CHAPTER 1

INTRODUCTION

The purpose of this study is to construct a groundwater vulnerability map of Phuket island in the south of Thailand using a GIS-based DRASTIC method (GIS stands for Geographic Information System). A study of groundwater vulnerability is essential for Phuket island, which is a one of the most beautiful and important island in Southeast Asia, known as “the Pearl of Andaman Sea”. Recently, a rapid growth in population due to increasing human activities such as tourism, expansion of industry, and extensive agricultural activities causes groundwater contamination. Computer software of the GIS-based DRASTIC method is used to carry out the analyses, and to identify the groundwater regional sensitivity to contamination. It has been shown that groundwater vulnerability mapping is a very useful tool for land-use planning and groundwater resources management, because it helps direct regulations, monitoring, education, and policy development for the areas where protection is really needed.

This thesis contains five chapters. The first chapter includes an introduction of the study area, i.e. location, purpose and scope, methodology, and previous investigations. The second chapter describes the physical environment including geographic setting, geologic setting, hydrogeological setting, reconnaissance field observation, and origin of groundwater. The third chapter explains the DRASTIC analysis, including groundwater vulnerability mapping method, parameters and database design, data processing, and DRASTIC analysis. The fourth chapter is an assessment of groundwater vulnerability using a GIS-based DRASTIC method and the impacts of the tsunami disaster on 26 December 2004 to groundwater in Phuket island. The fifth chapter contains conclusions and recommendations.

1.1 Location of the study area

The Phuket island is situated in the Andaman Sea, along the west coast of the Malay Peninsula of southern Thailand. The geographic coordinates of the island is between latitude 7°45’23.3” and 8°11’54.5”N, and longitude 98°15’40.0” and 98°26’53.0”E. It is bordered to the north with Phang Nga province and to the east with Krabi province, and is surrounded to the south and the west by the Andaman Sea. The study area covers about 543 km^2 encompassing Muang, Khathu, and Thalang districts. The Phuket island is elongated in a north-south direction. The longest distance from north to south is 48.7 km and the width from east to west is 21.3 km. The location map of the island is presented in Figure 1.1.

