Analysis of dominant land cover class based on land change cluster pattern in West Java Province

Christopher Imanuel Simanjuntak, Albertus Deliar, Riantini Virtriana
Geodesy and Geomatics Engineering, Bandung Institute of Technology 10 Ganesha Street, 40132 Bandung, Indonesia
e-mail: christopher30simanjuntak@yahoo.com

Abstract. Study of land cover change is important in order to understand the global environmental change. One of the causes of land cover change is human activity in an effort to fulfil their needs, such as agriculture and settlement. In an administrative area, land cover change occurs in several locations and sometimes grouped in adjacent locations. Each location may have different type of land cover change. The understanding of land cover dynamics can be enhanced by identifying the dominant land cover change, which will lead to a better land cover management. By analysing each grouping area, it indicates the pattern and concentration of the type of land cover change, so it can appropriately support the regional management and development strategies. Hence, it is necessary to identify the characteristics of each grouping area so that the characteristics of the class of land cover change can be obtained. The dominant land cover change is identified by analysing the mode of land cover change in each area. The results show that the dominant land cover change in West Java in 2005-2010 are heterogeneous, with the top three broadest classes changes are rice field to field/moor (144,662.76 hectares), forest to fields/moor (36,339.84 hectares), and fields/moor to settlement (36,069.39 hectares). This study managed to identify 99.94% of the grouping areas are the dominant land cover change and 0.06% of the grouping areas are remained the same class. These results are expected to continue the development of land cover change model in West Java.

1. Introduction
There are three components that affect the global environmental change, i.e. the increasing concentration of carbon dioxide in the atmosphere, alteration of the global nitrogen cycle, and land use/land cover change (1). Among these components, land use/land cover change is the most important in understanding the global environmental change (1-4). Therefore, research on land use/land cover change is important in order to design the strategies to overcome sustainable challenges (2, 4, 5).

Land use/land cover change is the result of human activities and impacting the environment, including climate change up to the Earth’s ecosystem (6-8). Land changes that are often used to fulfil the human needs can reduce the portion available for other species and ecosystem functions (9). Their needs of shelters, for example, make forests turn into settlements (10).

Land cover changes are spreading anywhere in a particular area. So, it is necessary to analyse the patterns of the land cover changes. The information of land change patterns can be the basis for supporting the strategies in managing and planning the regional development appropriately (11). Land cover change patterns are not randomly or uniformly distributed, but clustered (9). It is because the land does not develop independently at each location, but affecting nearby and distant locations (12). For example, a research conducted in Bandung area, the result shows that land cover changes in Bandung area are clustered [15]. Based on the former studies (13-17), cluster analysis is able to identify the pattern and concentration of data that being the object of the research, so the stakeholders can plan preventive actions appropriately.
One aspect that needs to be observed from the cluster is the dominant land cover class change. Through this, it can identify the dominant land cover class change partially, not as a whole study area, so that in one study area can be found various dominant class changes occur in several locations. This identification can support smart and sustainable land use management practices. It is also expected to increase the understanding of the land cover dynamics, which can lead to more effective policy making, planning, and implementation by the government. Therefore, a cluster-based analysis of dominant land cover class changes will be conducted in this study.

2. Method

2.1. Data
The data used are land cover of West Java province in 2005 and 2010 in raster format with a 90 meters spatial resolution. These raster data have been classified into eight land cover class, i.e. forests, fields/moors, plantations, settlements, rice fields, bushes/shrubs, rivers/lakes/reservoirs/situ, and fishponds/ponds/swamps. These data can be seen in figure 1 and figure 2 below.

![Figure 1 Raster data of land cover classification of West Java in 2005.](image1)
![Figure 2 Raster data of land cover classification of West Java in 2010.](image2)

2.2. Spatial Cluster
The data is processed by applying spatial cluster analysis to generate land cover change clusters in 2005-2010. The method used is Cluster and Outlier Analysis. This method identifies high clusters (High-High), low clusters (Low-Low), and spatial outliers using Anselin Local Moran’s I statistics. Spatial outliers represent spatial objects whose attribute values (non-spatial) are significantly different from the values in their spatial neighbourhoods. As an illustration, a low value point is surrounded by a neighbour with a high value (Low-High), vice versa (High-Low). In contrast to outliers in general statistics, which indicating extreme values in the data and must be removed from the analysis process, spatial outliers can provide additional information in various applications.

