USE OF GLOBAL MAP DATABASE FOR MODELING SHRIMP FARMING IN SOUTHERN THAILAND

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INTRODUCTION

The concept of Global Map came out of an issue addressed at the Earth Summit in Brazil in 1992: the need for decreasing the gap in availability, quality, standardization, and accessibility of spatial data between nations. In 1994, the Geographical Survey Institute of Japan proposed a draft of Global Map specifications and called for the participation of interested nations. Over 80 nations and regions are now participating in the database project.

Global Map is built upon existing global databases. These databases include GTOPO30, a global digital elevation model with a grid spacing of 30 arc seconds (about 1 km); Global Land Cover Characteristics Database, a database derived from the 1-km Advanced Very High Resolution Radiometer (AVHRR) data between April 1992 and March 1993; and Vector Map (Vmap) Level 0, a global vector-based database at a scale of 1:1 million, formally known as the Digital Chart of the World. The participating nations of Global Map use these databases and other local data sources to produce eight themes: boundaries, transportation, drainage, and population centers as vector data, and elevation, vegetation, land use, and land cover as raster data. Global Map data for Japan, Laos, Nepal, the Philippines, Sri Lanka, and Thailand have been completed and can be downloaded at the organization’s website (http://iscgm.org/).

Sponsors of Global Map have suggested that the global database can be used for regional development planning, disaster mitigation, resources management, and research on global environmental changes. Designed as an application of Global Map, this study used the database to examine shrimp farming in southern Thailand.

STUDY AREA

Because of its high cash value, shrimp farming has become the leading aquaculture growth industry in Southeast Asian countries and in other parts of the world. Thailand is the world's leading producer of shrimp, with a shrimp culture area of about 726 km^2 and a total production of 227,560 metric tons in 1997. Studies have shown natural resource degradation caused by shrimp farming in Thailand such as destruction of mangrove forests, water pollution through the release of shrimp waste, saltwater intrusion, and land subsidence.

This study focuses on shrimp farming in Nakhon Si Thammarat (NST), a province in southern Thailand, which doubled its land devoted to shrimp farming from 107 km^2 in 1989 to 213 km^2 in 1994. Figure 1 shows the distribution of shrimp farming and mangrove forests in NST from 1989 to 1994. The main objective of this study was to analyze the spatial distribution of shrimp farming in NST and its relationship to environmental factors using a logistic regression model.

RESEARCH DESIGN

To develop a logistic regression model, we used the presence or absence of shrimp aquaculture as the dependent variable and proximity to coastline/estuary, mangrove forest, proximity to paved road, and slope as the explanatory variables. Logistic regression is commonly used when the dependent variable is a binary phenomenon (e.g., presence or absence) and the independent variables are categorical or quantitative variables. The selection of the explanatory variables in this study was based on a previous land suitability study in NST.

This study used two sets of input data. We compiled the paved road and slope map layers from the Global Map database for Thailand. Although the database also included vegetation and land use, both based on the AVHRR data from 1992-93, they did not have separate categories for shrimp farming or mangrove forest. The cell resolution of 1 km actually ruled out any possibility of identifying shrimp ponds on the AVHRR data. Shrimp culture systems in Thailand have three levels of intensity: extensive, semi-intensive, and intensive. The average pond sizes are 5-10 ha, 1-2 ha, and <1 ha for extensive, semi-intensive, and intensive operations respectively. Shrimp ponds are too small to be isolated on the AVHRR data.

We derived the shrimp aquaculture, coastline/estuary, and mangrove forest map layers from a database maintained by the Environmental Quality Promotion Department of the Thai Ministry of Science, Technology, and Environment. At a scale of 1:50,000, the environmental quality database grouped land uses in NST into agricultural (rice paddies, mangrove forests, shrimp farming, para-rubber, and orchards), residential, commercial and industrial uses, and environmental protection. Because an area of interest in this study was the replacement of mangroves by shrimp ponds over time, we decided to use 1992 data for shrimp aquaculture and 1989 data for mangrove forest.

DATA ANALYSIS

We chose raster format for data analysis because it was easier to perform distance measure and map overlay with raster data than vector data. The cell size was 1 km, same as raster data in the Global Map database. We used ArcInfo to process and analyze the input data and ArcView to display data.

