A Spatial Modeling Approach with Logistics Binary Regression for Bamboo Forest Distribution Mapping

Lutfy Abdulah[a] , Mira Yulianti[a]
a. Center of Research and Development for Improving Forest Productivity on Indonesia Environment and Forestry Ministry
Email : lutfyalam@gmail.com

Abstract : The management, utilization and conservation of bamboo resources needed technology. that is cheap, easy and reliable. Landsat 8 OLI is one of the technologies in question. However, the necessary data analysis methods in use. In general, the use of Landsat 8 OLI and binary logistic regression analysis has been widely applied. But, not specific products and location. To that end, this study was designed to test the use of binary logistic regression and Landsat 8 OLI in identifying the presence of bamboo in a wide spatial distribution. The method used is to create observations plots with random technique in a wide spatial distribution. Plot size adjusted to the pixel size of Landsat ie 30 x 30 m. The results showed that by using a binary logistic regression can accommodate 83% of the data (or R2 = 83%). This shows that this model is quite good and reliable used as an identification tool distribution of bamboo.

Keywords : bamboo forest, spatial model, logistics binary regression

Introduction

Management of natural resources and land resources is the interaction of social and natural processes. The patterns of bamboo use and land use are generally presented in the form of thematic maps. Making maps can use modeling approach (Liang 2008). In the construction of the model, there are some important information such as the type and performance of ecosystems, hydrology and atmospheric models are usually presented in the form of satellite imagery and data products DEM (Digital Elevation Model) (Bounoua et al. 2002; Jung et al., 2006; Miller et al. 2007). It tends to be easier and cheaper. But it have to valid.

Nowadays, remote sensing technology continues to evolve. These developments include the resolution and information that can be built from the remote sensing products. One of remote sensing products are widely used Landsat. Landsat 8, the new generation of Landsat series satellites, was successfully launched and began to supply data for the worldwide community of researchers and educators in May 2013. The OLI data performance was slightly better than the ETM + data performance in the VIS bands, especially for the NIR band of the OLI data, where a clear improvement was found. Clear improvement was not founded in the SWIR bands. OLI data had a satisfactory performance in land cover classification; the overall classification accuracy using the SVM classifier was higher than for the MLC classifier. It will make easy and cheap for bamboo survey for production and conservation. At this time, opportunity to improve bamboo productivity still expensive because of high cost inventory.

Several studies conducted to explore the digital image information from, among others, build indexes and to build a model estimators. Silleos *et al*, (2006) using vegetation indices and indices of land in modeling forest biomass. While Roy *et al*, (1996) using vegetation indices in land cover classification. Vegetation indices can reduce the effects of bias and assist in the extraction of the significant features of a specific ground object (Curran 1980; Malila *et al* 1981: Roy et al, 1996).

Rikimaru et al, (2002) establish forest cover density (FCD) index. The Forest Canopy Density (FCD) Mapping and monitoring of forest canopy density Utilizes model as an essential parameter for the characterization of forest conditions. FCD Data indicates the degree of degradation, thereby indicating the intensity Also of rehabilitation treatments that may be required. Thus, the use of the index in the distribution of bamboo is not a valid identification. This is due to the reflection of electromagnetic waves is almost similar to the pine bamboo, sugar cane and corn (Lobovikov et al, 2007).

To that end, the approach regression models were developed. Anselin (2003) using the R statistical construct spatial regression models. Hoek, et al., (2008) mentions that the land-use regression method is more focus on developing models that can be transferred to other areas, inclusion of additional predictor variables Reviews such as wind direction or emission of data and further exploration of focal sum models. Regression models are now widely used binary logistic regression (Jose et al, 1991); (Pradhan & Lee, 2010).
Spatial modeling approach in describing the bamboo distribution has also been developed. Menon (1995) construct a map of the distribution of bamboo with aerial photographs. He concluded that the land cover map showing the distribution of bamboo area along with other vegetation types was prepared in 1:25 000 scale for management purpose. The mapping accuracy was evaluated and was found to be of 90% in the case of aerial photographs. The classification accuracy of the data satellite products was found to be 65-70%. Thammincha, (1995) using Landsat imagery in the delineation of bamboo distribution in Thailand. However, some problems mapping the distribution of bamboo is bamboo distribution in nature is not always clustered and form pure forest. Distribution of bamboo in nature tend to follow the severe slopes and along rivers. This is due to the social behavior of people who put bamboo as soil conservation, while the economic value obtained is a plus. To that end, the spatial model approach (especially binary logistic regression models) tested. This method will reduce cost inventory and make easy bamboo utilization.

