Journal of Geography and Earth Sciences
June 2016, Vol. 4, No. 1, pp. 17-30
ISSN 2334-2447 (Print) 2334-2455 (Online)

Published by American Research Institute for Policy Development
DOI: 10.15640/jges.v4n1a2
URL: https://doi.org/10.15640/jges.v4n1a2

The Change of Carbon Stocks and CO_2 Emission as the Result of Land Cover Change for Tin Mining and Settlement in Belitung Island Indonesia

Dedi Hermon[1]

Abstract

The research was aimed at formulating the model of land cover mode to determine the change of carbon stocks and CO_2emission. Furthermore, this research was conducted to analyze the change of forestry land cover due to tin mining activity and settlement as well as the qonsequences toward carbon stock and CO_2emission of Belitung Island, Bangka-Belitung Province, Indonesia. Method used in analyzing the land cover refers to Geography Information System (GIS) analysis previously applied by Zain (2002) and modified and developed by Hermon (2010[a]); Hermon (2012[a]); Hermon, (2014[a]), Hermon (2015); and Hermon (2016). The instrumentation of the analysis of the change of the land cover is GIS-ERDAS 9.1 dan GIS-ENVI 5.1. While the instrumentation used to analyze the carbon stock in each land coved is *stratified purposive composite sampling* referring to plot technique developed by Hairiah and Rahayu(2007); Hermon (2012[b]); Hermon (2015).Tree biomass is analyzed through allometric equation developed by Kattering (2001), while calculation of the carbon stock and CO_2 emission is determined through a formula developed by Hairiahand Rahayu (2007). The result of the study shows that the width of forestry land cover is decreased and the land cover of active tin mining, farming, and settlement is increased in Belitung Island. The condition directly influences the volume of carbon stock in Belitung Island that the volume of CO_2 emission in 1995-2005 was 800.193.032, 6 ton. The emission of CO_2 released is 663.658.471, 8 ton. This is the result of the change of forestry land cover to tin mining areas active and tin mined land as well as human settlement land cover.

Keywords: Land Cover, Carbon Stocks, Emission

[1] Lecturer of Geography Department and Postgraduate in Padang State University and Environmental Disaster Researchers in Padang State University. e_mail: dihermon006@gmail.com

1. Introduction

Belitung Island is the second largest island after Bangka Island in Bangka Belitung Province. Beside the two mainlands, this province possess a number of small islands like Sellu Island, Mendanau Island, Nangka Island ring, Memperak, Buku Limau, Sekunyit and Long Island ring. Belitung Island lies on strategic location in trading and economic position in within trading and economic route in Souh East Asia region, Asia, and Indonesia.

Main earning activity of the people dominantly lies on coastal activities and tin mining. The activity of the community in the coastal are mostly fishing and coastal toursim that the the settelement of Bangka Belitung people is concentrated all along the beaches. While tin mining activity is usually conducted almost in the center of the land initiated by the government, private companies, or people who live around the area who conducted the mining illegally. The sytem of mining implented in those areas are categorized as open cut mining that the area of the production is left openly that any forest vegetation cannot anymore grows. Moreover, the tin mining activities in Belitung Island is located in deep forest that uncontrolled conversion of forest land occured (Anonimous, 2007 and Bidayani, 2009)

The condition of Belitung Islands is recently apprehensive for the forest as a natural carbon stock is extremely damaged by the irresponsible mining activities. The biodiversity of Belitung Islands is almost extinct as the corrupted land is getting worse since the waste of the mining is thrown to river and the sea. (Anonimous, 2007). As the result the natural coastal vegetation functioned as a natural carbon stock in coastal area is either obviously damaged. The tin mining and other coastal economic activities influence the pattern on the land cover for the settlement centered in the coastal areas.

Hermon (2010[a]), Hermon (2010[b]), Hermon (2012[b]), Hermon (2014[b]), and Hermon (2015) explains that the development of the settlement may cause the dominant change of the land cover pattern and it annually decreases the function of the forests as natural carbon stocks. The change of the land cover (forest) and coastal areas into tin mining continuously occurred. The functional change of the land cover (forest) and coastal areas into mining areas and settlement increases 70% in 1995-2015 (Central Bureau Statistics, Belitung District, 2016).