Based on Tobler’s First Law of Geography, “everything is related to everything else, but near things are more related than distant things,” adapted to the study of land cover change, the LH outlier has the possibility to change in the future. Because the central point that has not changed (L) has the potential to be affected by the neighbour that has changed (H). Based on this possibility, a land cover change
cluster in this study consists of HH and LH. A total of 2590 cluster polygons were generated as can be seen in figure 3.

![Figure 3 Land cover change clusters of West Java in 2005-2010.](image)

### 2.3. Identification of Dominant Land Cover Class Change

After obtaining the cluster, the dominant analysis is performed by calculating the mode of land cover change that occurs in each cluster. Mode is the most frequently occurring value in the data set (26). Mode is usually used to determine the level of occurrence of an event.

This stage is performed by overlaying land cover change data and cluster polygons. Then the highest frequency of land cover change is calculated in each cluster. By applying this, the dominant land cover class changes can be identified in each cluster.
3. Result and Discussion
The results of the analysis of dominant land cover class change are shown in table 1.

Table 1. The number of clusters of dominant land cover class changes.

| 2005   | 2010   |
|--------|--------|
| Forests| Fields/Moors | Plantations | Settlements | Rice Fields | Bushes/Shrubs | Rivers/Lakes/Reservoirs/Situ | Fishponds/Ponds/Swamps | Total  |
|        | 1       | 67        | 2           | 0           | 6           | 12                      | 0                      | 88     |
| Fields/Moors | 269    | 7         | 57          | 224         | 182         | 20                      | 3                      | 762    |
| Plantations | 6       | 36        | 0           | 1           | 3           | 4                       | 0                      | 50     |
| Settlements | 15      | 761       | 6           | 6           | 192         | 3                       | 2                      | 6991   |
| Rice Fields | 51      | 199       | 22          | 366         | 2           | 0                       | 1                      | 13     | 654    |
| Bushes/Shrubs | 13     | 1         | 0           | 0           | 0           | 0                       | 0                      | 0      | 14     |
| Rivers/Lakes/Reservoirs/Situ | 0      | 1         | 0           | 3           | 0           | 0                       | 1                      | 0      | 5      |
| Fishponds/Ponds/Swamps | 2       | 15        | 0           | 0           | 9           | 0                       | 0                      | 0      | 26     |
| Total       | 357     | 1087      | 87          | 600         | 394         | 39                      | 7                      | 19     | 2590   |

It can be identified that the most dominant land cover class changes occurring in West Java are fields/moors turn into settlements (761 clusters), followed by settlements to rice fields (366 clusters), forests to fields/moors (269 clusters), settlements to fields/moors (224 clusters), and so on. There are 2573 polygon clusters (99.34%) which are the dominant clusters that encounter land cover change. These results are not enough to show the success of this study since each cluster polygon does not have the same size. Therefore, it is necessary to calculate the total area of each cluster and the results are shown in table 2 below.
Table 2. The area (hectares) of dominant land cover class changes.

| 2005          | 2010      |        |        |        |        |        |        |        |        |
|---------------|-----------|--------|--------|--------|--------|--------|--------|--------|--------|
|               | Forests   | Fields/| Plantations | Settlements | Rice Fields | Bushes/ | Rivers/ | Fishponds/ |
|               |           | Moors       |                |               |            | Shrubs | Lakes/ | Ponds/ |
|               |           |            |                |               |            |        | Reservoirs/ | Swamps | Total   |
| Forests       | 0,81      | 5.222,07    | 2.151,36      | 0              | 134,46     | 3.960,09| 0        | 0        | 11.468,79|
| Fields/Moors  | 36.339,84 | 193,59     | 23.748,39     | 6.185,16       | 144.662,76 | 30.470,58| 3,24     | 0        | 241.603,56|
| Plantations   | 914,49    | 8.509,86   | 0             | 2,43           | 14,58      | 7.099,65| 0        | 0        | 16.541,01|
| Settlements   | 296,46    | 36.069,30  | 1.788,48      | 6,48           | 14.929,11  | 300,51  | 4,05     | 58,32    | 53.452,71|
| Rice Fields   | 1.980,45  | 25.487,46  | 1.450,71      | 2.161,89       | 1,62       | 0       | 64,80    | 63,99    | 31.210,92|
| Bushes/Shrubs | 1.423,98  | 370,98     | 0             | 0              | 0          | 0       | 0        | 0        | 1.794,96|
| Rivers/Lakes/ | 0         | 0,81       | 0             | 7,29           | 0          | 0       | 0,81     | 0        | 8,91    |
| Reservoirs/   |           |            |               |                |            |        |         |          |         |
| Situ          |           |            |               |                |            |        |         |          |         |
| Fishponds/    | 83,43     | 306,18     | 0             | 0              | 484,38     | 0       | 0        | 0        | 873,99  |
| Ponds/        |           |            |               |                |            |        |         |          |         |
| Swamps        |           |            |               |                |            |        |         |          |         |
| Total         | 41.093,46 | 76.160,25  | 29.138,94     | 8.363,25       | 160.226,91 | 41.830,83| 72,90    | 122,31   | 356,954,85|