Material and Method

a. Site Description

Astronomically, Bangli Regency is located at $115^0$13'4 " until $115^0$27'24 " East longitude and $8^0$8'30" up to $8^0$31'87" South Latitude. The total area of 520.81 km^2 with elevation reached between 100m.asl (above a sea level) -2152 m.asl. Bangli has several tourist attractions, among others, bamboo collection in Panglipuran gardens, nature lake Batur and Mount Batur and other religious tourist attraction. For Bangli, it takes 60 minutes from Denpasar, Bali. The population reached 213 808, with a growth rate of 0.41%. Population density reaches 411 inhabitants. Km^{-2}.
Bamboo is an important part of people's lives. There are 42 species of bamboo in Bali (Widjaja et al, 2005) and 19 species were found in Bangli. Bamboo is also a source of foreign exchange. Department of Trade and Industry, Bali Province reported that export of bamboo handicraft from Bali province on may-October 2014 period recorded more than 9.8 million USD. Bamboo handicraft exports to 64 countries (Figure)

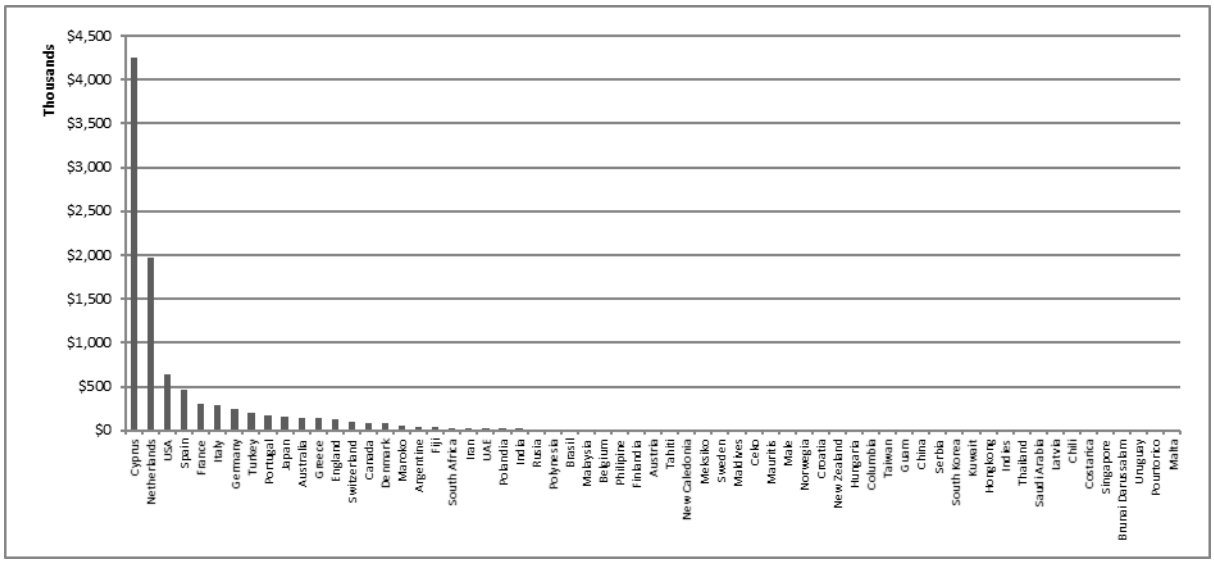

Figure 1. The value of exports of bamboo handicrafts from Bali Province (periods may - October 2014)

Based on Figure 1, Cyprus, the Netherlands and the USA has the largest import value to the craft of bamboo in Bali. When the main raw material of bamboo from Bangli the bamboo position information is needed.

b. Material

Materials used in this study were Landsat 8 OLI, Aster DEM, administrative maps, soil maps and maps of climate and rainfall map. The tool used is Arc GSI 10.1, Minitab, MS. Excel, GPS receivers, tally sheet and camera pocket.

c. Method

The data is divided into two namely primary data (data obtained in the form of field surveys) and secondary data (data collected from relevant agencies such as soil type maps, climate and rainfall maps, administrative maps and Landsat 8 OLI and daisies from USGS DEM) . Primary data collection to make GCP (ground check points) with a plot size of 30 x 30 m. This is to adjust the pixel size of Landsat 8 OLI. Determining the location of sampling intentional. Sampling is done in some type of land-use such as gardens, forests, settlements and field's area.

d. Data Analysis

Data analysis was conducted according to the following diagram conceptual framework.