Carbon obviously influences a myriad things, namely climate change (Murdiyarso, 2003[a]; Hermon 2014[a]), environmental stability (Hermon, 2014[d]), hydrology cycles (Hermon 2012[a]), and hydrometeorology disaster (Hermon, 2012[a] dan Hermon (2014[a]), that the lack of carbon will negatively influence the world life and earth stability. Lusiana *et al*, (2005); Forestry Department and IFCA (2007); WWF (2008); Hermon (2010[b]),explain that 20% of world green house emission is caused by the deforestation or the functional change of the land cover (forest). The change might be into the mining areas, open land, and community settlement. The percentage of carbon emission occurred as the result of the change of the land cover into mining and settlement areas in Indonesia is 20% of the total world carbon emission.

The importance of carbon stock was globally initiated trough Rio de Janeiro conference in 1992. It was identified that the emission of CO_2into the atmosphere is the most crucial world concern. Thus, the Kyoto Protocol arranged the initial efforts to stop the increasing number of the emission and regaining the clean or green emission in industrial countries. As the land changes become the source of CO_2, deforestation for community settlement and growth of vegetation raise a high concern in every global debate (Lusiana *et al*, 2005). Murdiyarso (2003[b]) explains that Protocol of Kyoto defines that forests are not merely a number of woods that might be the temporal national income of a country, but they also have global commodity potentials. The uncontrolled forest exploitation often causes unexplainable disaster. Related to the forest capability in absorbing carbon, the emission trading or carbon trading might becomes the latest paradigm in the forestry sector that it may become an opportunity for Indonesia as a developing county to gain the national income trough Clean Development Mechanism (CDM) (Murdiyarso, 2003[c])

2. Method

2.1. Spatial Model of Land Cover Change in Belitung Island.

The formulation of spatial model of land cover changing into tin mining and settlement areas according to Zain (2002) modified and developed by Hermon (2010[a]); Hermon (2012[a]); Hermon, (2014[a]), Hermon (2015); and Hermon (2016) referring to interpretation of Citra Landsat 5+TM year1995 and Citra Landsat 7+ETM year 2015 and analysis of GIS-ENVI 5.1 to converse and to combine the band for further analysis.

GIS-ERDAS 9.1 was conducted to classify the land cover and the change through tools analysis supervised classification in each satellite that six pattern of temporal land cover were classified, namely: (1) forest, (2) cultivation, (3) tin mined land, (4) tin mining areas active, (5) settlement, and lakes former tin mine. The analysis of land cover change in 1995-2015 (20 years) was conducted through GI-ENVI 5.1 converted to GIS-ENVI 9.1 with GIS analysis matrix tools.

2.2. Analysis of Change of Carbon Stocks and CO_2 Emission

The analysis of carbon stock in each land cover was conducted though systematic survey technique. The sample was drawn through stratified purposive composite sampling referring to plot technique developed by Hairiah and Rahayu (2007); Hermon (2012[b]); Hermon (2015). The size of plot of the tree sample was 10x10 m and the plot size of smaller plants as well as manure is 1x1 created in each land cover. Sample of the tree (long, branch and twig as well as the leave) was compositely taken and analyzed through non-destructive method, while sample of manure and the smaller plants was analyzed by destructive method (Hermon, 2012[b]; Hermon (2015).

Algometric equation developed by Kattering (2001) *in* Hermon (2012[b]) and Hermon (2015) was used to analyzed the tree biomass that a simple formula was used that DW=0, 11 $\varrho D2.62$ (DW = Dried Weight/gr), (D = Diameter of the tree /cm), and (ϱ= Density Wood). The Biomass of the manure and small trees was determined pursuant to Dried Weight per quadrant (the finding was obtained in gr/$m^2$and converted into ton/ha). The formula used was BK Total (gr) = DW/GB x BB Total (gr), in which DW (Dried Weight, gr) and GB (Gross Weight, gr). Total of the carbon stock was obtained through total biomass multiplied by 0, 46 (C concentration in organic matters around 46 %) (Hairiahand Rahayu, 2007).

Conversion of carbon stock into CO_2 emission unit was obtained through the multiplication of carbon stock with -44/12. Conversion of CO_2 removal was obtained through the multiplication of carbon stock with +44/12. Total of carbon stock could be measured by multiplying the carbon stock with the area of the land cover.

The conversion of the values were conducted to obtained the biomass in ton/ha (Hermon, 2012[b] and Hermon, 2015), while the analysis of carbon stock in 1995 was pursuant to the measurement on carbon stock in 2015 converted with the width of the area in land cover (Hermon, 2012[b]and Hermon, 2015). The analysis was focused on the change of carbon stock due to the change of forest land cover to tin mining and settlement area within the period of 1995-2015.

