Land resource availability and climate change disasters in the rural coastal of Central Java – Indonesia

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Abstract. This paper describes the land resource availability and climate change disaster events in three rural coastal area of the Central Java Province, Indonesia, i.e.; Wonokerto sub district – Pemalong Regency, Sayung sub district – Demak Regency, and Lasem sub district – Rembang Regency. Land resource availability was assessed into land use cover change from the Landsat Image from three periods (1990, 2000, and 2015). Those images data then were combined with the climate change disasters that mostly occurs in the coastal area as the impact of the sea level rise. The results show that most of the land use in the coastal area was converted to fishpond from agricultural land and it happens periodically since 1990 as the disasters frequently found which also transform the occupation of community living in the area. From the assessment, it is also shown that the increasing of water body in specific period has a direct impact to the decreasing of rice field. This indicated that tidal flood as an impact of climate change has contributed in changing the availability of land resource in the study area.

Keywords: land resource, land use cover, climate change disaster

1. Introduction
The availability of land resources is a prerequisite for a sustainable livelihood in rural area since most people is very much depend on the agricultural activities. Agriculture has played an important role in the development of human civilization and it is the most important sector for considerable changes towards a sustainable resources balance in the future. The exploitation of the resources is considered as a key to solve the problem of food while the availability and quality of resources are closely linked to the economic efficiency of resources that directly effecting living standards of the people [1]. Efficient management and the availability of land resources are most important factors for socioeconomic development in rural area including coastal area [2]. Research on socioeconomic development in rural area were mostly found that rural land resource has been degraded periodically due to the extensive utilization and exploitation [3, 4, 5]. Therefore, rural people has always tried to find the way to improve and to sustain their land resource as the main resource in family’s livelihood.

Farmland as the main resource for the agricultural productivity should be considered from the shortage and hence its existence need to be preserved and conserved. According to Knaap and Chakraborty, farmland preservation and conservation have a subtle meaning where preservation is to maintain the farmland while to conserve means to use sparingly [6]. However, to preserve and to conserve farmland are depend on the actual condition of the environment as well as the policy from...
the related authorities. Sometimes, and mostly occurs in coastal area, the sustainability of farmland is threatened due to the impact of climate change disasters such as tidal flood from the sea level rise. Disasters have become the biggest threat to the livelihood of coastal communities and the sustainability of their socio-economy activities in many coastal areas [7, 8]. For long term activities, climate change phenomena will certainly be devastatingly negative and the impact is varied in regional and local scale [9]. As for example, most of the rural coastal area in Demak Regency, Central Java Province has been experiencing with climate change disaster such as flood and tidal flood where forced the farmer to convert their farms and into fishponds to continue their livelihood [2, 10].

2. Data and Method

2.1. Study Area
Coastal areas are more prone to climate change effects thus the three rural coastal areas in northern Central Java Province were chosen as the main focus of this research. The study areas were Wonokerto sub district in Pekalongan Regency, Sayung sub district in Demak Regency, and Lasem sub district in Rembang Regency. They were justified as study areas because of their history on climate change disasters. Tidal flood, flood, and drought were some of frequent events on those areas which also contributed to the change of land resource utilization there.

![Figure 1. Location of Study Areas.](image)

2.2. Data Needs
Primary data used in this research was satellite image data produced from remote sensing. It served to identify the availability of land resource and to analyse its availability in the study areas. A time series of landsat image data (1990, 2000, and 2015) was applied to provide information on land use cover in study areas. As for identifying climate change disaster events in the study area, report of disaster events was gathered from PODES data (village potential data; the formal-secondary data provided by village office and Central Bureau of Statistics). As this research aimed to show kind of climate change disasters within the study area, the data on flood and tidal flood events in 2010 were used.
2.3. Method

Each satellite image used for this research was projected into a map to be able to be processed and analysed. To distinguish different types or classifications of land resource, image interpretation had to be done. A visual on-screen interpretation was selected as the technique to acquire information on landsat images into land use-cover maps. This technique was applied to extract available information in landsat images by a visual analysis through image interpretation. In applying this interpretation technique, a cross-check on past studies done in the area as well as local news and statistical data were conducted prior to as well as during the interpretation process. Statistical data on climate change disaster events are quantitatively described to show the amount and distribution of the events in each study area. Results from the analysis of climate change disaster event distribution was then combined with classification of land use-cover derived from image interpretation. This process would give us information on the change in land resource availability and its relationship with climate change disaster events in the study areas.

