EVALUATION OF NET PRIMARY PRODUCTIVITY OF OIL PALM PLANTATION IN SOUTH SULAWESI INDONESIA

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ABSTRACT: Net primary productivity (NPP) is able to be used for assessing the carbon balance at regional and global scales and play a significant role in demonstrating the compliance of Kyoto Protocol. Recently, expansion of oil palm plantation is widely and rapidly growth as well as replaced large forested coverage in Indonesia. Therefore, estimation of NPP for oil palm plantation is needed in order to determine the current patterns of carbon balance from major crop in Indonesia. In this study, four local major area of oil palm plantation of South Sulawesi, Indonesia have been selected to be used estimating NPP by using MODIS satellite image. Those area are Luwu, Tomata, Malili and Beteleme whereby covered oil palm plantation, 12629ha, 10145ha, 1680ha and 3442ha, respectively. They will be used to estimate NPP in this study by using MODIS satellite images. In addition, list of monthly meteorology data such as temperature, humidity, precipitation and solar radiation have been used as input data in order to extract NPP information from MODIS images. As a result shown the NPP at 8.67 g cm^2yr^{-1} to 39.20 g cm^2yr^{-1} for 2009 and 13.44 gcm^2yr^{-1} to 85.41gcm^2yr^{-1} for 2010. However result from MODIS product based on MOD17A3 indicates the range from 10.02 gcm^2yr^{-1} to 37.56 gcm^2yr^{-1} for 2009 and 12.67 gcm^2yr^{-1} to 87.98 gcm^2 yr^{-1} for 2010. Therefore this study has successful determiner the range of NPP extracted for local oil palm plantation in coincide to the MODIS product (MOD17A3).

INTRODUCTION

Oil palm is a vegetable oil producing plants that can be relied upon because of the oil produced has many advantages over oil produced by other plants. The advantages of which have lower cholesterol levels even without cholesterol. Vegetable oil is the main product can be produced from palm oil. Oil palm as a crop producer of palm oil (CPO-crude palm oil) and core palm oil (CPO) is one of the plantation a source of non-oil foreign exchange earner for Indonesia. Bright outlook for commodity palm oil in world vegetable oil trade has encouraged Indonesian government to spur the development of oil palm plantation area.

Indonesia palm oil sector experienced significant development, it is seen from the total area of oil palm plantation are growing to 7.3 million ha in 2009 from 7.0 million ha in 2008. Meanwhile, palm oil production (crude palm oil/CPO) continuous to increase from year to year, from 19.2 million tons in 2008 increased to 19.4 million tons in 2009. While total exports also increased, in 2008 reached 18.1 million tons to 19.9 million tons and then up September 2009. Oil palm plantation area owned by private companies experienced the highest growth. The growth in the sub-sector of oil palm plantations have resulted in benefits to the economic, development of oil palm plantation area was led to a growing threat to the existence of natural tropical forests of Indonesia. This happens because the planting of oil palm plantation involved the conversion of new forested area.

NPP (Net Primary Productivity) is needed to assessing the carbon balance at local and global scale. The validation of annual global MODIS (Moderate Resolution Imaging Radiometer) NPP (Net Primary Production) at 1 km spatial resolution posed a great challenged and this issue has been seriously discussed by many researchers (Turner et al, 2006). During this NPP estimates only done in forests but very rarely research NPP estimates mainly on oil palm plantations in tropical oil palm plantations. The study was conducted to determine the estimated oil palm in Indonesia especially in South Sulawesi.

METHODS

STUDY AREA

The area of this study is confined to oil palm plantation in South Sulawesi Indonesia. Widely throughout the plantation are 27916 ha. Which four major located at North Luwu and East Luwu are Luwu (2°36'30.00"S; 120°35'29.78"E); Tomata (1°45'60.00"S; 120°45'26.64"E); Malili (2°25'30.00"S; 120°54'59.83"E); Beteleme (2°42'30.00"S; 121°16'7.64"E (PTPN IV, 2010).

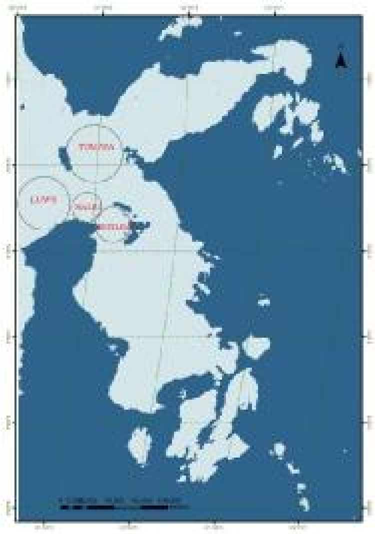

Figure 1 Study area Luwu, Tomata, Malili and Beteleme in South Sulawesi

This area was chosen because four largest area of all oil palm plantation area in South Sulawesi. The area has flat topography with a height of land 0-2866 amsl. And rainfall > 2000mm3 per year for 2009 and <500mm3 for the year 2010 (Meteorology climatology and Geophysical Makassar Regional IV, 2011).