The total area of the dominant clusters that encounter land cover change is 356,751.54 hectares. The proportion of this against the total cluster area is 99.94%. These results indicate that this study successfully identified the dominant changes by 99.94%. It can also be identified that the broadest dominant land cover class changes are rice fields turn into fields/moors (144,662,76 ha), followed by forests to fields/moors (36,339,84 ha), fields/moors to settlements (36,069,30 ha), bushes/shrubs to fields/moors (30,470,58 ha), and so on.

Based on Table 1 and Table 2, it can be inferred that the most frequent dominant land cover change is fields/moors to settlements and the broadest is rice fields to fields/moors. Both are shown in Figure 4 and Figure 5.
Figure 4 Clusters of changes from fields/moors to settlements.  
Figure 5 Clusters of changes from rice fields to fields/moors.

Through these examples, it indicates that the number of clusters is not comparable to the size of clusters. The number of clusters of change from fields/moors to settlements is 761 clusters but only cover 36,069.30 ha, whereas, clusters of change from rice fields to fields/moors which have an area of 144,662.76 ha only forming 182 clusters. Average area per cluster from fields/moors to settlements is 47.40 ha/cluster, while rice fields to fields/moors is 794.85 ha/cluster. These numbers coupled with the visualization in figure 4 and figure 5, it can be stated that the change of fields/moors to settlements is the most because they are divided into small-sized clusters, while rice fields to fields/moors clusters is divided into a bigger size.

Another thing to note is the change that dominant turn into settlements, since West Java’s population growth is among the highest in Indonesia. Table 2 shows that land cover that turn into settlements is 53,452.71 ha in 2005-2010. Meanwhile, based on BPS data, in 2005, West Java’s population was 39,960,869 people, while in 2010 it was 45,053,732 people. Thus, there was a population growth of 5,092,863 people during this period. This indicates that there is a growing need for settlements along with population growth. If calculated, there is a growing need of 95.28 people/ha in 2005-2010.

4. Conclusion
Based on the result of the analysis, it can be concluded that:

1. Overall, the dominant land cover change in each cluster in West Java is heterogeneous, with the three broadest class changes are rice fields turn into fields/moors (144,662.76 ha), forests to fields/moors (36,339.84 ha), and fields/moors to settlements (36,069.30 ha).
2. Based on the total area of the clusters of land cover class changes in West Java in 2005-2010, this analysis managed to identify 99.94% of the dominant land cover class change and 0.06% are remained the same class.