3. Results and Discussion

3.1. Land Use-Cover in Rural Coastal Area of Central Java

The dynamics of land use-cover change in rural coastal area has a tendency to be the result of human and environment interaction which mostly related to the socio economic activity [11]. In this first study area, Wonokerto sub district in Pekalongan Regency, the image interpretation showed a very significant increase of fishpond on the northern part near the shoreline (Figure 2). The fishpond has also contributed to the increasing of the waterbody which both could be seen reaching the settlement area on the middle of the sub district. The settlement area has also seen a rise as it grew more apparent from 1990 to 2015 to the south and southwest sides of Wonokerto. Farm field area was also seen growing in accordance to the movement of settlement area.

![Figure 2. Land Use-Cover of Wonokerto Sub District (Periods: 1990, 2000, 2015).](image)

As shown in Table 1, the change of land use-cover area was detailed into each type. Over the course of 25 years, the most significant increase in term of area was fishpond (199.21 ha) and settlement area (102.53 ha) which both reached more than 30% increase. Meanwhile, at the same period from 1990 to 2015, rice field and moor areas were decreased for more than 256 ha (30%) and 100 ha (53%) respectively. The increasing of fishpond and the development of more settlement area
largely caused the decreasing of rice field area and moor area because of sea level rise as well as land conversion. The decrease of those areas however followed by the increase of farm field area which reached 39%. Although it was not big in term of area, this could indicate the shift of farm-based activity in Wonokerto.

Table 1. Land Use-Cover Change of Wonokerto Sub District in Three Different Periods.

| No | Land Use Cover          | Area [Ha]              | Land Use Cover Change               |
|----|-------------------------|------------------------|-------------------------------------|
|    | Year 1990 | Year 2000 | Year 2015 | Area [Ha] | [%]     |
| 1  | Waterbody       | 66,01     | 62,85     | 87,96     | 21,96   | 33%     |
| 2  | Fishponds       | 641,3     | 671,49    | 840,51    | 199,21  | 31%     |
| 3  | Building        | -         | -         | 1,25      | 1,25    | 100%    |
| 4  | Farm field      | 25,84     | 17,35     | 35,82     | 9,97    | 39%     |
| 5  | Settlement      | 330,79    | 369,07    | 433,32    | 102,53  | 31%     |
| 6  | Grass           | 1,47      | 5,51      | 6,43      | 4,96    | 337%    |
| 7  | Rice fields     | 863,91    | 769,87    | 607,28    | -256,63 | -30%    |
| 8  | Rain-fed rice field | -  | 20,18    | 16,85    | -3,33   | -16%    |
| 9  | Moor            | 187,68    | 200,68    | 87,58     | -100,1  | -53%    |

One of the major causes of land use-cover change in rural coastal area is the increasing of sea level rise as the impact of climate change phenomenon. Land use-cover change in Sayung sub district area was found very significant from 1990 until 2015 where most of rice fields near shoreline were converted into fishponds. Land use change was also identified to grow rapidly into industrial and settlement area from 1990 until 2015. It was especially apparent along the main road of the sub district (Figure 3). As Sayung is also a part of northern Java road network and directly bordered with Semarang City, this area is growing faster than other areas in Demak Regency. From data compilation of land use in Sayung sub district, most of land use cover was changed in term of use and the area. Among those land uses; fishpond, settlement, industrial area, rice field, and waterbody have shown a significant change. The increasing of industrial land use was formed from farm field, settlement, and rice field. Meanwhile, settlement area was improved from the changing of bush, grass, farm field, and rice field. And the waterbody has grown from the shift of fishpond and rice field.

Figure 3. Land Use-Cover of Sayung Sub District (Periods: 1990, 2000, 2015).
Table 2 showed a detailed dynamic of land use cover change on the total area of each land use in 1990, 2000, and 2015. Most of the land in Sayung sub district was dominated by rice field followed by fishpond and settlement area. Rice field and settlement area have increased for about 6% from 1990 to 2015 while fishpond area decreased up 38% during the same period. Concerning the climate change issue, this area was also experiencing sea level rise which was shown by the increased of waterbody area from 150 ha in 1990 into 379.86 ha in 2015 or equal to 153%. The industrial area also showed a huge surge of 387% over the course of 25 years.