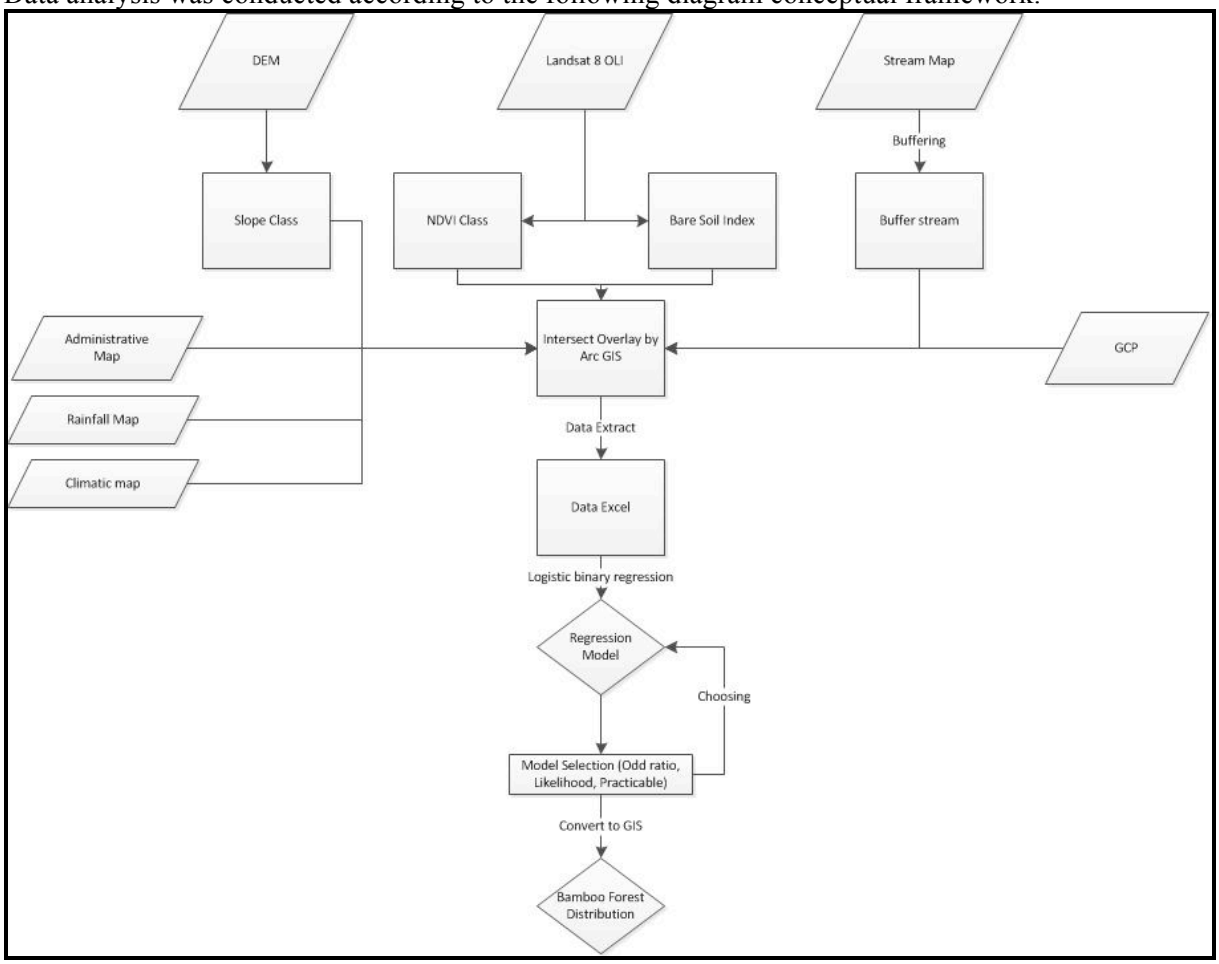

Figure 2. Conceptual framework diagram

Based on Figure 2, there are two indices that NDVI (normalized density of vegetation indices) and BI (bare soil index), was built with the following formula:

$$BI = \frac{(Band+Band\ 4)-(Band\ 5+Band\ 1)}{(Band+Band\ 4)+(Band\ 5+Band\ 1)}\ x\ 100 + 100$$ .....Rikimaru et al, (2002)

$$NDVI = \frac{Band\ 5-Band\ 4}{Band\ 5+Band\ 4}$$ ..... (Waqaret al, 2012)

A general model of binary logistic regression is:

$$P = (Y = 1) = \pi = \frac{e^{\beta_0+\beta_1 x_1+\cdots++\beta_k x_k}}{1+e^{\beta_0+\beta_1 x_1+\cdots++\beta_k x_k}}$$

Buffer river made on 4 class which is 10 m, 50 m, 100 m and 200 m. It is based on the observation in the field

Result and Discussion

a. Distribution of bamboo based on biophysical criteria

There are 6 variables were constructed to model the distribution of bamboo, the river, rainfall, soil type, slope, NDVI and BI. As for the distribution of data for each variable against GCP presented in Figure 3 below.