3. Result and Discussion

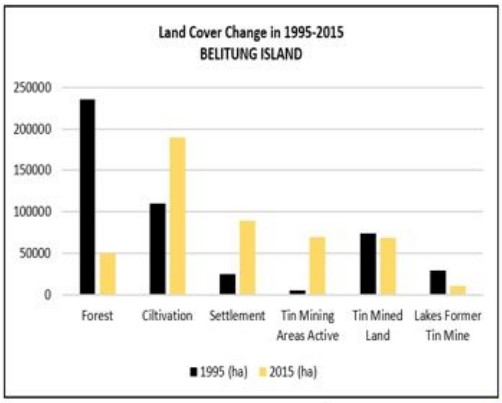
3.1. Spatial Model of Change of Land Cover in Belitung Island

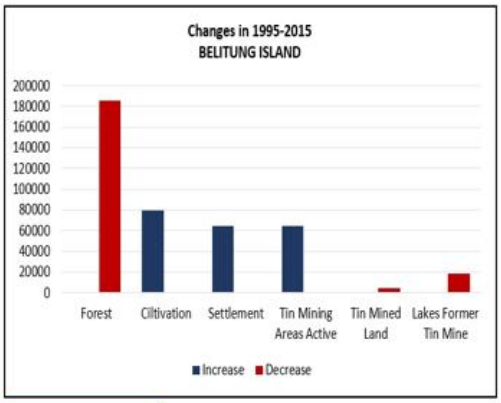
Spatial Model of land cover in Belitung Island in 1995-2015 was obtained from the analysis of satellite Citra Landsat 5+TM in 1995 and Citra Landsat 7+ETM in 2015 inform varied land cover in 1995 and 2015 (Figure 1). The land cover is dominated by forest, cultivation, tin mining areas active, tin mined land, the lakes former tin mine, and settlement. The model shows the spatial information that there had been changes found in every land cover in Belitung Island within the period of 1995-2015 (20 years). The change of forestry land cover occurred for the massive forest conversion for tin mining, settlement and farming (dominated by palm oil trees, coconuts and other traditional farming type) conducted by government, private sector, and community within this past 20 years.

Figure 1. Spatial Model of Change of Land Cover in Belitung Island in 1995-2015 (20 years)

(Sources: Analysis of Citra Landsat 5+TM 1995 and Citra Landsat 7+ETM 2015 with GIS ENVI 5.1 and GIS ERDAS 9.1)

The total are of Pulau Belitung is 480.010.000 ha. In 1995, the widht of forestry land cover was 236.114,21 ha, farming was 110.090,02 ha, settlement (25.430,11 ha), tin mining areas activewas (5.111,24 ha), tin mined land(full of grass and any other small trees) was 73.844,21 ha, and lakes former tin mine was 29.420,24 ha. There was a significant changes on forestry land cover in 2015 compared to the one in 1995. The forestry land cover was 50.154,67 ha, the decrease was 185.959,50 ha. Moreover, the decrease of tin mined land was 4.863,16 ha and the decrease of the lakes former tin mine was 18.417,03 ha. The increasing number land cover occurs on farming, settlement, and tin mining areas active. A number of farming, settlement area and tin mining areas active are 79.998,00 ha, 64.351,10 ha, 64.891,60 ha (Figure 2).