Table 2. Land Use-Cover Change of Sayung Sub District in Three Different Periods.

| No | Land Use Cover         | Area [Ha] | Year 1990 | Year 2000 | Year 2015 | Land Use Cover Change |
|----|------------------------|-----------|-----------|-----------|-----------|-----------------------|
| 1  | Bush                   | 12.85     | 12.85     | 6.62      | -6.23     | -48%                  |
| 2  | Fishpond               | 1,940.28  | 2,073.77  | 1,206.41  | -733.87   | -38%                  |
| 3  | Swamp forest           | 0.7       | 0.7       | 24.6      | 23.91     | 3432%                 |
| 4  | Industry               | 48.39     | 75.33     | 235.56    | 187.16    | 387%                  |
| 5  | Farm fields            | 447.31    | 428.5     | 402.29    | -45.02    | -10%                  |
| 6  | Settlement             | 1,064.92  | 1,077.26  | 1,132.36  | 67.44     | 6%                    |
| 7  | Swamp                  | 24.54     | 24.54     | 16.28     | -8.26     | -34%                  |
| 8  | Grass                  | 26.7      | 29.57     | 16.44     | -10.26    | -38%                  |
| 9  | Rice fields            | 4,766.57  | 4,607.92  | 5,061.97  | 295.39    | 6%                    |
| 10 | Rain-fed rice fields   | 128.23    | 128.23    | 128.23    | 0         | 0%                    |
| 11 | Waterbody              | 150.14    | 151.96    | 379.86    | 229.73    | 153%                  |

In the third study area on the eastern side of Central Java, Lasem sub district in Rembang Regency has gained the most significant increase of settlement area and followed by fishpond as well as farm field area. The rain-fed rice field suffered from decreasing as it could be seen that most of the area was turned to settlement. Similar cause might be affecting the change in moor area as it also could be seen that settlement area were growing into the moor area. On the other hand, the forest area seemed to be conserved well as it did not show significant decrease. Unlike the first two study areas which both showed an increase of waterbody, Lasem had the opposite condition.

Figure 4. Land Use-Cover of Lasem Sub District (Periods: 1990, 2000, 2015).
The amount of decrease and increase area of land use cover in Lasem could be closely monitored in Table 3. Settlement area increased 290,79 ha from 1990 to 2015 or equal to 88%. This conversion mainly came from rain-fed rice field area which still dominated the total area of Lasem although it showed a decrease of 309,97 ha (21%). The decrease of 117,42 ha of moor area also contributed to the increase of settlement area as it can be seen in the map of 2015 of Figure 4. With the decrease of waterbody by 5,93 ha and the increase of fishpond by 69,96 ha, it was still hard to see how climate change affecting the rural coastal area in Lasem. However, the significant increase of farm field area by 66,81 ha which grew near settlement area could suggest that the rural community still likely depend their livelihood on farm-based activities.

Table 3. Land Use-Cover Change of Lasem Sub District in Three Different Periods.

| No | Land Use Cover          | Area [Ha] | Year 1990 | Year 2000 | Year 2015 | Area [Ha] | Land Use Cover Change |
|----|-------------------------|-----------|-----------|-----------|-----------|-----------|-----------------------|
| 1  | Waterbody               | 34.08     | 21.37     | 28.14     | -5.93     | -17%      |                       |
| 2  | Bush                    | 10.61     | 14.09     | 14.09     | 3.48      | 33%       |                       |
| 3  | Fishpond                | 409.78    | 477.79    | 479.74    | 69.96     | 17%       |                       |
| 4  | Forest                  | 263.2     | 258.05    | 258.05    | -5.15     | -2%       |                       |
| 5  | Farm fields             | 55.44     | 64.71     | 122.25    | 66.81     | 121%      |                       |
| 6  | Settlement              | 329.58    | 404.74    | 620.37    | 290.79    | 88%       |                       |
| 7  | Grass                   | 4.93      | 43.04     | 12.37     | 7.44      | 151%      |                       |
| 8  | Rain-fed rice field     | 1.443.33  | 1.225.04  | 1.133.36  | -309.97   | -21%      |                       |
| 9  | Moor                    | 1.887.23  | 1.929.35  | 1.769.81  | -117.42   | -6%       |                       |