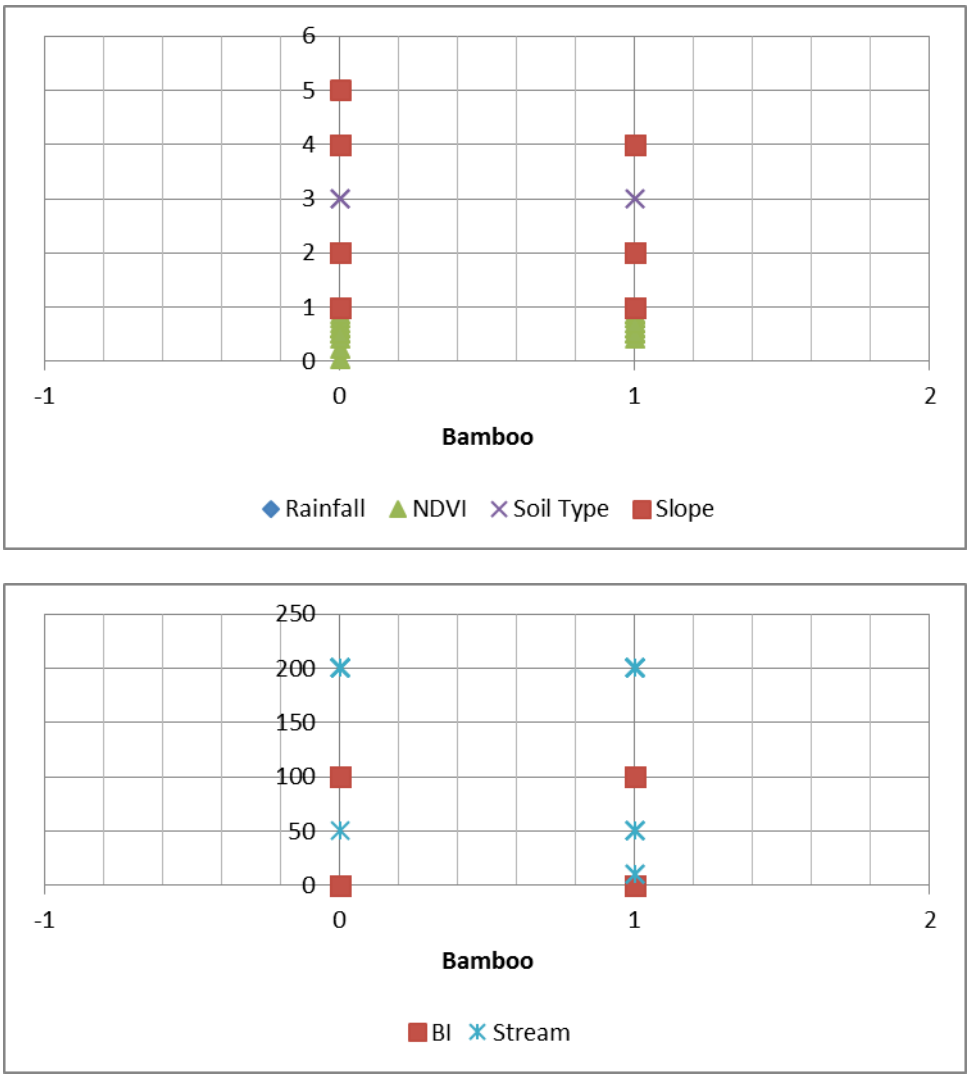

Figure 3. Distribution of predictor variables to the data of bamboo

Based on Figure 3, the distribution of predictor variable data (streams, rainfall, slope, soil type, BI index and NDVI) for the existence of bamboo is very wide and varied. This can be explained each predictor as follows: (1) the intensity of rainfall: bamboo is the rainfall from 1750 to 2500 mm / year, (2) types of soil: there are 3 types of soil which is a place to grow bamboo, (3) distance of the river: bamboo can be found at a distance of 10 m, 50 m and 200 of the river, (4) NDVI, bamboo is the interval 0 -1. (5) BI: bamboo can be found in the area without the stand and wet and also areas with dense stand density (0-100). However, bamboo is not present in areas non-vegetation area and dry lands (200).

b. Binary logistic regression model

Formulation of the regression model is done by a combination of predictor variables (independent variables) in predicting the distribution of bamboo as the dependent variable. The best combination is acquired slope, distance from stream and NDVI. Best able to explain more than 80% of data, have a real relationship in predicting the distribution of bamboo. This is demonstrated by the statistics-G and Odds ratios and practical. Practical criteria made to the model generated can be directly applied to the user and does not require a lot of basic data. The best model is shown in box 1 below.

