

# Land Suitability Analysis Based on Management for Rubber Plantation Using Mamdani's Fuzzy Inference System

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## Abstract

*Thailand is the world's largest natural rubber producer and exporter. The most important factor in gaining higher productivity is plantation management. This research, therefore, aims to use Mamdani's fuzzy inference system (FIS) to evaluate land suitability based on rubber plantations in Nakhon Ratchasima and Buriram provinces. The system is comprised by developing fuzzy membership functions of criteria, estimating criterion group indexes of soil physical and chemical properties, climate, and plantation management, establishing and applying fuzzy rules to agglomerating fuzzy classes of indexes and air-dried rubber sheet productivity, and defuzzifying to attain crisp productivity and generate land suitability maps of different management levels. The agglomeration was raster-based analysis using GIS facilities. The study proved that the productivity was strongly dependent on the levels of plantation management. Higher application levels resulted in higher yields. The study was validated by the use of 30 samples, the relationship of modeled results and observed data was about 1:1 and the RMSE was 25.67 kg/rai/year.*

## 1. Introduction

The rubber plantation that provides a high yield consists of 3 main factors: rubber clones, environment, and plantation management (*Ma*). Normally, farmers should select varieties of rubbers and *Ma* methods appropriately as recommended by the Department of Agriculture (DOA, 2012). The environment is considered as limitations varying on nature of each area. Nevertheless, according to the survey, the relationship that can affect the yield is more influenced by the relationship between the environment of the cultivated area and the *Ma* of farmer. In the past, suitable area for rubber plantation was mapped based on only physical factors without considering the level of *Ma* due to its difficulty on evaluation. In practice, this led to the presence of conflicts. For example, some areas with poor physical factors but high *Ma* possibly provided higher yield. The better management of course provides the higher yield.

Furthermore, in land suitability analysis (*LSA*), Multi-Criteria Decision Analysis (*MCDA*) such as Sieve Analysis, Multiplication, Simple Additive Weighting (*SAW*), Analytical Hierarchy Processing (*AHP*), etc. was widely used. These methods are related to weight and score evaluation of criteria (Malczewski, 1999 and Prakash, 2003). The classification could cause loss of accuracy in the interface between suitability classes (Baskoro, 2008). Besides, weighting and scoring each criterion

was so often difficult and subjective (Qiu et al., 2013) that could cause difficulties on interpretation and decision making in the real world. For example, in case that specified suitable mean annual rainfall for rubber cultivation was 1,350-2,500 mm, if the rainfall of most areas was 1,349 mm, it would immediately evaluate the area into an unsuitable class although rainfall 1,350 and 1,349 mm were virtually the same. Plus, characteristics of spatial data and their distributions as criteria for the analysis are actually not completely deterministic or stable as well.

To solve the problem mentioned above, the study aims to operate *MCDA* for mapping suitable land for rubber plantation using Mamdani's *FIS* (Mamdani and Assilian, 1975) which is the method that can be properly applied to scoring and agglomerating vague and uncertain spatial data such as soil properties, climate, and topography affecting crop requirement (Prasetyo et al., 2012, Ranst et al., 1996, Keshavarzi et al., 2010, Reshmidevi et al., 2009, Baskoro, 2008, Jiang and Eastman, 2000 and McBratney and Odeh, 1997). For more practical achievement, *Ma* as a group of criteria was also added to incorporate with physical criteria in the system. Nakhon Ratchasima and Buriram Province in the northeastern Thailand (Figure 1), where in the historic record had low potential for rubber plantation, were chosen for this study.