3.2. Climate Change Disaster Events

Climate change has various impact on human activities. Drought will significantly influence agricultural activities [12]. Tidal flood is very likely to influence people working on fishery sectors. Flood will lead to a broader impact, both physical impact on infrastructure and also socio-economic impact on people daily activities. Flood is also regarded as the most frequent natural disaster in Asia including in Indonesia [13, 14, 15]. According to PODES data, drought was not found in the study areas of this research as most of the drought along the northern side of Central Java happened toward the more inner area of the region. Climate change disaster events that occurred were flood and tidal flood (Table 4). In 2010, Wonokerto faced 5 events of flood and 4 events of tidal flood. Sayung which has a larger area experienced 3 flood events and 6 tidal flood events. Lastly, unlike the two previous study areas, Lasem had seen more flood events than tidal flood. It experienced 6 flood events while there was only a single event of tidal flood.

Table 4. Climate Change Disaster Events in Study Areas.

| Sub District | Climate Change Disaster Events |
|--------------|-------------------------------|
|              | Flood | Tidal flood |
| Wonokerto    | 5     | 4           |
| Sayung       | 3     | 6           |
| Lasem        | 6     | 1           |

Source: [16]

3.3. Change in Land Resource Availability and Climate Change Disaster Events

Land use-cover analysis showed that there were some changes on the availability of some types of land resources in all three study areas. In Wonokerto and Sayung where an increase of waterbody was seen, tidal flood events were also occurred more. This pattern was followed by the decreasing of rice fields. This indicated that tidal flood as an impact of climate change has contributed in changing the availability of land resource in the study area. In Sayung, not only that the settlement area increased significantly, the industrial area also grew fast in the heart of the sub district. These conditions
answered why land conversion happened from other land use-covers to provide more development to the community. People in the community will need to readjust their activity pattern and type of livelihood while there is other possibility to the exposure to more flood as catchment areas decrease and follows with the raise of the built areas especially into the industrial one.

The land use-cover change in Sayung showed the sub district vulnerability to coastal disaster as well as to unsustainable rural livelihood. Past research in Demak Regency supported this finding as according to socio-economic measures as well as the occurrence of climate change disaster events, most villages in coastal areas of Sayung sub district was categorized as most vulnerable. Villages that fell into this category were mostly those exposed by tidal flood or both tidal flood and flood with around 24% to 48% of its people were working in farming and fishery [10]. It can be said that those whose livelihood depended on the availability of land resource affected directly by the climate change disaster events. With the uncertainty that may come from change in land resource availability and possible disaster events in the future, the livelihood of the people in Sayung sub district could further be in a vulnerable state if they do not start to develop resilience as a community.

Meanwhile, the settlement area in Wonokerto that tended to move to south and southwest parts of the sub district, away from the increasing amount of waterbody and fishpond on the northern part, showed that the community tried to settle in the safer areas which are less exposed to climate change impacts such as tidal flood. Lasem on the other hand had showed an opposite trend compared to the other study areas. The decreasing of its waterbody area and its single event of tidal flood showed that the climate change impact happened in coastal area of the sub district was not as severed as Wonokerto and Sayung. This was proved by the growing of some settlement areas near waterbody and fishpond areas in northern part of Lasem.

![Figure 5. Socio-Economic Vulnerability in Coastal Area of Sayung Sub District](image)
4. Conclusion
The availability of land resource in three study areas through the land use cover change analysis had shown a significant relation to the climate change disasters where the disaster has posed the local community to be adapted to the environment. Most of the agricultural land where previously utilised as the paddy field and other commodities was converted into fishpond as the reaction of local people to keep the livelihood. Since they do not have other alternatives in terms of occupation and source of income, people tend to accept the condition with their limitation. Climate change disasters in the rural coastal area has also been the major factor for the local people to make other decision on how their livelihood should be sustained. This is very possible since human being is the centre as the decision maker in the rural livelihood system.