The first step was to process data from the Thai environmental quality database. For the shrimp aquaculture layer, the process included attribute data manipulation and vector-to-raster conversion. A weight table was used in vector-to-raster conversion to make sure that a cell was classified as shrimp farming so long as shrimp farming was present in the cell. The mangrove forest layer was processed in the same manner. To derive the proximity to coastline/estuary layer, we converted coastlines and estuaries to raster data and then ran a distance measure operation on the grid. Distance measures to coastline/estuary were grouped into six classes: 0-1, 1-2, 2-3, 3-4, 4-5, and > 5km.

The second step was to process Global Map data. Vector data from Global Map are distributed in the Vector Product Format (VPF), and raster data are distributed as Band Interleaved (BIL) files. Each data file covers a theme over an area that measures 5^0 by 5^0 on the geographic grid. Figure 2 shows the processing of the paved road layer, which involved data extraction, map projection, vector-to-raster conversion, and distance measurement. Proximity measures to the paved road grid were classified into six classes: 0-1, 1-2, 2-3, 3-4, 4-5, and > 5km. Figure 3 shows the derivation of the slope map from Global Map's elevation data. Slope values were grouped into seven classes: 0-2, 2-4, 4-6, 6-8, 8-10, 10-12, and > 12^0.

The five input layers (Figure 4) were overlaid cell by cell and the output was exported as an ASCII file to SAS for logistic regression analysis.

RESULTS

The result from logistic regression analysis using the maximum likelihood estimation method shows that the independent variables of proximity to coastline/estuary and presence of mangrove forest are statistically significant. The fitted model is: Logit (p) = 1.7198 - 0.3143 mg - 1.2898 dw, where p is the probability of occurrence of shrimp farming, mg represents presence or absence of mangrove forest and dw represents proximity to coastline/estuary. Table 1 shows the parameters, parameter estimates, standard errors of estimates, computed Chi-square values, and probabilities > computed Chi-square values.

Of the two independent variables that are statistically significant, proximity to coastline/estuary is far more important than presence of mangrove forest. According to the model, the probability of having shrimp farming is 0.61 if the land is within 1km of coastline or estuary and was previously classified as mangrove forest. The probability drops to 0.55 if the land is within 1km of coastline or estuary and was not previously covered by mangroves.

Table 1. Analysis of maximum likelihood estimates

Parameter	Estimate	Standard Error	Chi-Square	Pr > ChiSq
Intercept	1.7198	0.1135	229.64	<.0001
mg	-0.3143	0.0750	17.57	<.0001
dw	-1.2898	0.0569	513.04	<.0001

CONCLUSION

Our study in NST has shown statistically the relationship between shrimp farming and closeness to coastline/estuary and, to a lesser extent, between shrimp farming and mangrove forest. This finding is consistent with previous studies on shrimp farming in Thailand (Flaherty and Karnjanakesorn 1995, Dierberg and Kiattisimkul 1996).

Coastal shrimp aquaculture was first developed in central Thailand along the Gulf of Thailand. Intensive shrimp farming in southern Thailand including NST began in the late 1980s. Narrow coastal zones were ideal for shrimp farming primarily because of the saltwater requirement. Recent studies (Flaherty and Vandergeest 1998) have reported the inland migration of shrimp farms as a result of the introduction of low-salinity shrimp culture in the early 1990s. In NST, for example, some shrimp farms were more than 4 km away from the coastline in 1992. Destruction of coastal mangrove forests has been lessened because of government regulations and low-salinity shrimp culture. The threat of shrimp farming has shifted to rice paddies (Flaherty, Vandergeest, and Miller 1999).

The Global Map project has so far achieved its objective of creating globally consistent thematic map products for six nations. Researchers who plan to use this global database must be aware of its data quality, data structure, and data currency. For studies of local-level environmental issues such as shrimp farming in southern Thailand, integration of Global Map data with other higher-resolution data sources is possible for certain types of data analysis.

REFERENCES CITED

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Flaherty, M. and P. Vandergeest. 1998. "Low-salt" shrimp aquaculture in Thailand: Goodbye coastline, hello khon kaen. *Environmental Management* 22: 817-830.

Flaherty, M., P. Vandergeest, and P. Miller. 1999. Rice paddy or shrimp pond: Tough decisions in rural Thailand. *World Development* 27: 2045-2069.

