Land use/land cover and land capability data for evaluating land utilization and official land use planning in Indramayu Regency, West Java, Indonesia

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Abstract. Land utilization in Indonesia is regulated in an official spatial land use planning (OSLUP), stipulated by government regulations. However in fact, land utilizations are often develops inconsistent with regulations. OSLUP itself is also not usually compatible with sustainable land utilizations. This study aims to evaluate current land utilizations and OSLUP in Indramayu Regency, West Java. The methodology used is the integrated analysis using land use and land cover (LU/LC) data, land capability data and spatial pattern in OSLUP. Actual LU/LC are interpreted using SPOT-6 imagery of 2014. The spatial data of land capabilities are derived from land capability classification using field data and laboratory analysis. The confrontation between these spatial data is interpreted in terms of future direction for sustainable land use planning. The results shows that Indramayu regency consists of 8 types of LU/LC. Land capability in research area range from class II to VIII. Only a small portion of the land in Indramayu has been used in accordance with land capability, but most of the land is used exceeding its land capability.

1. Introduction
Indonesia is fourth most populated country in the world after China, India and the USA with the population at more than 255 million in 2015 [1,2]. One of the problem related to this high number of population is the imbalance of the population between islands. Actually, a total of 60% of the population stay in Java Island, which have only 6.7 percent of total Indonesian territory [1]. This high density of the population in Java island give high pressure on land due to the need for settlements, industrial sector and other need for human being. As a result, land utilization is often done in the way so as it exceeds its land capability. Land utilization exceeding its land capability will in turn lead to land degradation [3,4]. The existence of cultivation on steep slopes, existence of urban slums as well as dense settlements on river banks is an example of land utilization that exceeds land capability and environmental carrying capacity [5].

In Indonesia, land utilization is actually regulated in a government regulation namely official spatial land use planning (OSLUP), which is regulated in the Act No. 26/2007. In such regulation, land allocation is given for each sector in a spatial pattern, for example land allocation for agriculture, for settlements, for
industry and others. Such regulation is intended to regulate that this limited natural resource can be used for various purposes with sustainable manner, which means minimize land degradation. This spatial pattern of OSLUP is given at any governmental level, i.e. provinces, districts and cities.

Although land has been allocated formally, factually however land utilization break often such regulation [6]. Factually also, the regulations themselves do not guarantee whether the formal allocations are correct from the point of view of land carrying capacity. This is because agencies that allocate such land, give less technical considerations that ensure sustainability. For this reason, it is necessary to review both the existing land utilizations as well as formal allocations in the spatial pattern of OSLUP in order to know whether both land utilizations and land allocations are done in a sustainable way [7, 8].

One way to evaluate existing land utilizations as well as formal land allocations in spatial pattern of OSLUP is using a reference which reflect land potency. In this case, Indonesian Ministry of Environment suggest the use of land capability as parameter control. The rationale is that both the existing land utilization as well as land allocation in OSLUP should be in accordance with land capability in order to use land in sustainable way. Such an evaluation has been done for example study in Tuban Regency, East Java [8] and in West Sulawesi [9]. With such an evaluation, it can be shown that the existing land utilization as well as OSLUP requires improvements in order to be conform with land capability, or in other word, to environmental land carrying capacity.

Based on such background, the research objectives of this paper are: (i) to delineate existing land utilizations (ii) to delineate land capability, and (iii) to evaluate the conformity between existing land utilization and spatial pattern of OSLUP with land capability.

2. Methodology

The study was done in Indramayu Regency, West Java, Indonesia (Figure 1). The regency covers an area of 209,942 ha, and is consisted of 31 districts and 309 villages. Geographically, the regency is located at 107°52'-108°36'E and 06°15'-06°40' S. Indramayu Regency is spread out along the north coast of Java Island and has coastline approximately 147 km. Referring to the climatologic factors, Indramayu Regency is suitable for agriculture. It has a tropical climate with daily air temperature ranges between 27°C to 34°C. The air humidity range from 70 to 80%. The average rainfall is 200.08 mm.month⁻¹ with an average rainy days of 3.25 days per month. Average annual rainfall was 1,428.45 mm with the number of rainy days 75 days. The minimum rainfall of 47 mm occurred in December, while the maximum rainfall of 602.4 mm occurred in February.

