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Accuracy of ALOS AVNIR-2 Image Technology for Mapping Oxygen Need and Green Open Space Priority in Denpasar City, Bali

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Abstract: Green Open Space (GOS) in Denpasar City is getting narrower in proportion to the increase in the need for built-up area. This study was aimed to study the accuracy of the ability of ALOS AVNIR-2 image technology with geographical information system in extracting vegetation density and land use for mapping GOS and estimating oxygen availability; determining GOS need based on oxygen need; determining the location priority of GOS based on vegetation density and land use. ALOS AVNIR-2 image technology became the main source of data in extracting green cover and land use. Oxygen need was calculated by using Gerrarkis method based on the number of population, vehicles industries and hotels from satellite image interpretation. Neighborhood priority was determined by overlaying step-by-step quantitative approach based on the variables of distance to the main road, rate of green cover, air pollution level and GOS need. The result showed that NDVI transformation produced a better correlation coefficient (R^2, that is, 0. 8371 compared to SAVI (0.8368). The interpretation of the cover and land use produced the precision value of 91% and the GOS of 38. 96% from the area of Denpasar city. Estimation of oxygen availability is 945.852.19 kg/day while the oxygen need of the population, motor vehicles industries and hotels is 1.483.561, 66 kg/day, thus, they need an additional amount of oxygen of 537. 709,47 kg/day which is produced by GOS with the area of 1.062.06 ha. The priority areas of the GOS location spread is composed of 5 villages in North Denpasar District, 4 villages in East Denpasar District, 4 villages in South Denpasar District and 6 villages in West Denpasar

Key words: ALOS AVNIR-2 image, GIS, GOS priority interpretation, villages, precision, area

INTRODUCTION

The development of tourism in Denpasar has led to the growth in population accompanied by physical infrastructure and facilities such as housing, transportation industries, etc. The population of Denpasar City in 2013 was 846,200 with rate of growth of 3. 72% and population density of 6.622 people/km^2 (CBS., 2013). The space and land need to accommodate the population and activities which keep on increasing causes Green Open Spaces (GOS) to undergo land use conversion into built up areas (Suharyadi, 2011).

Based on Act RI No. 26 of 2007, GOS is a linear/and/or cluster tract of land with relatively more open land use, a place for growing plants, both natural and cultivated. The 30% proportion is stated as the minimal size to guarantee ecosystem balance. Provision of GOS can be developed from environmental problems such as oxygen need with the development priorities which consider other aspects such as land use, green cover, etc. Supply demand analysis, that is by considering the GOS availability and need is also, important to use in order the GOS planning and management can be prioritized well (Sagala and Saraswati, 2013). The development of GOS needs a good planning and management to make the GOS functions be able to be realized optimally (Fandeli, 2009).

The availability of ALOS AVNIR-2 image with 10 m resolution has opened the opportunity to get information needed in a GOS study (Anonymous, 2007). ALOS AVINIR -2 image has not been commonly used for GOS studies. A study done by Sarker and Nichol (2011) puts an emphasis on the use of ALOS AVNIR-2 to estimate forest biomass by using vegetation index and texture parameter. While Hou *et al*. (2011) integrate ALOS ANVIR-2 data and Airbone Laser Scanning (ALS) through hybrid modeling to estimate physical characteristics of tropical forests in Lao PDR. The use of remote sensing technology which is supported by GIS helps in making the planning of GOS development easier (Longley *et al*., 2005).

Based on the explanation above, the main objectives of this study were to study the ability of ALOS AVNIR-2 image in extracting vegetation density and land use for

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mapping GOS in estimating oxygen availability and to determine GOS need based on oxygen need and to recommend the development of GOS in Denpasar City by using GIS.

MATERIALS AND METHODS

Location of research: This study was conducted in Denpasar City, Bali Province which is located in coordinate 08°35'31"S. Latitude-08°44'49"S. Latitude and 115°10'23"E. Longitude-115°16'27" E. Longitude with the area of 127.78 km^2.

Materials and equipment and instrument: The data used was ALOS AVNIR-2 image recorded in 2010 to extract vegetation density and land use. Quick bird image as updating of land cover information. RBI map with the scale 1:25,000, supported secondary data and field check result. The equipment and instrument were GPS, a meter supported by ENVI 4.5 and ArcGIS 10.1.

Stages of research

Radiometric and geometric correction: Radiometric correction was done in three stages, at-sensor radiance, at-sensor reflectance and at-surface reflectance (Donoedoro, 2012). Geometric correction used image to map method based on RBI map with the scale 1:25,000. Piksel relocation used polynomial algorithm with nearest neighbor spectral value interpolation.

