JSPS Science Fund Basic Research (S) No. 21222003

Project Leader: Yukio Himiyama (Professor, Hokkaido University of Education)

科学研究費基盤研究（S）課題番号 21222003

研究代表者　氷見山幸夫（北海道教育大学教育学部教授）

SLUAS Science Report 2013

Towards Sustainable Land Use in Asia (IV)

アジアにおける持続可能な土地利用の形成に向けて(IV)

Edited by Yukio Himiyama

氷 見 山 幸 夫 編

March 2013

平成 25 年 3 月

Hindustan Plain, India –photograph
taken by Y. Himiyama, November 2012

LUCC Inconsistency Analysis to Spatial Plan and Land Capability (Case Study: Jabodetabek Region)

Ernan Rustiadi[1], La Ode Syamsul Iman[1], Tutuk Lufitayanti[2], Andrea Emma Pravitasari[3]

[1] Center for Regional Systems, Analysis, Planning and Development (Crestpent/P4W-IPB), IPB Baranangsiang Campus, Jl. Pajajaran, Bogor, West Java, Indonesia
[2] Faculty of Agriculture, Bogor Agricultural University (IPB), Indonesia
[3] Graduate School of Global Environmental Studies (GSGES), Kyoto University, Japan

Keywords: Spatial plan inconsistency, land use, spatial planning, land capability, Jabodetabek region

1. Introduction

1.1 Background

Jabodetabek region is the largest and most dynamic metropolitan in Indonesia with high rate demand for settlements and other urban facilities. Spatial pattern in this region is characterized by spatial inconsistencies that occurred between existing land use and spatial plan. This condition generally occurs in urban areas and their surrounding areas. Inconsistencies also occurred between due spatial planning (RTRW) and land capability (as a proxy of carrying capacity). National Law no. 26/2007 mentioned that the national spatial plan should pay attention to the carrying capacity (including supportive and assimilative capacity). This shows that the spatial plan of Jabodetabek should be based on the carrying capacity in which one parameter can be seen from land capability of the region.

The land use which inconsistent with the spatial plan caused some problems, such as land conflict as well as environmental degradation which may impact on the occurrence of anthropogenic disasters (floods, landslides, and so on). The previous research states that there have been land use inconsistencies in Jabodetabek (2001) by 8.50% of the total area (Nurhasanah 2004). There were 10.21% inconsistent actual land use in 2010. This indicates that the land use inconsistency in the spatial planning will continue to rise if allowed to continue. The urban expansion (urban sprawl) and the inconsistency of spatial planning in Jabodetabek have a great consequence against the environment of the region. The tendency of more areas to experience flood and landslides is a significant indication that the growth of this region has exceeded its enviroumental carrying capacity and followed by increased anthropogenic disaster (Rustiadi et al. 2012). Therefore, land use inconsistency analysis is needed to see the actual amount of inconsistencies based on spatial planning. Land capability analysis also should be considered because land use planning should be based on environmental carrying capacity. It requires a significant breakthrough that can improve the controlling system of spatial planning effectively and gear it into a more efficient, productive and competitive Global Megacity.

1.2 Research Objectives

The aims of this study are: (1) to analyze the actual land use of Jabodetabek in 2010, (2) to evaluate inconsistency of actual land use in 2010 towards allotment of land according to the spatial plan of Jabodetabekpunjur Area (based on President Regulation No. 54/2008), (3) to evaluate the actual land use incompatibility in 2010 toward the land capability, and (4) to evaluate the incompatibility of land use according to the Spatial Plan of Jabodetabekpunjur Area (based on President Regulation No.54/2008) toward the land capability.

2. Methodology

Jabodetabek area consists of several administrative regions: DKI Jakarta, Bogor, Depok, Tangerang, and Bekasi. Secondary and primary data were used in this research, including administrative maps, land use maps of Jabodetabek year 2010, soil maps, land system maps, and Spatial Planning map of Jabodetabek and other supporting data. Primary data were obtained from field surveys/ground checks. This study consists of several

stages: (1) preparation and data collection, (2) spatial analysis, (3) field surveys/ground checks, and (4) data analysis. Spatial analysis had done by employing Arc GIS software. Land use map derived digitized the 2010's Landsat imagery. After that, the results were overlaid with the administrative maps in order to obtain land use maps in each regency/municipality. Furthermore, land use maps were overlaid with a Spatial plan map of Jabodetabek and land capability map to obtain land use inconsistencies map and incompatibility map of land capability. Then, inconsistency map and incompatibility map were analyzed descriptively. Field surveys and ground checks conducted in August 2012.

3. Results and Discussion

Based on the analysis results was known that there are 11 types of actual land use/land cover of Jabodetabek in 2010, namely: built up areas, forests, water bodies, ponds, irrigated rice fields, rain-fed rice fields, farmlands, shrubs/ bushes, gardens, swamp/mangrove and grass (Figure 1). The predominant actual land use was irrigated rice fields (169,156.5 hectares or 26.45%) and built up areas (157,728.5 hectares or 24.66%).

