means that the research is directly affects the geography study development as well as the management of natural and environmental resources. Furthermore, research can enrich and focus on research roadmaps for research activities with multidisciplinary approaches in land resource conservation associated with efforts to develop food self-sufficiency efforts.

Sebaiknya elaborasi research implication lebih dalam dan fokus, hingga 750-1000 kata

CONCLUSION AND SUGGESTION

Overall, all sub-districts in Batang Regency have sufficient availability of paddy fields. By 2017, Batang Regency indicated surplus of productive rice fields, with an area of 24,081.4 ha of irrigated rice fields (equivalent to 28% of the district's area). Such a large number has not been added to the rainfed rice fields which reach 3,134.4 ha (3.6% of the district area).

Based on the observations of Sentinel 2A satellite imagery, Batang Regency has a suitable cultivated land throught year during the rainy and the dry season. This can be identified by paddy field planted area that does not significant imagery differences from time to time. The most significant differences are found in the districts located near the coast which are rainfed rice fields, while the upland areas are simple to technical irrigation areas.

The total demand for rice in Batang Regency reaches 104,211,080 kg per year. Meanwhile, the results of the calculation of the daily rice needs of the population in Batang Regency reached 897.19 g per capita. According to the criteria, Batang Regency is classified as a surplus because the daily supply is 342 gr per capita above the daily needs

Batang Regency is categorized in the criteria for food self-sufficiency, with the value of the carrying capacity of 4.179356, which means the rice production in the region is able to meet the needs of its population, even experiencing an abundant surplus.

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Carrying Capacity and Food Self-Sufficiency of Paddy Field Resources: NDVI Analysis in Batang Regency, Central Java Province, Indonesia

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Abstract. Monitoring of paddy field area using remote sensing and mapping techniques has been well recognized and efficient. This study aims to monitor paddy with NDVI analysis with extensive GIS calculations and integrated with the food self-sufficiency formulas. The research was conducted in Batang Regency, Central Java Province, Indonesia, that annually produces 104,211,080 kg on average. The results show that the production of lowland rice is sufficient to meet the daily rice needs of 897.19 gr per capita. The regency also shows a surplus of rice production of more than 342 gr per capita above the daily needs, or categorized in the criteria of food self-sufficiency. Food self-sufficiency classification is related to carrying capacity (α) reaching ca. 4.179356 (α>1). This value shows that rice production can meet the needs of the population of Batang Regency.

Keywords: carrying capacity; land use; NDVI; rice; self-sufficiency

JEL Classification: 013; Q00; R11

INTRODUCTION (tambahkan hingga 1000 kata)

The increasing of population has resulted in increased development activities in various fields to meet the needs of the community (Li et al., 2017). It is associated with the construction of settlement facilities, infrastructure networks, commercial facilities, or social facilities. The increase in development activities will undoubtedly be accompanied by the rise in land requirements to accommodate these development activities (Trihatmoko, 2020). It means that the higher activities in the development led to lack land availability.

Since the enactment of regional autonomy in 2001, local governments in Indonesia have broader authority in determining the best development policies and programs for improving

the welfare of the people and the progress of their respective regions. The management of natural, human, and other resources requires development priorities by paying attention to regional excellence (Mawardi, 2007). The balancing of the potential local excellence with emphasis on the carrying capacity of the environment will be able to create efficiency and effectiveness in regions. The condition relates to the use and management of development resources can improve community welfare and regional development.

The concept of land carrying capacity is widely applied to animal studies, especially to measure the amount of environmental capacity to support animal life expressed per unit in certain area. Then the carrying capacity of the environment is applied to the human population. Another carrying capacity analysis is also based on plant biomass (rice) produced by rice fields in a certain area and time. Thus, the carrying capacity is the ability of the environment to be able to support human life (Li et al., 2017).

The development of regional potentials such as the agricultural sector refer to the Law No. 41/2009 concerning Protection of Sustainable Food Agricultural Land (PLP2B). The PLP2B program protects the agricultural sector in each region so that both quantity and quality of corresponding resources are maintained. One of the implementations of this program is based on productive land in Indonesia that meets the requirements for the carrying capacity of agricultural land. However, the fact is that agricultural land in many regions in Indonesia is decreasing both in quantity and quality (Asmuti & Tjandra, 2020).

As known, most of the population in Batang Regency are farmers who highly depend on the availability of the land to meet their needs. Besides, Batang Regency is well known as the agriculture area (Keris-Jateng, 2017) and potentially as it is considering the low geomorphological dynamic on its lowland including coastal area as its dominant area (Trihatmoko, 2020). The low geomorphological dynamic indicates this area is suitable for massive development precisely in the sector of food plant production. On the other hand, Batang Regency also displays very dynamic economic development in its coastal areas, along the Java Sea coast (Marfai et al., 2019). The economic development also seen at the fact that this regency has been targeted for the development of an industrial area which is very attractive for investment (KFMAP, 2021). In this regard, it is necessary to research the environmental carrying capacity of Batang Regency based on land availability and needs for agricultural sector, precisely on rice field availability as well as protecting the PLP2B program.

Introduction terlalu singkat, Sebaiknya ditambahkan paragraf untuk memberi fokus dan penajaman

This research was aimed to reveal the carrying capacity using geographic information system (GIS) by Normalized Difference Vegetation Index (NDVI) analysis from the series of Sentinel-

2 satellite images. The Sentinel-2 satellite images were chosen as the free and newest medium-high spatial resolution (10 m). Temporally, this satellite also has adequate revisit frequency (10 days and combined constellation revisit in 5 days) for three to four harvests of paddy in a year. The research is also related to how paddy field resources in Batang Regency, Central Java Province, Indonesia, indicate the carrying capacity of food self-sufficiency, especially for rice production. The collaboration of GIS-NDVI processes, and land carrying capacity for food self-sufficiency analysis are also filling the gap of the previous researches that were mostly conducted separately or being positioned as the preliminary statement for one to another (Sukmono & Ardiansyah, 2017; Zhou et al., 2020).

RESEARCH METHOD

This research was conducted in Batang Regency, Central Java, Indonesia, including geographical location between 6°51'46" S to 7°11'47" S and 109°40'19" E to 110°03'06" E. Area sampling selection comprises all districts or about 15 districts. The object of research was all paddy fields, i.e., technical irrigation paddy fields, simple irrigation, and rainfed paddy fields.

Primary data is the latest cross-check data on changes in land use in the field and data on agricultural commodity productivity. Secondary data includes statistical data and satellite image data (geographical information system data). Geographic information system data were taken from the website of the Geospatial Information Agency (BIG), as well as satellite imagery data from the United States Geological Survey (USGS).

The Sentinel-2 satellite imagery relies on multispectral high-resolution optical observations over the global terrestrial surface, including land change monitoring, emergency response and security services activitiesThe use of Sentinel 2A Satellite imagery emphasizes the design of a reliable multispectral land observation system by featuring a Multi-Spectral Instrument (MSI) with 13 spectral bands ranging from visible and near-infrared to shortwave infrared. Spatial resolution varies from 10 m to 60 m, depending on the spectral band, with a field of view of 290 km. The combination of high spatial resolution, wide field of view, and broad-spectrum coverage shows an advantage over other multispectral images.