Vegetation index transformation: This study used 2 vegetation indexes, i.e., DVI and SAVI (Soil Adjusted Vegetation Index):

$$NDVI = \frac{\rho_2-\rho_1}{\rho_2+\rho_1}$$

$$SAVI = \frac{\rho_2-\rho_2}{\rho_2+\rho_2+L}\times(1+L)$$

Where:

ρ_1 = Red band
ρ_2 = Close infrared band
L = Land calibration factor 0.5 (Liu and Yang, 2013; Jensen, 2000)

The values obtained from the two vegetation indices was related to the vegetation index resulted from the field measurement through linear regression analysis. The regression result with the best correlation coefficient was used as the equation to produce vegetation density map and its accuracy was tested (Yuan and Bauer, 2007).

Table 1: Land use classification system for urban areas

Level II use	Description
Residence/commercial	Dense residence/housing complex, shops, hotels and offices
Industries	Industrial area, mono industry
Road	Main road, path
Upright vegetation land	City forest, city park, green belt., river boundary, office/house plants
Rice field	Rice field, other farm land
Grass	Soccer field, grass park
River and canal	River, dam, aqueduct/dam
Open space	Dry land without vegetation

Anderson *et al.* (1976) with some modification

Multispectral classification: Multispectral classification was used to obtain maximum likelihood land use information (Liu and Yang, 2012). Classification scheme refers to Anderson *et al.* (2011) classification as shown in the following Table 1.

Sampling: Justice and Townshend in McCoy (2005) proposed the use of the smallest piksel unit to determine vegetation density sample, i.e.,:

$$A = P\ (1+2L)$$

Where:

A = Minimal sample size
P = Image piksel size
L = The 0.5 piksel location accuracy stratified random sampling was used to select the sample

Reclassification and accuracy: To correct object interpretation the data from the field check result were used. To update information about changes in land use quick bird image 2015 was used and to test the accuracy interpretation precision matrix was used.

Availability analysis: GOS availability was analyzed based on vegetation density map which was derived from the result of regression analysis of vegetation index and the vegetation density from the field measurement result. Vegetation density influences GOS types.

Gos need analysis based on oxygen need

Oxygen availability estimation: Oxygen volume was calculated by using Gerrarkis approach in which every 1 m^2 of GOS produces 54 grams of dry weight and 1 gram of dry weight is equivalent with the production of 0.9375 g oxygen/day (Wisesa, 1988).

Oxygen need estimation: The calculation of oxygen need of the population refers to White *et al.* in Wisesa (1988) that human consumes 0.864 kg oxygen/day.

Table 2: Motor vehicle oxygen need

Motor vehicle	Fuel	Fuel need (kg/PS)	O_2 Need per liter of fuel (kg)	O_2 Need (kg/h)
Motorcycle	Gasoline	0.210	2.77	0.58
Passanger car	Gasoline	0.210	2.77	11.63
Passanger bus	Solar	0.160	2.86	44.32
Cargo Car	Solar	0.160	2.86	22.88

Wisesa (1988) and Syailendra (2005)

Pt = Total number of population×human oxygen consumption (0.864 kg/day)

Oxygen need of motor vehicles was calculated based on the criteria in Table 2:

Kt = Number of vehicles (unit)×amount of fuel (L)× average oxygen need (kg/h)×24 h×10^{-3}kg

Oxygen need of the industries was determined in that the average fuel need of an engine is 185,759 kg/day (operating 8 h) and every kg of diesel fuel needs 2.86 kg oxygen:

It = Number of large industries×fuel average need (185.759 kg/day)×oxygen need/1 kg of fuel (2.86 kg)

The oxygen need of hotels was calculated through the process of fuel burnings by generators. The average fuel need of generators is 529. 41 kg/day for 5 h active time/day. Every kg of generator fuel needs 2.86 kg of oxygen:

Ht = total number of hotels×average fuel need (529. 41 kg/day) ×oxygen need for 1 kg of fuel (2. 86 kg)

GOS need based on oxygen need: The determination of GOS area needed (m^2) based on oxygen need was made based on Gerrarkis method in Wisesa (1988) as follows:

$$Lt\left(m^2\right) = \frac{\left(Pt+Kt+lt+Ht\right)\left(gram/hart\right)}{54 * 0.9375}$$

Determination of GOS priority: The development of GOS priority used overlay method using step-by-step quantitative approach (Longley, 2005). The variables for determining GOS priority comprises analysis of distance to the main road, green cover, air pollution based on land use and GOS need based on oxygen need.