Figure 1.

Irrigated rice fields were widely spread in most of the Bekasi Regency (76384.5 hectares or 11.94% of the total area of Jabodetabek), Tangerang Regency (46237.8 hectares or 7.23%), and Bogor Regency (31501.3 hectares or 4.92%), the rest spread evenly throughout the Jabodetabek area with a low proportion. Irrigated rice fields were widely spread in Bekasi and Tangerang since those areas closed in the area known as the rice granary of West Java, like Karawang, Purwakarta, and Cianjur (Agrisantika 2007). In addition, in those regions, especially in Bogor and Bekasi, there are some rivers flows through those areas.

The second largest land use was built up areas which predominantly spread evenly in Jakarta, Bogor Regency and Depok Municipality. Built up areas were the dominant land use spread widely in most of the regencies/ municipalities in Jabodetabek region when compared to other land uses. Total area for built up area in Jabodetabek was 39629.5 hectares (6.20%). The second largest built up area was in the Bogor Regency (34762.1 hectares or 5.43%). The growth of built-up areas were follow the urbanization as well as suburbanization in Jabodetabek region. This trend has been driven by economic expansion such industrial complex and new satellite towns, and it has resulted in extended areas of mixed land use of city peripheries (Rustiadi and Kitamura 1998. Rustiadi *et al.* 1999; Rustiadi and Panuju, 2000; 2002). The expansion of the suburban region tends to happen faster than its real growth as a result of less controlled and disordered urban expansion with a low urban population density (urban sprawl) (Rustiadi et al. 2012)

The use of land should be in accordance with land capability or carrying capacity. "Good and wise land use" requires a plan based on land capability is based on the carrying capacity of the land (Rustiadi et al., 2010). In an effort to apply the principles of sustainable land use planning, the ministry of environment issued guidelines (Ministerial Regulation No. 17 of 2009) for determining the spatial planning based on environmental carrying capacity, based on land capability class adopted from FAO. Land capability classification in this research was classified in 8 classes and many sub-classes. Land capability classification indicates that the higher land capability the higher the usage options and can be used more intensively. Land with high ability can be used for more intensive activities such as residential, industrial and agricultural activities. Instead of land with the low land capability indicates that the land has a lot more physical constraints. Low land capability is preferred as a provider of environmental services, such as the land is used as a conservation or protected forest. There are several parameters used in this analysis: slope (t), soil drainage (w), erosion and erosion sensitivity (e), soil texture and soil depth (s).

Figure 2.

The analysis results obtained land capability class II (the highest land capability) to land capability class VIII (the lowest class) in the Jabodetabek region (Figure 2). The largest land capability class in Jabodetabek area was a class III land with total area 222,937.6 hectares or 34.85% of the total area of Jabodetabek. Class III was almost spread in all regions of Jabodetabek except in Depok Municipality. The second largest area of land capability was the class II which equal to 192,537.6 hectares or 30.10%. Class II of land capability was widely spread throughout the Jabodetabek area except North Jakarta. Class VIII was the group classes with the least amount of area of 2106.6 hectares or 0.33%, were only found in Bogor Regency, especially in Cigudeg District.

Based on a spatial plan map of Jabodetabek (shown in Figure 3), it can be seen that the land use allotment was generally divided into the cultivated area and protected area. Protected areas are divided into protected forests and

conservation forests. Cultivated areas are divided into several land use types, namely wetlands, dense residential housing, medium, and low, and Zone B - 4 and B - 7 which is set for production forest.

Proportion of land use plan for protected areas and cultivated areas are imbalanced. Cultivated areas are much broader than the protected areas which only 8.11% of the total area of Jabodetabek. The largest area where land allotment for the B-1 which is zoned for dense residential housing (urbanized area), trade and services; non-pollutant light-industries and commercial activities (149,704.7 hectares or 23.40%). The second largest allocation was Zone B-4 which were allocated for low-occupancy housing; wet/dry land agriculture (with the appropriate technology), with a total area of 149,074.7 hectares or 23.3 1%). This shows that the largest of land use allocation in Jabodetabek is for settlements.

Vast areas of land uses that were inconsistent with spatial plan is approximately 65286.0 hectares or 10.21% (1.91% of the total area of Jabodetabek) of the total area of Jabodetabek region (Figure 4). There were 34 combinations of land use inconsistencies in Jabodetabek area. The largest inconsistencies occurred in the land allotment of zones B - 4/HP or B-4 which covering 12,208.7 hectares of land. This area was allocated for the permanent production forest area or limited forest production but currently have been dominated by shrubs/bushes. The second largest inconsistency occurred in conservation areas/nature reserve zone (N2) which currently have been dominated by shrubs/bushes (10,830.1 hectares or 1.69%).