NDVI (Normalized Difference Vegetation Index) Analysis

Vegetation index is analyzed based on digital brightness values as a result of the near-infrared (NIR) and red band reflectance and absorption from vegetation (Campbell, 1987; Zhou et al., 2020). This analysis is part of the analysis and manipulation processes in GIS scope (Aronoff, 1989) that is conducted for experiments measuring biomass or vegetative level. NDVI

measures flourishing green vegetation and also investigates changes in the ecological environment (Li et al., 2017). The combination of the different formulation of normalization and the use of the highest absorption and reflection of the chlorophyll makes it durable under various conditions (Syamsia et al., 2018). The index value ranges from -1 to 1. The general range for green vegetation is 0.2-0.8 (*NASA Technical Reports Server (NTRS)*, n.d.), use equation as follows:

$$NDVI = \frac{(NIR - Red)}{(NIR + Red)}$$

Tolong didefinisikan persamaan tersebut

Shortly, to adjust the bright visualization from NIR effect, the function was being normalized by the difference/sum ratio of red band.

Land Availability Analysis

Land availability is determined based on the total of local actual production data of each commodity in a particular area adding up by the products of all commodities. The commodities such as agriculture, land availability analysis is carried out by calculating land availability. The formula for land availability used the equation below (Ministry of Environment, 2009)

$$SL = \frac{\sum(Pi \times Hi)}{Hb} \times \frac{1}{Ptv\bar{b}}$$

On this equation SL is land availability (ha), then Pi is the actual production of each type of commodity (the unit depends on the type of product), including agriculture, plantation, forestry, and animal husbandry. Hi is the unit price for each type of commodity (Rp/unit) at the producer level. Hb represents the unit price of rice (Rp/kg) at the producer level. Pt is Rice productivity (kg per ha). (ini contoh bagus untuk mendefinisikan formula, dan disertai satuan; bisa dicontoh untuk formula lainnya)

The Needs of Land Analysis

Population pressure on the carrying capacity of land can be determined based on the value of the ratio between the population and the percentage of farmers with a minimum area of land to live properly. The land requirement formula used in research is shown in equation below (Ministry of Environment, 2009).

$$D_L = N \times KHL_L$$

DL is the needs of land in total equal to rice (ha). N represents population and KHLL is the needs of land to live properly.

Carrying Capacity of the Land

Food self-sufficiency is an attempt to meet their own food needs by cultivating food crops such as cereal (rice and the like), secondary plants, cassava, and others. Another researcher suggested that land capability implies land carrying capacity (Notohadiprawiro, 1987). Previous research said that the land carrying capacity degradation is influenced by an increasing population and a low percentage of farmers (Mantra, 1986; Trihatmoko, 2020).

The carrying capacity of the land is obtained from a comparison between the availability of land (SL) and land requirements (DL) (Ministry of Environment, 2009):

$$Cc = \frac{S_L}{D_L}$$

If $s_L > D_L$, a surplus of land carrying capacity. If $s_L < D_L$, a deficit of land carrying capacity. To get the precise carrying capacity of the land (α) the calculation is continued as follows:

$$\alpha = \frac{X}{K}$$

Where X is the available area on site location. The formula as follows:

$$X = \frac{Total\ Area\ of\ Harvest}{Population}$$

On the other hand, K is the area needed for food self-sufficiency. The formula as follows:

$$K = \frac{minimum\ rice\ consumpsion}{Average\ rice\ production\ -\ average\ in\ Ha}$$

The surplus of land carrying capacity is emphasizes to the rice production analysis by using formula:

$$Rice\ production\ in\ Total = Total\ area\ of\ paddy\ field\ (Ha) * IP * productivity\ (tons/ha)$$

The total rice production was assumed as the conversion value of milled unhusked rice (GKG) then the value of rice obtained is as follows:

$$Rice = Index\ GKG * total\ harvest$$

The level of productivity of paddy fields in meeting the needs of the population of rice in Batang was calculated based on the following formula:

$$Supply = \frac{Rice\ production\ in\ 1\ year}{Population\ in\ one\ regency}$$

Paragraf ini tidak perlu membuat definisi, diganti dengan bagaimana cara metode analisis Carrying Capacity of the Land (cantumkan referensinya)

RESULT AND DISCUSSION (terlalu singkat, Sebaiknya ditambahkan paragraf untuk menemukan kedalaman dan perspektif lebih luas, tambahkan hingga 3500 kata)

Carrying Capacity of the Land

Batang Regency has abundant natural resource potential in agriculture, especially the availability of paddy fields. The area of rice fields reaches 24,081.4 ha or equivalent to 28.0% of the total area of Batang Regency. The land does not include rainfed rice fields which reach 3,134.4 ha or the equivalent of 3.6% of the total land area. This condition indicates that Batang Regency has a very significant carrying capacity of agricultural land as stated in the Central Statistics Agency (BPS, 2016) (Table 1).

Kalau bisa ditambahkan pembahasan lagi dari setiap Tabel

Table 1. Land Carrying Capacity Status of Batang Regency in 2017

District	Land Availability	Land Required	Carrying Capacity of the Land	Status
Wonotunggal	3,523.65	218.25	32.66	Surplus
Bandar	3,299.83	409.60	16.54	Surplus
Blado	1,570.51	539.15	6.48	Surplus
Reban	1,241.75	624.59	4.58	Surplus
Bawang	1,828.26	540.98	7.82	Surplus
Tersono	4,855.25	167.85	60.74	Surplus
Gringsing	5,132.30	247.64	41.90	Surplus
Limpung	3,411.77	210.02	33.43	Surplus
Banyuputih	1,567.76	565.71	5.97	Surplus
Subah	3,278.63	319.41	23.11	Surplus

Pecalungan	2,203.62	367.13	13.50	Surplus
Tulis	3,801.68	197.82	50.18	Surplus
Kandeman	3,173.66	306.32	20.95	Surplus
Batang	1,340.23	808.28	13.32	Surplus
Warungasem	4,665.30	325.50	28.83	Surplus

Stated in Table 1, 15 districts show abundant carrying capacity of the land. The highest carrying capacity is located at Warungasem District which located in the lowland area as part of the coastal area. The lowest carrying capacity is located at Reban District which located at the highland area (south part). The result shown in Table 1 indicates that the government should control the development of built-up area as the side effect of the rapid economic development that commonly occur in north coast of Java Island (Aris Marfai, 2011; Hartatik, 2016; Trihatmoko, 2020).

Spatial Pattern of Batang Regency

Batang Regency is a hilly area, both in the north and in the southern region bordering Banjarnegara Regency. The south part of Batang is dominated by tea plantations, which are located in a cold area because it is a plateau area. Most of the Batang Regency area (30.2%) is a plantation area situated in the southern part. Batang Regency forest area is in the north, which is a teak forest or tree plantations. The industrial sector in Batang Regency is centred on Batang Regency mostly spread along the north coast road as the densest road in Indonesia (Hartatik, 2016), i.e. Kandeman, Tulis, Subah, and Banyuputih Districts. This condition is considering that the industry requires adequate accessibility. For the detail, land uses, as shown in Table 2.

Most of Batang Regency (30.2%) is a plantation area located in the southern part. The forest area to the north is found in large areas of teak forest or tree plantations. The industrial sector in Batang Regency is mostly spread along the north coast road as the busiest traffic road in Indonesia (Hartatik, 2016), through the route along the Kandeman, Tulis, Subah, and Banyuputih districts. The industry requires adequate accessibility to connect to the supply chain and distribution channels. Land use in Batang Regency is presented in Table 2.

Table 2. Land use distribution in Batang Regency, 2016.

Land use type	Area (ha)	%
Forest	13,309.4	15.5
Industry and Tourism	141.9	0.2
Water body	1,275.6	1.5
Grassfield	615.1	0.7
Dry field	3,134.4	3.6
Mix garden	6,158.5	7.2
Settlement	11,209.4	13.0
Garden	25,980.7	30.2

Paddy Field	24,081.4	28.0
Total	85,906.4	100.0

Source: Spatial Plan (RTRW) data analysis of Batang Regency.