EXTRACT NPP FROM MODIS

Meteorological data are temperature, relative humidity, sun radiation and precipitation in 2009, 2010 and satellite data. Satellite remote sensing provides consistent and systematic observations of vegetation and has played an increasing role in the characterization of vegetation structure and estimated Gross Primary Production (GPP) and Net Primary Production (NPP) of forest (Xiao et al.2004). For evaluation of NPP, used MOD17A2 (GPP) 1-km 8 days and MOD15A2 (LAI/FPAR) 1-km 8 days.

The satellite-based studies have used the Light Use Efficiency (LUE) approach to estimate Gross Primary Production. The Radiation use efficiency logic requires an estimate of APAR, while the more typical application of remote sensing data is to provide an estimates of the fraction of incident PAR absorbed by the surface (FPAR).

Light Use Efficiency (LUE) in GPP calculation from empirical relationship of meteorological data. LUE is a biome-specific value representing optimal potential of the vegetation for converting PAR to GPP (Nichol et al.2002). LUE is expressed (Ibrahim et al.2007) where the are Ta mean temperature (°C), Pt mean annual precipitation (mm) and GDD mean of Growing Degree Day (derived from differences of mean and minimum value of temperature).

Table 1. Equation

Index	Formula	Sources
GPP	LUE*APAR	Ibrahim et al.2007
LUE	0.8932+(0.163*TA)+(0.0015*Pt)-(0.0022*GDD)	Ibrahim et al.2007
APAR	FPAR*PAR	
PAR	0.5*solar radiation	Prasad et al.2002., Brogaard et al.2005., Sims et al.2005
SR	$\frac{1+NDVI}{1-NDVI}$	Chen et al. 2010
FPAR	$FPAR_{\min} + (SR - SR_{i,\min})\frac{(FPAR_{\max} - FPAR_{\min})}{SR_{i,\max} - SR_{i,\min}}$	Chen et al. 2010
NPP	GPP-Ra	Running et al.2004
Ra	$GPP * \left[\frac{(1.825+1.145T)}{100}\right]$	Furumi et.al.2002

FPAR is usually estimated as a linear or linear function of Normalized Difference Vegetation Index (NDVI). The NDVI algorithm subtract the red reflectance value from the near-infrared and divides it by the sum of near-infrared and red bands (Xiao et al.2004). NDVI values are represented as a ratio ranging in value from -1 to 1 but in the practice extreme negative values represent water, values around zero represent bare soil and value over 6 represent dense green vegetation. NPP is allocated to wood, foliage, roots and reproductive tissues (Running et al.2004). NPP is expressed by GPP and autotrophic respiration (Ra). GPP had a relation with autotrophic respiration is affected by air temperature (Furumi et.al.2002).

RESULTS

Two years of local scale NPP (2009 and 2010) using meteorological data approach. NDVI values from MOD15A2 can calculated and then get the NPP values. The result shown in table 2 which shows the results of the NPP values calculated using empirical equations available. Figure 2 is the NDVI maps showing pattern of greenness level at all area.

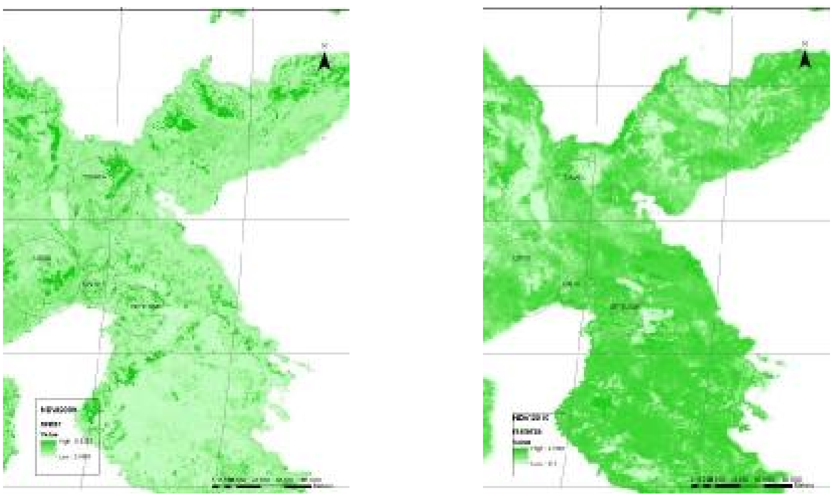

Figure 2(a) NDVI 2009, 2(b) NDVI 2010

Table 2. Result

Area	Year	NDVI		NPP (gCm^2y^{-1})	
		Min	Max	Min	Max
Luwu	2009	-0.91	-0.72	8.67	28.28
	2010	-0.86	-0.75	13.44	26.31
Tomata	2009	-0.93	-0.64	7.10	43.54
	2010	-0.83	-0.70	8.35	43.51
Malili	2009	-0.91	-0.75	8.80	28.87
	2010	-0.88	-0.69	12.26	37.10
Beteleme	2009	-0.88	-0.34	12.87	39.20
	2010	-0.87	-0.40	13.49	85.41

