ANALYSING THE ENVIRONMENTAL CONDITION FOR FORESTRY AREA USING GIS-AHP APPROACH IN FOREST RESEARCH INSTITUTE MALAYSIA CAMPUS, SELANGOR

BY

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ABSTRACT

Forests are fundamental resources that provide a significant aesthetic, cultural, biological and economical source for the social community in every country throughout the world. Besides, forest also plays another essential role which it serves as a valuable carbon sink by removing carbon dioxide from the atmosphere and storing the carbon in a long-term reservoir that contribute to the environmental quality as a whole. Degradation of environmental condition has become a serious issue faced by many countries today. The primary cause of this problem is related to human disturbance towards natural resources. Urbanisation requires lots of land clearing and deforestation for the development process. This situation is very relevant in a fast developed state like Selangor whereby its valuable forested areas are now under continuous development pressure. Therefore, the concern of this research is to assess the condition level of artificial and naturally regenerated forestry area in Forest Research Institute Malaysia Campus, consisting of 54 fields, to see how best it can contribute in balancing the ambient of air quality. For data collection, this research depends on a series of GIS database covering five criteria, namely slope, altitude, crown perimeter, tree height and carbon stock. These data were then analysed using Analytic Hierarchy Process (AHP) through a composite score from eigenvalue of priority ratings and producing a composite map, which classified the site as the healthiest, moderately healthy and less healthy condition. The results indicate that most of the forested areas in FRIM campus lie under the category of healthiest condition with 45.5% in the area of 220.8 hectares whereby the key contributor is the carbon stock. Relating these criteria for ecosystem health will be beneficial toward monitoring forest change in landscapes, assisting in management and planning the urban development in any geographical setting.

ملخص البحث

تعد الغابات من الموارد الأساسية التي توفر مصدرًا مهمًا للمظهر الجمالي، والجانب الثقافي والبيولوجي والاقتصادي لأبناء المجتمع الواحد في كل بلد بجميع دول العالم، وفضلًا عن ذلك تؤدي الغابات دورًا أساسيًا آخر يعدّ بمثابة حوض كربون له دور مهم في إزالة ثاني أوكسيد الكربون من الغلاف الجوي، وتخزين الكربون في خزان طويل الأجل؛ وهي تسهم في جودة البيئة بشكل عام. لقد أصبح تدهور الظروف البيئية مشكلة خطيرة يواجهها العديد من البلدان اليوم؛ والسبب الرئيس لهذه المشكلة يعود إلى اضطراب العالم أجمع تجاه الموارد الطبيعية. يتطلب التحضر والتقدم القيام بتطهير الأراضي وإزالة الغابات من أجل عملية التنمية، وهذه الحالة مهمة جدًا في ولاية سيلانجور التي تسير في تقدّم ونمو سريع؛ حيث تتميز بمناطق حرجية قيّمة في الوقت الحاضر، وتقع تحت ضغط التطور المستمر فيها؛ ولذلك، يركز هذا البحث على تقويم مستوى الحالة المصطنعة وإعادة إنشاء مساحات الغابات في حرم أبحاث المعهد الماليزي للبحوث ويتألف من (54) حقلًا لمعرفة أفضل الطرق التي يمكن أن تسهم في تحقيق التوازن بين نوعية الهواء المحيط بها. يعتمد هذا البحث في جمع البيانات على سلسلة من قاعدة البيانات لنظم المعلومات الجغرافية، والتي يشمل خمسة معايير، هي: المنحدر، والارتفاع، ومقياس محيط الشجرة، وارتفاع الشجرة، والكربون المخزون. وهذه البيانات تم تحليلها باستخدام عملية التسلسل الهرمي التحليلية (AHP) من خلال نقاط مركبة أخذت من تصنيفات ذات أولوية وإنتاج خارطة مركبة صنفت الموقع بوصفه من أصح المواقع وأكثرها اعتدالاً في مجال الصحة، والموقع الأقل صحة. تبيّن النتائج أن معظم المناطق المشجرة في حرم FRIM تقع تحت فئة الظروف الصحية الأفضل بنسبة (45.5 %) في منطقة مساحتها (220.8) هكتار؛ حيث إن الإسهام الرئيس فيها هو مخزون الكربون؛ أما فيما يتعلق بهذه المعايير لصحة النظم الإيكولوجية فستكون مفيدة في رصد تغير الغابات في مناظرها الطبيعية، وسوف تساعد في إدارة التنمية الحضرية وتخطيطها في أي مكان جغرافي بماليزيا.

APPROVAL PAGE

I certify that I have supervised and read this study and that in my opinion, it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a thesis for the degree of Master of Urban and Regional Planning

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DECLARATION

I hereby declare that this dissertation is the result of my own investigations, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at IIUM or other institutions.

