3. MATERIALS AND METHODS

3.1 Study Area

The study area is located in the northern region of Thailand. Chiang Mai province consists of 24 districts (Figure 3.1). It lies between 435781 mE, 1906108 mN to 560236mE, 2224370 mN covers the areas of about 2,208,865 hectare. The northern and eastern areas have its border connected to Chiang Rai, Lampang and Lampoon provinces, while the western and the southern areas have its boundary connection to Mae Hong Son, Tak and Lampoon provinces. The study selects medium and large-scale mills as the facility to find out the interaction between them and the rice areas.

3.2 The Study Framework

The model of the optimum solution for location and allocation of agricultural products (Stollsteimer, 1968) was used as a theoretical framework in this study. Under this approach, the precise trade flows (interaction) and related transfer cost over active trade route must be known. GIS and its network analysis functions can generate necessary information and tool for analyses of distance cost, accessibility and spatial interactions to employ this theoretical framework. The major steps involved in achieving the goal of this study is presented in Figure 3.2.

Figure 3.1 Study area, Chiang Mai province.

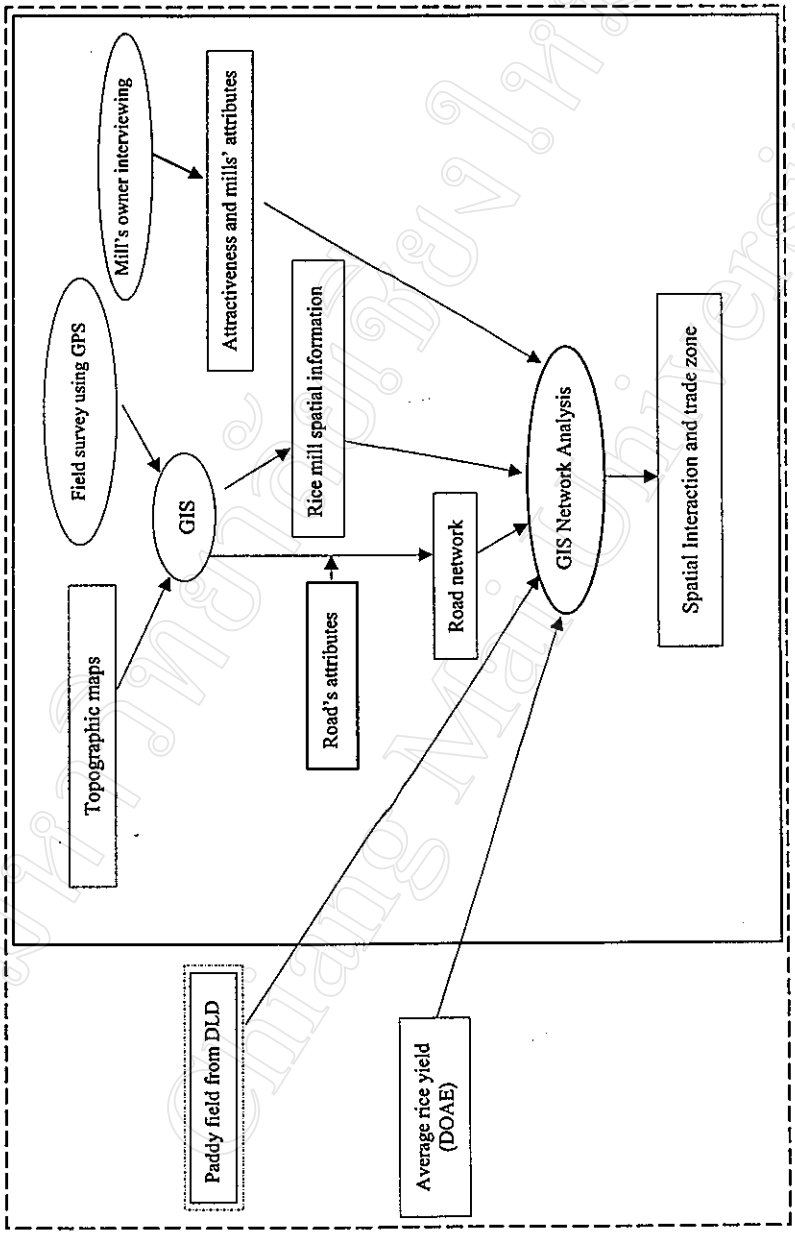

Figure 3.2 Major steps involved in this study.