The inconsistencies areas were identified in 11,051 polygons where 3,016 polygons on wetland agriculture/ technical irrigation (B-5) which currently have been occupied by settlements. On average, the largest polygons of inconsistencies occurred in the inconsistency case where the B-5 zone (wetland agriculture/ technical irrigation) which currently has been the use of rain-fed rice fields (69.2 hectares) and followed by the land in protected areas (N-1) which currently have been used as irrigated rice fields (29,9 hectares).

The widest inconsistency on the spatial plan in Jabodetabek region occurred in Bogor regency (45,987.5 hectares or 7.19%), and then followed by Bekasi Regency (13,136.3 hectares or 2.05%), and Tangerang Regency (5,927.4 hectares or 0.93%) as seen in Figure 4. This result is in line with previous research which concluded that Bogor, Bekasi and Tangerang Regency were areas that have biggest inconsistencies between land use in 2001 towards the Spatial Plan of Jabodetabek (Nurhasanah 2004). In terms of land allotment, refer to the spatial plan of Jabodetabek, the highest inconsistency occurred in the zone B-4/HP (21,439.8 hectares or 32.84% of the total area of inconsistency), followed by zone N-2 (allocated for conservation area /nature reserve) covering 16,335.8 hectares or 25.02% of the total area of inconsistency. While the largest actual land use that inconsistent with spatial plan is shrubs/bushes (24,514.1 hectares or 37.55% of the total area of inconsistency). However, inconsistencies in shrubs/bushes are not fully considered absolutely inconsistent toward a spatial plan, because the shrubs/bushes can serve as a medium for the conservation land and be able to be converted again into the forests. The second largest inconsistency occurred in the actual land use of settlements (8,789.9 hectares or 13.46% of the total inconsistency).

Figure 3

Figure 4

Land nse/land cover which was in inappropriate with land capability covering 134,874.9 hectares of area in Jabodetabek (21.09%) consisting of 35 combinations of mismatches. (Figure 5). The largest incompatibility area occurred in residential/settlement areas situated in areas with land capability class III which covering 33437.8 hectares or 5.23% where the drainage factor as limited factor.

Figure 5

The largest number of incompatible polygons occurs in settlement areas situated in subclass IIIw with a total of 20,815 polygons. This illustrates that as many as 20,815 locations of settlements were not in accordance with sub-class IIIw. Shrubs/scrub located in sub-class land capability VIIIt emerged as an inconsistent type in the widest area in average (38 hectares) for each location. Based on observations types of inconsistent areas were clearly found in Cigndeg subdistrict, Bogor Regency.

Bogor Regency has the largest mismatches/incompatible land use/cover (71,984.5 hectares or 11.25%) with its spatial plan followed by Bekasi Regency (23,919.7 hectares or 3.74%) and Tangerang Regency (13,832.9 hectares or 2.16% of the area of Jabodetabek).

As shown in Figure 5, more than about 145,600 hectares or 22.8% of land allotment (according to spatial plan) was incompatible to land capability. There were 25 combinations of mismatches between land allotment types in spatial plan and land capability class. The largest incompatibility occurs in zone B-I which allocated for dense residential housing (urban) which located in the class III of land capability. This inconsistency covers more than

42,450 hectares or 6.6% of the total area. The numbers of this discrepancy between land allotment on spatial plan and land capability indicates that the current spatial plan still lack of attention in environmental carrying capacity that urgently should be considered in the regional planning.

Figure 6.

The highest number of incompatible types of land allotment polygons (432 polygons) occur in land capability class IIIw (drainage as limited factor) which were promoted as a B-2 zone. The most dominant incompatible land allotment happens on allocation of dense residential housing, medium, and low. Land capability class III has the largest areas (polygons) allocated in incompatible planed areas (land allotment) to the B-2 zone (medium residential housing) with an average area of 1357.8 hectares for each location in average. The largest inappropriate land allotment in current spatial plan was land allotment for zone B-2 (medium residential housing) which cover almost 72,800 hectare area or about a half of the total area of mismatch/incompatible land allotment and followed by B-1 zone (62,500 hectares) or about 42.9% of the mismatch planned area.

Most of inappropriate land allotment areas were characterized by land with several high limited factors such as high sensitivity to erosion (e), inappropriate soil texture, shallow soil depth (s), or relatively poor drainage (w). Failure in considering these limiting factors in land use planning could potentially increase the potential risk of various anthropogenic disasters, landslides and flooding disasters in particular. Table 1 describes the correlation between some land use/cover types and missallocated (inconsistent) land use of villages (Desa/kelurahan) with landslide disaster in Jabodetabek Region. Villages with higher coverage of forest and dryland agriculture areas tend to have a negative correlatiou with the occurrence of landslide while higher coverage of settlement tends to have a positive correlation with the occurrence of landslide. Inappropriate settlement with land capability and spatial plan tend to have a positive correlation with the occurrence of landslide in the villages.

