CHAPTER 7

Conclusion and Recomendations

7.1 Land Mapping Unit

In this study, there were many different focuses. One of them was creating a spatial data map, which was improved and updated later on. This map was especially important to improve the information known at the field level of study so that there would be an accurate understanding of the district's land usage and area. The land maps of 2006, which came from the Land Development Department, were used and improved upon by including the information provided by the orthophoto images (1:4000). These images were taken during the month of January 2002. All of the new information was digitized as instructed by the Land Development Department. The results from this process were new land maps with detailed information, especially concerning the areas of land newly-classified as longan orchards with the ages of the trees included. The location and classification of the longan orchards was one of the main goals of this study. Another main goal was to identify and classify the small water resources, wells, and other sources of water usage for the production of longan fruits.

The spatial database was used in the overlay analysis process to create a Land Mapping Unit for longan production. There were three layers of data which pertained to this process: a map of the ages of the trees throughout the district, a map of the various types of watering systems, and a map of the land slope. These three layers were overlayed on top of each other to create the Land Mapping Unit. Within the LMU were 27 map units. These map units were used for the process of randomly choosing farmers for interviews as well as sampling farm sites for photographing longan trees and their canopies. The initial LMU displayed 27 map units grouped within Phrao District, but only 18 were considered important for this study, based on the map units' areas. Any map unit with 100 rai or more was used in this study. Thirty farm sites were randomly chosen from the 18 accepted map units for the next step in this study.

7.2 Longan Fruits Image Analysis

Concerning the image analysis of the photos taken of the trees' canopies, the purpose was to identify the longan fruit areas and estimate their numbers in each of the 60 trees. Altogether, there were 360 pictures taken of the longan canopies. The photos were taken with a digital camera and were in the JPG format. The minimum resolution was no 1600x1200 pixels per inch. Each picture was focused on a part of the canopy enframed in a 1 x 1 meter square of plastic pipe. The ERDAS Image 9.0 program was used to perform a knowledge classification in order to identify the areas of the fruits. Model Maker was used to create a model capable of identifying longan fruits in multiple photos within a short timeframe. It also separated the many images into groups with similar lighting conditions. These five conditions were sunny with less light, sunny with medium light, sunny with bright light, cloudy with less light, and cloudy with medium light. The knowledge classification process determined the factors in the layered data which should be used to define the threshold in identifying the different objects in each photo, particularly concerning the longan fruit. The layered data were initially in the RGB format but were converted into other formats which made it easier to classify. The relationships between the data in the RGB format were also recorded. The threshold value was used in the classification process for each object in the photos. The objects were categorized into six types

In order to identify the objects in the photos, first the photos' imbalance issues had to be fixed, and they had to be cropped correctly so that the focus was only on the area within the 1 x 1 meter square of plastic pipe. Once that was done, the photos were fed through the model, and the results were very good. The model was able to view many photos within a short time period. The accuracy of the model's results was tested by comparing it to the results of the same process done with the naked eye. In order to perform the process with the naked eye, a grid of 100x100 squares was overlaid on each photo and 30 of the squares were randomly chosen for identification of the object(s) within their boundaries. After comparing the results, the model's accuracy and kappa were calculated, and it was determined that they were at good levels (more than 70% accurate).

7.3 Longan Yield Predictions using BBN Model.

In order to create the flowchart of all the factors which affect longan production, it was necessary to collect data from questionnaires and focus group interviews with farmers. The flowchart displays the relationships between the various factors of longan production and makes reasonable connections between the various data collected. It also is easily adjusted by increasing or decreasing the number of factors or the input data of each factor. The flowchart enables an effective method of predicting future yields of longan fruit despite changing circumstances. Whoever wants to use the flowchart and BBN model can input any data from his field studies or interviews with farmers, and the results will be accurate predictions.

In this study, three types of data were used to create a working model that predicts longan production. Type A data is information collected from questionnaires filled out by farmers, Type B data is first-hand information collected from on-site during harvest time, and Type C data is information on longan production based on image analysis of the tree canopy photos. All of thes data were used to create a CPT, which was used to help create three BBN models. The predictions of longan production from each of these models were compared to one another. The results of that comparison showed that the Type B model had the least RMSE value (at 20.2). Type A and C models had RMSE values of 44.7 and 73.3 respectively. The average output levels estimated from the three models were compared to the actual results of the sample groups, and the difference between predicted and real was generally not significant. The Type B model had a difference of 15 kg/rai, which is a difference by 1.7%. The Type A model had a difference of 123 kg/rai, whichi is a difference by 16.5%, and the Type C model had a difference of 87 kg/rai, which is a difference by 11.2%.