Paddy Field Area in Batang Regency

Batang Regency has favorable and reliable natural resource potential for food crop agriculture (paddy) on condition that meets proper resource management support. In the region, the area of irrigated paddy fields reaches 28% of the district's area (Table 2) and is spread over all districts (Table 3).

Table 3. Paddy fields distribution in 2017 of Batang Regency.

District	Area size	
	%	ha
Bandar	10.2	…
Banyuputih	5.1	…
Batang	7.6	…
Bawang	7.4	…
Blado	5.9	…
Gringsing	8.9	…
Kandeman	6.5	…
Limpung	5.5	…
Pecalungan	3.6	…
Reban	7.0	…
Subah	8.3	…
Tersono	7.8	…
Tulis	4.1	…
Warung Asem	5.2	…
Wonotunggal	6.9	…

Most of the rice fields are located in the northern and southern areas of Batang Regency (Figure 1). The central area is dominated by teak forest. Besides, the central area is also used for residential and industrial areas. The districts with the small size area of paddy fields are found in Warung Asem, Limpung, Pecalungan, and Tulis districts. The area is mostly hilly and some areas are indicated to have developed rapidly.

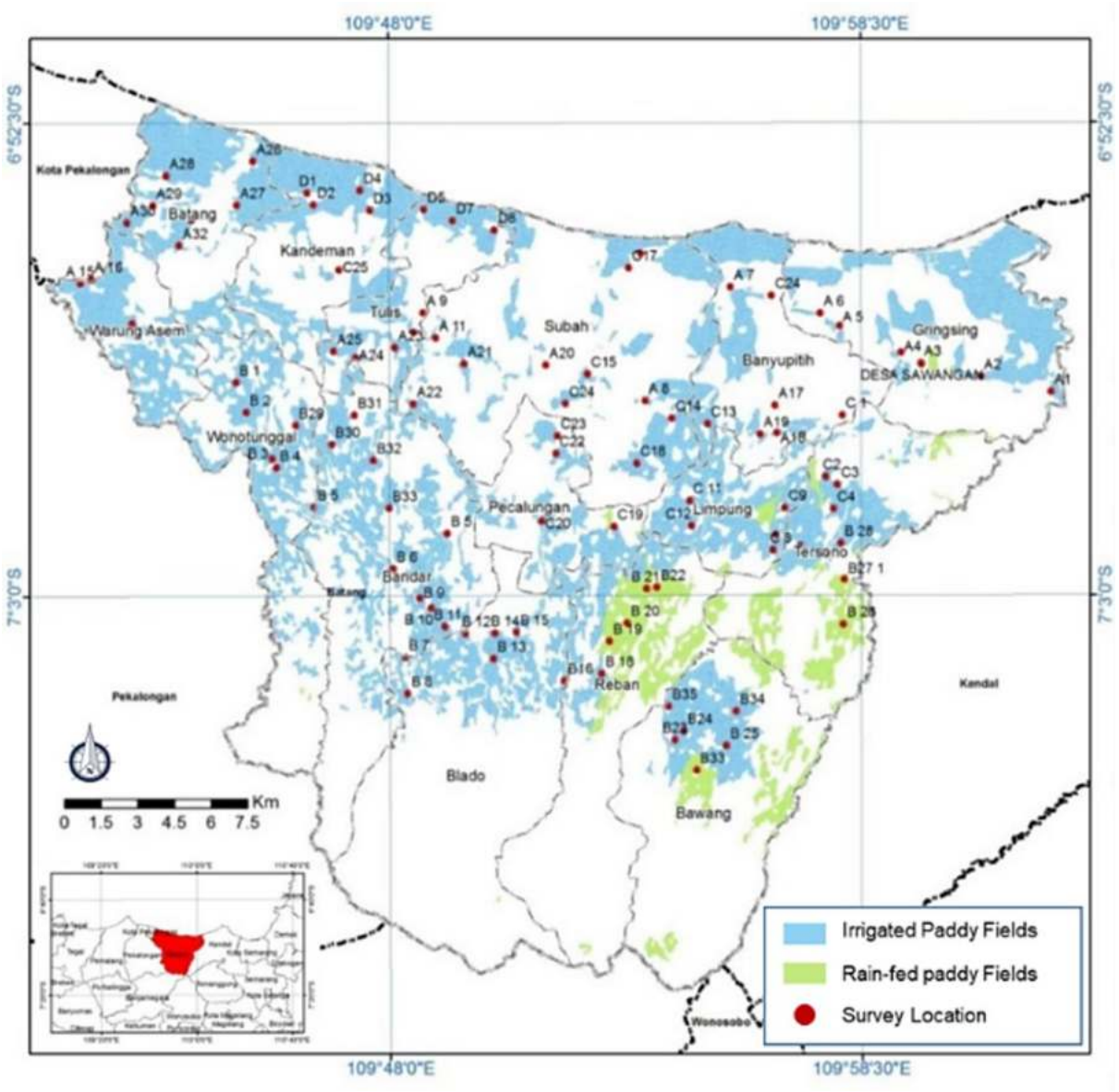


Figure 1. Paddy field area in each district.

The NDVI analysis identifiy rice field from of the amount of chlorophyll that reached its maximum point in its growth phase. NDVI analysis was able to estimate the area of rice field to reach 6,967.5 ha. The mature rice plants are visually recorded from the spectral reflection which is very bright compared to other plants. NDVI can identify high brightness sensitivity even though it is lower than the brightness of water bodies (Figures 2 – 4). In panchromatic satellite image analysis, the amount of cloud cover will cover or reduce the accuracy of image classification.