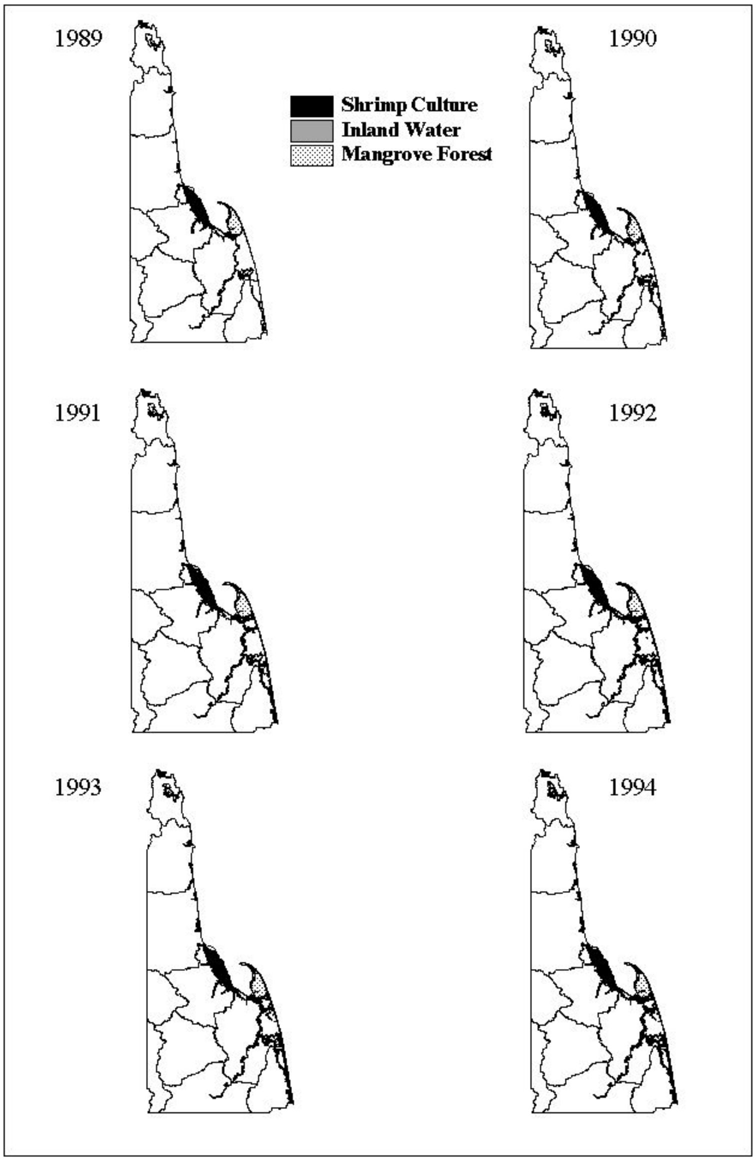

Figure 1. Distribution of shrimp culture and mangrove forest, 1989-1994

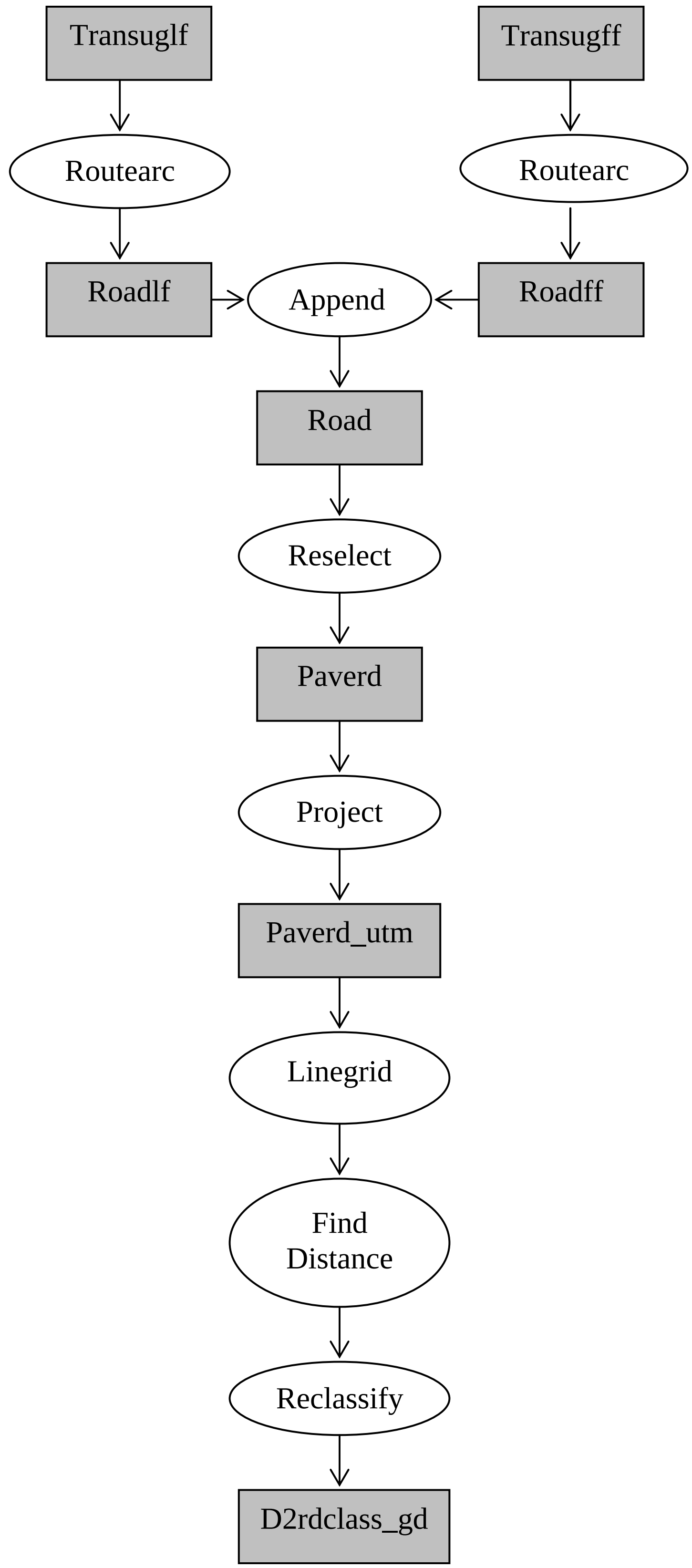