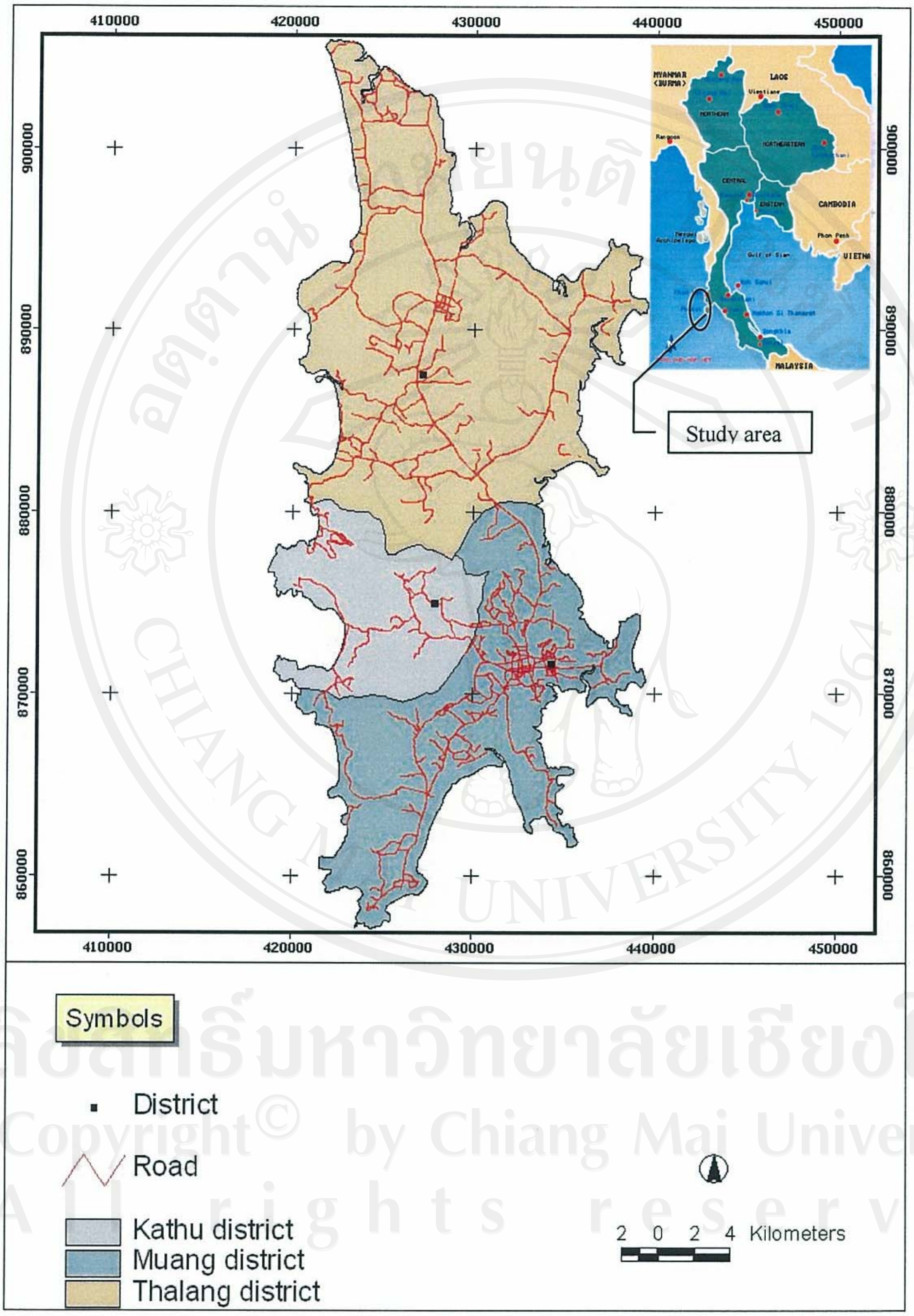

Figure 1.1 Location map of Phuket island (modified after Department of Mineral Resources, 2001).

1.2 Purpose and scope

The purpose of this study is to assess the vulnerability of groundwater resources of Phuket island using a GIS-based DRASTIC method.

The study area covers about 543 km^2 that include Muang, Kathu, and Thalang districts of Phuket island. This study focuses on the groundwater vulnerability mapping using a DRASTIC method based on seven parameters including depth to water table, net recharge, aquifer media, soil media, topography, impact of vadose zone, and hydraulic conductivity. These vulnerability factors were reclassified to vulnerability scores using ArcView GIS software.

1.3 Methodology

The methodology of the study consists of:

(1) Reviews of the topographic, geological, hydrogeological, meteorological, soil, and land-use data.
(2) Field work for measurement of groundwater levels in 73 shallow wells and water sampling (31 samples) for isotope analyses (O^{18} and H^2).
(3) Data syntheses of the seven hydrogeological criteria in the forms of digital data, maps, and models using the ArcView Geographical Information System version 3.1.
(4) Groundwater vulnerability mapping of the study area using a GIS-based DRASTIC method.

1.4 Previous investigations

1.4.1 Geologic setting

Putthapiban (1984) studied the Phuket granites and categorized them into four suites based on the detailed mapping, petrography, geochemistry, and Rb/Sr and K/Ar age determination. These include G1-suite (Khao Pratiu suite), G2-suite (Kata Beach suite), G3-suite (Naithon Beach suite), and G4-suite (Khao Tosae suite).

Chaimanee and Teerarungsikul (1990) mapped the geology of Changwat Phuket and Thalang district on a 1:50,000 scale. The rocks are composed of unconsolidated sediments, meta-sedimentary rocks, and igneous rocks. The oldest rock unit is the Permo-Carboniferous sedimentary sequence of the Kaeng Krachan group. The igneous rocks are granitic rocks of Cretaceous age. The Quaternary unconsolidated sediments include colluvial deposits, floodplain deposits, and coastal plain deposits.

Chaimanee and Teerarungsikul (1993) mapped the geology of Phuket Island and divided the Quaternary sediments into 5 suites based on the sediment types and depositional environments. These include colluvial deposits (Qc), residual deposits (Qr), fluvial deposits (Qf), near-shore deposits (Qn0-Qn3), and beach ridge deposits (Qb). In addition, they grouped the granitic rocks into five suites by separating the Khao Rang granite from the Khao Tosae suite.