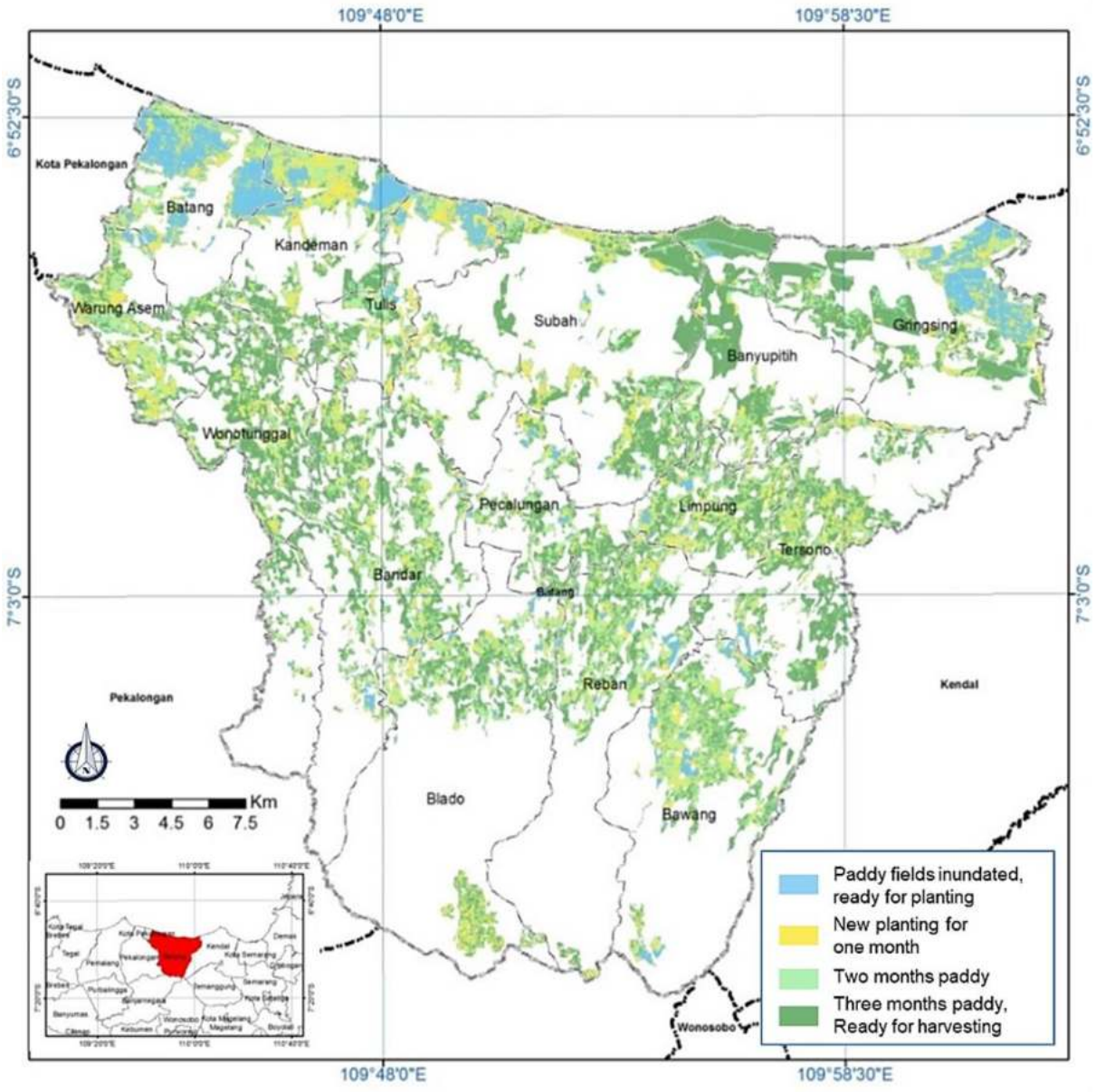


Figure 2. The paddy filed identification in February 2017 year??.

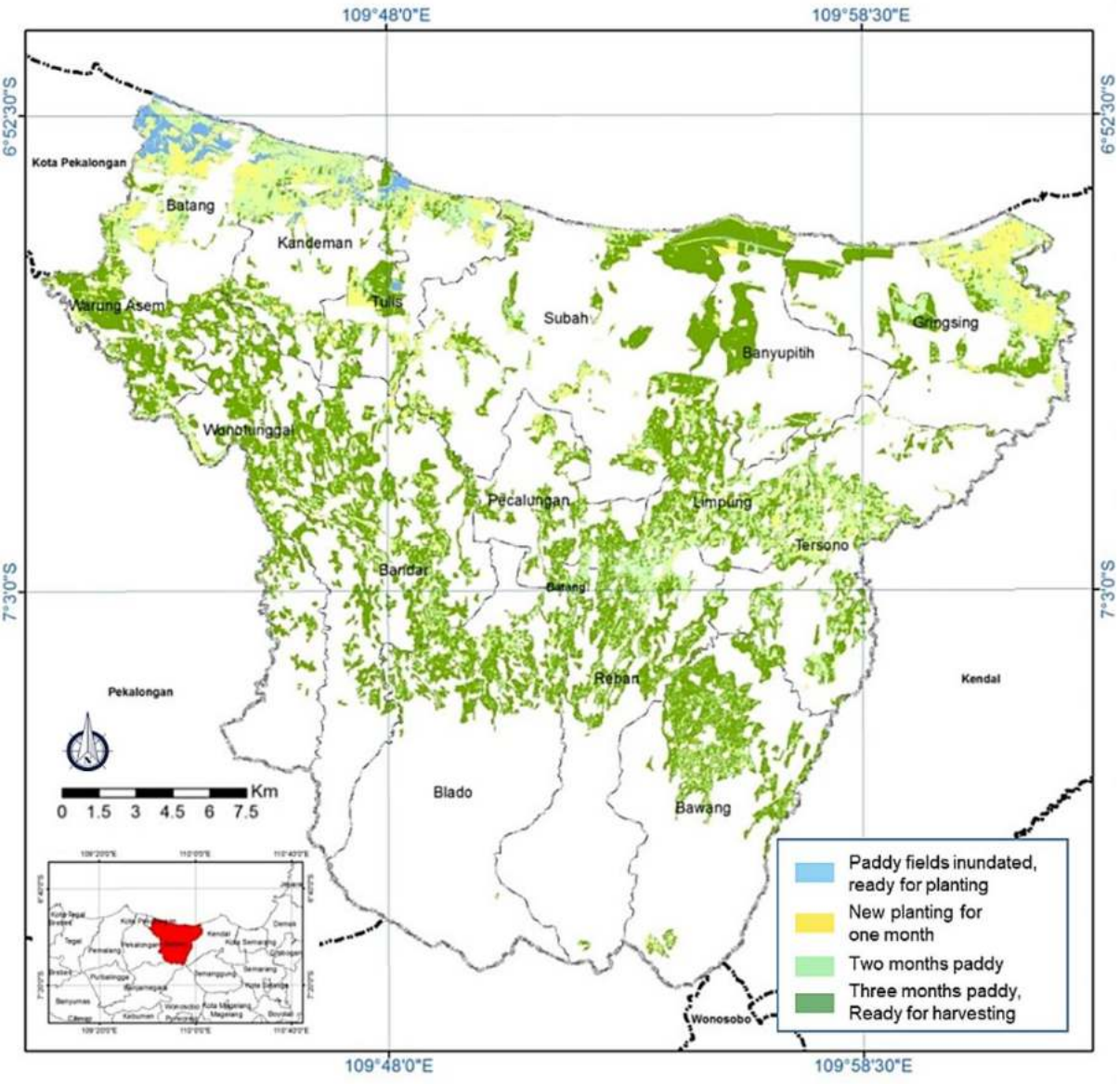


Figure 3. The paddy filed identification in August 2017 year??..