Figure 2. The processing of the paved road layer

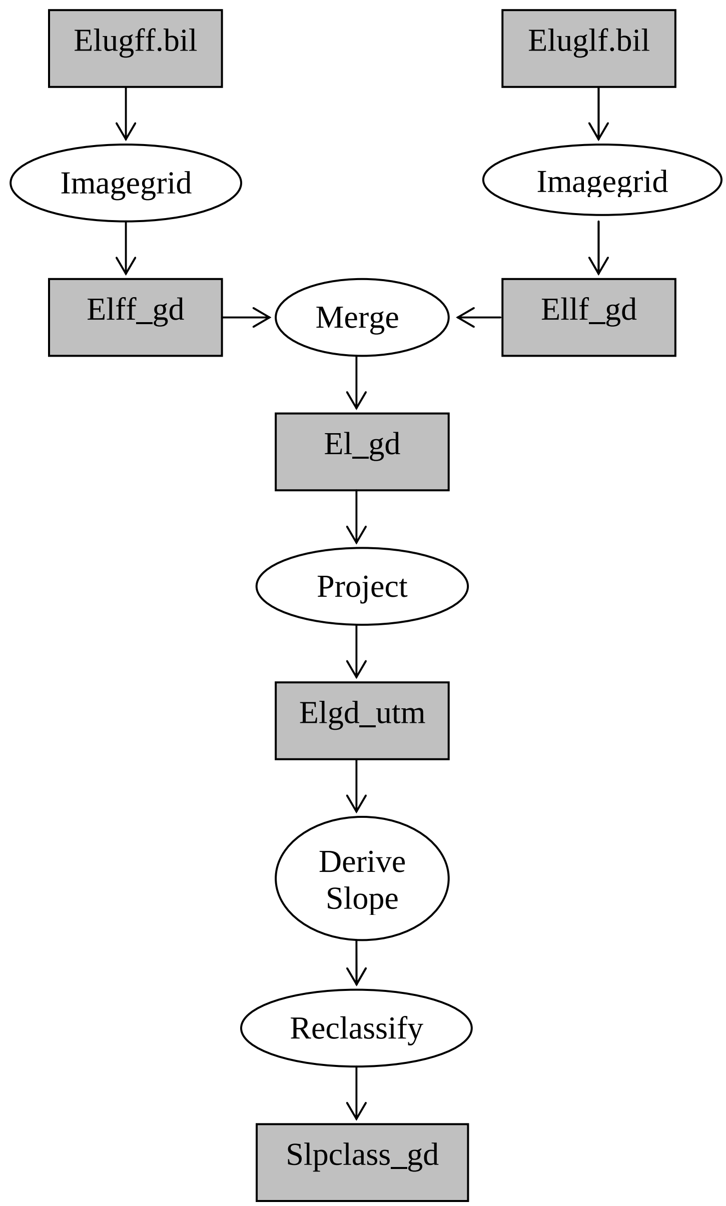

Figure 3. The derivation