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CHAPTER ONE

INTRODUCTION

1.1 INTRODUCTION

Forestry is essential to many environmental functions and ecological services. Besides providing habitat for wildlife, forest ecosystems are also the sources of wood, timber and various edible products for human survival. Other than that, forests are also one of the important elements in the global cycling of carbon, oxygen, and other gases which influences the composition of the earth's atmosphere. Nevertheless, forest can deliver the functions of protection or conservation expected from it only if it is either under good natural ecological conditions or, when in use, it is managed in a sustainable manner.

Degradation of environmental health condition has become a serious issue that developing countries are facing today and this is caused by some factors. The primary cause of this environmental degradation is human disturbance towards natural resources especially for forestry areas. Thus, this situation should not be taken for granted as forestry areas are one of the ultimate natural resources that give contribution to a healthy environment as a whole.

This research is focusing on the environmental condition for forestry areas that considered as Environmental Sensitive Areas (ESA) category at Forest Research Institute Malaysia (FRIM) Campus in Selangor, Malaysia. In this chapter, the study background and the research problem will be discussed. In the end, the research question and objective as well as limitation will be clarified.

1.2 BACKGROUND

Approximately 40% of the earth's land surface (over 5 billion hectares) is forests, open woodlands and shrub lands (Stanturf et al., 2014). Forests are fundamental resources that provide a significant aesthetic, biological and economic source for social community in every country throughout the world. According to Forestry Department of Peninsular Malaysia (2013), Malaysia is recognized as one of 12 nations with "mega-biological diversity" in the world because its forest is the habitat to approximately 17,631 species of flora and 9,563 species of fauna. Besides having unique and beautiful landscape that meets recreation and ecotourism needs, tropical rain forest in Malaysia also plays an important role in terms of protection of biodiversity as well as for Malaysia's socio-economic growth.

There is an increasing awareness that forest condition is very vital to the human health and well-being as well as microclimates since it affects the quality of air. Previous studies by Bentley et al. (2002), Bietler (2006) and Sandifer et al., (2015) shows that trees affect air quality through the direct removal of air pollutants, altering local microclimates and building energy use, and through the emission of volatile organic compounds (VOCs), which can contribute to help reduce urban O_3 levels. As a result, many initiatives to improve the level of forest condition is enforced including the monitoring of healthy trees on productive sites, reduction of losses to pest organisms and careful harvesting that protects standing trees from injury as well as maintains the integrity of riparian areas (United States Department of Agriculture, 2001).

Presently, Selangor is the most developed state in Malaysia that faces the challenge to balance between conservation efforts on environmental resources of forest and its socio-economic growth. Even though Selangor is an urbanized city, the

number of forest reserve areas is numerous with the total area of 148,324 hectare (Ministry of Natural Resources and Environment Malaysia, 2004). Over the years, there are many environmental issues occurred in Selangor such as flash floods, loss of mangrove and so forth. Bukit Lagong Forest Reserve which is located in Forest Research Institute Malaysia Campus is one of the forest reserves in Selangor that is currently facing these environmental issues. Selangor has identified its Environmental Sensitive Areas (ESAs) covering various aspects of natural resources ranging from forest and coastal areas. At the international level, there are various methods used like GIS and remote sensing to identify the health condition of any natural resources (Herrington et al, 1988; Levinsohn et al., 1991; Tabor and Hutchinson, 1994; Mather, 2000 and Julian et al., 2001). In the local context however, currently there is no mechanism to measure the level of health of ESAs.

1.3 RESEARCH PROBLEMS AND RESEARCH QUESTIONS

Urbanization is one of the most critical issues that caused global changes in the world today. Globally, more people live in urban areas than in rural areas. In 2007, for the first time in history, the global urban population exceeded the global rural population, and the world population has remained predominantly urban thereafter (refer figure 1.1). The planet has gone through a process of rapid urbanization over the past six decades. The result of the World Urbanization Prospects Reports by the United Nations (2014) shows that in 1950, 30 per cent of the world's population was urban, and by 2050, 66 per cent of the world's population is projected to be urban. The urban population of the world has grown rapidly since 1950, from 746 million to 3.9 billion in 2014. Asia, despite its lower level of urbanization, is home to 53 per cent of the world's urban population, followed by Europe (14 per cent)

and Latin America and the Caribbean (13 per cent). The coming decades will bring further profound changes to the size and spatial distribution of the global population. The continuing urbanization and overall growth of the world's population is projected to add 2.5 billion people to the urban population by 2050, with nearly 90 per cent of the increase concentrated in Africa and Asia which includes Malaysia. At the same time, the proportion of the world's population living in urban areas is expected to increase, reaching 66 per cent by 2050.