In term of physiography, most of the regency is dominated by lowland area with slope less than 8% reach 56% of the area. It has 14 rivers which flows to the Sea of Java. Due to its climate, soil fertility and hydrology, Indramayu regency is one of the rice production center in Indonesia. The altitude of Indramayu Regency range from 0 to 18 m asl., where the lowland area occupies the widest part, ± 90% of the area.

This research was generally divided into 4 steps, which are: (i) establishing actual land utilization by making land use/land cover (LU/LC) map, (ii) analyzing land capability, and (iii) confrontation between land capability, actual land utilization and spatial pattern of OSLUP map (Figure 2). The data applied in this research are satellite remote sensing imagery (SPOT 6), soil map, topographic map, spatial pattern of OSLUP map of Indramayu Regency as well as statistical data and climatology data of study area.

Actual land utilization was derived from remotely sensed satellite imagery SPOT 6 of 2014. SPOT 6 is one of the passive sensor satellite imagery which can be used for mapping LU/LC [10]. The SPOT 6 which was launched on 2012, is an optical imaging satellite, capable for imaging the earth with a resolution of 1.5 meter panchromatic and 6 meter multispectral (blue, green, red, near-IR). SPOT 6 are the ideal solution for national mapping 1:25,000 map series [11]. In this research, SPOT 6 was used for deriving Land Use Land Cover map. Pre-processing has been done to correct the imagery from radiometric and geographic distortion. Image classification was performed by supervised classification. Then the tentative map was validated on
September 2016. All the image processing was done by using ERDAS Imagine software. The Indonesia National Standard [12] classification system was applied in this research for making LU/LC map.

Figure 1. Situation map of the research area of Indramayu Regency, West Java Province, Indonesia.

Land capability evaluation is done, based on analysis in land mapping unit (LMU). For that reason, land mapping unit on a scale of 1: 50,000 was first established. Determination of LMU at 1: 50,000 scale is required for analysis at the regency’s level. The LMU is designated using a slope class map, derived from a 1: 25,000 scale of topographic map of Indonesian Geospatial Information Agency, assisted with the soil map of 1:100,000 and field observation. In the study area there are a total of 35 LMU. At each LMU, the soil samples were taken for land capability analysis [13]. The field work for checking soil morphology and soil sampling was done on September 2016. In this field work, verification of actual land utilizations was also carried out. The soil samples were collected from each LMU from soil depth of 0-25 cm for laboratory analysis, which was conducted in the Laboratory of the Department of Soil Science and Land Resources at Bogor Agricultural University. A total of 58 soil samples were analyzed.

Land capability is an assessment of the land capacity for a general use [14]. This method assessed limiting factor of each LMU. In this research, we use matching method described by [15,13]. The criteria used are given in Table 1. LU/LC which is allowed for each land capability class was presented in Table 2. The land capability class I is very suitable for all land utilizations, while land capability class VIII is only permitted for forest conservation and natural reserve area. Land with land capability class I to IV can be considered as moderate to high class of land capability which can be used for cultivation use, while land with land capability V to VIII can be considered as moderate to low class of capability, where cultivation was not allow, they only can be used as conservation area [15].
Figure 2. Flow chart of the research.

Table 1. Criteria for land capability assessment.

| No. | Land Characteristics | Land Capability Class |
|-----|----------------------|-----------------------|
|     |                      | I   | II  | III | IV  | V   | VI  | VII | VIII |
| 1.  | Soil texture (t)1)   |     |     |     |     |     |     |     |      |
| a.  | Upper layer (40 cm)  | t2/t3| t1/t4| t1/t4| (*) | (*) | (*) | (*) | t5    |
| b.  | Bottom layer        | t2/t4| t1/t4| t1/t4| (*) | (*) | (*) | (*) | t5    |
| 2.  | Slope (%)2)         | i0  | i1  | i2  | i3  | (*) | l4  | i5  | i6    |
| 3.  | Drainage3)          | d0/d1| d2  | d3  | d4  | (**)| (*) | (*) | (*) |
| 4.  | Effective soil depth 4) | k0  | k0  | k1  | k2  | (*) | k3  | (*) | (*) |
| 5.  | Erosion5)           | e0  | e1  | e1  | e2  | (*) | e3  | e4  | (*) |
| 6.  | Gravel/stone6)      | b0  | b0  | b0  | b1  | b2  | (*) | (*) | b3    |
| 7.  | Flooding7)          | 00  | 01  | 02  | 03  | 04  | (*) | (*) | (*) |