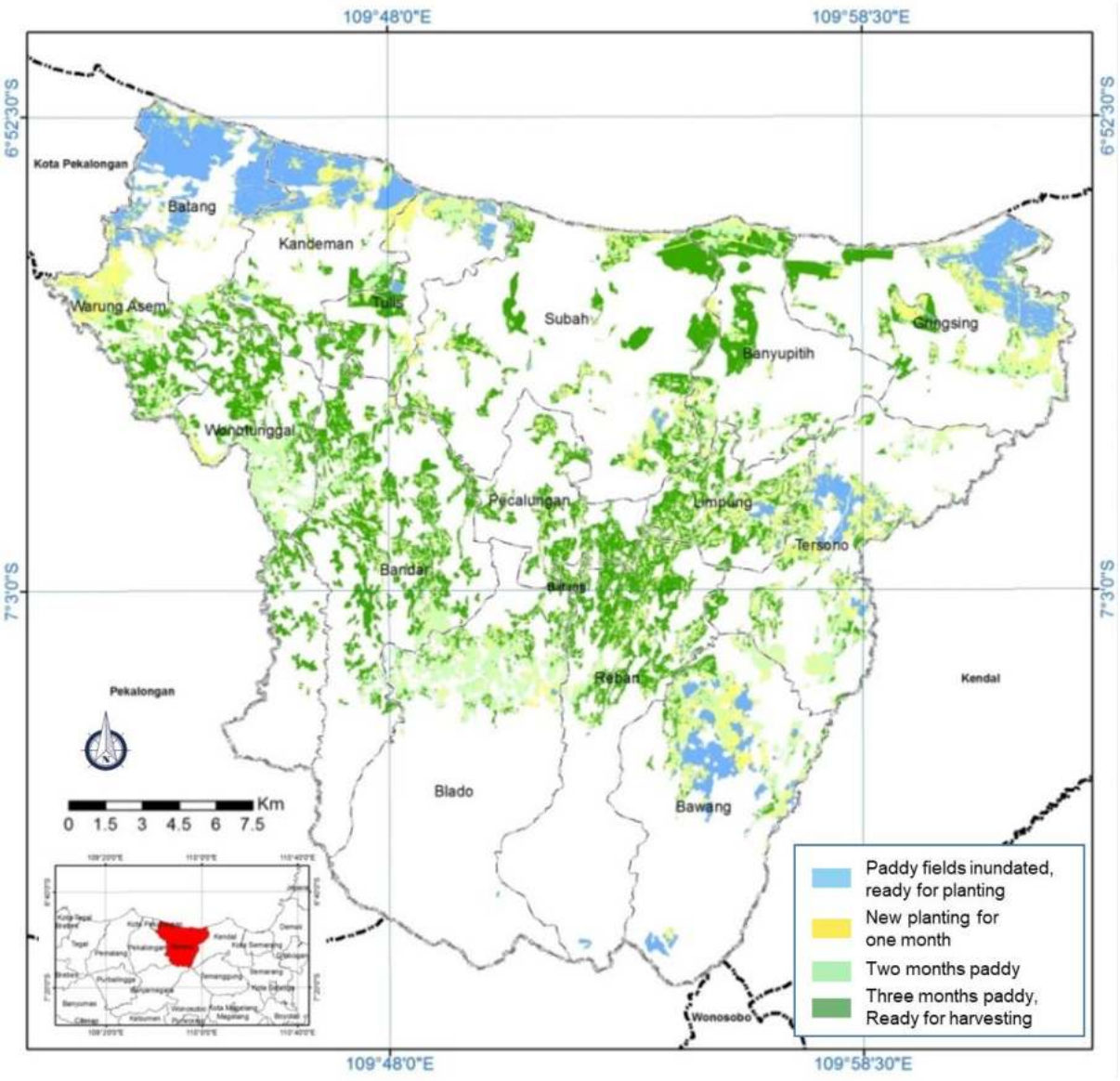
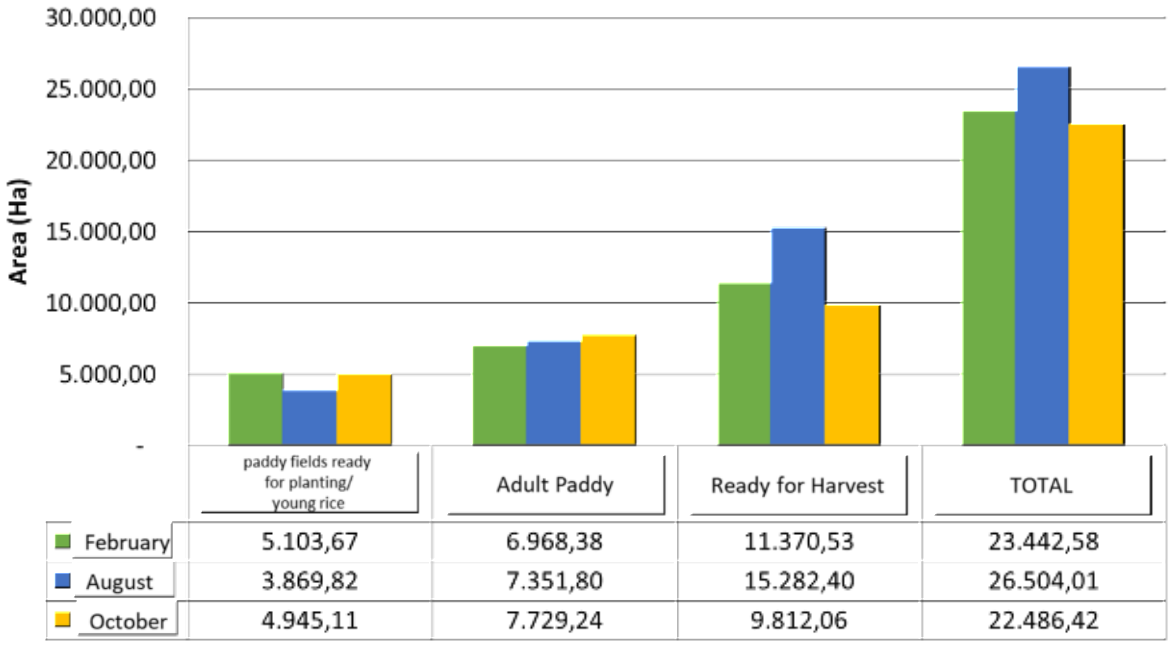


Figure 4. The paddy filed identification in October 2017 year??..

Overall, observations of the Sentinel 2A Satellite imagery (Figure 5) indicate that Batang Regency has a very suitable planting area. This means that paddy fields can be cultivated throughout the year, both in the rainy and dry seasons. This can be justified by observing the imagery of rice planted land that does not show extreme differences between the northern and southern parts of Batang Regency (Figure 6), represented by survey locations A2 and B8, respectively, as shown in Figure 2. Meanwhile, areas with simple to technical irrigation show relatively productive farming management. Indeed, NDVI analysis has proven to be able to provide an accurate assessment of the observation of paddy fields, and allows for the development of other environmental analyzes (Zhou et al., 2020).



	paddy fields ready for planting/ young rice	Adult Paddy	Ready for Harvest	TOTAL
February	5.103,67	6.968,38	11.370,53	23.442,58
August	3.869,82	7.351,80	15.282,40	26.504,01
October	4.945,11	7.729,24	9.812,06	22.486,42

Figure 5. Paddy observations from Sentinel 2A in 2017.

Figure 6. Paddy filed survey from A2 location, the south region (left), and B8 location, the north region (right).

Batang Regency Rice Needs

The total demand for rice in Batang district is 104,211,080 kg per year. The amount of production must be met to achieve food self-sufficiency. These results can be achieved, thus

placing Batang Regency as a mainstay agricultural area (Keris-Jateng, 2017), instead the government needs to consider the allocation of industrial areas in this district (KFMAP, 2021). On the other hand, Batang Regency was asked to contribute to the rice needs of other regencies in Central Java, because this province was not self-sufficient in food in the 2014-2018 period (Pratiwi et al., 2020). Planning for rice production needs estimate without considering the main potential of land resources can lead to degradation (Wilis et al., 2020).

Sebaiknya ditambah diskusi

Rice Production Calculation in Batang Regency

The area of paddy fields with irrigation systems is 24,081.4 ha (28% of the total area in Batang Regency), which is very likely to result in significant deep rice production. In addition, the planting intensity (planting index) in several locations also reached three planting seasons in a year. The results of the study show that the average planting index reaches five harvests in 2 years or the equivalent of 2.5 times a year, with an average productivity of 6.5 tons/ha. Thus, the total rice production in all Batang Regency is calculated as ca. 391,322.75 tons per year or 245,515.89 tons per year in milled grain conversion (GKG) (62.74 percent conversion). The production is higher than the demand for one year (104,211,080 tons per year), which shows an indication of a production surplus. Furthermore, the calculation of food needs (Wilis et al., 2020) found an annual production of 327.476 kg per capita or equivalent to 897.19 gr per capita.

Sebaiknya ditambah diskusi

Carrying Capacity Calculation of Paddy Field in Batang Regency

Daily rice consumption needs are 342 gr per capita or equivalent to 124.89 kg. Meanwhile, the average productivity of rice is 6.5 tons/ha, so that the K value is 0.0192138. With the values of X and K, the carrying capacity of the land (α) is 4.179356. Average rice production per Ha is converted from paddy to rice (62.74%). The value α is used as an indicator of the ability of paddy fields to the population in one region (Ma, 2017). The evaluation standard as $\alpha>1$ means that the area has a functional carrying capacity so that it is capable of food self-sufficiency (the population is below the optimal community). $\alpha<1$, the region has inadequate carrying capacity so that food self-sufficiency is unable to exceed the optimal population. $\alpha = 1$, the area has an optimal carrying capacity, the availability of food can support the people within regency or even broader out of the regency.

