APPLYING GIS AND MATHEMATICAL MODEL TO ESTABLISH SUITABLE MAPPING FOR JATROPHA

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ABSTRACT

There are many theses researching about applying GIS and mathematical model in land use and management effectively and bring out satisfactory results. In this study, SMART, linear regression methods and least square algorithm (LSA) are chosen to analyze multi-criteria in seeking suitable mapping for Jatropha. SMART is the approach finding weights, linear regression method and least square algorithm (LSA) that control the consistency in the experts' evaluation. The result of this study is proposal of land use mapping for Jatropha. This study also contributes to the method diversification in scientific research.

Keywords: GIS, Mathematical Model, SMART, Jatropha.

1. INTRODUCTION

"Land use planing" is one of the measures for government to manage the land, direct to use sustainable resources with criteria about economy – society – environment. Thus, it is essential to develop a way of exploiting and using the land resources to satisfy humans' demands, yet remains safe and sustainable.

Evaluation of land use has appeared for along time ago (has existed for quite some time?) and there are so many approaches to evaluate. Each method is both dominant and defective, depending on the specific site. To surmount these defects, FAO announced (introduced?) the land evaluating method in 1976, an approach that has been applied widely all over the world. It has become the crucial factor in land use planning method.

There are many decision-making support algorithms such as *Electre* (Roy, 1968), *SMART (Simple Multi-Attribute Rating Technique)* (Edwards, 1971), *Analytic Hierarchy Process (AHP)* (Saaty, 1981), *Promethee* (Brans et al., 1986), …Each method is both dominant and defective; nevertheless, SMART is chosen as a decision support due to its simplicity to support decision-making in this study as its simpleness. Although the defect of this approach is not able to control consistency in experts' evaluation, a combination of linear regression methods and least square algorithm (LSA) will surmount this defect.

The fossil fuel is being utilized and becoming more exhausted with every passing day. In that circumstance, a demand for alternative fuels is a pressing need and *Jatropha curcas* L., usual name is Jatropha, is the plant suitable for this necessity. Besides supplying biofuel, all the part of Jatropha is useful for green manure, wood, drug…

2. STUDY AREA

Ninh Thuan is a province of Vietnam located in the southern – central coast. Khanh Hoa Province is at the northern border while Binh Thuan Province is in the south, Lam Dong in the west and the sea in the east. There are 7 administrative divisions, including 1 city and 6 suburban districts. Phan Rang Thap Cham City is part of Ninh Thuan Province, the centre for politics, economy and culture. It is about 350 km from Hochiminh city, 60 km from Cam Ranh international airport, 105 km from Nha Trang sea city and 110 km from Dalat city, convenient for developing soci-economy.

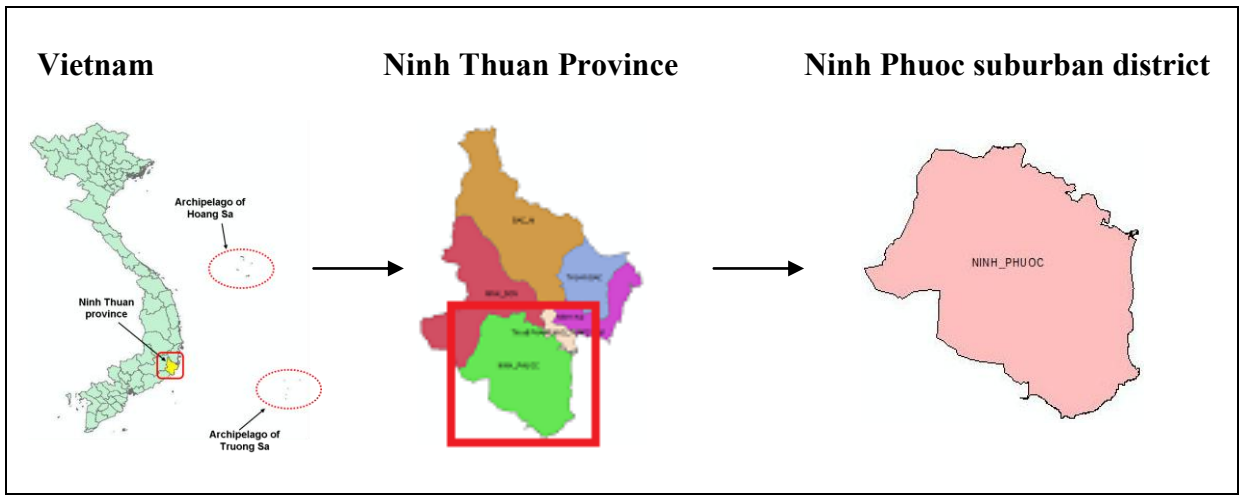


Figure 1. Study area

3. METHODOLOGY

3.1. SMART Method

SMART (*Simple Multi-Attribute Rating Technique*) is a compensatory method of multiple criteria decision analysis, developed by behavioral psychologist and decision analyst Ward Edward, 1971. The simplifications inherent in SMART can lead to errors. Edwards and Winterfeldt Von also developed new versions of SMART in 1986, called SMARTS. SMARTS is simply SMART using the more defensible Swing weight method for eliciting weights. In 1994, Edwards and Barron also presented a different version, latest version, called SMARTER, which only uses the ranking of attributes to derive the weights.