The minimum value for all the area has increased from 2009 to 2010. While the maximum value decreased to Luwu and Tomata area. And increased for the area Malili and Beteleme. Even for Beteleme area increased very significantly. Figure 3 shown the range of minimum and maximum value of NPP for all areas.

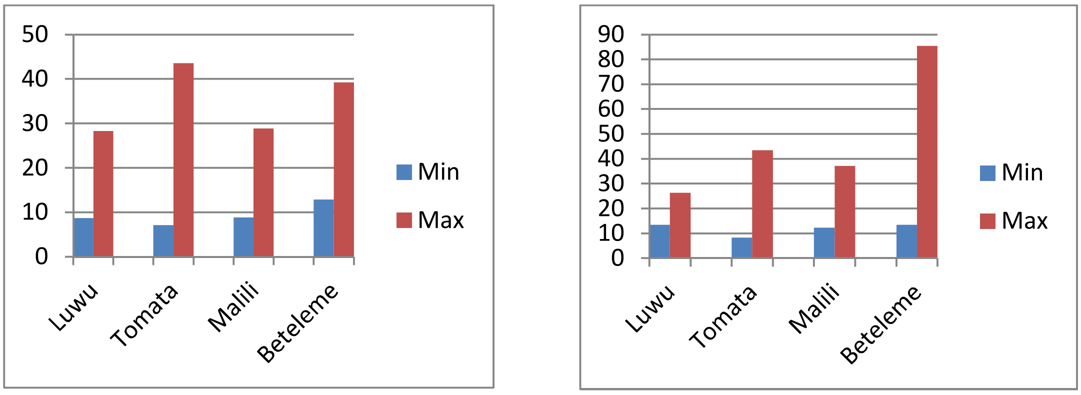

Figure 3 Histogram (a) NPP 2009, (b) NPP 2010

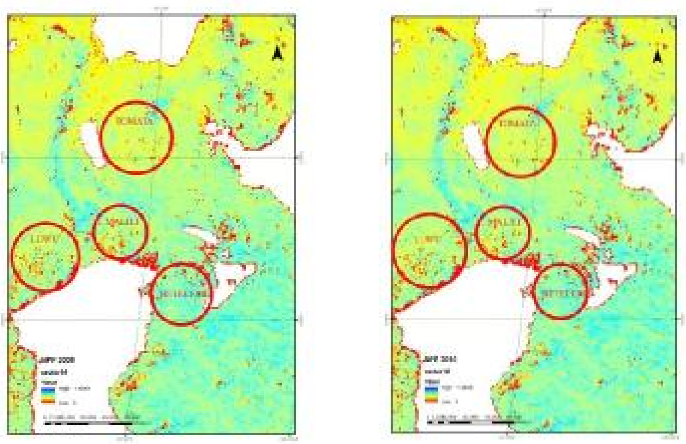

Figure 4 (a) NPP 2009, 3(b) NPP 2010 from MOD17A3

Used the MOD17A3 (Figure 4), can shown the values of NPP are increased also. The selected oil palm plantation areas indicated NPP values in the range 8.67 g cm^2yr^{-1} to 39.20 g cm^2yr^{-1} for 2009 and 13.44 gcm^2yr^{-1} to 85.41gcm^2yr^{-1} for 2010. Meanwhile, MODIS product from MODIS 15A2 show range for NPP of the similar plantation 10.02 gcm^2yr^{-1} to 37.56 gcm^2yr^{-1} for 2009 and 12.67 gcm^2yr^{-1} to 87.98 gcm^2 yr^{-1} for 2010.

CONCLUSION

This study has shown the used of MODIS images for estimation of NPP using meteorological data approach at 27916 hectares area. Two years of MODIS images for 2009 and 2010 used MOD15A2 and MOD17A3 have been used to determine NPP in oil palm plantation. Range for Luwu area decreased from 2009 to 2010 while an increase in the value of the NPP. For areas Tomata and Malili range increases with increasing value of NPP. And the increased range Beteleme significant with increasing NPP values.The pattern of NPP concentration in oil palm seems to be increased from 2009 to 2010 although not significant.

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