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Variable  Value  Count
Bambu     1         45  (Event)
          0         32
          Total     77

Frequency: Slope

Logistic Regression Table
                                                    Odds     95% CI
Predictor        Coef    SE Coef      Z      P  Ratio  Lower  Upper
Constant      4.04057    1.31410     3.07  0.002
Stream       -0.0102251  0.0054634  -1.87  0.061   0.99   0.98   1.00
Slope        -0.449187   0.243484   -1.84  0.065   0.64   0.40   1.03
NDVI         -0.0261156  0.0068063  -3.84  0.000   0.97   0.96   0.99

Log-Likelihood = -34.387
Test that all slopes are zero: G = 35.765, DF = 3, P-Value = 0.000

Goodness-of-Fit Tests

Method           Chi-Square  DF      P
Pearson             29.0513   9  0.001
Deviance            32.9157   9  0.000
Hosmer-Lemeshow     20.0863   5  0.001

Table of Observed and Expected Frequencies:
(See Hosmer-Lemeshow Test for the Pearson Chi-Square Statistic)
                       Group
Value     1    2    3     4     5    6    7  Total
1
  Obs     0    4    8     6    12   10    5     45
  Exp   0.9  1.9  5.6  12.0  10.7  9.1  4.8
0
  Obs    13    4    4    10     1    0    0     32
  Exp  12.1  6.1  6.4   4.0   2.3  0.9  0.2
Total    13    8   12    16    13   10    5     77

Measures of Association:
(Between the Response Variable and Predicted Probabilities)

Pairs       Number  Percent  Summary Measures
Concordant    1206     83.8  Somers' D              0.73
Discordant     154     10.7  Goodman-Kruskal Gamma  0.77
Ties            80      5.6  Kendall's Tau-a        0.36
Total         1440    100.0
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Box 1. Model bamboo forest distribution

Based on box 1, there are 45 data indicate that the area there are bamboo and 32 data indicating the area is not bamboo. Based on the statistic Z, only the NDVI variable that has a value of Z = -3.84 with a p-value = 0.00. Thus it can be said that the NDVI coefficient is not equal to 0, while the variable slope and distance from stream = 0. Statistics G = 35.765 with a p-value = 0.00 which strengthens the above results, that there are at least one variable that is not equal to 0. While most Odds Ratio is the distance from stream (99%) and NDVI (97%). Goodness of fit test with three kinds of test namely Pearson, Deviance and Hosmer-Lemeslow, 29.0, 32.9 and 20.0 and the p-value <5% explained that this model is very good for estimating the distribution of bamboo. The percent Concordant 83.8% shows that 83.8% of the data can be explained by this model.
Thus, the distribution of bamboo in Bangli district may be suspected by the formula:

$$P = \frac{exp^{4,04-(0,01*Stream)-(0,45*Slope)-(0,026*NDVI)}}{1 + exp^{4,04-(0,01*Stream)-(0,45*Slope)-(0,026*NDVI)}}$$

c. Model of spatial distribution of bamboo

Based on the above binary logistic model, the spatial distribution of bamboo in Bangli regency shown in Figure 4.