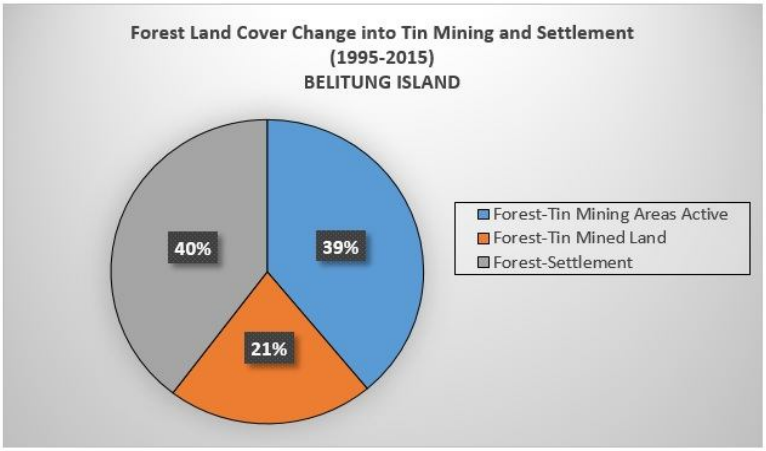
Land Cover	1995 (ha)	2015 (ha)	Change in 1995-2015	
			Increase (ha)	Decrease (ha)
Forest	236.114,21	50.154,67		- 185.959,50
Ciltivation	110.090,02	190.088,01	+ 79.998,00	
Settlement	25.430,11	89.781,22	+ 64.351,10	
Tin Mining Areas Active	5.111,24	70.001,88	+ 64.891,60	
Tin Mined Land	73.844,21	68.981,05		- 4.863,16
Lakes Former Tin Mine	29.420,24	11.003,21		- 18.417,03
Total	**480.010,00**	**480.010,00**	**+ 209.240,00**	**- 209.239,70**

Figure 2. The Change of Land Cover in Belitung Islan in 1995-2015 (20 years)

(Sources: Analysis of Citra Landsat 5+TM 1995 and Citra Landsat 7+ETM 2015 with GIS ENVI 5.1 and GIS ERDAS 9.1)

Forest is regarded as natural carbon stock that has to be reserved that humans and other organisms live continuity can be saved. Forest is fuctioned to supply O_2 take the CO_2 from the atmosphere that stabibility of life can be guaranteed(Antrop, 2004 and Berenguer *et al*., 2016).

The change of forestry land cover into tin mining areas active, tin mined land and settlement in Belitung Island cause the decreasing of the forest area within past 20 years, namely 154.951,9 ha (Figure 3).



Forest-Tin Mining Areas Active	60351.7 ha
Forest-Tin Mined Land	33109.4 ha
Forest-Settlement	61490.8 ha

Figure 3. The Change of Forestry Land Cover as the Result of Tini Mining Activity and Settlement within period of 1995-2015 in Belitung Islands

(Sources: Analysis GIS ERDAS 9.1 *tolls GIS-Analysis Matrix*, 2016)

The data shows that the number of change of forestry land cover in Belitung Island within past 20 years (1995-2015) becomes tin mining areas active is 60.351, 7 ha (39%) and tin mined land is 33.109,4 ha (21%). The total change of forestry land cover for tin mining activity is 94.061,1 ha or 60%. The data implied that the effect of tin mining in reducing the forest land cover is really dominant . Meanwhile the effect of the settlement is regarded as 40% (61.490,8 ha) in reducing forest land cover within 20 years in Belitung Island.

3.2. The Change of Carbon Stocks and CO_2Emission Due to Change of Land Cover in Belitung Island.

The change of land cover in Belitung Island within 20 years influences the stock of carbon. The finding shows that the availability of carbon stock in forest land cover is only 1.168,09 ton/ha and other carbon stock in cultivation area is 276, 87 ton/ha, while the stock in the tin mined land is 209, 12 ton/ha (Table 1).

Table 1: Biomass and the Carbon Stocks in Every Land Cover in Belitung Island in 2015

Land Cover	Number of Tree/ha	Tree Biomass		Manure Biomass		Total Biomass (ton/ha)	Carbon Stock (ton/ha)
		(kg/m²)	(ton/ha)	(kg/m²)	(ton/ha)		
Forest	302	242,72	2427,20	11,21	112,10	2.539,30	1.168,09
Cultivation	221	49,85	498,50	10,34	103,40	601,90	276,87
Settlement	0	0	0	0	0	0	0
Tin Mining Areas	0	0	0	0	0	0	0
Active Tin Mined Land	7	3,90	39,00	41,56	415,60	454,60	209,12
Lakes							
Former Tin Mine	0	0	0	0	0		0

Sources: Data Analysis (2016)

The Carbon stock in Belitung Island is estimated as 125.640.153,0 ton in 2015. This amount is significantly decreased compared the those in 1995 namely 321.725.572,6 ton. The reduction occurs in forest land cover around 217.217.478,6 ton and the tin mined land around 1.016.984 ton. The increasing of carbon stock occurs in cultivated areas, namely 22.146.044,6 ton (Table 2).