Source: [15] (modified); [13]; [6]

Description:

1) Texture: t1: fine; t2: rather fine; t3: medium; t4: rather coarse; t5: coarse;
2) Slope: I0 (0 – 3 %); I1 (3 – 8 %); I2 (8 – 15 %); I3 (15 – 30 %); I4 (30 – 45 %); I5 (45 – 65 %); I6 ( > 65 %);
3) Drainage: D0 (good); D1 (rather good); D2 (rather bad); D3 (bad); D4 (very bad)
4) Effective soil depth: K0 (deep); K1 (moderately deep); K2 (shallow); K3 (very shallow);
5) State of Erosion: e0 (no erosion); e1 (light); e2 (moderate); e3 (heavy); e4 (very heavy).
6) Gravel/Stone: b0: nothing or little; b1: medium; b2: many; b3: very much
7) Flooding: O0: none; O1: rarely; O2: sometimes; O3: Frequently; O4: very frequently.

(*) : It can have any limiting properties of the lower classes
(**) : The ground surface is always inundated
Table 2. Land utilization criteria which are permitted on each land capability class.

| No. | Land Capability Class | Permitted Land Usage |
|-----|-----------------------|----------------------|
| 1   | I                     | All types of land use|
| 2   | II                    | All types of land use, except Via |
| 3   | III                   | All types of land use, except Via dan Ia |
| 4   | IV                    | L,a, all types of grazing and all types of forest |
| 5   | V                     | all types of grazing (Ig, Mg, Ltg), all types of forest |
| 6   | VI                    | Mg, Ltg, all types of forest |
| 7   | VII                   | Ltg, forest |
| 8   | VIII                  | Nature preserve and protected forest |

Sources: [16] (modified), [6]
Description: Via: Very intensive agriculture; Ia: intensive agriculture; Mia: moderate intensive agriculture; La: limited agriculture; Ig: intensive grazing; Mg: moderate grazing; Ltg: limited grazing.

3. Results and Discussions

Result of LU/LC analysis are presented in Figure 3. Based on the LU/LC map, a total of 8 classes of land utilizations have been identified, which were forest, shrub, plantation, built area, rice field, dry land agriculture, ponds and water body. The rice field is the main land utilizations in the study area which is spread out in the middle of the study area. The second main land utilization is pond which is distributed in the north part of the Indramayu Regency, in the coastal area. Built area is the third land utilization and located in along the infrastructure such as road and river. The plantation and forest mostly found in the southern part of study area and in the more highly altitude.

| No. | Land use/ Land cover | Area (ha) | % |
|-----|----------------------|-----------|---|
| 1   | Forest               | 7,919.5   | 3.8 |
| 2   | Built area           | 18,213.8  | 8.8 |
| 3   | Dry Land Farm        | 4,099.2   | 2.0 |
| 4   | Water body           | 1,452.8   | 0.7 |
| 5   | Plantation           | 12,485.4  | 6.0 |
| 6   | Rice field           | 144,429.0 | 69.4 |
| 7   | Shrubs               | 75.0      | 0.0 |
| 8   | Pond                 | 19,333.9  | 9.3 |
|     | **Total**            | **208,008.6** | **100.0** |

Figure 3. Land use/land cover of Indramayu Regency.

Result of land capability analysis is presented in Figure 4a. The study area are composed of 4 classes of land capability, which are class II, class III, class IV and class VIII of land capability. The dominant class of land capability in the study area is land capability class III that is spread out on the mostly rice field and pond as well as settlement. The class III signify that the land that is capable for all land utilizations except for very intensive agriculture and intensive agriculture. The second main class of land capability is class II which is land that capable for many land utilization except for very intensive agriculture. This class of land capability is found in rice field area, forest and plantation of study area. Land capability class IV is found
only on some part of built area. The major limiting factor in land capability classes II to IV are soil texture, drainage, effective depth, slope and erosion. There are few areas that belong to land capability class VIII. The main limiting factor on this class VIII is high erosion, located on very sloping land and rough soil texture.

Figure 4. (a) Land capability map and (b) OSLUP map of Indramayu Regency.