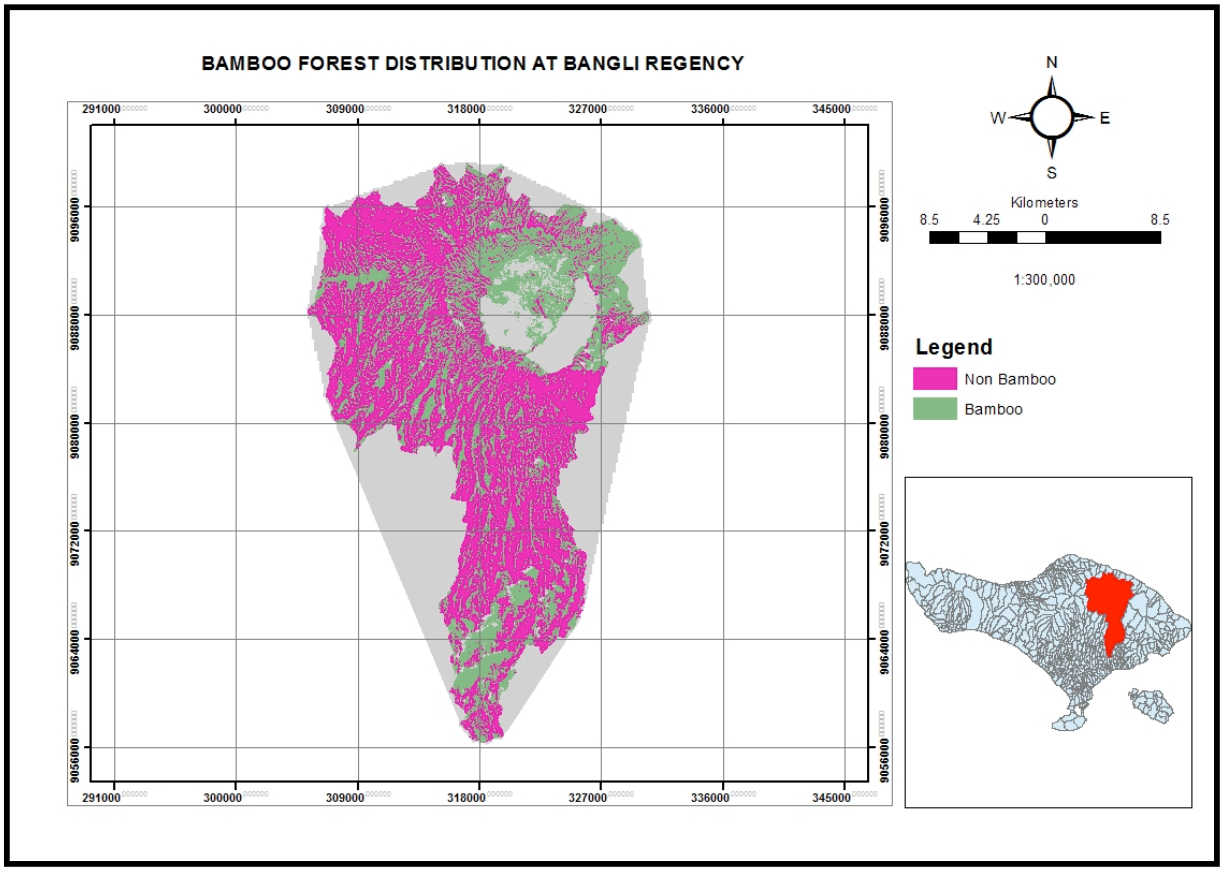

Figure 4. Bamboo forest distribution map in Bangli regency

Map above shows that most of the land area of bamboo vegetation found on the north, west and south of Bangli district. The proportion of bamboo vegetated land is smaller. At the slope class 0-25% used to settlements, fields and gardens etc. While bamboo, located in an area with heavy slope and distance from stream <200 meters. Bamboo as a necessity of life (religion, culture and livelihood) did not become a major commodity in the use of land. Distribution of bamboo in each sub-district is different and varied (Figure 5).