Table 2: Total of Carbon Stocks in 2015 and the Total Estimation of Carbon Stock in 1995 in Every Land Cover in Belitung Island

Land Cover	2015			1995	
	Carbon (ton/ha)	(ha)	Carbon Stock (ton)	(ha)	Est. Carbon Stock (ton)
Forest	1.168,09	50.154,67	58.585.168,5	236.114,21	275.802.647,6
Cultivation	276,87	190.088,01	52.629.667,3	110.090,02	30.480.623,8
Settlement	0	89.781,22	0	25.430,11	0
Tin Mining Areas Active	0	70.001,88	0	5.111,24	0
Tin Mined Land	209,12	68.981,05	14.425.317,2	73.844,21	15.442.301,2
Lakes Former Tin Mine	0	11.003,21	0	29.420,24	0
Total		**480.010.000**	**125.640.153,0**	**480.010.000**	**321.725.572,6**

Sources: Data Analysis (2016)

The result of correlational analysis between carbon stock and CO_2 emission potentials in 2015 in Belitung Island is 460.680.563,1 ton, in which the emission potential of CO_2 on forestry land cover is 214.812.287,7 ton. Moreover the potential on cultivated land 192.975.447,8 ton and land cover of tin mined land 52.892.830,6 ton as it is shown in Table 3

Table 3. Emission Potential of CO_2 in Belitung Island in 2015

Land Cover	Total of Cabon Stock (ha)	Carbon Removal Potential	CO_2Emission Potentials (ton)
Forest	58.585.168,5	214.812.284,7	214.812.284,7
Cultivation	52.629.667,3	192.975.447,8	192.975.447,8
Settlement	0	0	0
Tin Mining Areas Active	0	0	0
Tin Mined Land	14.425.317,2	52.892.830,6	52.892.830,6
Lakes Former Tin Mine	0	0	0
Total			**460.680.563,1**

Sources: Data Analysis (2016)

CO_2 emission potentials in Belitung Island in 1995 was estimated as 1.179.660.434,2 ton. The emission potential in the forest was expected as 1.011.276.375,8 ton. The potential emission of cultivated land was estimated as 111.762.287,7 ton while the emission of the tin mined land was 56.621.771,8 ton (Table 4).

Table 4: Estimation of CO_2 Emission Potential in Belitung Island in 1995

Land Cover	Estimation in 1995		
	Total of Carbo Stock (ton)	Potential of Carbon Remova	CO_2Emission Potentials (ton)
Forest	275.802.647,6	1.011.276.375,8	1.011.276.375,8
Cultivation	30.480.623,8	111.762.287,7	111.762.287,7
Settlement	0	0	0
Tin Mining Areas Active	0	0	0
Tin Mined Land	15.442.301,2	56.621.771,8	56.621.771,8
Lakes Former Tin Mine	0	0	0
Total			**1.179.660.434,2**

Sources: Data Analysis (2016)

The change of the land cover in Belitung Island within 20 years (1995-2015) had released 800.193.032,6 ton of the CO_2 emission into atmosphere. According to Hermon (2012[a]), Hermon (2014[c]), and Hermon (2014[d]), CO_2 emission will result extreme climate change that the temperature will significantly increase during the day as well as night that the summer season will be hotter than usual and firing is extremely potentials to happen. Morover CO_2will also causes the extreme raining season that massive flood and landslide might happen.

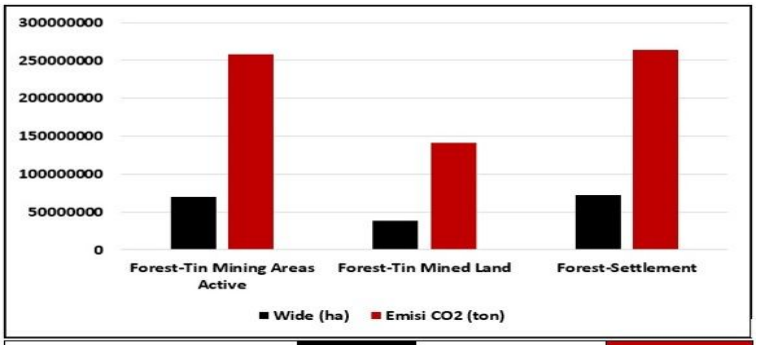
Table 5. CO_2 Emission in Belitung Island within 1995-2015

Land Cover	CO_2 Emission Potentials in 1995	CO_2 Emission Potentials in 2015	Total Emission CO_2 (ton)
Forest	1.011.276.375,8	214.812.284,7	796.464.091,1
Cultivation	111.762.287,7	192.975.447,8	- 81.213.160,1*
Settlement	0	0	0
Tin Mining Areas Active	0	0	0
Tin Mined Land	56.621.771,8	52.892.830,6	3.728.941,2
Lakes Former Tin Mine	0	0	0
Total			**800.193.032,6**

Sources: Data Analysis (2016)

Emission CO_2greatly took place due to the decrease amount of forest land cover in Belitung Island as the result of expansion of tin mining activities and the settlement.

