

**GIS based Land use Simulation of Sustainable Forest
Management and Wood Utilization
in Thai Nguyen Province, Vietnam**

Dissertation

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Declaration

I hereby declare, under oath, that I have written the present dissertation on my own and have not used any resources and aids other than those acknowledged.

A handwritten signature in blue ink, consisting of a stylized 'D' followed by 'C' and 'N'.

Hamburg, July 2018

.....
Dang Cuong Nguyen

English review testimonial

I certify that the English in the thesis:

GIS based Land use Simulation of Sustainable Forest Management and Wood
Utilization in Thai Nguyen Province, Vietnam

written by Dang Cuong Nguyen was reviewed and is correct.

Susan J. Ortloff (US citizen), freelance translator and editor

A handwritten signature in black ink, appearing to read 'S. J. Ortloff', written over a horizontal line.

Susan J. Ortloff, July 10, 2017

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Research summary

The concept of Sustainable Forest Management (SFM) is well established. Its principles of sustainable forest development and land use planning often require a compromise between socio-economic development and environmental interests. Biophysical factors have a significant effect on the productivity of forest plantations, while socio-economical and economic factors impact profitability and management systems. To enhance profits from forest plantations, the tree species grown need to match the specific site conditions. At the same time, the efficiency of forest plantations depends not only on forest site productivity, but also on market driven factors such as timber price, timber demand and transportation cost..

This study uses a combination of a land suitability assessments based on FAO framework for land suitability classification, multi-criteria, linear programming (LP) and a Geographic Information System (GIS) framework to identify suitable locations and achieve the highest profit for forest plantation management. A suitability analysis and an optimization analysis were used. The suitability analysis with classes highly suitable, moderately suitable, marginally suitable, and unsuitable was conducted through a combination of land suitability assessments and multi-criteria decision analysis (Analytic Hierarchy Process, AHP). Three main criteria were used in the suitability analysis comprising soil properties, climate and topography. Maps presenting suitability classes were established in ArcGIS environment by Weighted Linear Combination (WLC). To reflect growth of the studied species, volume growth was modeled using three models including Chapman Richard, Gompert and Koft models. All three models reflected growth well based on coefficient of determination (r^2) and root mean square error (RMSE). However, the Koft model performed best and was selected in the optimization analysis to assign productivity on each suitability class.

The results of the suitability analysis were used in the optimization analysis. The optimization model was built by combining programming (visual basic application environment) and GIS (ArcGIS environment). The optimization model indicates

that the optimal harvest age of a *Acacia mangium* plantation in the study area is 6 years, at which time the highest profits can be reached. The model used shows the tradeoff between timber demand and timber supply. When timber demand increases, profit obtained from forest plantations has a decreasing trend because of the assignment of areas having lower profit due to lower productivity and higher costs. The optimization model also illustrates that even considerably small variations in timber price and costs have significant effects on the profit obtained and land area allocated to respective mills.

The optimization model suggests the possibility of combining the needs of environmental conservation with socio-economic demands of stakeholders by establishing nature conservation areas. Shadow pricing can be used as a mean to derive compensation payment to assign and maintain forest areas for protective use. Additionally, the optimization model provides a tool to study the establishment of co-operated mills. Three new mills could replace 215 existing mills and 3 new mills could be added with higher capacities.

The findings of this study provide evidence for the need of a concurrent forest land utilization and mill development planning in order to maintain and enhance economic and ecological objectives and to improve local livelihoods. This holds especially true under extensive afforestation and reforestation activities, as recently promoted by the Bonn Challenge and the New York Declaration.

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