Peri-urbanization of small cities in Java and its impacts on paddy fields: The case of Tegal Urban Region, Indonesia

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Abstract. Extended urban formation and peri-urbanization processes have characterized the urbanization process in small cities in Java, the most fertile island that produces more than half of the national rice production. The process has brought the growth of small cities’ urban activities expand to their rural surroundings and reduce the available paddy fields, which increase the impact on greenhouse gas production and spoiling rural resources. Using the case of extended formation in Tegal Region, formed by Tegal City and the two surrounding kabupaten (regencies/districts), this paper aims to discuss the influences of such urbanization process on paddy fields in the region. The analysis uses time serial statistical data gathered from the monograph of the region from 1990 until now. It uses kecamatan (sub-districts) as the observation units that are classified into some groups based on their distance to the city. The result shows that the peri-urbanization process of small cities also brings impacts on the availability of paddy fields, including those that are equipped with technical irrigation systems. Later, a discussion on policy implications of the peri-urbanization process of small cities that can be useful for formulating better approaches in managing small cities’ growth in the future concludes the paper.

1. Introduction
Java is the smallest among the five largest islands in Indonesia, with only 7% of the country’s land area as the home for about 145.0 million populations (56.8% of the total population) in 2015, including 90.8 million or 67.0% of urban populations of the country. As an island with the largest urban and total population, Java is also the place for the largest cities in Indonesia, where eight of 13 cities with more than a million populations are located, including Jakarta, the largest city with about ten million urban populations [1]. The importance of Java is also presented by the contribution of its GRDP (Gross Regional Domestic Products) to the national, which always counts about 57% to 59 for the latest decades. Moreover, Java has about 3.18 million hectares or 42.6% of 7.46 million hectares of paddy fields in the country, so it contributes a dominant portion of the annual rice production, the main staple in the country.

However, the rice contribution has tent to decrease for decades, from 58.8% in 1993 to 51.7% in 2015, as Java lost more than two hundred thousand hectares of paddy fields in the period as they are influenced by urbanization processes in the region [2]. Firman [3] argues that the urbanization process in Java has come into a regional process, reflected by the intensification of urban belt formations that connecting large cities. The main characteristic of the regional urbanization process is an expansion of urban growth beyond the city’s administrative boundaries [4]. Mardiansjah [5] and Fahmi et al. [6] show that this process has also come in much smaller cities like Tegal and Cirebon that also experienced an expansion of their urban growth into their surrounding kabupaten (regency or non-urban districts).
Urbanization has been a global concern as it brings environmental changes at regional-to-global scales and brings unsustainable processes through degradation of agricultural land and ecosystems and increasing greenhouse gases, air pollution, waste, and congestion [7]. Direct loss of vegetation in urban expansion process also contribute CO2 emissions and enlarge urban heat island that also affects global climate change [8][9], and could also increase the potential of inundation [8].

The heat increase in the urbanization process also influences land-use change [9], and with more intensive transportation activities and energy consumption, they increase the heat intensity of the area [10]. Qiu et al. [7] explain that in collaboration with climate change, urbanization shifts the land surface phenology by shifting temporal change of the start of seasons (SOS) and end of the season (EOS). Some cities could have earlier SOS, while others have later SOS; and also delayed EOS for some cities, while others experience earlier EOS [7]. Increased temperature, caused by climate change and urbanization, advances SOS, delay EOS, and reduces accumulated precipitation that will lead to later SOS and earlier EOS in the following year, particularly in cities within dry climate regions [7].

Qiu et al., [7] also argued that managing the amplitude of urbanization, which was quantified as changes of the percentage of rainproof urban land could bring opportunities to compensate for the negative effects of climate change, i.e., later SOS or earlier EOS, as well as to amplify its positive effects, i.e., earlier SOS or later EOS. Therefore, careful planning of urban expansion, as well as the conservation of the water bodies and natural environment is urgently needed in rapid and extensively growing cities, as the combined effects of urban sprawl and climate change poses great challenges in preparing flood mitigation for the city [8].

Using the case of Tegal Urban Region, this study aims to discuss urban population growth in a peri-urban area of small cities in Java to figure out how the urban expansion of small cities affects the availability of paddy fields, which also play an important role in providing the main staple of the country. We expect that the result could increase awareness in implementing careful planning of urban expansion in such cities in Java as well as in other areas.

Following the introduction, the paper explains the data and methods employed in the research. Next, the analysis of urban population growth as well as the increasing urbanization level in kecamatan (sub-district) in the peripheries, and the discussion of the availability of paddy fields in the areas will be held. In the end, some conclusions and recommendations conclude the paper.