Value of α is used as an indicator of the capacity of paddy fields relative to the population number in an area. The α more than 1.0 means that the area has a functional carrying capacity so that it indicates food self-sufficiency. On the other hand, α value less than 1.0 indicates that the area does not have the carrying capacity so that food self-sufficiency is not met.

While α value equals to 1.0 , the region has an optimal carrying capacity, the availability of food can support the community needs in or outside the region.

Research Implication

By receiving detail result of land carrying capacity and its variables, namely land availability, the needs of land for total rice production, this research can be used as two function faces, those are for the evaluation and control guide in the management of the PLP2B program in each regency, especially to support agricultural development. As discussed earlier, this research is also related to regional development, as well as development planning especially for Batang Regency. Also, the results of this study can be used as evaluation material for the government in importing rice policy which is still being carried out nowdays (Widarjono, 2018). The implementation of the PLP2B program to maintain agricultural land in Batang Regency needs attention, to consider the proposed allocation of industrial estates because Batang Regency has the potential to become a rice barn in Central Java and even at the national level (KFMAP, 2021).

The potential of rice farming by considering the carrying capacity of land, land availability, and population should provide incentives for farmers' livelihoods or at least increase the farming activity pride. The farmers of Batang Regency can carry out rice farming activities and have an interest in supplying outside the region or export, where the value of α reaches 4.179356. This means that the achievement of a surplus occurs up to more than four times the threshold. This can be a source of pride for farmers because it produces high production for Batang Regency.

This research led to multidisciplinary studies approach in which involve many fields of GIS, regional planning, and environmental science as part of the geographical analysis. It means that the research is directly affects the geography study development as well as the management of natural and environmental resources. Furthermore, research can enrich and focus on research roadmaps for research activities with multidisciplinary approaches in land resource conservation associated with efforts to develop food self-sufficiency efforts.

Sebaiknya elaborasi research implication lebih dalam dan fokus, hingga 750-1000 kata

CONCLUSION AND SUGGESTION

Overall, all districts in Batang Regency have sufficient availability of paddy fields. By 2017, Batang Regency indicated surplus of productive rice fields, with an area of 24,081.4 ha of irrigated rice fields (equivalent to 28% of the district's area). Such a large number has not been added to the rainfed rice fields which reach 3,134.4 ha (3.6% of the district area).

Based on the observations of Sentinel 2A satellite imagery, Batang Regency has a suitable cultivated land throughout the year during the rainy and the dry season. This can be identified by paddy field planted area that does not significant imagery differences from time to time. The most significant differences are found in the districts located near the coast which are rainfed rice fields, while the upland areas are simple to technical irrigation areas.

The total demand for rice in Batang Regency reaches 104,211,080 kg per year. Meanwhile, the results of the calculation of the daily rice needs of the population in Batang Regency reached 897.19 gr per capita. According to the criteria, Batang Regency is classified as a surplus because the daily supply is 342 gr per capita above the daily needs

Batang Regency is categorized in the criteria for food self-sufficiency, with the value of the carrying capacity of 4.179356, which means the rice production in the region is able to meet the needs of its population, even experiencing an abundant surplus.