3.3 Road Network

The road networks were digitized from the topographic maps provided by Royal Thai Survey Department, using ARC/INFO software. The topographies available for the study is obtained from the latest version of topographic maps surveyed during year of 1969 to 1992 (1:50,000). The 'road IDs' assigned in digitizing process were specified by code number of road type. This study classified road types based on the identification of road types from the topographic map sheet as in Table 3.1.

Table 3.1 The road types and average speed used in the study.

Road ID	Surface	Road type	Average Speed (km/hr)
1	Hard surface, two or more lanes wide	National high way	65
2	Hard or light surface, two or more lanes wide	Provincial high way	65
3	Hard or light surface, one lane wide	Rural highway	40
4	Cart track	Cart track	25
5	Foot path	Foot path	25
6	Masonary dam carrying road	Road over masonary dam	20
7	Road over levee	Road over levee	20

The average speed from each road type was linked to each segment of the network, these values were collected from ground survey and traders interview.

Road coverages were initially digitized as map sheets and later joined together for the whole Chiang Mai province using ARC/INFO commands. The dangling arcs of length less than 50 meters were eliminated. The speed, length in meter and kilometer and drive time of each road segment were added into the attribute table to provide the necessary information for network analysis. The process of building up the road network using GIS technique can be illustrated in Figure 3.3. The road network attribute table is displayed on Table 3.2.

In order to use ArcView network analysis model the road network was converted into a shape file. The conversion can be done both in ARC/INFO's ARCSHAPE command or load into the ArcView theme and select the desired submenu to create a new shape file from the current theme.