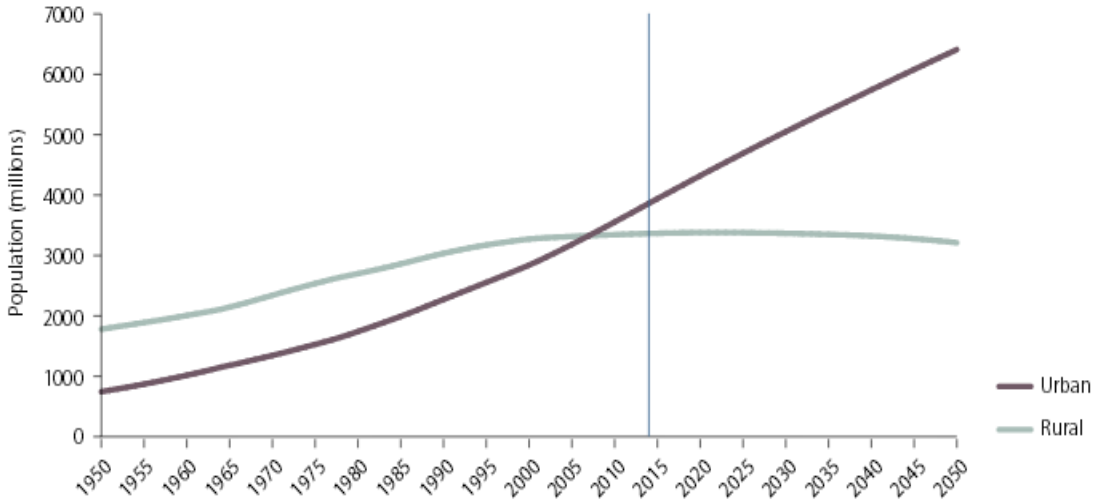

Figure 1.1 Urban and Rural Population of the World from 1950 to 2050
Source: the 2014 Revision Report of World Urbanization Prospects by the United Nations, New York

Since the last centuries, these rapid urban growths and population expanding have exerted heavy pressures on land and resources not only within the city areas, but in the rural areas as well. It is massively sprawled and cannot be controlled which consequently becomes the greatest environmental challenge of development towards forestry. In order to fulfill the needs and greediness of human being, the availability of forest area become decreasing day by day. According to the World Resources Institute (2000), the world has lost about half of its forest cover. Despite a number of initiatives to stop forest decline, the world continues to lose some 15 million hectares of forests

every year. Furthermore, the forest reserves area mostly are not managed in sustainable manners anymore.

As the importance of healthy forest areas are now being neglected by the citizens and developers, many environmental issues had arisen in recent years. One of the critical environmental issues that are hard to solve and recover is the decreasing of air quality. According to World Health Organization (2016), more than 80% of people living in urban areas that monitor air pollution are exposed to air quality levels that exceed the health limits. While all regions of the world are affected, populations in low-income cities are the most impacted. The latest urban air quality database shows that 98% of cities in low- and middle income countries with more than 100 000 inhabitants do not meet World Health Organization's air quality guidelines. As Malaysia is categorized under middle income countries, this situation is very relevant specifically to a developed state like Selangor whereby its valuable forested areas are now under continuous development pressure. Therefore, the concern of this research is to analyze the level of the environmental condition of a forested area in order to see how best it can contribute to the environmental quality as a whole.

In addition, urbanization also responsible in tackling climate change, as they consume close to 2/3 of the world's energy and account for more than 70% of global greenhouse carbon emissions (International Energy Agency, 2016). As cities develop, their exposure to climate and disaster risk also increases. The existence of forested areas which produce clean oxygen can be seen as an essential element to balance the emission of carbon suspending in the ambient air. The ability of identifying the level of the health condition of a forest area can assist in managing and planning the urban development in any geographical setting as generally it relates to the quantity of oxygen produced that could balance the carbon emission in the ambient air quality.

Evident elsewhere indicates that there is a potential relationship between forest reserves in balancing the ambient of air quality. However, currently in the academic world, the ways to measure the contribution of forest reserves to the ambient air quality is rarely being discussed, particularly in the local context.

Based on the problem statements, a few research questions have emerged as stated:

1. What are the elements/ criteria of forest that can influence its health condition?
2. Is there any potential contribution of a forest towards the ambient of air quality?
3. How can the development pressure affect the forest health?

1.4 RESEARCH OBJECTIVES

Based on the stated research problems, the aim of the study, and objectives have been determined for this research. The aim of this research is to analyse the health status of forest reserve in the FRIM Campus in order to find out its relations with the air quality ambient.

This leads to the objectives which are:

1. To identify the elements/ criteria of forest that contributes to its health condition.
2. To examine the existing health level of forest reserve in FRIM Campus.
3. To study the effect of development pressure towards forest condition level.