and classification of the slope layer.

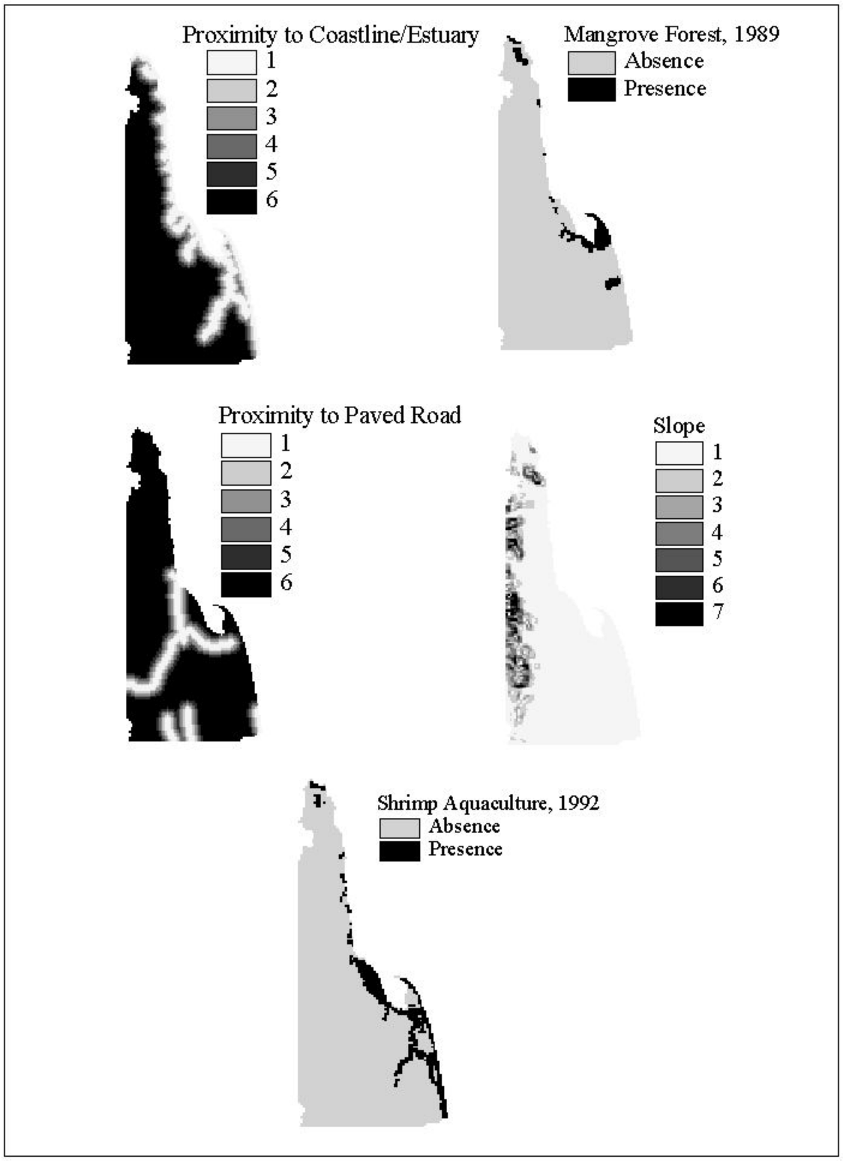

Figure 4. Input map layers to logistic regression analysis