Modeling of LULC Dynamics in Bekasi District-Indonesia by Linking NDVI Measurement and Socio-Economic Indicators

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Abstract: This study discusses an effort to build a model to link normalized difference vegetation indices (NDVI) and socio-economic indicators derived from village survey (1990, 1993, 1996, and 2000) statistical data in Bekasi, West Java, Indonesia. Socio-economics indicators of sub-district level, in this study the number of agricultural households (AH), are aggregated from village level data. NDVI from Landsat-TM resolution data (1989 and 1997) are computed to detect land use/land cover (LULC) dynamics in the sub-district areas. Attention is mainly paid on the examination of agricultural land cover changing in the sub-district level. NDVI measurements might be used to predict AH dynamics as showed by computed linear regression models.
Keywords: NDVI, land use/land cover (LULC)-change model, agricultural land, agricultural households (AH)

1. Introduction

Studies about LULC have been placed in the framework of human-environment interaction in the International Geosphere-Biosphere Program (IGBP) and the International Human Dimension Programme on Global Environment Change (IHDP) [1]. As human activities are done mostly on the earth surface, they give significant influence to change land cover. Especially in urban and suburban area the rate of land use changing from agricultural land to urban and industrial areas are very high. Land use change affects environmental as well as socio-economic condition. On the other hand socio-economic dynamics request the use of land to support its development. The fact is obviously true when studies of land use change are directed in local scale analysis.

Previous studies already evaluated relationship between measurements of NDVI in rectangular based areas with socio-economic indicators [2]. The aim of this study is to investigate relations between NDVI and manpower dynamics in agriculture in sub-district based areas. Preliminary linear models will be computed to express the relationship to give a prediction of agricultural households (AH)-dynamic from NDVI measurements.

After giving a description about the study area, the paper will discuss the research method. It is followed by presentation of result and conclusion.

2. Study Area

Bekasi district is located between 106º58'15"–107º17'30" East and 5º54'50"-6º39'13", on the eastern direction from Jakarta Metropolitan. Its area covers approximately 1,484 km^2, stretching around 36 km in east-west direction and 65 km in south-north direction. Together with Tangerang and Bogor, it is part of a special area around Jakarta Metropolitan called Jabotabek, an abbreviation of Jakarta, Bogor, Tangerang and Bekasi. Jabotabek area established to anticipate a very rapid development of Jakarta Metropolitan that requires an integrative approach to handle environmental and socio-economic matters.

The topography is characterized by low-land, 72.85% of the land are below 25m above sea-level and 93.62% has slope of 0-8%. Nine from 22 sub-districts, the total number of sub-districts in Bekasi, are notified as very suitable or suitable for agricultural land. In fact agriculture is an important livelihood. It absorbed 47.4% manpower in 1989. However land transformation from paddy field to settlement and industrial area has been significant. According to the spatial planning for 1993-2003, the area is covered by approximately 51.81% by agricultural land in 1989 and becoming 46.9% in 1991 or decreasing of about 7,250 hectares. More than a half of this is due to increasing of housing and industrial areas, which respectively increased from 17.3% to 18.2% and 0.6% to 2.7% of the total Bekasi area [3].

Previous study shows that the growth activity of paddy field in Bekasi reflects a significant NDVI dynamic in the area [4]. Another study has shown the decreasing of paddy field over 5,000 hectares in Lemahabang (34,122 ha), Tambun (14,434 ha) Serang (9,265 ha), Cibitung (9,181 ha) and Kedungwaringin (5,040 ha) sub-districts [5].

Land use change is most probably caused by regional development policy that enforces Bekasi-area to become center of middle and big industries. Botabek development plan for instance, directs sub-districts Cikarang, Tambun and Cibitung for this purpose.

3. Data

Satellite images from Landsat-TM data of 6 July 1989 and 12 July 1997 are utilized to measure NDVI values. Geometric correction is performed using 1:25,000 scale topographic maps produced by Bakosurtanal (Indonesian Surveys and Mapping Agency).

AH statistical data are gained from Village Survey on the years 1990, 1993, 1996 and 2000. The survey was done by Bekasi district statistical office. The data consist of various village conditions and potentials including demography and land use data. The data is aggregated into sub-district data.

Since this study tries to link mentioned statistical data the image data are also subset into the sub-district areas. NDVI measurements are then carried out in sub-district based. Geo-reference vector data of sub-district areas are utilized to create sub-district area based image set data.

4. Methods

The development of NDVI from red and near-infrared multi-spectral values is based on the differential absorption and reflectance of solar energy by green vegetation. In this study measurements of NDVI in two different years, 1989 and 1997, are used to evaluate land cover change. The computed vegetation indices for two dates are subtracted to generate a band of vegetation differences [6]. NDVI are measured for every sub-district area. Average values of NDVI are computed to give a total picture of sub-district areas.

Socio-economic indicators analyzed are the amount of AHs. Analysis is also given to the dynamics of land use as recorded in field survey carried out by Bekasi-district statistical office.

Statistical correlation between NDVI and agricultural manpower dynamics is carried out in parallel as well as crossing-time. The first is comparing NDVI of the years 1989 and 1997 with respectively socio-economic data of the years 1990 and 1996. The second are evaluating correlation of NDVI across all evaluated years.

5. Result and Discussion

NDVI is transformed linearly to digital number (DN) as follows: DN-NDVI=NDVI*100+128. DN-NDVI is regarded as NDVI in this paper. The last 7 sub-districts, i.e. from Bantargebang until Pondokgede, are administratively separated to become Bekasi-city after 1996.