5. References
[1] Doppler, W. (2006) Resources and livelihood in mountain areas of South East Asia: farming and rural systems in a changing environment. Weikersheim: Margraf Publisher.
[2] Rudiarto, I. (2009) ‘Sustainable land use concept in mountain area of Java, Indonesia.’, in Proceedings of the international DAAD alumni summer school, pp. 1–29.
[3] Bhatta, G. D. (2010) Socio-economic and spatial assessment of smallholder peri-urban farming in the middle mountains of Nepal. Margraf Publisher.
[4] Doppler, W. and Bahadur, K. C. K. (2013) ‘Impact of Natural Resources and Infrastructure on Future Livelihood in Mountain Farming in the Himalaya Region’, in The Future of Mountain Agriculture. Springer Berlin Heidelberg, pp. 145–170.
[5] Rudiarto, I. and Doppler, W. (2013) ‘Impact of land use change in accelerating soil erosion in Indonesian upland area: a case of Dieng Plateau, Central Java-Indonesia’, International Journal of AgriScience, 3(No. 7), pp. 558–576. Available at: http://www.inacj.com/attachments/section/17/Temp July 2013-827 Rudiarto and Doppler F P 2 (558-576).pdf.
[6] Knaap, G.-J. and Chakraborty, A. (2007) ‘Comprehensive planning for sustainable rural development’, Journal of Regional Analysis and Policy, 37(1), pp. 18–20. Available at: http://purl.umn.edu/132972.
[7] Fakhruddin, S. H. M. and Rahman, J. (2014) ‘Coping with coastal risk and vulnerabilities in Bangladesh’, International Journal of Disaster Risk Reduction, 12, pp. 112–118. doi: 10.1016/j.ijdrr.2014.12.008.
[8] Nanlohy, H., Bambang, A. N., Ambariyanto and Hutabarat, S. (2015) ‘Coastal Communities Knowledge Level on Climate Change as a Consideration in Mangrove Ecosystems Management in the Kotania Bay, West Seram Regency’, Procedia Environmental Sciences, 23, pp. 157–163. doi: 10.1016/j.proenv.2015.01.024.
[9] Pinto, R. and Martins, F. C. (2013) ‘The Portuguese National Strategy for Integrated Coastal Zone Management as a spatial planning instrument to climate change adaptation in the Minho River Estuary (Portugal NW-Coastal Zone)’, Environmental Science and Policy, 33, pp. 76–96. doi: 10.1016/j.envsci.2013.04.005.
[10] Rudiarto, I., Pamungkas, D., Hajar, A. and Adam, K. (2016) ‘Kerentanan Sosio-Ekonomi terhadap Paparan Bencana Banjir dan Rob di Pedesaan Pesisir Kabupaten Demak’, Jurnal Wilayah dan Lingkungan, 4(3), pp. 153–170. doi: 10.14710/jwl.4.3.153-170.
[11] Rudiarto, I., Handayani, W., Wijaya, H. B. and Pangi (2016) ‘Assessment of Land Use-Cover Change in Rural Landscapes in Central Java, Indonesia’, in The 3rd International Conference on Regional Development Enhancing Resilience: Bridging Knowledge and Policy for Cities and Regions. Biro Penerbit Planologi UNDIP, pp. 41–49.
[12] Bhatta, G. D., Aggarwal, P. K., Shrivastava, A. K. and Sproule, L. (2015) ‘Is rainfall gradient a factor of livelihood diversification? Empirical evidence from around climatic hotspots in Indo-Gangetic Plains’, Environment, Development and Sustainability, 18(6), pp. 1657–1678. doi: 10.1007/s10668-015-9710-6.
[13] Marfai, M. A., King, L., Singh, L. P., Mardiatno, D., Sartohadi, J., Hadmoko, D. S. and Dewi, A. (2008) ‘Natural hazards in Central Java Province, Indonesia: an overview’, Environmental Geology, 56(2), pp. 335–351.

[14] Chandrappa, R., Gupta, S. and Kulshrestha, U. C. (2011) Coping with Climate Change: Principles and Asian Context. Springer Science & Business Media.

[15] Gu, C., Hu, L., Zhang, X., Wang, X. and Guo, J. (2011) ‘Climate change and urbanization in the Yangtze River Delta’, Habitat International, 35(4), pp. 544–522. doi: 10.1016/j.habitatint.2011.03.002.

[16] Central Bureau of Statistics (2011) Village Potential Data 2010. Jakarta.

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