Total emission of CO_2 released due to the decrease of forest land cover is 796.464.091,1 ton, while the total emission occured in former mined land refunctioned as cultivated areas, active mining land and the settlement is 3.728.941, 2 ton.



Land Cover Change	Wide (ha)	Total Loss of Forest Carbon Stock (ton)	CO_2 Emission (ton)
Forest-Tin Mining Areas Active	60.351,7	70.496.217,3	258.486.129,7
Forest-Tin Mined Land	33.109,4	38.674.759,0	141.807.449,7
Forest-Settlement	61.490,8	71.826.788,6	263.364.891,6
Total	**154.951,9**	**180.997.764,9**	**663.658.471,8**

Figure 4.Emission Total of CO_2as the Result of Land Cover Changes from Forest to Tin Mining Land and Settlement

(Sources: Data Analysis, 2016)

The fact that the great changes of forest functions to tin mining areas, settlement, and cultivated land becomes a worrying stage. In 2015 the area of forest decrease significantly compared to those in 1995.

The changes of the forest function to tin mining areas relasead 258.486.129,7 ton of CO_2emission, while the change of forest to former tin mined area released 141.807.449,7 ton of the emission. Moreover, the change of forest to settlement area in Belitung released 263.364.891,6 ton of the emission. Further the total of the emission released due to active mining area, former tin mined area, and settlement is 663.658.471,8 ton. According to Frackowiak and Beguin (2001) and Sun *et al*., (2016), emission of CO_2 e confluence the climate changes that serious consequences must affect humans life and the environment. The emission of CO_2 must cause global warming as the temperature released by sun energy is held out in the atmosphere. It may affect the water reservoir and weather changes, farming seasons, harvesting and aberration for those who live in the coastal areas.

4. Conclusion

The changes of the land cover had taken place in Belitung Island within the period of 1995-2015. The changes dirctly affect the carbon stock and the emission of $CO_2$to the atmosphere. The changes occured significantly within the past 20 years, whether the function of the forest was changed into active mining land, former mined land, palm oil farming as well as the settlement areas. The greatest CO_2 emissionwas contributed by the change of forest function to active mining land, former mined land, and settlement areas. The consequences of the great emission release in natural imbalance that surely endanger humans life and the environment.

5. References

Anonimous. (2007). The Condition of Coral Reefs in Babel. http://kompascomunity

Antrop, M. (2004). Landscape Change and the Urbanization Process in Europe. Landscape and Urban Planning. 67: 9–26. www.elsevier.com/landurbplan

Berenguer, A.G., M. Seredych, J. Iniesta., J.C. Lima., T.J. Bandosz., and C.O. Ania. (2016). Sulfur-Mediated Photochemical Energy Harvesting in Nanoporous Carbons. Science Direct. Elsevier Journal. Vol. 104: 235-259

Bidayani, E. (2009). Analisis Ekonomi Tambang Konvensional (TI) dengan Kegiatan Perikanan Tangkapdan Pariwisata di Pesisir Tanjung UlarKabupaten Bangka Barat. Akuatik-Jurnal Sumberdaya Perairan. Vol. 3: 10-12

Central Bureau Statistics. (2016). Belitung District in Figures. Belitung. Indonesia

Departemen Kehutananand IFCA. (2007). REDDI, Reducing Emissions from Deforestation and Forest Degradation in Indonesia, REDD Methodology and Strategies Summary for Policy Makers. Dephut. Jakarta

Frackowiak, E and F. Beguin. (2001). Carbon Materials for the Elektro chemical Storage of Energy in Capacitors. Science Direct. Elsevier Journal. Vol. 39: 937-950

Hairiah, K andRahayu, S. (2007). Pengukuran Karbon Tersimpan di BerbagaiMacam Penggunaan Lahan. Bogor. World Agroforestry Centre – ICRAF, SEA Regional Office, University of Brawijaya, Unibraw, Indonesia.