In this study, SMARTS is chosen, and called SMART, the original name of this approach, to distinguish from other methods.

In SMART, the DM gives ten points to the least important attribute. Then, he/she gives more points to the other attributes to address their relative importance. In SWING, the decision - maker (DM) first gives hundred points to the most important range of attribute

changing from its lowest level to the highest level. Then, he/she gives fewer points to the other attribute ranges to denote their relative importance compared to the most important attribute change. The attribute weights are elicited by normalizing the sum of the points to one.

This method was designed to provide a simple way to implement the beginnings of Multi - Attribute Utility Theory as follows (equation 1).

$$w_i = \frac{x_i}{\sum_{i=1}^{n} x_i} \tag{1}$$

Where x_i is the consequence of an alternative x for attribute i, n is the number of attributes, and $w_i \geq 0$ is the weight of the attribute i. The sum up weights is normalized to one.

3.2. Linear regression

Linear regression attempts to model the relationship between two variables by fitting a linear equation to observed data. One variable is considered to be an explanatory variable, and the other is considered to be a dependent variable. For example, a modeler might want to relate the weights of individuals to their heights using a linear regression model.

The most common method for fitting a regression line is the method of least-squares algorithm. This method calculates the best-fitting line for the observed data by minimizing the sum of the squares of the vertical deviations from each data point to the line as follows (equation 2).

$$Y_i = \widehat{\beta}_0 + \widehat{\beta}_1 X_i + e_i \tag{2}$$

Where X_i is the explanatory variable and Y_i is the dependent variable. The slope of the line is $\widehat{\beta}_0$ and $\widehat{\beta}_1$ is the intercept, e_i is the residual.

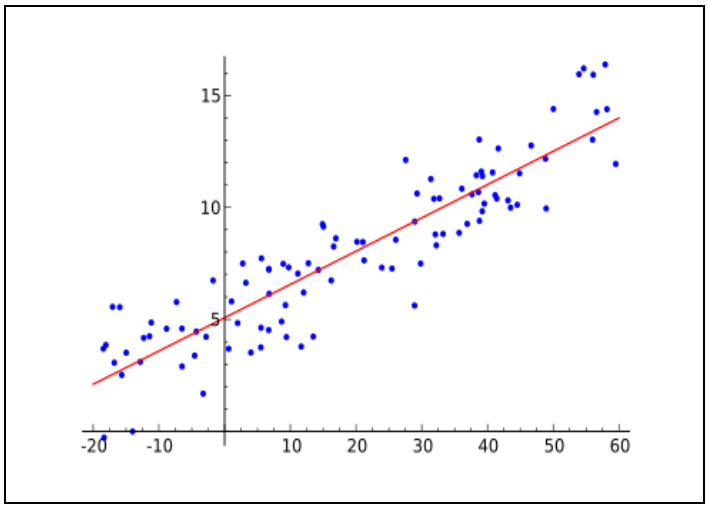


Figure 2. Example of simple linear regression, which has one independent variable

Estimating value the confidence interval for a particular value of Y (Yi) at a particular value of X (Xi) by following formula. (Equation 3).

$$\widehat{Y}_i \pm t_{n-2} \times S_{yx} \times \sqrt{1+\frac{1}{n}+\frac{(X_i-\overline{X})^2}{\sum_{i=1}^{n}(X_i-\overline{X})^2}} \quad (3)$$

4. RESULTS

4.1. Applying linear regression and of least-squares algorithm

In this study, SMARTS is chosen, and called SMART, the original name of this approach, to distinguish from other methods.

Y is a value calculated by SMART and X is the value calculated by SWING. Applying linear regression and least-squares algorithm to experts' evaluation, we have a function to control experts' evaluation following the suitable factor of nature, economy, society and environment.

Nature : **Y= -57,9 + 10,432X**

Economy : **Y= -49,752 + 10,16X**

Society : **Y= -12 + 9,822X**

Environment : **Y= -14,052 + 9,86X**

If we want to check reliability of some experts' evaluation in future, the following formula (equation 3) will be useful.