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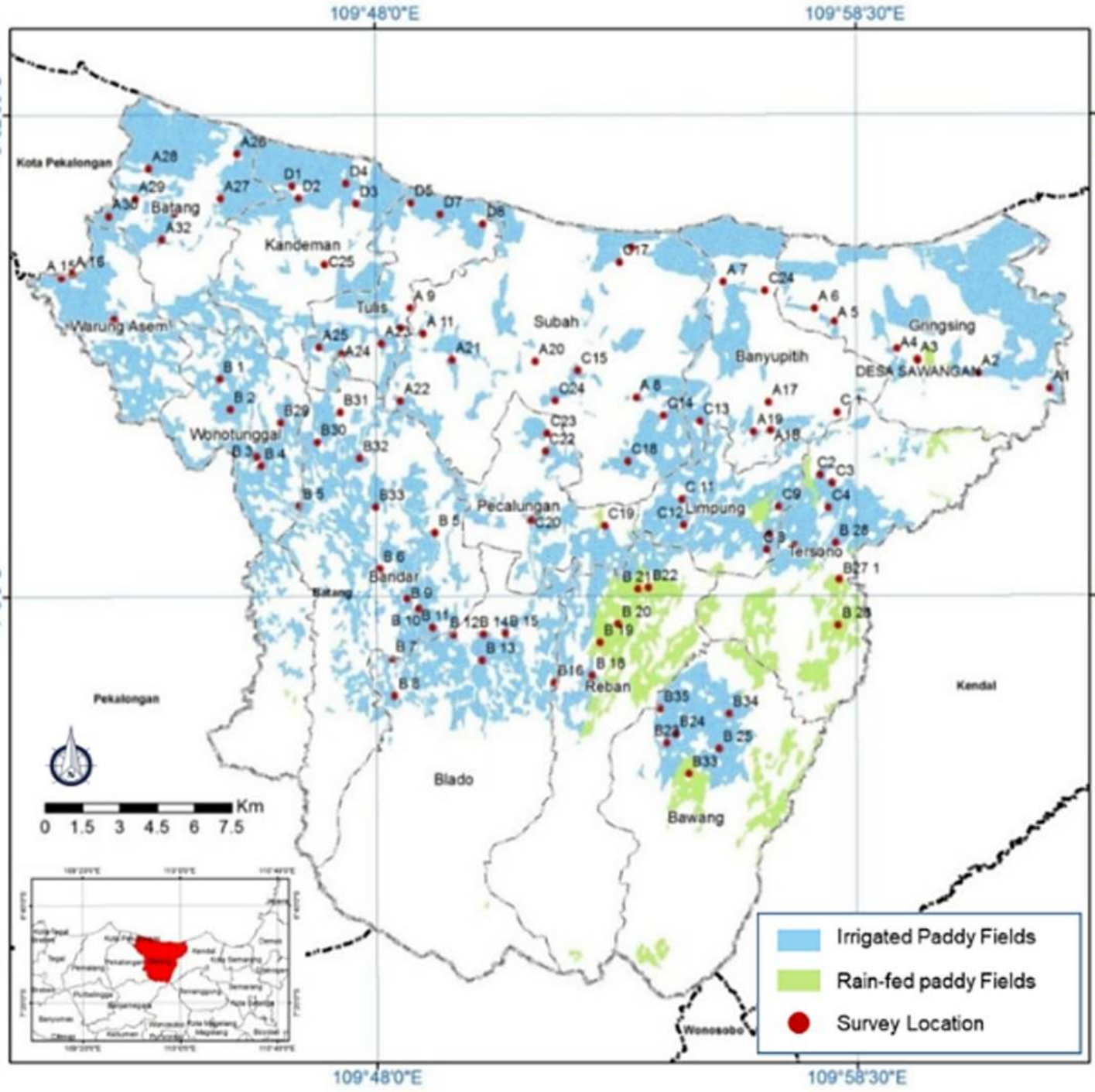
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Irrigated Paddy Fields
Rain-fed paddy Fields
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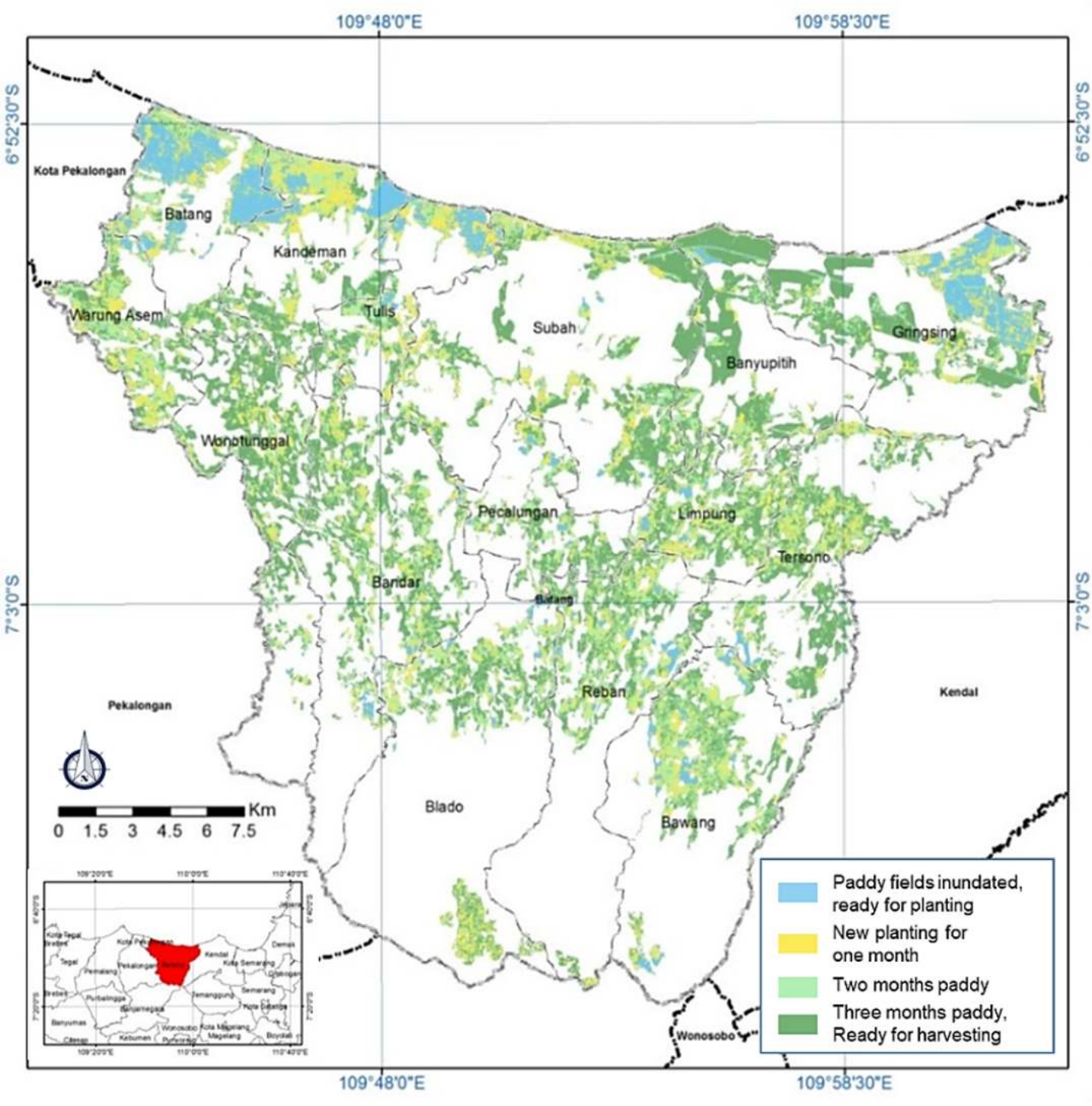
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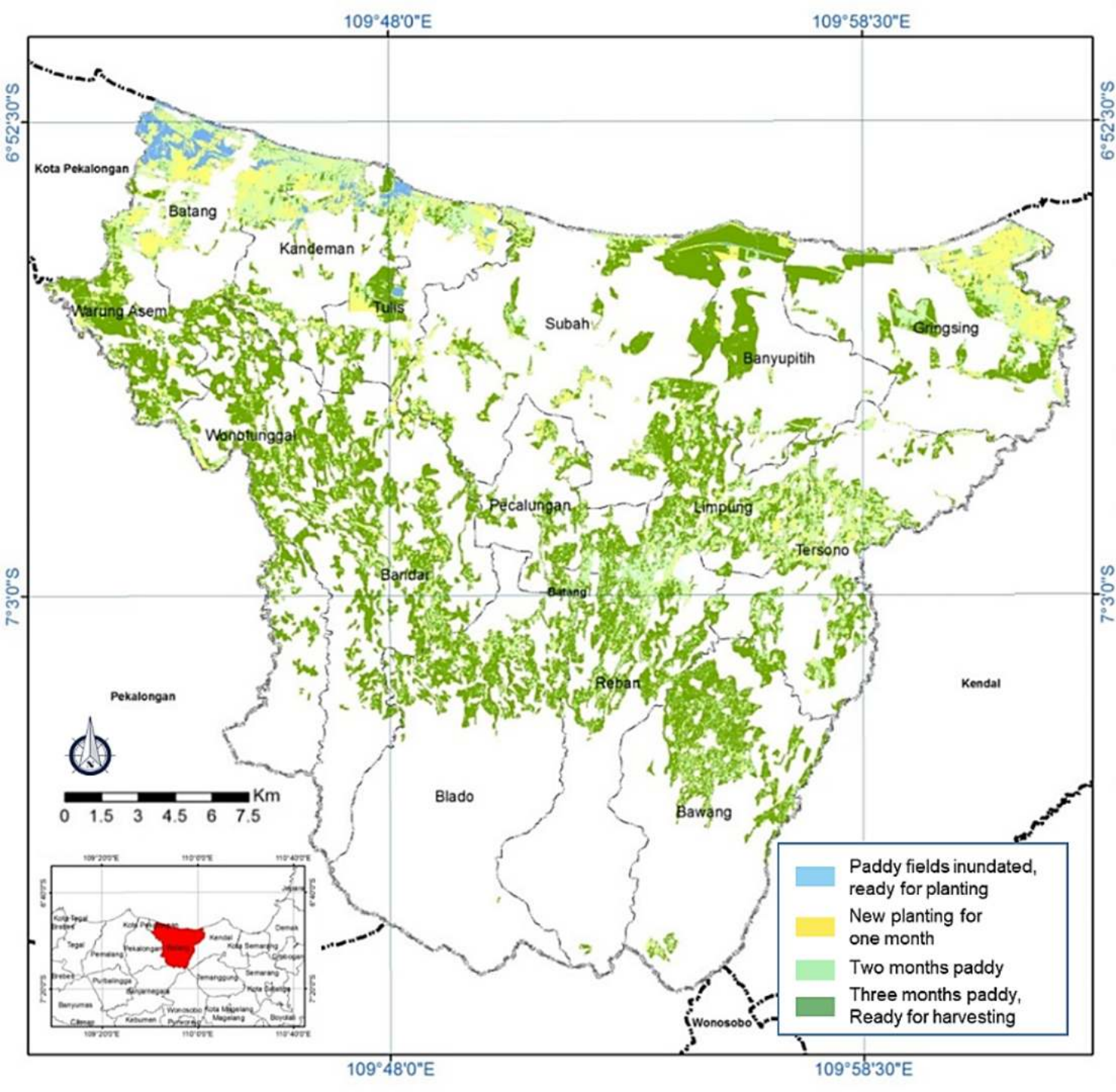
Paddy fields inundated, ready for planting
New planting for one month
Two months paddy
Three months paddy, Ready for harvesting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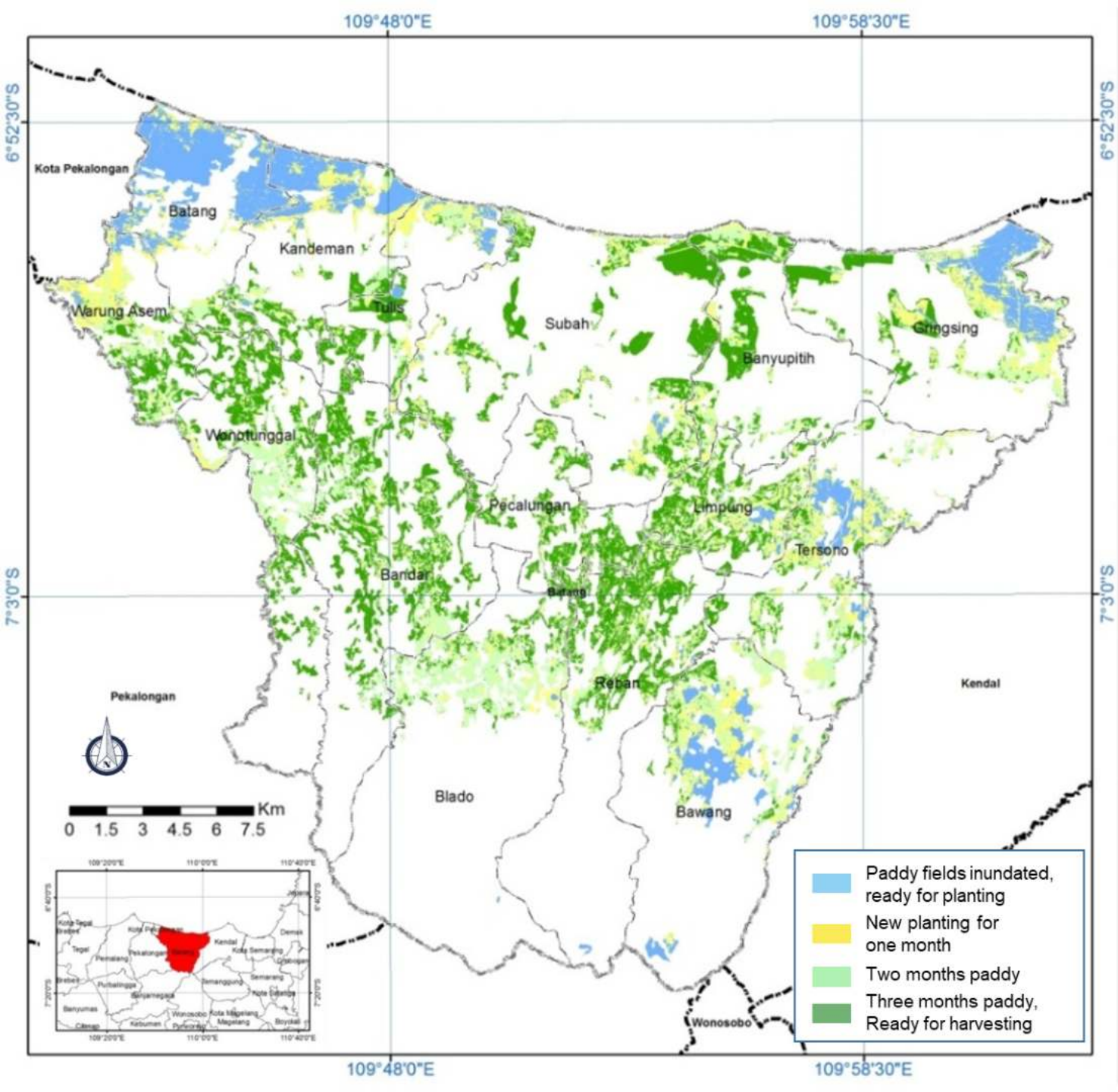
6°52'30"S
7°3'0"S
Kota Pekalongan
Batang
Kandeman
Tulis
Warung Asem
Subah
Banyupitih
Gringsing
Wonotunggal
Pecalungan
Limpung
Tersono
Baridar
Reban
Pekalongan
Kendal
Blado
Bawang
Wonosobo
0 1.5 3 4.5 6 7.5 Km
Paddy fields inundated, ready for planting
New planting for one month
Two months paddy
Three months paddy, Ready for harvesting