Table 1. Coefficient of correlation between some land use/cover and missallocated (inconsistent) land use of villages (desa/kelurahan) with landslide disaster in Jabodetabek Region (2010)

No	Variable	Correlation with landslide evidence*
1	Forest (%)	-0, 141
2	Settlement (%)	0, 146
3	Dryland Agriculture (%)	-0, 236
4	Greenery Area (%)	-0, 172
5	Land Capability class III missallocated to Settlement (%)	0, 158
6	Land allotment for B-5 zone missallocated occupied by Settlement (%)	0, 089

Based on the overlay result between actual land use/cover map, spatial plan map and land capability maps, the total of inconsistent areas in Jabodetabek region covers approximately 110,720 hectares or 17.31% of the total area. Land use/land cover which inconsistent with the spatial plan but compatible with land capability was 41,500 hectares or 6.5%. There was about 23,450 hectares land or 3.67% which both not consistent and not appropriate/incompatible to spatial planning and land capability (Figure 7).

Figure 7

4. Conclusions

Actual land use inconsistency of Jabodetabek in 2010 to spatial planning was 65,286.0 hectares or 10.21% of the total area. The largest inconsistency land use with the spatial plan occurred in the B-4/HP zone, while the largest inconsistency land use occurred as shrubs/bushes. Bogor Regency, Bekasi Regency and Tangerang Regency are the area which has largest inconsistency in Jabodetabek.

There was 134,874.9 hectares or 21.09% of the total study area which incompatible to land capability. The largest mismatches/incompatibility occurred on land capability class III which occupied by settlements. There was 145,650 hectares land or 22.8% of land use which not compatible to land capability with the largest discrepancy occurred in land capability class III, while the incompatible land use occurred in the zone B-2 (medium residential housing). The total of inconsistent areas in Jabodetabek region covers approximately 110,720 hectares or 17.31% of the total area. Land use/land cover which inconsistent with the spatial plan but compatible with land capabil-

41,500 hectares or 6.5%. There was about 23,450 hectares land or 3.67% which both not consistent and not appropriate/incompatible to spatial planning and land capability.

The expansion spatial pattern of urbanized areas characterized by an increase in the total area of settlements etc. forestry and agriculture loss and along with its inconsistency with spatial plan and land capability in the region have been becoming a very serious threat to the environment and have positive correlation with landslide disaster in particular.

References

Agrisantika T. (2007) Urban Area and Open Greenery Area Spatial Dynamic Model. Study Case of Jabodetabek (Script). Department of Soil science and Land Resource, Faculty of Agriculture. IPB. Bogor.(in Indonesian).

Nurhasanah. (2004) Consistency of Jabodetabek Region Spatial Plan. [script]. Department of Soil science and Land Resource, Faculty of Agriculture. IPB. Bogor.(in Indonesian).

Presiden Republik Indonesia. 2006. Undang-undang Undang-undang Republik Indonesia Nomor 26 Tahun 2007 Tentang Penataan Ruang. Jakarta: RI.

Rustiadi, E., and Kitamura, T. (1998) Analysis of Land Use Change in City Suburb. A case study on some subdistricts of the Bekasi Area of West Java, Indonesia. *Journal of Rural Planning Association Japan* 17 (1), 20-29.

Rustiadi, E., Mizuno, K., and Kobayashi, S. (1999) Measuring spatial patterns of the sub urbanization process. A case study of Bekasi District, Indonesia. *Journal of Rural Planning Association Japan* 18 (1), 31-41.

Rustiadi, E., and D.R. Panuju. (2000) A Study of Spatial Pattern of Suburbanization Process: A Case Study in Jakarta Suburb. Unpublished paper on Pre-Congress Meeting in Tsukuba, 8 Agustus 2000.

Rustiadi, E. and D.R. Panuju. (2002) A Spatial Pattern of Suburbanization Process: Case Study of Jabotabek Region. *In* Himiyama, Y., M. Hwang and T. Ichinose (Eds). Land Use Change in Comparative Perspectives. Science Publishers, Inc. pp 33-52.

Rustiadi E, B Barus, Prastowo, and L.O.S. Iman. (2010) Preparation of Land Use Evaluation Guidelines. Revision to Annex Revisions of Minister of the environment Regulation No. 17/2009. Center for Regional Systems Analysis, Planning and Development (P4W), Crestpent Press. Bogor Agricultural University (in Indonesian).

Rustiadi, E., D.O. Pribadi, A.E. Pravitasari and T. Agrisantika. (2012) The Dynamics of Population, Economic Hegemony and Land Use/Cover Change of Jabodetabek Region (Jakarta Megacity).