Chapter 3

Materials and Methods

3.1 Study area

The study area covers Chiang Mai – Lamphun valley, one of the main agricultural production and the most intensively cropping areas in northern Thailand. It extends from 18° 20’ and 19° 10’ north latitude and 98° 50’ and 99° 10’ east longitude (Figure 2), covers 23 districts of Chiang Mai and Lamphun provinces with a total area of about 150,000 hectares (Gypmantasiri *et al.*, 1980). The valley is situated along the Ping river and lies between the Thanonthongchai mountain to the west and the Phipannum mountain to the east. The elevation of the land in the valley ranges from 270-330 meters above mean sea level (Surarerks, 1986).

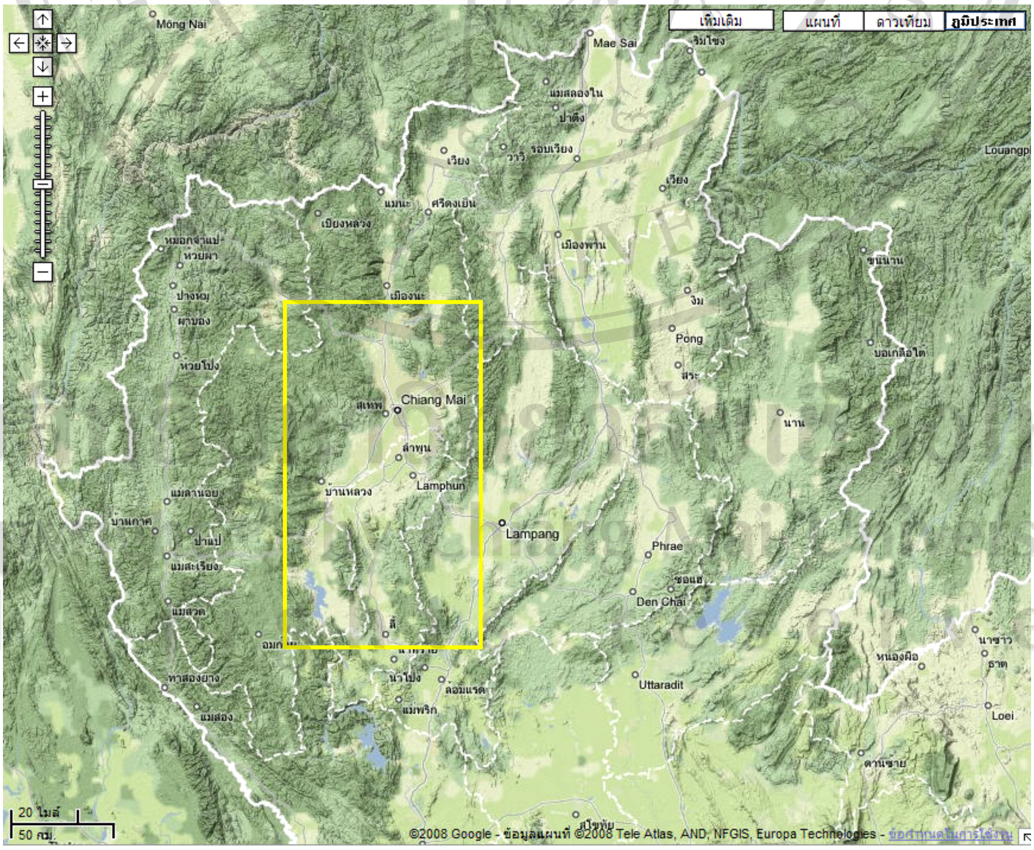

Figure 2 Study site in Chiang Mai – Lamphun valley (Google, 2008)

This land is a fertile flood plain derived from alluvial deposits. The dominate soils are Hang Dong (Hd) and San Sai (Sai) series. The soils characteristics are very similar. In general, the soil texture varies from loam to silty clay loam (Land Development Department, 2004; 2005).

The average annual rainfall is 1,200 mm and the most areas have a good water supply from the irrigation projects. The common cropping patterns in the valley are double cropping with paddy rice as a main crop followed by cash crops such as soybean, potato, shallot, onion and garlic. The main orchards are longan and mango (Sangchyoswat *et al.*, 2005).

