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Building Geoprocessing Models for Land Suitability Assessment for "Thanh Tra" Pomelo in Nam Dong District, Thua Thien Hue Province, Vietnam

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1. Introduction

"Thanh Tra" pomelo (*Citrus Grandis* L. Osbeck) is one the major special fruit crops in Hue-Central Vietnam. "Thanh Tra" pomelo in Hue has its special characters that differ from other types in other regions with the shape, yellow sun skin, small size and less water. In compensation for their lower weight this pomelo genotype is delicious, has sweet flavor which is retained longer in the mouth after enjoying. Since 2005 "Thanh Tra" pomelo is officially registered from the authorities as a famous specialty of Thua Thien Hue province with the name "Thanh Tra Hue" (Chuong, 2005). The land evaluation for "Thanh Tra" pomelo was carried out in Thuy Bang commune, Huong Thuy district, Thua Thien Hue province, Vietnam (Chuong and Böhme, 2005). The Thua Thien Hue province government decided to enlarge the cultivation area for "Thanh Tra" pomelo in order to increase income for farmer in future (Hung, 2010). The Nam Dong district is located in the South of Thua Thien Hue province, in Central Vietnam. There is a lack of strategies or programs for selecting the suitable land for efficient cultivation of the "Thanh Tra" pomelo. Hence, land suitability assessment for "Thanh Tra" pomelo in the district is essential to support land use policy in order to meet the increased demand for horticulture production and in particular for the "Thanh Tra" pomelo.

2. Research methods

Data Collection

Data set required includes maps of land use, soil types, digital elevation model (DEM) scale 1: 25,000 were collected from Nam Dong cadastral department, with the soil map was classified by the method of FAO/UNESCO. Monthly precipitation, temperature and sunshine were obtained from Nam Dong statistical department as followed the Nam Dong Weather Observation Station. The land use requirements for "Thanh Tra" pomelo were adopted Sys *et al*. (1991).

Field works were carried out and workshop was organized to define the score weight of each factor according to AHP (Saaty, 1980). Fifteen participants participated in the workshop including specialists of

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agricultural extension, experienced farmers, young farmers (men and women) who are involved in growing the "Thanh Tra" pomelo in order to obtain data for the weighting factors calculation.

Data analysis

To achieve the objective of the study, multi-criteria evaluations and GIS technique were used to evaluate land suitability as structured in figure 1. Multi-criteria decision making in GIS approach involves the evaluation of alternative choices based on the criteria for land suitability. Factors or criteria used in land evaluation were standardized with fuzzy method by selecting suitable membership function (MF). With this approach, the attribute values were converted to common membership grades (from 0 to 1.0), according to the class limits specified by crop requirements (Sys, *et al.*, 1991).

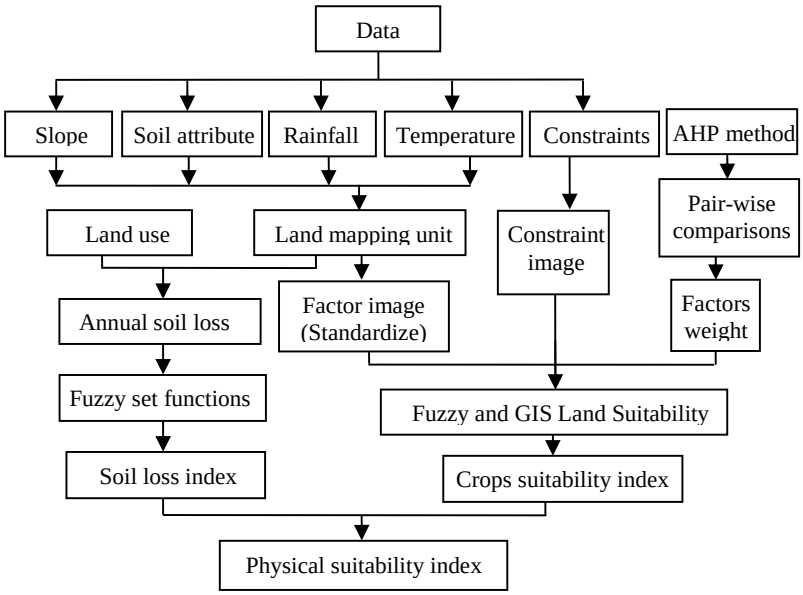

Figure 1: The framework for land suitability assessment implemented in GIS in this study

According to Baja, *et al.*, (2002), if $MF(x_i)$ represents individual membership value for i^{th} land property x, then, the basic model function take the following form in the computation process (Equation 1):

$$MF(x_i) = [1/(1 + \{(x_i - b)/d\}^2)] \quad (1)$$

where: d = width of transition zone (x at MF = 0.5 or at crossover point); x_i = value of i^{th} land property x; and b = value of land attribute x at the ideal point or standard index.