Hermon, D. (2010[a]). Dinamika Permukimandan Arahan Kebijakan Pengembangan Permukimanpada Kawasan Rawan Longsor di Kota Padang Sumatera Barat. Disertasi. PSL IPB. Bogor

Hermon, D. (2010[b]). GeografiLingkungan: Perubahan Lingkungan Global. UNP Press. Padang

Hermon, D. (2012[a]). Mitigasi Bencana Hidrometeorologi: Banjir, Longsor, Degradasi Lahan, Ekologi, Kekeringan, dan Puting Beliung. UNP Press. Padang

Hermon, D. (2012[b]). Dinamika Cadangan Karbonakibat Perubahan Tutupan Lahanuntuk Permukiman di Kota Padang Sumatera Barat. Forum Geografi: Indonesian Journal of Spatial and Regional Analysis. Vol. 26: 45-52

Hermon, D. (2014[a]). Geografi Bencana Alam. Radja Grafindo. Jakarta

Hermon, D. (2014[b]). Dampak GempadanIsu Tsunami terhadap Dinamika Pendudukdan Perubahan Lingkungan di Kota Padang. Prosiding Seminar Internasional Serumpun. Riau-Malaysia

Hermon, D. (2014[c]). Impacts of Land Cover Change on Climate Trend in Padang Indonesia. International Journal of Geography. Vol. 46: 138-142

Hermon, D. (2014[d]). Arahan Mitigasi Bencana Longsor Kawasan Gunung Padang Kota Padang Sumatera Barat. JurnalGeografi. Vol. 9: 1-7

Hermon, D. (2015). Estimates of Changes in Carbon Stoks Based on Land Cover Changes in the Leuser Ecosystem Area (LEA) Indonesia. Forum Geografi: Indonesian Journal of Spatial and Regional Analysis. Vol. 29: 187-196

Hermon, D. (2016). The Strategic Model of Tsunami Based in Coastal Ecotourism Development at Mandeh Regions, West Sumatera, Indonesia. Journal of Environment and Earth Science. Vol. 6: 40-45

Ketterings, Q.M., Coe R., Meine van Noordwijk., Ambagau Y., and Palm C.A. (2001).Reducing Uncertainty in the of Allometric Biomass Equation for Predicting Above Ground Tree Biomass in Mixed Secondary Forest. Forest Ecology and Management146: 199-209

Lusiana, Betha., Meine van Noordwijk., and Surbekti Rahayu. (2005). Cadangan Karbon di Kabupaten Nunukan kalimantan Timur: Monitoring Secara Spasialdan Pemodelan. ICRAF. Bogor

Murdiyarso, D. (2003[a]). Sepuluh Tahun Perjalanan Negosiasi: Konvensi PerubahanIklim. Kompas. Jakarta

Murdiyarso, D. (2003[b]). CDM: Mekanisme Pembangunan Bersih. Kompas. Jakarta

Murdiyarso, D. (2003[c]). Protokol Kyoto. Kompas. Jakarta

Sun, W., S.M. Lipka., C. Swartz., D. Williams., and F. Yang. (2016). Hemp-Derived Activated Carbons for Super Capasitors. Science Direct. Elsevier Journal. Vol. 103: 181-192

WWF. (2008). Deforestation, Forest Degradation, Biodiversity Loss and CO_2Emissions in Riau, Sumatra, Indonesia-One Indonesian Province's Forest and Peat Soil Carbon Loss over a Quarter Century and its Plan for the Future. WWF Indonesia Technical Report. Jakarta.

Zain, A.F.M. (2002). Distribution, Structure and Function of Urban Green Space in Southeast Asian Mega-Cities with Special Reference to Jakarta Metropolitan Region (JABOTABEK). Doctoral Degree Program. Department of Agricultural and Environmental Biology Graduate School of Agricultural and Life Sciences. The University of Tokyo. Japan

Dedi Hermon: Born in Padang, West Sumatra, Indonesia on September, 24, 1974. Obtained the Doctorate Degree in Doctor Program Natural Resources Management and Environment in Bogor Agriculture University (IPB) Indonesia, 2009. He is actively involved in any researches regarded to environment, natural disaster and land cover as well as carbon stock published in any national and international seminars. He is positioned as the Head of Master Program of Geography Education Faculty of Social Science Padang State University, Indonesia as well as the head of Study Center of Disaster and Environment, Padang State University, Indonesia.