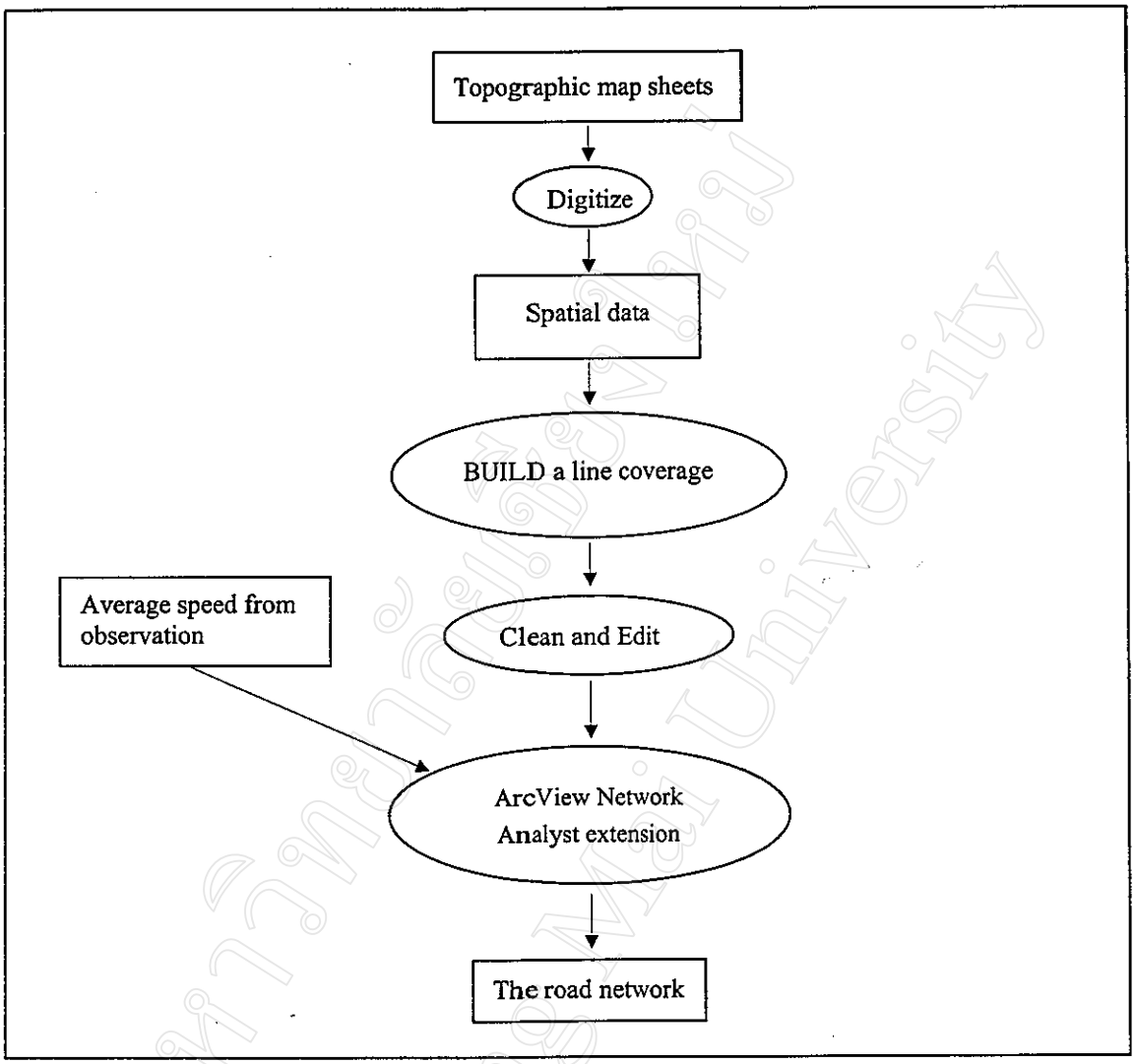

Figure 3.3 The process of creating spatial digital data and necessary attributes for road network.

Table 3.2 The road attribute table.

Item	Item wide and type	Description
FNODE#	11,N,0	from node ID
TNODE#	11,N,0	to node ID
LPOLY#	11,N,0	left polygon ID
RPOLY#	11,N,0	right polygon ID
LENGTH	13,N,6	length of road (meters)
ROAD#	11,N,0	system ID
ROAD_ID	11,N,0	code of road type
SPEED	11,N,0	average speed at the segment (km/hr)
METERS	16,N,2	line length (meters)
KILOMETERS	16,N,1	line length (kilometer)
MINUTES	16,N,1	drive time (minute)
STREET	11,N,0	the foreign key to be linked Street.dbf

3.4 Mills locations and attributes

The secondary data describing characteristics of medium and large-scale mills were collected from the inventory data provided by Ministry of Industry for Chiang Mai province. The ground survey was performed to investigate and to collect the existing mill coordinates by GPS (Global Positioning System) receiver. The 'rover' GPS was used to record the satellites signals at the mill site with an adequate number of observations. A base station GPS was used to collect all available satellites at the known reference location. Improving the accuracy of data deployed by GPS equipment were achieved by differential correction technique using the data collected at the base station as the reference. The results of computation were the values of x_coordinate and y_coordinate of the specific mill. The interviews were made to collect information on storage capacity required to compute attractiveness

The 'GENERATE' command of ARC/INFO was used to read in the mill data and generate them into a point coverage and converted into an ArcView shape file (Figure 3.4). The information on engine, address, annual milling capacity and annual storage of each mill are stored in the attribute table of mills as in Table 3.3.

Table 3.3 The attribute table of the mill.