The results of these tests show one model type having an accuracy of 80%. When the model's predictions were applied to a group of 30 samples, the accuracy rate increased even more. If more than 30 samples are used to collect on-site data, this may increase the model's accuracy rate for larger groups as well.

However, the model's predictions still have many errors, so it is not yet a perfect method for predicting an entire orchard's yield. It is still useful for predicting longan fruit yields, though, even at the tambon- level, and it may even be useful in predicting for the entire country's production levels. This requires further study.

7.4 Map of the Production Distribution Based on the BBN Model

The results from the best model were used as the average rate for longan yields throughout the District. The average rate was used as new data in the LMU. Based on this new information, the LMU predicted the yield levels for key locations throughout Phrao District. The LMU also predicted that the total production for all of Phrao areas (40,400 rai of used land) will be 35,316,227 kg of longan fruits. When compared to the predictions made by the Department of Agriculture of Amphoe Phrao for the 2010-2011 season, which totaled at 34,945,000 kg, there was a difference of 341,227 kg or a 1% difference.These two numbers are very close, but the predictions made for each sub-district were significantly different from each other due to the difference in the acreage of land registered with the Department of Agriculture and the area of land calculated in this study using geoinformatics. Therefore, the predicted output results for each sub-district were significantly different.

7.5 Limitations and Suggestions for Future Studies

The BBN Model based on the photographic analysis of the tree canopies was found to provide inaccurate conclusions for this study. This was due to the photographic analysis itself being full of errors. Therefore, the Type C model had inaccurate results because it had faulty inputs. However, if the photographic analysis were to be corrected in future studies, the BBN Model might give accurate results.

The photographic analysis proves that photographic documentation can be used to predict fruit yield. It is an adjustable technique that has the potential to be more accurate in its predictions than the crop-cutting method, but further research is required. The relationship between the yield and other factors is still not adequately defined. Another limitation that this study showed was that photographic analysis relies heavily on the quality of the photos taken. In this study the accuracy of the identification process was also affected by the quality of the photos used. The lighting condition with the best accuracy results was cloudy with medium light. Accuracy levels were also highest when there were fewer types of objects in the photos. For example, if there were only fruits and leaves in the frame, the identification process was easier. When other objects were present—such as grass, branches, trunk, and bamboo sticks which support the tree during fruit-setting—the identification process decreased in accuracy. This was due to the statistical data for each of those types of objects being very similar to those of the longan fruits in the model. For example, sometimes grass was mistaken as part of the fruit area. Therefore, to reduce this type of error, each photo shot has to be planned out to have the least number of different objects in frame. This study proved that the best time to take pictures is when the weather is cloudy but with a moderate light intensity, like in the late afternoon. The worst time to take pictures is in sunny weather with bright light, like at noontime to early afternoon because there are a lot of shadows. This is especially difficult in identifying longan fruits because of the circular shape of their shadows, which can be mistaken for fruits themselves. Sunny weather also negatively affects the clearness of a photo, which makes identification even more difficult. Furthermore, photos must be taken at certain times, and it is recommended to use equipment capable of taking photos in both the RGB and the near-infrared (NIR) formats.

This study proved the effectiveness of using the BBN Model to analyze and organize layered data of many different factors, but the development of the model was very time-consuming and required a large team. This meant that the communication within the team and the use of CPT were very important. This was done through team meetings which appeared highly beneficial for sharing information among the team members and for determining new factors to be included in the research. However, it was felt that all of these meetings were not easy as they took lengthy time and were effective only if the person leading the meetings was prepared at an expert level to share necessary information and direct the team in the right direction.

The BBN Model's results in this study were able to adequately predict the yield of longan fruits at the district level; but for the prediction at individual farm level, there were too many errors. This was due to the modeling being based on the average features or representation of all farms together in a given area rather than taking into account individual variation in management styles. Therefore, in the future a BBN Model should be extended to cover inputs of individual farm in order to predict the production performance of that specific farm. Such a model will be more useful in predicting the aggregate performance at the local level and for suggesting improvements in individual style of orchard management.

Additionally, future studies should be carried out to develop tools which can predict longan yields based on the flowchart data collected in this study. Especially, focus should be placed on studying the Decision Support System (DSS) program in order to find ways to use the data effectively.