RESULTS AND DISCUSSION

Analysis of GOS availability

Vegetation index transformation: Based on regression analysis, both vegetation indices showed a very strong correlation. Vegetation index by using NDVI produced a slightly better correlation, i.e., 0.8371 compared to the correlation by using SAVI which is 0. 8368. According to Sugiyono (2012), the coefficient of correlation between 0.80-1.00 categorized as very strong correlation. Area of green cover based on NDVI transformation can be seen in Table 3.

Table 3: The area of green cover based on NDVI transformation

Categories	NDVI value	Area (ha)	Percentage	Vegetation density (%)
Non GOS	≤-0.1298	7,648.01	61.08	-
Very low	-0.1298 -0.0345	2,162.75	17.27	<25
Low	0.0346-0.1989	1,565.54	12.00	25-50
Medium	0.1990-0.3633	974.94	7.79	51-75
High	≥0.3634	169.11	1.35	>75

Land use mapping: McCoy (2005) states that the minimal accuracy percentage that can be tolerated is 80-85% based on characteristics of the area being studied. From the result of the inter pretation precision test it was found that the accuracy of the precision of interpretation reaches 91%, thus, it can be used for a land use analysis especially, in relation to GOS analysis.

Based on the explanation above, GOS availability in Denpasar City through vegetation density analysis, the area of 4,872.34 ha or 38.92% of Denpasar area was found while based on the result of land use classification (mixed forest land, agriculture land, and grass field) in Table 4 was 4,87.07 or 38.95% of Denpasar City area.

The analysis of GOS availability based on NDVI transformation and multispectral classification shows a result which is not much different, so that both methods can be used for extracting data on existing GOS availability.

GOS need analysis based on oxygen need

Estimation of oxygen availability and need: GOS need can be found out after calculating GOS availability and oxygen need. The area of mixed forests is 1,868.35 ha; thus, oxygen availability is 945,852.19 kg/day. The estimation of oxygen need for each indicator is as shown in Table 5.

Estimation of GOS need: GOS need was calculated based on oxygen need by using Gerraki's method and Fandeli (2009):

$$Lt = \frac{\left(\begin{matrix}740.082,5+585.718,5+\\116.879,6+40.881,04\end{matrix}\right)\left(kg/h\right)}{\left(54gr/m^2\right)\times\left(0.9375\ gr/hr\right)} = 2,930.41\ ha$$

GOS need is 2.930.41 ha while GOS availability is only 1,868.35 ha, thus, there is a need to provide an additional GOS of 1,062.06 ha which can produce additional oxygen of 537,709.47 kg/day to maintain GOS balance in Denpasar City.

Table 4: The characteristics of land use in Denpasar city in 2015

Land use	Area (ha)	Percentage	Description
Mixed residential building	6.253	49.97	Residence, house complex, shops, hotels and offices
Industrial Building	373.650	2.99	Industrial area, mono industry
Road	309.990	2.48	Main road, local road, path
Mixed Forest Land	1,868.350	14.93	City forest, city park, green belt, river boundary, office park/ house park
Farm Land	2,375.200	18.98	Rice, Garden and Farm Land
Grass Land	631.520	5.05	Soccer field, grass park
River/Canal	56.080	0.45	River, channel/ canal
Open Space	643.520	5.14	Empty land without vegetation

Table 5: Estimation of oxygen need for each variable

Variable	Oxygen need (kg/day)
Population (human)	740,082.5
Motor Vehicle	585,718.5
Industries	116,879.6
Hotels	40,881.04

Table 6: Rating of the level of inconvenience based on distance to main road

Distance to main road (m)	Level of inconvenience	Rating
<100	Very high	4
100-200	High	3
201-300	Medium	2
>300	Low	1

Table 7: Rating of the level of air pollution based on land use

Land use	Level of air pollution	Rating
Industry	Very high	4
Road	High	3
Residence	Medium	2
Upright vegetation land, farm land, grass land, open space	Low	1

Determination of GOS priority: GOS priority was determined based on the rating of each parameter in each variable. The variables were inconvenience based on the distance to the main road Table 6, level of air pollution based on land use Table 7, rating of level of green cover (Table 8) and GOS need based on oxygen need (Table 9). Then, each of the variables was given weighing in accordance with its level of impact on the determination of GOS priority as shown in Table 10.