Item	Item wide and type	Description
MILL_ID	16,N,0	the code number of each mill
MILL_SIZE	11,N,0	1 is large-scale, 2 is medium scale mill
ENGIN	11,N,0	horse power of engine
CAPACITY	11,N,0	annual capacity (ton)
MILL_ENAME	30,C	name in English
MILL_TNAME	30,C	name in Thai
ADDRESS	75,C	address of the mill (in Thai)
STORAGE	11,N,0	annual storage (ton)

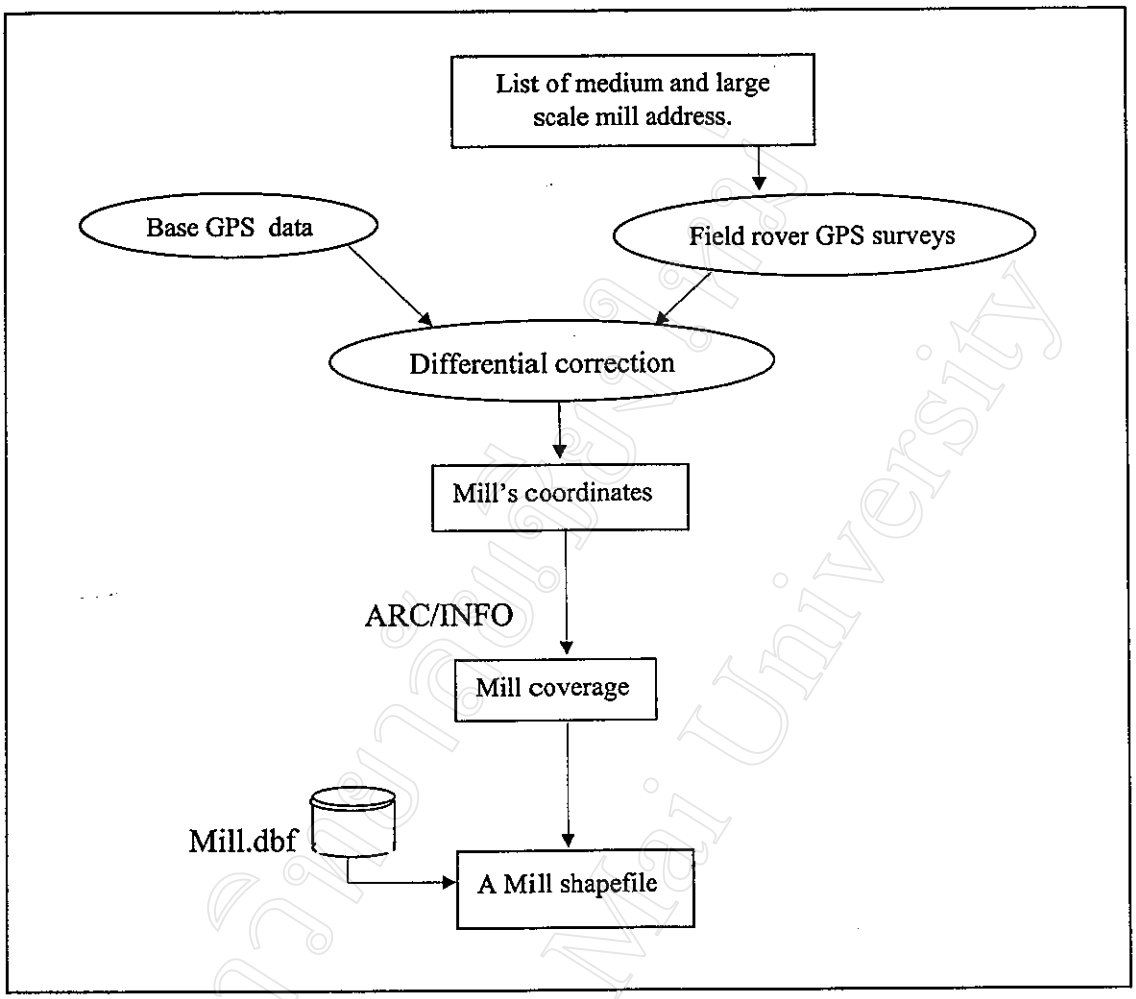

Figure 3.4 The steps of building a mill coverage.