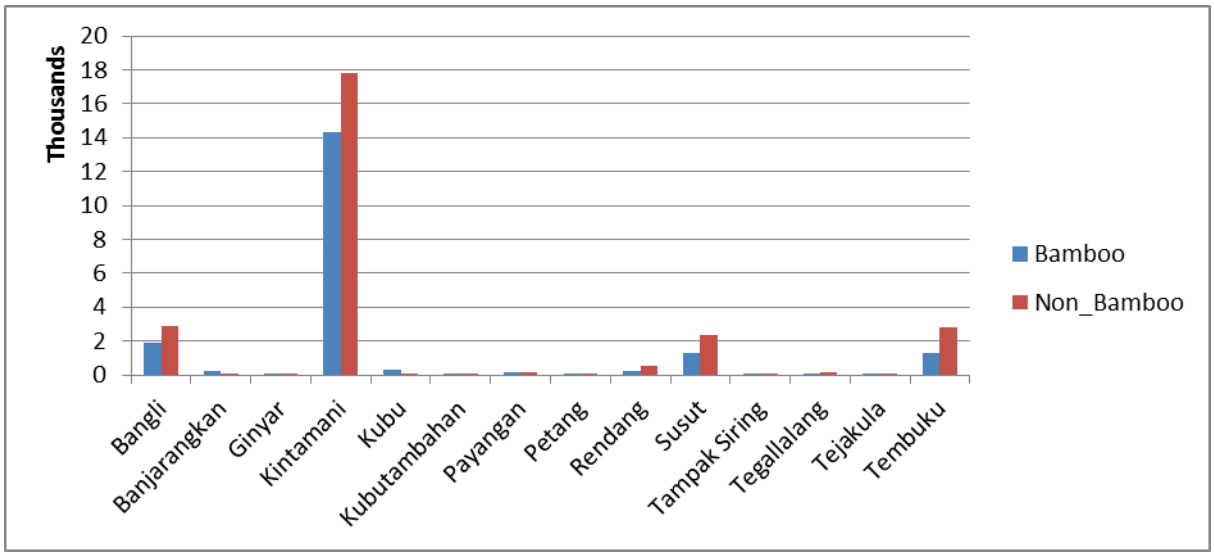

Figure 5. Bamboo distribution on sub district

Sub-district of Kintamani has the largest bamboo vegetated land (16,000 ha). This is caused by the wide the administrative territory reaches 70.45% of the Bangli district administration. Kintamani have largest bamboo vegetated land (16,000 ha), because one of subdistrict with large area (>70%). But, it is not potential for use. Some existing problems such as transportation, the low selling price of bamboo and bamboo growing areas in severe topography makes bamboo raw material potential untapped.

Meanwhile, in the sub-district of Bangli, there are plantations of bamboo. This forest developed since Indonesian independence war. Until now, the existence of a bamboo forest is maintained and managed by the local indigenous communities. Is a traditional village Panglipuran still maintain this bamboo forests.

Bamboo forest located on flat topography, close to the highway and is part of the traditional village tour. Utilization is based on the request of indigenous peoples. Harvesting system set by custom. This makes bamboo forests grow well and be one of the bamboo collection field in Bali.

d. Discussion

Bamboo is a natural resource with multiproduct. As a plant, bamboo belongs to the *Gramineae* family and has about 90 genera with over 1 200 species (Lobovikov et al, 2007). Bamboo is naturally distributed in the tropical and subtropical belt between approximately 46° north and 47° south latitude, and is commonly found in Africa, Asia and Central and South America. Bamboo shoots and culms grow from the dense root rhizome system. There are two main categories of rhizomes: monopodial and sympodial. Bamboo can be used for household appliances and equipment, foodstuffs and medicines as well as for energy. Natural bamboo forests in Indonesia only area of 723 thousand hectares and planted area of 1.4 million ha, with a potential of 10 million tons per hectare assuming potential is 5 tons / ha, or 7.5 kg / clumps or clumps 133 / ton. In other words that the potential of bamboo in Indonesia reached 10.4 million tons. Indonesia is rich in diversity of species of bamboo, there are 118 species native to Indonesia and only 17 species were brought in from outside. Meanwhile, Bali is one region that is heavily dependent on bamboo (religious, cultural and other needs) has at least 19 species of bamboo, 12 species of them are native types Bali (Ketut Arinasa, 2005). Type with the largest population distribution in Bali, Schizostachyum five or reed taluh in Balinese language.

The results of this study showed that the distribution of bamboo can be simplified by studying the distance from stream and slope. Bangli district is one of the sources of local revenue from the agricultural sector. Land use for citrus, horticulture others, cattle and pigs became a priority. While bamboo is grown in region with heavy topographic characteristics. Planting bamboo is not due consideration earn income from the cultivation of bamboo, but for the purpose of conservation. However, in some region, there is a forest of bamboo plants developed as part of the local wisdom.

This is affecting the estimation of the distribution of bamboo. To that end, the NDVI index is used as auxiliary variables in predicting the spread of bamboo.
Binary logistic regression models generated showed that 83% of data can be explained by this model. Thus, the selection of variables are valid. This is certainly very easy for the user either to find the source of raw materials, establish bamboo handicrafts industry and bamboo processing even for the purpose of rehabilitation and enrichment of bamboo forest.
Formulation of the business plan will be very easy. Data can be obtained for free by accessing the USGS Landsat imagery and DEM data gained from DEM Aster. The use of this model will directly help map the distribution of bamboo in different areas. The next step is to create sample plots for verification.
However, this model does not distinguish bamboo by type distribution. The resolution of the Landsat 8 OLI that only 30 x 30 m, so it does not clearly distinguish bamboo by type. The use of high-resolution imagery or with drones at some point will help identify the distribution based on types. Thus method can reduce the cost for inventory and have to validate with some real plots in the field. But in this study, we have not validate in another area and different plot size.