The overlay was done by multiplying weighing factor with the rating and it was then followed by the addition of each value of rating of each rating of parameter:

$$\text{Total rating} = (H_1 \times 10)+(H_2 \times 25)+(H_3 \times 25)+(H_4 \times 40)$$

- H_1: rating of the unit in the determination of level of inconvenience based on distance to main road
- H_2: rating of the unit in the determination of air pollution based on land use
- H_3: rating of the unit in the determination of green cover
- H_4: rating of the unit in determination of oxygen need

Table 8: Rating of level of green cover density harka

Green cover (%)	Class	Rating
<25	Very low	4
25-50	Low	3
50-75	Medium	2
>75	High	1

Table 9: Rating of GOS need based on oxygen need

Class of GOS need	Rating
Needs additional GOS	4
Does not need additional GOS	1

Table 10: Weighing factors for each parameter for determination of GOS priority

Parameter GOS priority	Weighing factor
Inconvenience based on the distance to main road	10
Level of air pollution based on land use	30
Green cover	30
Gos need based on oxygen need	30

Table 11: Total rating and category of priority for GOS development

Total rating	Category 1
100-200	Less priority
201-301	Sufficient Priority
302-400	Priority

After the result of the overlay processes of some maps above was known, then GOS priority classification was determined using the following equation:

$$\frac{\text{Maximal total rating value-Minimum total rating value}}{\text{Number of classes}} = \frac{400\text{-}100}{3}$$

GOS priority is differentiated into 3 categories, less priority, sufficient priority and priority, with the classification according to the total of ratings as shown in Table 11. The three GOS development priorities according to their locations can be visualized in the form of map as shown in Fig. 1.

Based on GOS priority map in Fig. 1, the area which tends to be prioritized for developing GOS is the area which has undergone the cramming of buildings. Areas at the sides of a main road is sufficiently prioritized for GOS development by considering level of inconvenience of the population who live there. The problem of inadequate GOS in Denpasar city can be solved by using open space of 643.52 ha which has the potential to produce

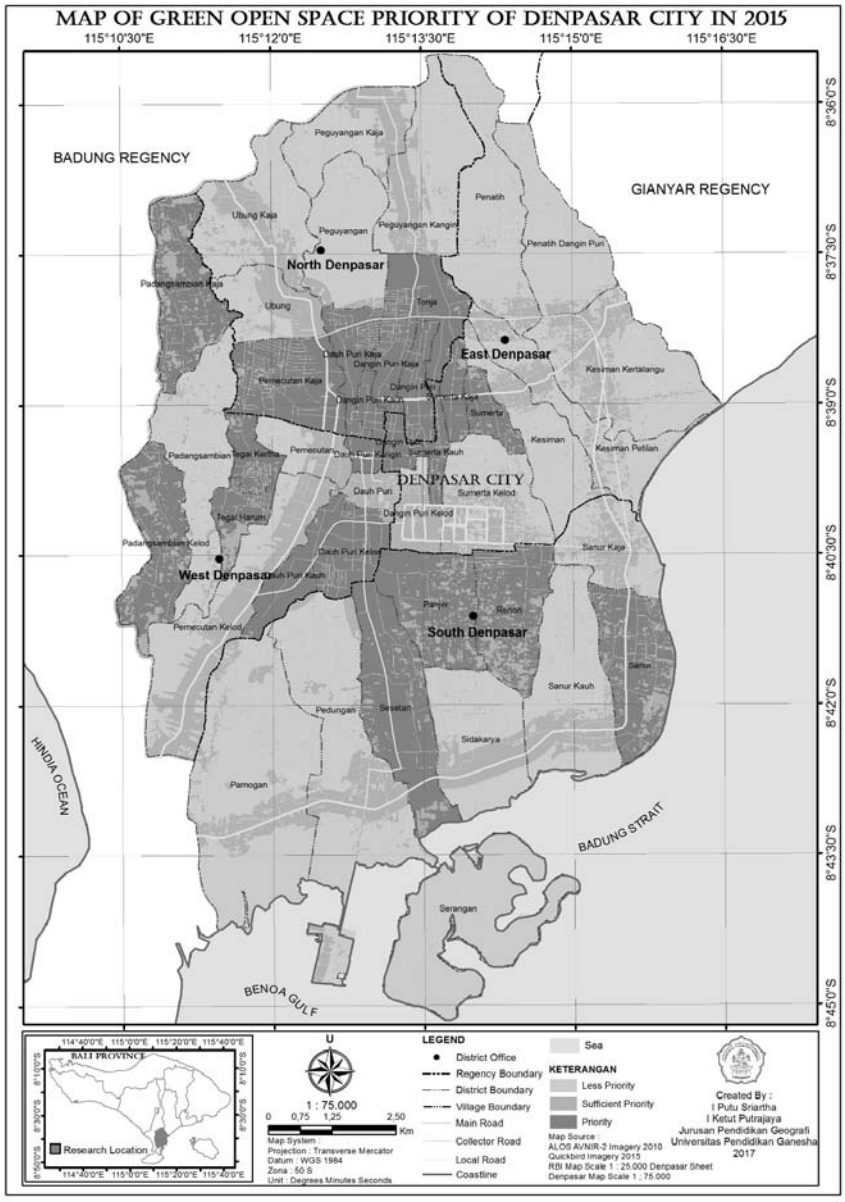

Fig. 1: Map of green open space priority of Denpasar City

325,782 kg of oxygen/day. The provision of GOS can also be done by increasing vegetation density in GOS areas with low density and by developing better great belts.

