CHAPTER 1

INTRODUCTION

1.1 Problem

The increasing expansion of rubber plantations and the deforestation of South and Southeast Asia's, Africa's and Latin America's forests are evident. The world's rubber plantations, of which 91% lied in Southeast Asia in 2010, have increased by 20.22% between 1990 and 2010 (Rubber Asia and FAO, 2010a, p. 33). Between 2000 and 2010, the world's largest deforestation occurred in Africa and South America, reaching 3.4 and 4.0 million ha per year, respectively (FAO, 2010a, p. 172, 181). Land use change, such as the conversion of woodlands and grasslands to arable land, and agricultural management usually result in large offsets of greenhouse gases, mainly of carbon (i.e. carbon dioxide and methane). As a result, carbon concentration in the atmosphere increases, which is considered as a major contributor to the current climatic variability and climate change in several regions of the world (FAO, 2010b, p. 9 and Bernstein et al., 2007, p. 37). Rubber plantations continue to expand rapidly in Xishuangbanna and are leading to deforestation since the 1970s (Xu, 2006, p. 256) at a mean deforestation rate of 13,722 ha per year (Li et al., 2008, p. 20). The carbon sequestration potential, CO_2 emissions and carbon balance in Xishuangbanna are changing as a result of the area's land use change (Yang et al., 2005, p. 297), creating the need to assess these changes.

1.2 Background

The Naban River Watershed National Nature Reserve (hereafter NRWNNR) is located in Jinghong County that is in the Dai Autonomous Prefecture of Xishuangbanna, which lies in Yunnan Province in southwest China (Grötz et al., 2008, p. 1). Xishuangbanna is a tropical area that comprises tropical forests. These forests have been reduced by 67% between 1976 and 2003. Around 2009, rubber

plantations covered 20% of Xishuangbanna's entire terrestrial area (Qiu, 2009, p. 246). Rubber was introduced in Xishuangbanna in the 1950s, and it has lead to massive deforestation since the 1970s. Due to its climatic characteristics, the area is considered to be the last frontier where rubber can be planted (Xu, 2006, p. 254-256).

The Naban River Watershed Nature Reserve was founded in 1991. Currently it is a protected nature reserve that is managed under the "Man and Biosphere" program of UNESCO (Xishuangbanna Tropical Botanical Garden, 2008). The NRWNNR comprises a core zone, where primary forests prevail; a buffer zone around it, where agricultural activities are restricted; and an experimental zone, where agriculture is less restricted (Cotter, 2011, p. 6). Agricultural activities mainly comprise rubber, tea, paddy rice, maize and watermelon cultivation, shifting cultivation, and animal husbandry (Wehner, 2007). For small-scale private farmers, rubber is one of the area's most important cash crops, having displaced vegetables, orchards, and other crops, like tea and maize (Cotter, 2011, p. 2-4).

Deforestation and land use change in the NRWNNR are increasing as rubber plantations rapidly expand (Berkhoff and Herrmann, 2009). This process could convert the area's carbon sinks into sources of carbon (Yang et al., 2005, p. 296 and Bernstein et al., 2007, p. 37). China's agricultural sector was estimated to emit about 20% of the entire country's greenhouse gases in 2005, i.e. 1,023 $MtCO_2$ equivalents (Leggett et al., 2005, p. 17-18), making agriculture important when it comes to greenhouse gas emissions. Perennial plantations, such as rubber, can store carbon over many years, and contribute to carbon sequestration (Yang et al., 2005, p. 296). However, it is not clear if rubber plantations can make a valuable contribution to carbon sequestration compared to other land uses in the NRWNNR, i.e. mainly primary and secondary forests, grasslands, orchards/tea and paddy rice and maize fields. Therefore, this study focuses on evaluating the environmental impact of a land use change that is strongly driven by the fast rate of rubber expansion on CO_2 emissions, carbon sequestration and carbon balance in the NRWNNR.

1.3 Hypothesis

The biomass carbon sequestration potential per ha of rubber trees at higher elevations is lower than at lower elevations, as temperature decreases with increasing elevation, thus limiting biomass development and latex yield. The biomass carbon sequestration per ha of primary forests will be the highest compared to all other land uses. Mature rubber plantations are expected to sequester less biomass carbon per ha than primary and mature secondary forests. The biomass carbon sequestration per ha of mature secondary forests is expected to be higher than in grasslands, orchards/tea, maize and paddy rice fields. The carbon sequestration of rubber plantations will be higher than in grasslands, orchards/tea, and annual crop fields.

1.4 Objectives

The principal aim of this thesis is to study the environmental impact of a land use change that is strongly by expanding rubber plantations on carbon sequestration, CO_2 emissions and carbon balance in the Naban River Watershed National Nature Reserve between 1992 and 2003. The specific objectives are to:

1 Determine the biomass of rubber plantations at different elevation ranges in the study area,

2 Investigate the carbon sequestration potential of the area's different land uses (primary and secondary forests, rubber, maize, paddy rice, orchards/tea, grasslands),

3 Assess the carbon emissions of the changing land use in the region, and

4 Assess the carbon balance that results from land use change.

Chapter Two of this thesis presents the materials and methods used to accomplish this study. Chapter Three describes the case study area, the NRWNNR, in terms of climate, soils, biological diversity and ecosystem services, land use, and demography and economy. This aims at giving a description of the environmental conditions, and to show the need to estimate carbon sequestration potential, CO_2

emissions and carbon balance in the area. Chapter Four gives a description of the plant *Hevea brasiliensis* and shows its requirements to be productive in agricultural systems in order to evaluate possible positive and negative environmental effects based on data about the NRWNNR and case studies from other locations. Chapter Five shows the biomass and carbon sequestration of rubber and primary and secondary forests grown at different elevation ranges, of paddy rice, maize, orchards/tea and grasslands. This is done by including data about Xishuangbanna, the NRWNNR and case studies from other countries. Chapter Six presents the simulated biomass, litter inputs, exported carbon, soil carbon, carbon dioxide emissions and carbon balance in the area over the simulation period, i.e. from 1992 until 2003. This is done to assess if rubber can offer a valuable contribution to carbon sequestration compared to primary and secondary forests, and other land uses in the area. Chapter Seven is a discussion of the thesis' results, and Chapter Eight presents the conclusions of the thesis. Chapter Nine lists all the references used to write this thesis.