1.4.2 Hydrogeological characteristics

Chuamthaisong and Intrasutra (1992) described six groundwater provinces in Thailand based on physiographic features. In the southern peninsula, groundwater can be found in small basins. Groundwater occurs in alluvial deposits accumulated in intermontane basin; and in karstic limestone, granitic, and meta-sedimentary rocks. The aquifers in the alluvial deposits have the average depths of 35-140 m and yield approximately 5 to 250 m^3/hr of groundwater. In karstic limestone, granitic, and meta-sedimentary rocks, the average depth of aquifers is 45 m and yield approximately 10 to 200 m^3/hr. Water quality is suitable but is rather high in iron. In some localities, warm water with the temperature of 40-45 ^oC is observed.

Wichiantong (1993) studied water resources in Phuket for an underground dam project and divided the aquifers into five units including, Chao Phraya aquifer (Qcp), beach sand aquifer (Qbs), colluvial aquifer (Qcl), meta-sediments aquifer (Pcms), and granite aquifer (Gr).

The Department of Mineral Resources (2001) issued the hydrogeological map on a 1:100,000 scale of Phuket province, where the rocks are divided into Quaternary unconsolidated sediments, Permo-Carboniferous meta-sedimentary rocks, and Cretaceous granite rocks. The aquifers in the area are classified into unconsolidated and consolidated aquifers, based on the degree of compaction and cementation. Unconsolidated aquifers consist of beach sand, floodplain, and colluvium aquifers, while consolidated aquifers consist of meta-sedimentary and granitic aquifers. Beach sand aquifer can be found at the depth of 2-4 m with the rate of yield at 5-10 m^3/hr. Floodplain aquifer is found at a deeper level; around 10-25 m with 2-10 m^3/hr of yield and colluvium aquifer has a yield of 5-15 m^3/hr, and is found at the depth of 20-30 m. The groundwater quality is good; except in some areas where fair to poor water quality is assigned, particularly near shoreline and mangrove environments. The highest potential resource is from the meta-sedimentary aquifer from the depth of 20-40 m at a rate of 10-30 m^3/hr. The lowest groundwater potential resource is the granitic aquifer, which yields less than 2 m^3/hr of fresh and iron-rich water from the depth of 25-35 m.

1.4.3 Groundwater vulnerability in Thailand

Margane and others (1998) described the groundwater vulnerability of Chiang Mai-Lamphun basin where they found that the vulnerability of aquifer depends on the thickness and lithological composition of a continuous protective layer, which is dominated by clayey and silty sediments, on the top of a particular aquifer.

Saykawlard (1999) studied the impact on groundwater environment due to the construction of an underground dam in Phuket island. A GIS technique is promoted for environmental risk assessment and monitoring. The major expected problem is a groundwater quality degradation. Physical characteristics such as topography, lithology, land-use, geophysical survey result, and depth to bedrock are inputs in the GIS model. These basic data are closely related to the groundwater storage capacity and pollution transfer. More data of thematic maps, for example, satellite images, depth to water table, groundwater quality, soil characteristics, aquifer hydraulic conductivity, aquifer thickness, and current land-use, may be included in the GIS analyses to obtain a better outcome in environmental study of groundwater resources.

Thapinta and Hudak (2002) implemented GIS technology to evaluate the vulnerability of groundwater with respect to pesticide pollution in Thailand. Their study area covers Kanchanaburi, Ratchaburi, and Suphanburi provinces in west-central Thailand. The factors used in the vulnerability assessment including soil texture, slope, land-use, well depth, and rainfall. Their vulnerability factors were reclassified to a common scale, and a weight average was computed to yield a vulnerability score. Vulnerability factors and weights were assigned considering pesticide concentrations in 90 wells throughout the study area. Groundwater vulnerability maps were established for several pesticides. They are effective for identifying locations warranting more detailed groundwater pollution and vulnerability investigations.

Kwansirilul and others (2004) studied the vulnerability of groundwater resources to contamination in the Lampang basin of northern Thailand based on a GIS-based DRASTIC method. The vulnerability map shows groundwater areas that are sensitive to contamination on the basis of hydrogeological conditions.