2. Data and methods
This research utilizes the case of urban growth in the peri-urban of Tegal Urban Region to understand how the extended urban process of small cities affects the availability of paddy fields in their peripheries. The urban region is a medium-sized urban region, formed by Tegal Municipality with its two surrounding kabupaten, i.e., Kabupaten Tegal and Kabupaten Brebes. Tegal City is a municipality with a population of about 250 thousand population in 2015, in a 34.49 km2 administrative area, while the two kabupaten could still be considered as agricultural kabupaten although they are becoming more urbanized in the last decades as their proportion of the urban population to the totals are increasing. Almost all of the territories of the two kabupaten are within the area with a radius of 45 km from the city center. In this context, the study assumes that the two kabupaten are the peri-urban areas in the region, as the municipality is considered as the core.

This study observes three aspects: the urbanization process, the increasing urbanization level of the peripheries, and the changes in paddy fields available in the peri-urban areas. They are observed in a long period from 1990 until 2017, in spatial analysis with kecamatan area as the analysis unit. In doing so, the study employs two levels of data, i.e.: the result of census 1990, 2000, and 2010 that is combined with 2017 monograph data to understand the urbanization process; and monograph data to elaborate changes in the availability of paddy fields. The kecamatan are categorized by two variables, i.e., distance from the city center and the availability of regional roads that cross the kecamatan, as the two factors are the main locational factors that influence the urban extension process [11].
3. Result and discussion

3.1. Urban population growth and peri-urbanization

Tegal City is located on the north-west coast of Central Java Province, about 300 km from Jakarta to the east, and about 160 km from Semarang, the capital of the province to the west. In 2010, the city’s population was 239,599, which increased to 275,789 in 2015. Based on its population, the city ranked 43rd among 94 municipal cities in Indonesia and 21st among 30 in Java, in 2015. Compare to other cities in Java which has seven cities with more than a million population and six other cities with a population of 500,000 to 1,000,000, in addition to Jakarta that has about 10 million population, Tegal City could be still considered as a small city of Java, even though its population is approaching the medium-sized one.

Table 1. The growth of urban populations in the Tegal Urban Region, 1980–2010.

| Region                  | 1980   | 1990   | 2000   | 2010   |
|-------------------------|--------|--------|--------|--------|
| Tegal City (core area)  | 131,440| 225,770| 236,900| 239,599|
| Peripheries             | 370,621| 783,180| 1,306,907| 1,561,263|
| - Kabupaten Tegal       | 262,375| 494,077| 755,651| 811,372|
| - Kabupaten Brebes      | 108,246| 289,103| 551,256| 749,891|
| Tegal Urban Region      | 502,061| 1,008,950| 1,543,807| 1,800,862|
| Total Population        | 2,495,365| 2,990,899| 3,316,119| 3,368,307|

Urban population growth in Tegal Area shows an expansion process into the surrounding kabupaten that created and developed many small towns in the kabupaten [5], and become an important process in the peri-urbanization process in the area (see Table 1). The expansion process changes many previously predominantly rural areas into urbanized areas with variation characteristics. The rural-to-urban changes have also reclassified the population who live in the areas into urban population, instead of non-urban in the previous classification. This process also makes urban population growth of the region was much rapid than that of the total population, as 4.35% annually between 1980 to 2010 for the urban population compared to only 1.00% per year for the total population. One important characteristic in the urban population growth was the growth in the peripheries was much rapid than in the core area. In the case of Tegal Region, the phenomena were much more obvious in 1980s that doubling the urban population.

3.2. Development of urbanization level of kecamatan in the peripheries

Mardiansjah [5] shows that the growth of the urban population in the peripheries of the city of Tegal has also formed and developed towns and other small urban concentrations in the two surrounding kabupaten. The process shows two combined regional urbanization processes, i.e., the formation of a new small town as the presence of some new individual urbanized villages and the enlargement or expansion of existing towns as larger towns. They have developed 31 towns in 1990 to 52 towns in 2017 with varying population sized from less than 10,000 inhabitants to nearly 200,000 urban dwellers in each town [5]. Urban population growth in the peripheries has also changed urbanization level, i.e. the proportion of the urban population to the total population, in every kecamatan in the two surrounding kabupaten, as shown in Figure 1 on the following page.