5. Acknowledgments
The authors would like to thank the ITB Research and Innovation Program 2019.
6. References

[1] Vitousek PM. Beyond global warming: ecology and global change. Ecology. 1994;75(7):1861-76.
[2] Chen J, Gong P, He C, Pu R, Shi P. Land-use/land-cover change detection using improved change-vector analysis. Photogrammetric Engineering & Remote Sensing. 2003;69(4):369-79.
[3] Fang S, Gertner GZ, Anderson AB. Prediction of multinomial probability of land use change using a bisection decomposition and logistic regression. Landscape ecology. 2007;22(3):419-30.
[4] Meyfroidt P, Chowdhury RR, de Bremond A, Ellis E, Erb K-H, Filatova T, et al. Middle-range theories of land system change. Global environmental change. 2018;53:52-67.
[5] Ali M, Hadi S, Sulistiantara B. Study on land cover change of Ciliwung downstream watershed with spatial dynamic approach. Procedia-Social and Behavioral Sciences. 2016;227:52-9.
[6] Lambin EF, Turner BL, Geist HJ, Agbola SB, Angelsen A, Bruce JW, et al. The causes of land-use and land-cover change: moving beyond the myths. Global environmental change. 2001;11(4):261-9.
[7] Foley JA, DeFries R, Asner GP, Barford C, Bonan G, Carpenter SR, et al. Global consequences of land use. science. 2005;309(5734):570-4.
[8] Mendoza-Ponce A, Corona-Nuñez R, Kraxner F, Leduc S, Patrizio P. Identifying effects of land use cover changes and climate change on terrestrial ecosystems and carbon stocks in Mexico. Global environmental change. 2018;53:12-23.
[9] Lambin EF, Geist HJ. Land-use and land-cover change: local processes and global impacts: Springer Science & Business Media; 2008.
[10] Solaimani K, Arekhi M, Tamartsch R, Miryaghobzadeh M. Land use/cover change detection based on remote sensing data (A case study; Neka Basin). Agric Biol JN Am. 2010;1(6):1148-57.
[11] Singh P, Singh S. Landuse Pattern Analysis Using Remote Sensing: A Case Study of Mau District, India”. Archives of Applied Science Research. 2011;3(5):10-6.
[12] Verburg PH, van Eck JRR, de Nijs TC, Dijst MJ, Schot P. Determinants of land-use change patterns in the Netherlands. Environment and Planning B: Planning and Design. 2004;31(1):125-50.
[13] Jiwa M, Gudes O, Varhol R, Mullan N. Impact of geography on the control of type 2 diabetes mellitus: a review of geocoded clinical data from general practice. BMJ open. 2015;5(12):e009504.
[14] Biswas P, Chatterjee ND. Spatial Distributional Pattern of Ewe-Teasing in Urban Area; Mapping for Security, Safety and Prevention-A Case Study of Asansol Municipal Area, West Bengal, India.
[15] Khan D, Rossen LM, Hamilton BE, He Y, Wei R, Dienes E. Hot spots, cluster detection and spatial outlier analysis of teen birth rates in the US, 2003–2012. Spatial and spatio-temporal epidemiology. 2017;21:67-75.
[16] Sibagariang TN, Deliar A and Virtriana R 2018 The 39th Asian Conference on Remote Sensing 2018 I 10–16
[17] Ghalhari GF, Roudbari AD. An investigation on thermal patterns in Iran based on spatial autocorrelation. Theoretical and applied climatology. 2018;131(3-4):865-76.
[18] Liu G-X, Wu M, Jia F-R, Yue Q, Wang H-M. Material flow analysis and spatial pattern analysis of petroleum products consumption and petroleum-related CO2 emissions in China during 1995–2017. Journal of cleaner production. 2019;209:40-52.
[19] Dimobe K, Kouakou J, Tondoh J, Zoungnana B, Forkuor G, Ouédraogo K. Predicting the Potential Impact of Climate Change on Carbon Stock in Semi-Arid West African Savannas. Land. 2018;7(4):124.
[20] Anselin L. Local indicators of spatial association—LISA. Geographical analysis. 1995;27(2):93-115.
[21] Anselin L, Syabri I, Kho Y. GeoDa: An Introduction to Spatial Data Analysis. In: M F, A G, editors. Handbook of Applied Spatial Analysis: Springer, Berlin, Heidelberg; 2010.
[22] Scott LM, Janikas MV. Spatial statistics in ArcGIS. Handbook of applied spatial analysis: Springer; 2010. p. 27-41.

[23] Shekhar S, Lu C-T, Zhang P. A unified approach to detecting spatial outliers. GeoInformatica. 2003;7(2):139-66.

[23] Shi M, Yin R and Lv H 2017*Forest Policy and Economics* 78 200–209

[24] Liu X, Lu C-T, Chen F, editors. Spatial outlier detection: Random walk based approaches. Proceedings of the 18th SIGSPATIAL International Conference on Advances in Geographic Information Systems; 2010: ACM.

[25] Tobler WR. A computer movie simulating urban growth in the Detroit region. Economic geography. 1970;46(sup1):234-40.

[26] Clark-Carter D. Measures of central tendency. 2010.