109°48'0"E
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Kota Pekalongan
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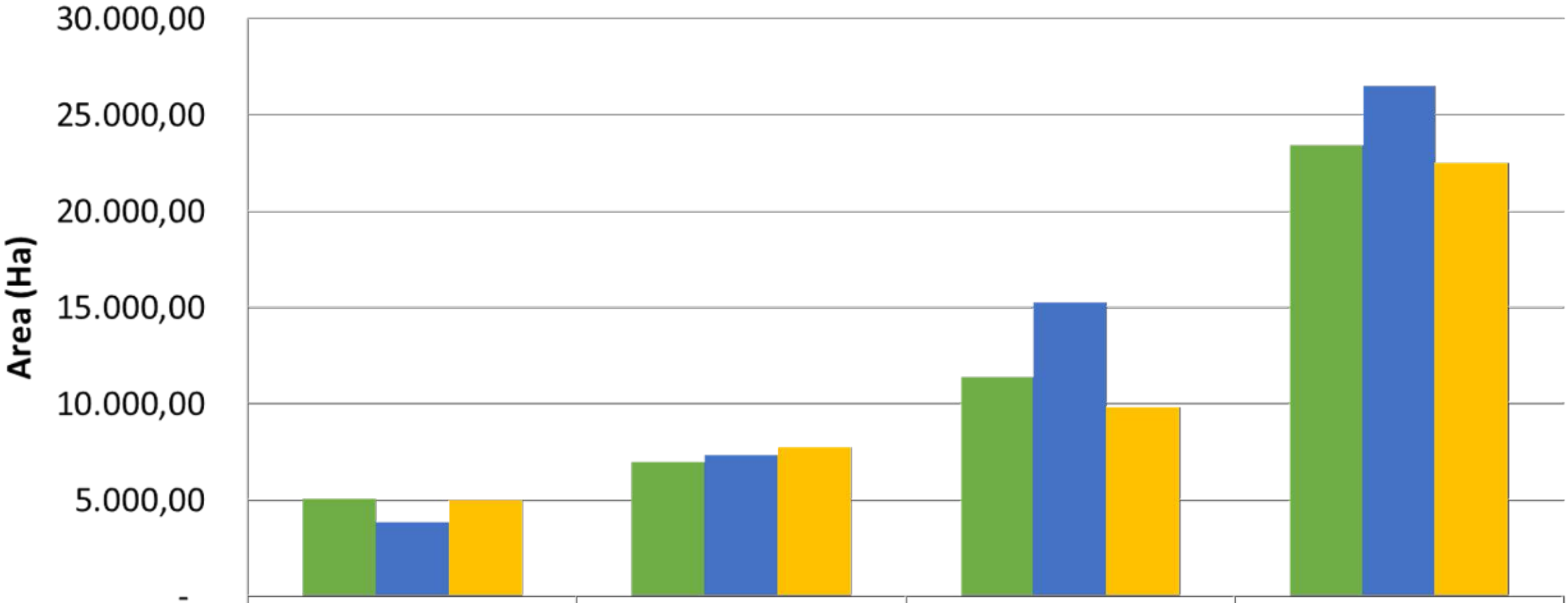

	paddy fields ready for planting/ young rice	Adult Paddy	Ready for Harvest	TOTAL
February	5.103,67	6.968,38	11.370,53	23.442,58
August	3.869,82	7.351,80	15.282,40	26.504,01
October	4.945,11	7.729,24	9.812,06	22.486,42