Maps in Figure 1 show the development of the urbanization level of every kecamatan in the peri-urban of Tegal Urban Region from 1990 to 2017. The urbanization level of kecamatan is shown by its color on the map. The white indicates that the urbanization level of the kecamatan still less than 50%, while red indicates that the level was in the range of 50 to 70 %, and blue indicates that has been more than 70%. Therefore, the colorized areas indicate that the kecamatan has been classified as urbanized kecamatan in that year, which means the kecamatan has had a larger number of the urban population in their territory than that of the non-urban. The kecamatan are also classified by their distance to the city center: i.e., in a radius less than 15 km (smaller corona), between 15 to 30 km (larger corona), and more
than 30 km (outer corona); and the availability of regional road(s) that crossing the kecamatan: i.e., kecamatan crossed by regional roads and those are not crossed.

The maps show that the closer kecamatan to Tegal City (the grey area) tend to have a higher urbanization level than those in a more distant kecamatan, except some kecamatan like Bojong of Kabupaten Tegal and Bumiayu of Kabupaten Brebes, which had larger urbanization level than many closer kecamatan. These happen since the two kecamatan are designated as one of the service centers in the respective kabupaten’s regional development, like Lebaksiu and Margasari of Kabupaten Tegal and Bulakamba, Kersana and Songgom of Kabupaten Brebes as well.

The maps also show that all kecamatan in the smaller corona or the closer radius has become urbanized kecamatan in 2017. This group of kecamatan was also the earliest urbanized group. Therefore, this group of kecamatan in the smaller corona could be considered as the primary peri-urban or the most urbanized peri-urban areas with the most urbanized character in the peri-urban areas. Also, the second group, i.e., in the following radius or the larger corona, has only three urbanized kecamatan with another

Figure 1. The growth of level of urbanization of the kecamatan, 1990 – 2017.
five kecamatan have been nearly reaching the 50% level, so this group could be considered as the secondary peri-urban area with a mixed character of urban and rural activities in the area. Next, the last group in the outer corona, which has only two urbanized kecamatan with most of the others still in a low level of urbanization, could be considered as the tertiary peri-urban areas with a more rural character.

Between the two factors, the proximity to the city center could be considered as the primary factors that support the peri-urbanization process in the areas, and the availability of regional road(s) that crossed the kecamatan plays as the second factor that reinforced the primary factor in supporting peri-urbanization in the region. It is indicated by the condition that said not all of kecamatan crossed by regional road(s) could strongly become urbanized kecamatan, even in some kecamatan in the closest category. However, the availability of regional road(s) that crossed the kecamatan brought reinforcement effects to the proximity factor, as most of the crossed kecamatan had a larger proportion of urbanization level than those that are not crossed.

3.3. Paddy fields available in peri-urbanization between 1990 to 2017

Figure 2 shows the changes in available paddy fields in the peri-urban of Tegal Urban Region from 1990 to 2017. It is presented that the areas of paddy fields are not decreasing. The area of paddy fields has been increasing from 1990 to 2017. However, the increase came from the increasing paddy fields in the secondary peri-urban areas. Meanwhile, in the primary and the rural peri-urban areas decreased in a larger decrease in the first area. Most of the decrease was contributed by the decrease in the crossed kecamatan, although the not-crossed kecamatan have larger administrative as well as paddy fields areas in the case of the rural peri-urban areas. These phenomena indicate the availability of regional roads in the kecamatan has also become one of the factors that support paddy field conversion in peri-urban areas of small cities like Tegal City.

Moreover, Figure 3 shows that the decrease of paddy fields, especially in the primary peri-urban areas, was highly contributed by paddy fields with technical irrigation technic, the most valuable paddy fields since their availability of technical irrigation system, as part of public investment to facilitate and support the paddy fields so they can produce three times rice production per year. Most of the decreasing paddy fields were contributed by paddy fields with technical irrigation systems, with some addition from those with half technical irrigation systems as well as those with simple irrigation systems. Meanwhile, most of the increase came from the rain-fed paddy field, which is the lowest quality since they depend on rain for the paddy’s raising, with the main contribution coming from the secondary peri-urban areas. These phenomena show the decreasing paddy fields, especially those with good irrigation systems in the primary peri-urban areas, brought motivations to create some other paddy fields in other places, with and/or without an irrigation system, to substitute the loss. As rice is the main staple for the people in the country, the availability of paddy fields in every region become part of strategic policies for every region. However, the substitution of the loss could not always be implemented in the same quality as the increase was dominantly in the rain-fed paddy fields although the loss was mostly in the irrigated ones. The creation or formation of these paddy fields surely consumed another type of land use outside paddy fields. The identification of the type of land use consumed to create these paddy fields will need continuing research, as this identification is not implemented in this research yet.
Figure 2. Changes of paddy fields in the peri-urban of Tegal Urban Region, 1990 – 2017
Figure 3. Changes of the type paddy fields in the peri-urban of Tegal Urban Region, 1990 – 2017
4. Conclusion
Using the case in Tegal Urban Region, the paper has shown that the extended urbanization and peri-urbanization of small cities in Java has also brought impacts to the availability of paddy fields in the peri-urban areas. Although the peri-urbanization does not bring an impact in decreasing the area of paddy fields, as there were also some responses to create some substitution for the lost paddy fields, the peri-urbanization process consumed irrigated paddy fields in several types, especially for supporting urban growth in the primary peri-urban areas. This paper also indicates that proximity to the urban core is considered the primary factor to the loss of paddy fields in peri-urban areas, which bring intertwined influences together with the availability of regional roads.