The result of conformity analysis between actual land utilization (LU/LC) and land capability class is given in Figure 5a. In the case of actual land utilization conform to land capability class, such land utilisations can be considered as sustainable. Contrarily, land utilisations which are more intensive than its land capability class permitted will cause land degradation. The result shows that the study area is dominated by state of conditionally conform (yellow color), at more than 90% of the area. The southern part of study area, which are dominated by forest is the area the most conform (green color) between actual land utilization and land capability. There are view area in Indramayu Regency (red color) where land utilization was not conform to its land capability. The conformity between spatial patterns of OSLUP (Figure 4b) with land capability is given in Figure 5b. Although condition is better in term of conformity, but still most of the region belong to conditionally conform to the spatial pattern, using a reference of land capability. Detailed conformity between actual land utilization and spatial pattern of OSLUP with land capability is presented in Table 3.

Figure 5. (a) Conformity between land capability with actual land utilisations, and (b) conformity between land capability with spatial patterns of OSLUP in Indramayu Regency.
Recapitulation of calculations is presented in Table 3 and Table 4. From these tables and figures, it can be seen that on land with high to moderate land capability that can be used for agriculture (that is class I to class IV but in case of Indramayu Regency, only class II until class IV), most of its land utilization is conditionally conform to its land capability. The total area of class II to class IV is 205,311.6 ha or 98.8% of the total area. In this group, land for which its utilizations is conform to land capability is 7,463.6 ha (or only 3.6% of the high to moderate land capability). For land of class II to class IV, its use for agriculture is still possible, but certainly should be given with input to compensate the limiting factor, or in other words, conditionally conform. The land which are classified as a conditionally conform is 197,847.9 ha, or 96.4% of the area of high to moderate land capability.

Table 3. Conformity between land capability, actual land utilizations and spatial pattern in OSLUP of Indramayu Regency.

| LCC 1) | ALU 2) | LC-LU 3) | Area | % 4) | SP 5) | LC-SP 6) | Area | % 4) |
|-------|-------|----------|------|-----|-------|---------|------|-----|
| II    | FOR, SHR | C 7) | 5,858.3 | 2.8 | ENC, PDF, SF | C | 33,860.9 | 16.3 |
|       | DLF, PLT, BA, RF, PND | CC 8) | 78,916.3 | 38.0 | IDT, FSH, PLT, STL, FDC | CC | 50,342.9 | 24.2 |
| III   | FOR, SHR | C | 1,446.5 | 0.7 | ENC, PDF, SF, PFA | C | 34,446.3 | 16.6 |
|       | DLF, PLT, BA, RF, PND | CC | 118,931.6 | 57.2 | IDT, FSH, PLT, STL, FDC | CC | 85,377.4 | 41.1 |
| IV    | FOR | C | 158.8 | 0.1 | PDF, SF | C | 154.4 | 0.1 |
|       | FOR | C | 0.3 | 0.0 | PDF, SF | C | 174.4 | 0.1 |
| VIII  | DLF, PLT, BA, RF, PND | NC | 1,086.0 | 0.5 | IDT, FSH, STL, FDC | NC | 876.9 | 0.4 |
|       | Water Body Not Rated | | 1,358.4 | 0.7 | Water Body Not Rated | | 2,523.0 | 1.2 |

Note:
1)LCC: Land Capability Class;
2)ALU: Actual Land Use; FOR: Forest; DLF: Dryland Farm; PLT: Plantation; BA: Built Area; RF: Rice Field; SHR: Shrub; PND: Pond;
3)LC-LU: Suitability between Land Capability with Actual Land Use
4)Persentage according to land unit
5)SP: Spatial Land Use Plan; PTA: Protected Area; PDF: Production Forest; ENC: Enclave (Production Forest); SCF: Society Forest; FDC: Food Crop; PLT: Plantation; FSH: Fisheries; IDT: Industry; STL: Settlement; RVR: River; LKE: Lake
6)LC-SP: Suitability between Land Capability with Spatial Land Use Plan
7)C: Conform
8)CC: Conditionally Conform
9)NC: Not Conform

In class III of land which is classified as conditionally conform, especially on poorly drained land with slow permeability, drainage improvements are required. Cropping pattern should be chosen ones that can improve soil structure for easy tillage. To prevent puddling and increase soil permeability, it is necessary to add organic matter, in addition to not till the soil in wet condition. Land class IV which is classified as conditionally conform with limiting factor of steep slope, when it is used for seasonal crops, they need a terrace bench or rotation with cover crops, fodder crops or green manure for 3 to 5 years.
Table 4. Recaptitulation of conformity between land capability with current land utilization and spatial pattern in OSLUP.