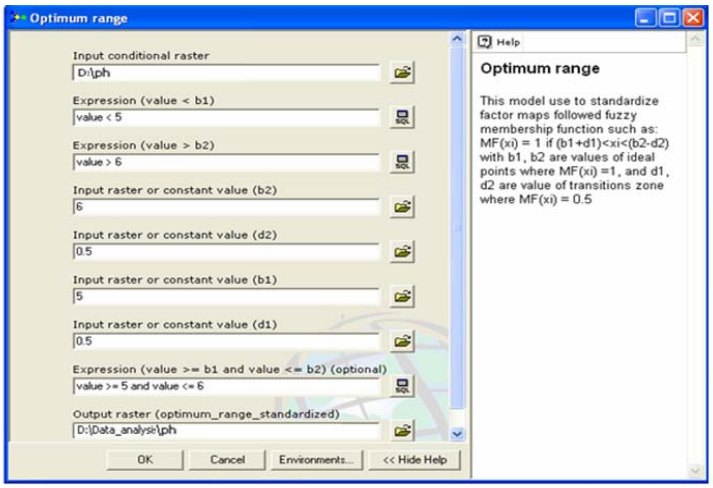

Figure 2: An example the window to enter parameters in optimum range model

This approach consists of two basic functions: symmetric and asymmetric. The first function, also called an 'optimum range', distinguishes two variants: one that uses a single ideal point, while the other employs a range of ideal points. The second function, an asymmetric model, is used where only the lower and upper boundary of a class has practical importance. This function consists of two variants: asymmetric left and asymmetric right.

Factors are standardized using fuzzy method by selecting suitable membership function with MF values of individual land characteristics, then combined using a convex combination function to produce a joint membership function (JMF) of all attributes (Baja, *et al.*, 2002) as follows the equation 2:

$$JMF(Y) = \sum_{i=1}^{n} W_i MF(x_i) \quad (2)$$

where: W_i = weight factor for the i^{th} land property x; $MF(x_i)$ = membership grade for the i^{th} land property x.

The weight factor was estimated by pair-wise comparison method (Saaty, 1980) based on a number of land characteristics. After structuring the problem as a hierarchy, workshop was organized and the matrix of pair-wise comparisons was established, checking consistency and ranking the weight of the factors were done.

Crop suitability index are expressed as continuous values ranging from 0 (very poor or not suitable) to 1.0 (excellent or high suitable).

Environment suitability is based on soil erosion index, the soil erosion index were generated by using fuzzy membership based on soil loss tolerance (T-value) was adopted Baja, *et al.*, (2002). The Revised Universal Soil Loss Equation (RUSLE) developed by Renard *et al*. (1997) was used to estimate the annual soil in the study area:

$$A = R \times K \times LS \times C \times P \quad (3)$$

where: A = annual soil loss (t/ha/y);

R = rainfall erosivity factor;
K = Soil erodibility factor;
LS = slope factor (L= slope length, and S = slope steepness);
C = land cover management factor;
P = conservation practice factor.

3. Results

Geoprocessing models

In order to facilitate processing of the procedure outlined above, geoprocessing models were built using Model Builder Extension in ArcGIS. Once the models are built, long and complex steps of spatial analysis can be processed without human errors. Models were developed in a raster

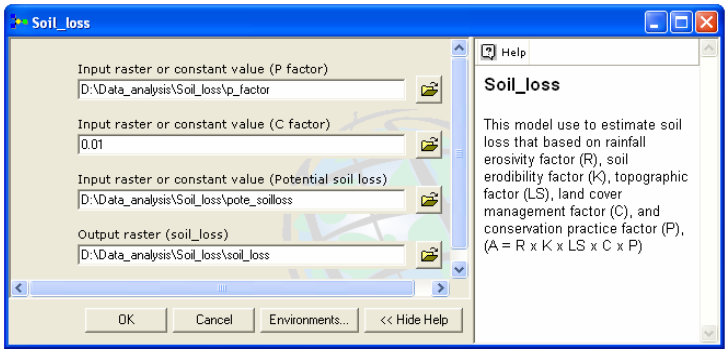

Figure 3: An example the window to enter parameters for soil loss estimation model.