3.5 Rice Coverage

The land use coverage created by the Department of Land Development (DLD) based on the survey done in 1989 was used to extract land use type representing rice areas. This rice coverage was then intersected by the road coverage. The 'IDENTITY' command is used to split paddy areas by the road coverage. The centroids of every polygon were determined by using command 'CENTROIDLABELS'.

The new coverage contains points which represent the centroid of each contiguous paddy land. This point coverage was then overlayed with the tambon administrative boundary in order to obtain the average rice yield for each tambon from the result of field survey conducted by Department of Agricultural Extension (DOAE), MOAC in 1996 (Table 3.4). These data were stored in an attribute table that can be linked to each paddy field and its centroid.

Once the road, mill location, and paddy field centroid coverage have been created, the centroid of each paddy field and mill point was snapped to the nearest road segment to form a node. The complete road network was then generated.

Table 3.4 The attribute table of the paddy area.

Item	Item wide and type	Description
AREA	16,N,3	area of polygon (m^2)
PERIMETER	16,N,3	perimeter of polygon (m)
RICE100_	11,N,0	system ID
RICE100_ID	11,N,0	polygon ID
LANDUSE	11,N,0	Land use ID
PADDY	11,N,0	Paddy ID
AREA_RAI	11,N,0	Paddy area per rai (0.16 ha)
PRODUCT	16,N,2	Production of the paddy area (ton)
YIELD_RAI	11,N,0	Yield per rai

3.6 Accessibility

The accessibility of each paddy areas from all rice mills was determined according to the following equation:

$$P_i = \sum_{j=1}^{n} \frac{w_j}{d_{ij}^{\beta}} \qquad (6)$$

Where P_i = accessibility of the paddy *i*

w_j = attractiveness of rice mill *j*

d_{ij} = distance along the transportation network between paddy *i* and mill *j*

β = exponent of the distance decay function

n = number of rice mills used in the analysis

The avenue scripts named FindFac.ave (Figure 3.5) was developed to d_{ij}. The script is not only able to use all point data as facilities or events on the network but also easier to select wide range of the cost field from the attribute table. The script finds pairs of the least cost and adds it to the view and also writes the output as a text file for further analysis. In order to use the script, the Network Analyst extension module has to be loaded into the active ArcView project. Three coverages, road, and paddy field node which form the road network have to be loaded into active ArcView project to make FindFac.ave function and compute d_{ij}.

In order to reduce the complexity of writing the avenue script, a small program called 'read_in_array.ave' was written using Visual Basic to read the result from FindFac.ave reformat it into a distance matrix.