| No | LCC$^1$ | LC-LU Area$^2$ (ha) | % | LC-SP Area$^3$ (ha) | % |
|----|---------|----------------------|----|----------------------|----|
|    |         |                      |    |                      |    |
| 1. | High until Moderate Capability Land (I-IV) | | | |
|   | C       | 7,463.6              | 3.6| 68,461.6             | 33.5|
|   | CC      | 197,847.9            | 96.4| 135,720.3            | 66.5|
|   | NC      | 0.0                  | 0.0| 0.0                  | 0.0|
|   | Total   | 205,311.6            | 100.0| 204,181.9            | 100.0|
| 2. | Rather low until low Capability Land (V-VIII) | | | |
|   | C       | 0.3                  | 0.0| 174.4                | 0.1|
|   | CC      | 0.0                  | 0.0| 0.0                  | 0.0|
|   | NC      | 1,086.0              | 0.5| 876.9                | 0.4|
|   | Total   | 1,086.3              | 0.5| 1,051.4              | 0.5|
| 3. | All Class (I-VIII) | | | |
|   | C       | 7,463.9              | 3.6| 68,636.0             | 33.0|
|   | CC      | 197,847.9            | 95.2| 135,720.3            | 65.3|
|   | NC      | 1,086.0              | 0.5| 876.9                | 0.4|
|   | Not Rated | 1,358.4              | 0.7| 2,523.0              | 1.2|
|   | Total   | 207,756.3            | 100.0| 207,756.3            | 100.0|

Notice:
$^1$LCC : Land Capability Class
$^2$LC-LU: Conformity between Land Capability with Actual Land Use
$^3$LC-SP: Conformity between Land Capability with Spatial Land Use Plan

Lands that should be managed more carefully are land with slightly low to low land capability, such as land of class V to class VIII, in the case of Indramayu Regency, this is land class VII. The total area of land class V to VIII, or slightly low to low land capability in Indramayu Regency is 1,086.3 ha (or 0.5% of the total area). Although the extent is small, but its use is not conform to the land capability, or it is used with more than its land capability.

The results of conformity analysis between land capability with land allocation in the spatial pattern of OSLUP indicated that land with high to moderate capability (land of class I to class IV, or in the case of Indramayu Regency are class II to class IV), several part (68,461.6 ha or 33.5% of land with high to moderate capability) has been allocated for utilizations in accordance with its capability. Several part of this land, which are 135,720.3 ha (or 66.5% of land with high to moderate capability), the allocation in the spatial pattern of OSLUP exceeds the land capability based carrying capacity, although still in the state of conditionally conform. This indicates that the quality of the OSLUP is rather poor, it is shown by the high amount of the land allocated exceeding land capability in spatial pattern of OSLUP.

Overall results analysis for all Indramayu Regency show that both actual land utilization as well as land allocation in the spatial pattern of OSLUP requires to be improved. In the parts of the area where land allocations in the spatial pattern of OSLUP are still exceeding their carrying capacity, OSLUP should be revised.

4. Conclusion

Indramayu Regency has land with land capability class range from class II to class VII. Most of the land has land capability that can support agricultural land utilization (class I to class IV), but there are some small parts of the region that should not be used for cultivation (class V to class VIII). The limiting factors determining land capability in Indramayu Regency are soil texture, effective depth, drainage, slope, and...
flooding. Actual land utilizations in Indramayu Regency includes forest, shrub, plantation, built area, rice field, dry land agriculture, ponds and water body. The rice field is the main land utilizations in the study area followed by pond and built area. Overall, a small portion of the land in Indramayu has been used in accordance with land capability, but most of the land is used exceeding its land capability.

Spatial pattern of OSLUP in Indramayu Regency allocates most of the land by exceeding land-based carrying capacity. The results of this study indicate that adequate efforts are required for improving land utilizations in the area where actually been used beyond the land capacity. This research can also be used as input for revision of official spatial land use plan on the cycle a 5 year revision in term of allocation of land in the spatial plan in order to more in line with the land carrying capacity. In other word, the land utilization as well as land OSLUP should be improved in term of conformity and consistency with land capability.

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