4.2. Applying SMART to calculate weights

Applying the following formula to compute weights (equation 1):

$$w_i = \frac{x_i}{\sum_{i=1}^{n} x_i}$$

The weights correspond with multi-criteria are:

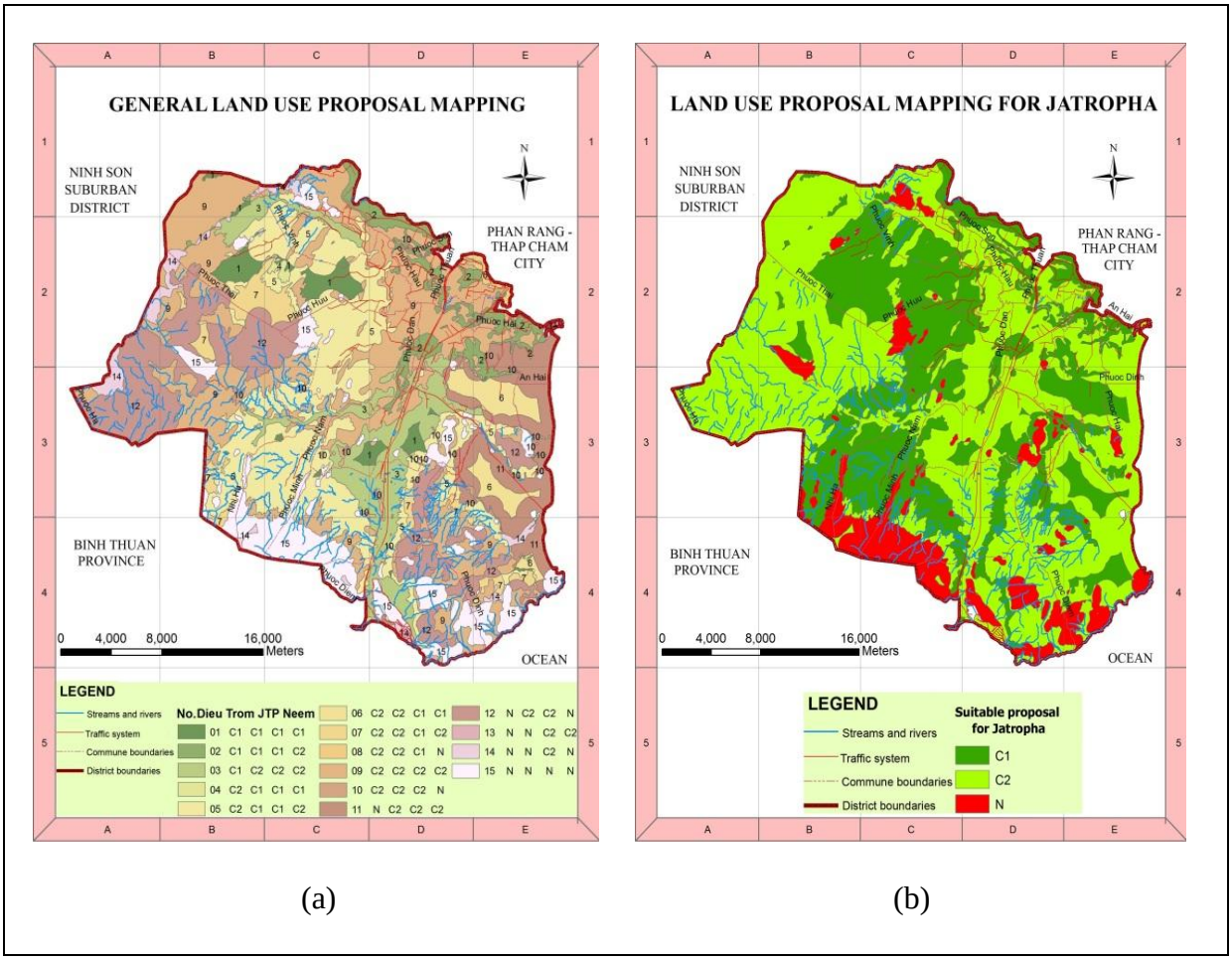
Nature:

$$\mathbf{Y= 0.038X_1 + 0.26X_2 + 0.18X_3 + 0.13X_4 + 0.06X_5}$$

Economy, society, environment:

$$Y = 0.323X_1 + 0.193X_2 + 0.13X_3 + 0.091X_4 + 0.067X_5 + 0.042X_6 + 0.042X_7 + 0.017X_8 + 0.039X_9 + 0.029X_{10} + 0.017X_{11} + 0.005X_{12}$$

After using GIS to establish mapping, we have the general land use proposal map (figure a), and the general land use proposal map for Jatropha (figure b)



(a) (b)

Figure 3. General land use proposal mapping (a) and land use proposal mapping for Jatropha (b)

5. CONCLUSIONS

Things applying SMART method, linear regression approach and least – square algorithm brought out the weights for experts' evaluation. Linear regression approach and least – square algorithm handled the experts' evaluation. The results created are General land use proposal mapping and land use proposal mapping for Jatropha. This study proposed a new way in analyzing multi-criteria, evaluating sustainable land use, making the premise for later research following this way.

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