Based on this research, therefore urbanization process of small cities in Java should need any particular attention since the process could bring impacts to form an extended urban formation that leads to the consummation of agricultural land, including the best type of paddy fields in the area. Without any better land-use control and management, the later process could lead to the loss of the agricultural land resources that are also needed by urban growth. Therefore, better policies and strategies, which incorporated urbanization and urban growth of small cities into their surrounding regions, will be part of important tools in dealing with the urbanization process in small cities. Without well-integrated policies, the urbanization process will become treats for the agricultural land resources that will increase its influences the climate changes.

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References
[1] Rahayu P and Mardiansjah F H 2019 The Growth and Distribution of Cities in Java, Indonesia Contemporary Urban Life and Development ed A S Permana, P Rahayu and H N Ismail (Surakarta: UNS Press) chapter 1 pp 1-26
[2] Daris E, Aminudin I and Feriansyah A 2018 Determinants of paddy fields conversion in Java Island, Indonesia Advances in Intelligent Systems Research (AYSR) 149
Febrina WD 2017 Determinants of paddy field conversion in Java 1995-2013 Jurnal Bina Praja 9 1–13
Nurwadjedi, Mulyanto B and Suwardi 2009 The Assessment of Rice Field Sustainability in Java base on Regional Spatial Use Planning (RSUP) Jurnal Ilmu Tanah dan Lingkungan 9 80–7
[3] Firman T 2016 The urbanisation of Java, 2000–2010: towards ‘the island of mega-urban regions’ Asian Population Studies 13 50–66
[4] Jones G W 2002 Southeast asian urbanization and the growth of mega-urban regions Journal of Population Research 19 119–36
[5] Mardiansjah F H 2020 Extended urbanization in smaller-sized cities and small town development in Java: the case of the Tegal Region IOP Conf. Series: Earth and Environmental Science 447 012030
[6] Fahmi F Z, Hudalah D, Rahayu P and Woltjer J 2014 Extended urbanization in small and medium-sized cities: The case of Cirebon, Indonesia Habitat International 42 1-10
[7] Qiu T, Song C, Zhang Y, Liu H and Vose JM 2020 Urbanization and climate change jointly shift land surface phenology in the northern mid-latitude larges cities Remote Sensing of Environment 236 111477
Avashia V and Garg A 2020 Implication of land use transitions and climate change on local flooding in urban areas: an assessment of 42 Indian cities Land Use Policy 95 104571
Zhang X Q 2016 The trends, promises and challenges of urbanisation in the world Habitat International 54 241–52
[8] Devi N N, Sridharan B and Kuiry S N 2019 Impact of urban sprawl on future flooding in Chennai city, India *Journal of Hydrology* **574** 486–96

[9] Maheshwari B, Pinto U, Akbar S and Fahey P 2020 Is urbanisation also the culprit of climate change? – Evidence from Australian cities *Urban Climate* **31** 100581

[10] Kataoka K, Matsumoto F, Ichinose T and Taniguchi M 2009 Urban warming trends in several large Asian cities over the last 100 years *Science of The Total Environment* **407** 3112–9

[11] Ginsburg N 1991 Extended metropolitan regions in Asia: A new spatial paradigm *The Extended Metropolis: Settlement Transition in Asia* ed N Ginsburg, B Koppel and T G McGee (Honolulu: University of Hawaii Press) chapter 2 pp 27–46

McGee T G 1991 The Emergence of desakota region in Asia: Expanding a hypothesis *The Extended Metropolis: Settlement Transition in Asia* ed N Ginsburg, B Koppel and TG McGee (Honolulu: University of Hawaii Press) chapter 1 pp 3–26