Conclusion

Based on the above results it can be concluded that a binary logistic regression model can be used to build a model of the distribution estimators bamboo. Variable distance from stream, slope and NDVI is the best combination in the distribution of bamboo suspect. However, based on the partial test, variable slope and distance from stream had no significant effect. This is due to the presence of vegetated land deliberately planted bamboo bamboo (traditional village Panglipuran) as a bamboo forest, and there can also be planted in the yard. By using NDVI from Landsat 8 OLI then these two variables can bias diminimlkan. Kintamani sub-district has the largest bamboo vegetated land (16,000 ha). Model estimates of the distribution of bamboo in Bangli is

$$P = \frac{exp^{4,04-(0,01*Stream)-(0,45*Slope)-(0,026*NDVI)}}{1 + exp^{4,04-(0,01*Stream)-(0,45*Slope)-(0,026*NDVI)}}$$

References

Anselin, L. (2003, May 23). *An introduction to spatial regresion analysis in R.* Retrieved December 26, 2014, from geodatacenter.asu.edu: www.geodatacenter.asu.edu/ drupal_files/ spdepintro.pdf

Bounoua L, DeFries R, Collatz GJ, Sellers P, Khan H. 2002. Effects of land cover conversion on surface climate. Climatic Change. 52: 29–64.

FAO, I. d. (2007). *World Bamboo Resources: A Thematic Study Prepared in the Framework of The Global Foret Resources Assessment 2005.* Rome: FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS.

Hoek, G., Beelen, R., de Hoogh, K., Vienneau, D., Gulliver, J., Fischer, P., et al. (2008). A review of land-use regression models to assess spatial variation outdoor air pollution. *Atmospheric Environment*, Vol. 42 (33); 7561-7578.

Jose , M., Pereira, C., & Itami, R. M. (1991). GIS-based habitat modeling using logistic multiple regression: a study of the Mt. Graham Red Squirrel. *Photogrammetric Engineering & Remote Sensing*, Vol. 57 (11): 1475-1486.

Jung M, Henkel K, Herold M, Churkina G. 2006. Exploiting synergies of global land cover products for carbon cycle modeling. Remote Sensing of Environment. 101: 534–553.

Ketut Arinasa, I. (2005). Keanekaragaman dan Penggunaan Jenis-jenis Bambu di Desa Tigawasa, Bali. *Biodiversity Vol 6 (1)*, 17-21.

Kun Jiaa, X. W. (2014). Land cover classification using Landsat 8 Operational Land Imager data in Beijing, China. *Geocarto International*, Vol. 29, No. 8, 941–951.

Liang S. 2008. Advances in land remote sensing. Dordrecht: Springer.

Lobovikov, M., Paudel, S., Piazza, M., Ren, H., & Wu, J. (2007). *World Bamboo Resources: A thematic study prepared in the framework of the Global Forest Resources Assessment 2005.* Rome: FAO.

Menon, A. (1995). Application of remote sensing in bamboo resources inventory in India. In J. Williams, Nur Supardi Md. Noor , & I. V. Ramanu, *Inventory Techniques and asessment of rattan and bamboo in tropical forest* (pp. 83-86). Malaysia: FRIM, DFID-UK/Oxford Forestry Institute & INBAR.

Miller SN, Phillip Guertin D, Goodrich DC. 2007. Hydrologic modeling uncertainty resulting from land cover misclassification. Journal of the American Water Resources Association. 43: 1065–1075.

Pradhan, B., & Lee, S. (2010). Delination of landslide hazard areas on Penang Island, Malaysia, using frequency ratio, logistic regression, and artificial neural network models. *Environmental Earth Sciences*, Vol. 60 (5): 1037-1054.

Rikimaru, A., Roy, P. S., & Miyatake, S. (2002). Tropical forest cover density mapping. *Tropical Ecology*, 43(1): 39-47.

Roy. P.S., S. K. (1996). Stratification of density in dry deciduous forest using satellite remote sensing digital data—An approach based on spectral indices. *Journal Biosci*, Vol. 21, Number 5: 723-734.

Silleos, N. G., Alexandridis, T. K., Gitas, I. Z., & Perakis, K. (2006). Vegetation Indices: Advances Made in Biomass Estimation and Vegetation Monitoring in the Last 30 Years. *Geocarto International*, Vol. 21, No. 4: 21-28.

Thammincha, S. (1995). Application remote sensing in bamboo resource inventory in Thailand.

Tokola, T. (2006). *Forest Inventory : Methodology and Application. editor : Kangas dan Maltamo.* Springer.

Waqar, M. M., Mirza, J. F., Mumtaz, R., & Hussain, E. (2012). Development of new indices for extraction of built-up area & bare soil from landsat data. *Scientific Report*, Vol 1 (1): 1-4.

Widjaja, E. A., Astuti, I. P., Arinasa, I., & Sumantera, I. (2005). *Identikit Bambu Di Bali.* Bogor: LIPI.