The provision of GOS in areas with "Priority" category becomes the most important thing to do. Some areas with this category comprises North Denpasar District, i.e., Tonja Sub district, Sumerta Kauh Village, Pemecutan Kaja Village, Dangin Puri Kaja, Dangin Puri Kauh and Dauh Puri Kaja Village. East Denpasar District which comprises Sumerta Subdistrict, Sumerta Kauh Village, Sumerta Kaja and Dangin Puri Subdistrict. South Denpasar District which comprises Panjer Subdistrict, Renon, Sesetan and Sanur Subdistrict. West Denpasar with the areas which comprises Tegal Harum Village, Padangsambian Kelod, Dauh Puri Kelod and Dauh Puri Kauh Village.

The development of GOS in densely populated areas or in the middle of the city is in the form of private GOS or yards. The limitation of yard areas with narrow environment roads does not rule out the possibility of realizing GOS through planting plants in pots or other plant media and GOS in the form of roof garden. Then, GOS can also be developed in the yards of offices, shops, hotels and other business places which generally take the

form of pavement and open parking areas. The development of public GOS is also important to do in roads by adding empty space on the sides of the road by planting trees. Besides, city forests can also be developed in main roads, like in by Pass Ngurah Rai street to the south which can still be planted with mangroves in a large number.

CONCLUSION

ALOS AVNIR-2 image analysis in 2020 to find out vegetation density through NDVI transformation produced a better correlation (R^2) that is 0.8371 compared to with SAVI (R^2 = 0.8368). The result of the accuracy of the mapping of vegetation density shows the precision level of 85% and it was found that GOS area is 4,872. 34 ha or 38. 92% while the interpretation of cover and land use in Denpasar city produced the 91% level of precision with the land use for GOS of 4,875. 07 ha or 38.96% of the total area of Denpasar City, especially for mixed forest land with the area of 1, 868. 35 ha.

The availability GOS with mixed forest category is 1, 868.35 ha which produces 945, 852. 19 kg of oxygen/daily. Oxygen need based on the number of population, the number of motor vehicles industries and hotels is 1, 483, 561.66 kg/day, so that to meet the oxygen need GOS is needed with the area of 2, 930.41 ha. This figure shows that the availability GOS has not met oxygen need of Denpasar city, thus, there is a need to provide additional GOS of 1, 062.06 ha which can produce additional oxygen of 537, 709.47 kg/day to maintain GOS balance in Denpasar City.

The determination of GOS priority is grouped into areas with less priority, areas with sufficient priority and areas with priority for GOS development which comprises North Denpasar District, i.e., Tonja Subdistrict, Pemecutan Kaja Village, Dangin Puri Kaja Village, Dangin Puri Kauh Village and Dauh Puri Kaja Village; East Denpasar District Administrative area which comprises Sumerta Subdistrict, Sumerta Kauh Village, Sumerta Kaja Village and Dangin Puri Subdistrict; South Denpasar District. which comprises Panjer Subdistrict, Renon Village, Sesetan Village and Sanur Subdistrict; and West Denpasar District. Denpasar District which comprises Tegal Harum Village, Tegal Kertha Village, PadangsambianKaja Village, Padangsambian Kelod Village, Dauh Puri Kelod Village and Dauh Puri Kauh Village.

SUGGESTIONS

The study of GOS by using ALOS AVNIR-2 image and satellite Image with spatial resolution to obtain a better result needs to consider some points as follows. The choice of a better transformation method and classification to produce better GOS information with a high accuracy.

The determination of parameters to be used for analyzing oxygen need, since every region has its own characteristics, so that, its oxygen need will always be different. The formula to calculate oxygen need can be modified according to the study area.

The choice of the appropriate GOS type to be developed in the area with GOS priority, considering the land availability which is getting more limited so that there is a need to use land optimally in providing GOS.

The use of satellite image with especially, high resolution enables the classification of detailed land use so that the determination of GOS priority can be done well in every unit of land use.

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