3.2 Conceptual framework

This study aims to develop spatial modeling tools to assess water productivity of the irrigated land in Chiang Mai-Lamphun valley according to the conceptual framework as presented in Figure 3.

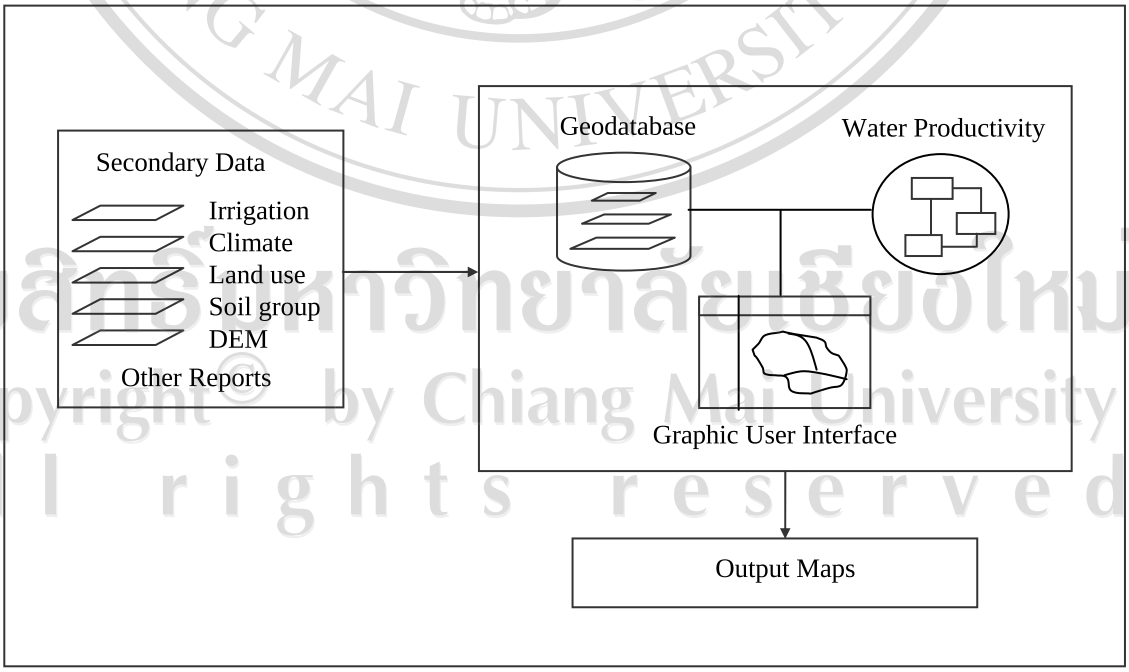

Figure 3 The conceptual framework of the study

Geodatabase development is an essential first step that covers data collection, design and implementation of geodatabases. It is necessary for exploratory analysis of the study area and providing input data for the spatial analysis modules. The spatial tools were developed for assessing crop water requirement, and water productivity at the filed and irrigation system levels. These modules were designed to use objects available in ArcGIS (ESRI, 2003b) and Visual Basic Programming to carry out necessary tasks required to do spatial analyses and calculation to estimate water requirement and water productivity. A graphic user interface (GUI) was developed to facilitate area selection, water productivity assessment and displaying the output maps.

3.3 Data collection

Most data were based on secondary data that have already collected by government departments mainly the Royal Irrigation Department (RID) and a number of geodatabases from the Decision Support System for Agricultural Resource Management and Services project (DSSARM) (Ekasingh *et al.*, 2005) and the Agro-Ecological Zoning and Land Use Change project (AEZ) (Sangchyoswat *et al.*, 2005) as summarized in Table 1.

Table 1 Sources of GIS layers for developing water productivity tools

GIS layer and report data	Sources of data
1. Irrigation (project sites, boundaries, zones, canals, structures, water supply)	RID, DSSARM
2. Soil group, DEM, yield, net return	DSSARM
3. Land use, climatic zones	AEZ

3.4 Data preparation

3.4.1 The Boundary of Chiang Mai – Lamphun valley

The Chiang Mai-Lamphun valley was defined as the areas of contiguous agricultural land along the Ping River in Chiang Mai and Lamphun provinces that have elevation lower than 350 meters above mean sea level. The boundary was delineated from Digital Elevation Model in ArcGIS system (ESRI, 2003a). The overlay analysis was used for analysis the relationship between the study area and four large irrigation projects (Mae Taeng, Mae Feag-Mae Ngad, Mae Kuang, and Mae Ping Kao) (Gypmantasiri *et al.*, 1980).