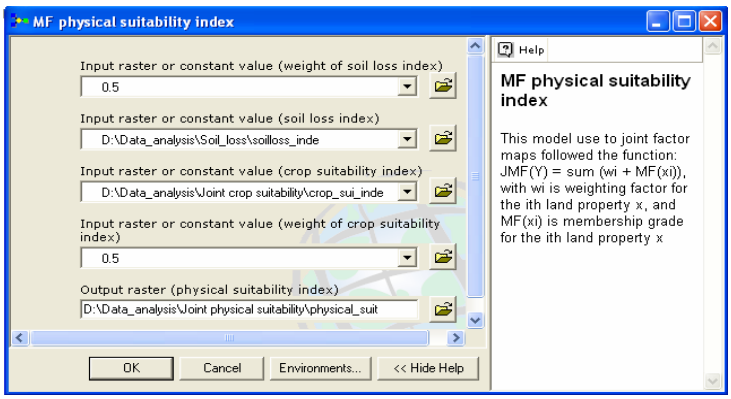

Figure 4: An example the window to enter parameters in joint MF of physical suitability model.

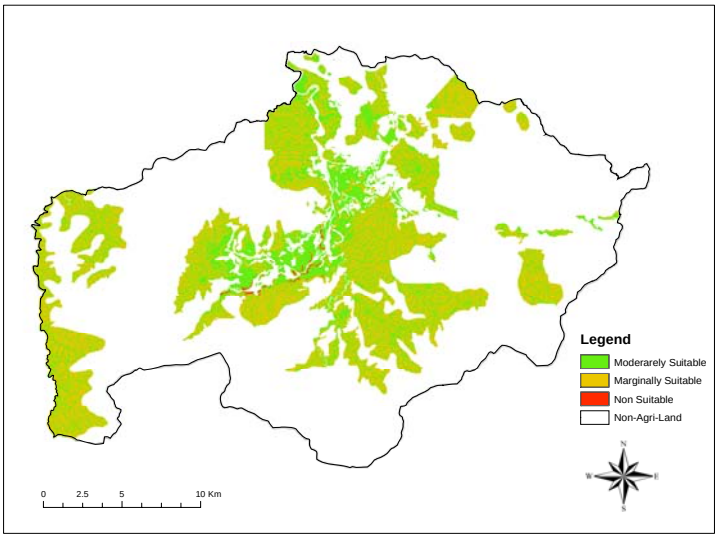

Figure 5: The physical suitability of Citrus in Nam Dong district

environment with grid format map layers. The raster system was used because it can store, manage, and analyze the data needed in a suitability analysis, as well as display the results effectively.

Models in this study were built to standardize all factors by using Spatial Analysis Tools for land suitability assessment in the study area based on fuzzy method with MF values of individual land characteristics such as the model to standardize factors (Figure 2), for soil loss calculation (Figure 3), then there factors will be combined using a joint membership function which are shown in the figure 4.

The suitability analysis

The results of spatial analysis physical suitability of “Thanh Tra” pomelo was obtained after run all geoprocessing models and represented in the figure 5. The results showed that there was non area is highly suitable, the highest percentage was belong to the marginally suitable which was 11,057 ha (53.30%), and following by moderately suitable with area of 9,619 ha (46.37%), while the non suitable was 0.34% (69 ha).

4. Conclusion

The geoprocessing models are very helpful tool in order to find an efficiency solution for land suitability assessment by excluding human error to get final map. Those models can be applied for other crops and other regions with highly reliable.

The physical suitability of “Thanh Tra” pomelo in Nam Dong district, Thua Thien Hue province was done that help local land users and administrator who need to have scientific support for their decision on the future land use systems.

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