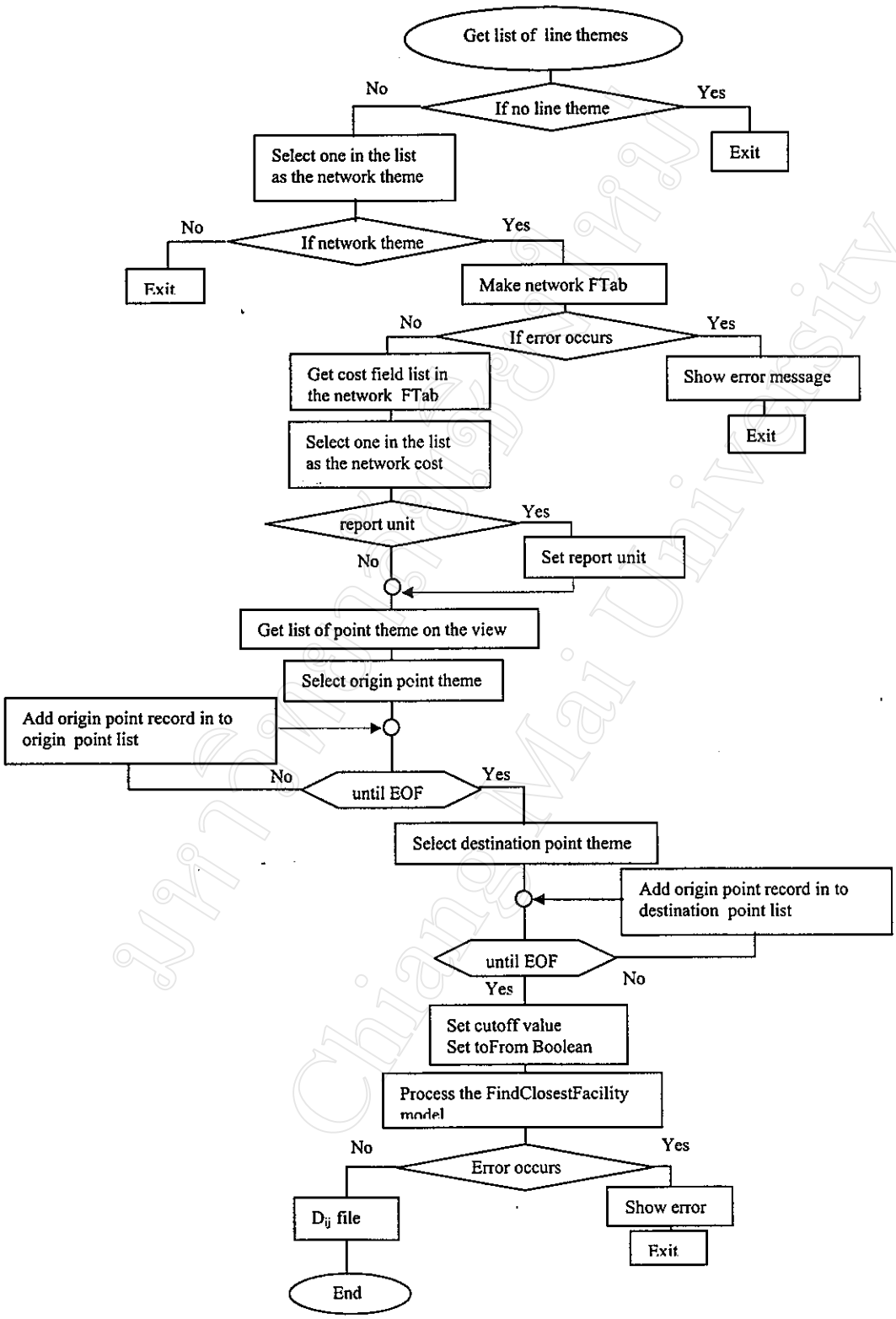

Figure 3.5 The 'FindFac' flow chart.

3.7 Spatial Interactions

Spatial interactions (I_{ij}) among each rice mill and paddy area were computed according to equation (7).

$$I_{ij} = \frac{y_i * w_j}{d_{ij}^{\beta}} \qquad (7)$$

Where I_{ij} = Interaction between location i and j

y_i = production of the paddy field i

w_j = attractiveness of rice mill j

d_{ij} = distance between i, j

β = exponent of distance-decay function

The avenue scripts already described in the previous section was used and the outputs of computation were written as an interaction matrix which can be later imported into ArcView for graphical display.

3.8 Potential trade zones

Potential trade zone of each rice mill can be identified in ArcView by using the results from traveling time (distance), accessibility index and spatial interaction analysis. In case of using traveling time to identify trade areas, a threshold value was specified, paddy fields that fall within this traveling time will be selected as the trade zone for each rice mill. If spatial interactions are used to suggest the trade area of each rice mill, cumulative probabilities of I_{ij} were calculated. If the threshold value of cumulative probability was chosen, paddy fields that fall within this threshold would be selected and displayed in GIS.

Trading activities can also be visualized using accessibility index of the paddy fields. In this case, accessibility index was standardized to the value between 0-100.

The higher the value, the more accessible the paddy field is to all rice mills in area, hence more competition among rice mills for rice produced from that piece of paddy field. The standardized accessibility for all paddy fields can be displayed as a map in GIS.