3.4.2 Weekly climatic data

The climatic zones (Sangchyoswat *et al.*, 2005) were created for separated periods, rainy season (July-December) and dry season (January-June). Each climatic zone has the similar climate characteristics such as rainfall, rainy day, maximum and minimum temperature grouping by cluster analysis procedure. Since the attribute data of the climatic zones were stored as monthly data but the simulation of water management requires weekly weather. Therefore, a weather generator module called SIMMETEO in DSSAT 3.5 (Tsuji *et al*., 1999) was used to generate daily data from monthly data and then summarize them into weekly data for representng in each of climatic zone.

3.4.3 Land mapping units

Land Mapping Unit (LMU) is assumed to be a homogenous area created by overlaying map layers of Chiang Mai - Lamphun valley boundary, irrigated areas, land use in 2000, soil groups and climatic zones using ArcGIS. They represent agricultural production units inherited by variable biophysical resources that determine water requirement, agricultural outputs and water productivity. The feature of LMUs layer was related with its attributes such as net return and water requirement through key fields. This LMUs layer was the basic unit to calcualate water balance, assess the water productivity and display the result from the analyses.

3.5 Geodatabase development

The collected data were entered into a computer system by typing, digitizing, and converting with careful editing to ensure the completeness of data. The existing spatial data and result from the analyses require data conversion to a format that is compatible with ArcGIS system. Descriptive statistics were done to check the reliability and consistency of data including the exploratory spatial data analysis of the study area. The structure of geodatabase was designed in object-oriented approach by using class diagrams within UML model in MS Visio 2002 (Zeiler, 1999). After building geodatabase schema, the input data were converted into three major classes namely feature class for spatial data, object class for tables, and relation class to represent the relationship between classes (ESRI, 2003c).

3.6 Spatial water productivity assessment

3.6.1 Spatial water productivity tools

The water productivity tools in irrigation project were developed by using programming technique in Visual Basic and compiled as Dynamic Link Library files (.dll). These tools were added as extension files for working with ArcGIS version 9.0 systems based on object oriented design called ArcObjects (ESRI, 2003b). The toolbar and menu systems had Thai and English language interfaces that facilitates the linkage between user input, geodatabases and process model for exploring and analyzing four irrigation projects are Mae Taeng, Mae Feag-Mae Ngad, Mae Kuang, and Mae Ping Kkao.

3.6.2 Spatial water requirement module

Weekly water requirement in the target areas was calculated for each LMU following the FAO Penman-Monteith equation (Equation 2) (Allen *et al.*, 1998). The irrigation water requirement was estimated from Equation 3 (Tingsanchali and Suiadee, 2002). Water consumed was calculated from irrigation water requirement and adjusted from irrigation water supply data of irrigation projects. Water consumption in the urban area was estimated to be 0.4 cubic meter/people /day in the city areas and 0.05 cubic meter/people/day in the rural areas (Nimitrapiboon *et al*., 2002). The results from analysis can be displayed as spatial water requirement map and summarized as a table for each land use type or irrigation zone.

3.6.3 Water productivity analysis module

The productivity of water was expressed as productivity per unit irrigation consumed (baht/m^3) from cross analysis between water components and net return for assessing the performance of the study areas. The net return value in each land units was obtained from the economic land evaluation in non water limit condition by Samranpong *et al*., (2005). The results of water productivity assessment were stored in a geodatabase that can be used for mapping and comparison among LMUs, irrigation zones or irrigation projects.

3.6.4 Scenario analysis module

Factors affecting crop production and water productivity are dynamic and easily altered by climate change, farmer's decision, marketing demand and government policy. The water productivity assessment tools were also designed to allow simple scenario analysis by changing some key factors that affect water productivity such as land use pattern, water supply, production costs and prices, apart from water allocation strategies. The results of the scenarios analysis were summarized and compared with the situation in 2000 to provide that a guideline for realizing the effects from the possible situations that may occur in the future so that the planners can seek alternative solutions to achieve the goal for improving water productivity.