Table 1. NDVI-values and AH-data

Sub-district	NDVI89	NDVI97	AH90	AH96
1 Babelan	107.6	103.9	10370	9530
2 Cabangbungin	110.8	107.1	6166	7353
3 Cibarusah	129.3	118.3	9691	8889
4 Cibitung	134.9	119.1	14129	6756
5 Cikarang	136.3	125.1	7429	7882
6 Kedungwaringin	128.9	122.1	7994	6361
7 Lemahabang	134.5	121.0	15548	8698
8 Muaragembong	112.0	112.0	2964	2589
9 Pebayuran	117.4	115.1	8555	10428
10 Serang	125.1	113.8	13617	7787
11 Setu	130.0	120.8	9218	10942
12 Sukatani	129.3	111.9	13023	9546
13 Tambelang	126.9	116.0	9998	7939
14 Tambun	118.1	110.5	13943	7698
15 Tarumajaya	107.4	105.6	5121	6121
16 Bantargebang	124.2	113.7	5675	4546
17 Bekasi Barat	090.7	084.6	2680	32
18 Bekasi Selatan	106.8	099.8	1069	170
19 Bekasi Timur	107.7	098.6	4759	2015
20 Bekasi Utara	091.1	090.3	4658	1001
21 Jatiasih	115.1	104.6	4275	2885
22 Pondokgede	111.3	103.8	5651	2068

NDVI values and number of AHs are given in Table 1. The NDVI-dynamic for Bekasi-district is shown from a shifting of NDVI-average from 123.2 to 114.8, while at the same time Bekasi-city moves from 106.7 to 99.3. It explains that land conversion in Bekasi-city has already occurred before 1989. AH for Bekasi-district and city between 1990 and 1996 shifted respectively around 148,000 to 118,000 and 29,000 to 13,000. The numbers reflected an evidence of decreasing trend of AH in the period and Bekasi-city again shows a more rapid decrease trend. The most decreasing AH between 1990-1996 took place in Cibitung, Lemahabang, Serang and Tambun sub-districts, the darkest areas in the left-side of Fig 1, whereas in 1990 these four sub-districts are among the top 5 of sub-districts with more than 12,000 AH. The phenomena demonstrate how the LULC between 1990-1996 has influenced significantly the socio-economic structure in these 4 sub-districts, as reflected by a rapid changing of AHs.

Linear regression are computed to approximate the relation between NDVI values and AH data. Fig 2 shows one chart of the regressions, while the total across-years regression result is given in Table 2. By evaluating the coefficient of correlation (R^2) of NDVI-1989, the regressions give higher probabilities of using NDVI data to predict afterwards condition of AHs, i.e. AH-1990, 1993 and 1996. It might be interpreted that the land-use change affects the dynamics of AH than the opposite case. The R^2 of the cell NDVI-1997 and AH-1990, for instance, has a small correlation in comparison with other cells.

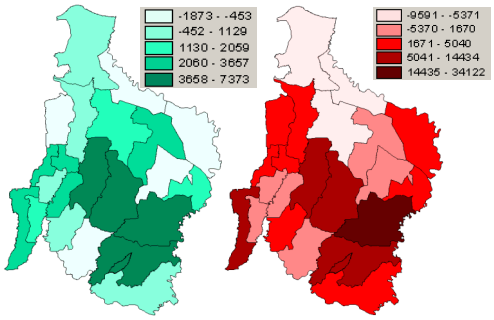

Fig 1. The dynamics of agricultural-land and AH between 1990 and 1996

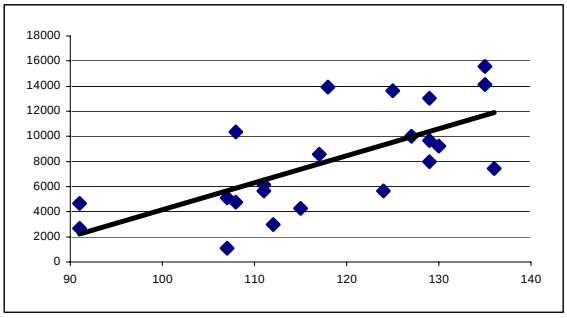

Fig 2. The relationship of NDVI-1989 (x-as) and AH-1990 (y-as)

Decreasing intercepts of NDVI-1989 regressions are caused by significant decrease of AHs in the whole area. It is remarkable between 1993 and 1996. Decreasing of gradient in the period explains decreasing AHs in sub-districts with relatively high NDVI values.

Comparing regression results of NDVI-1989 and NDVI-1997 with respectively AH-1990 and AH-1996 explains also dynamics of relationship between LULC and AHs. Higher gradient in NDVI-1997 regression explains decrease of NDVI between 1989-1997 in the whole area, while lower intercept reflects decreasing of AHs in the period.

Table 2. Linear regression of NDVI-values and AH-data; AH-data (y) are approximated by NDVI values (x).

	NDVI data			
	1989		1997	
AH	Regression	R^2	Regression	R^2
1990	y=214.0x-17224	0.459	y=238.4x-18198	0.350
1993	y=213.8x-18473	0.467	y=277.51x-23784	0.485
1996	y=180.9x-15375	0.474	y=246.3x-21132	0.540
2000	y=250.0x-21995	0.488	y=332.9x-29126	0.532

6. Conclusion

A simple linear modeling has been well computed to link NDVI measurements and AH dynamics in sub-district based areas in Bekasi-district Indonesia. The model suggests that the changing of NDVI, as representation of LULC-change, can be regarded as a driver of AH-dynamics. Further investigation could be related to link spatial planning of the area as a policy guideline of land use with LULC and other socio-economic dynamics.

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