Table 1.1 The Relationship Between Problem Statement, Objectives and Questions

Problem statement	Objectives	Question	Place of Discussion
1. The level of the health condition of forestry area contributes to the quality of air and environment as a whole.	To identify the elements of forest and trees that contributes to its health condition.	What are the elements/ criteria of forestry that can influence its health condition?	Chapter 2: Literature review Chapter 4: Analysis
2. Forest can become carbon sink to treat air pollution issues like carbon emission.	To examine the existing level of health of forest reserve in FRIM Campus.	Is there any potential contribution of a forest towards the ambient of air quality?	Chapter 2: Literature review Chapter 4: Analysis
3. Development pressure towards forest reserve areas cause degradation of forest health condition	To study the effect of development pressure towards forest health condition.	How can the development pressure affect the forest condition?	Chapter 2: Literature review Chapter 5: Conclusion

1.5 SCOPE OF STUDY

The study focuses on the current issue in the most developed state in Malaysia which is Selangor that faces the challenge of harmonizing its conservation efforts on environmental resources with its socio-economic development growth. From the identification of Environmental Sensitive Areas (ESAs), this study attempts to find out the current condition level of forestry area in the FRIM Campus.

As such, this study focuses on two main ideas. Firstly, the elements or features of the trees inside the forest that can influence its health condition. Secondly, the potential of forest reserves contribution in balancing the ambient air quality. Therefore, the concern of this research is to investigate the level of the health

condition of a forestry area in order to see how best it can sustain the air quality ambient thus contribute to the environmental quality thoroughly.

The study area chosen is forest reserve area in FRIM Campus, Selangor. The reasons for choosing the sites are based on its geographical location and topography of the forest reserve which is quite near to the urban centers.

1.6 SIGNIFICANCE OF THE STUDY

The significant of this study could be achieved in three different sectors which are academic, government, and community.

1. Community

   Through the study, information gain could give social benefits as it help the government to improve the environmental condition in Selangor. By having a healthy forestry area which gives a good quality of air, it gives opportunities for urban community to enhance their quality of life especially in terms of their health.

2. Government and NGO

   This study will bring such input for government to improve the environmental condition in Selangor. This input may form forestry in Selangor will be more appreciated in terms of its contribution towards air quality and environmental health as a whole. Government may use the result of this study to be base of preparing the policies, regulations and strategies towards enhancing the forestry protection for the socio-economic growth of the community.

3. Body of knowledge

   This study contributes to advancement of understanding how best the level of health of forestry area can contributes to the environment. It adds to existing knowledge by explaining how the variety elements of forest area can influence its health condition. The study is exclusive as it lies in the study region that has never done before. Thus, it may bring different result and perspective regarding to the forest health contribution.

1.7 LIMITATION

This research has the focus of study that forms the limitation. There are two limitations of this research that need to be acknowledged and addressed regarding the study which are:

1. Time constraint

   The first limitation concerns the time needed for data collection. Obtaining the satellite images for GIS technique methodology from the authority may take more than two weeks, therefore may limit the time to analyze the data collected. Furthermore, it is also time constraining to examine all parts of ESAs in Selangor as the size area is very large.

2. Resources constraint

   The second limitation has to do with the extent to which the data can be obtained. Currently, in the local context there is no specific mechanism to measure the level of the health of ESAs as thus it is hard to find the resources and references. Besides that, the secondary data document is also depending on the availability of the forestry department as the data

coverage is very limited. This leads to the difficulty in analysis process as the extensive environmental and forestry data in the form of GIS is required.

1.8 STUDY STRUCTURE

The study is conducted in two phases with 5 stages. The first and the second stage provide the theoretical background of the study. The third stage is the gathering of the primary and secondary data. The forth includes the analysis of data and findings, and finally the fifth stage consists of conclusion and recommendations. The organization of chapters are as explained below (Refer Figure 1.1).

Chapter One discusses the essential for overall overview of the study on the significance of forestry and the current issues that forestry facing nowadays. This chapter provides general picture of this research contents, and the most important is this part presents the problem statements, objectives and the process needed to achieve the aim of the study.

Chapter Two discusses the overall understanding regarding the main issue of this study which is the environmental condition for forestry areas and its contribution towards the ambient of air quality. This chapter consists of the review of various literatures regarding to the importance and function of forest, forestry and urban development pressure, environmental sensitive area, forest health and air quality issue as well as GIS in Forestry Management. The purpose of this literature review is to provide the information and the theoretical framework to conduct this study and achieve its objectives.

Chapter Three presents the methodology of the study which consists several processes of the research. This chapter begins with the overall research framework

that discusses the stages from preliminary study, gathering data and conducting research, data analysis and findings until the recommendations and conclusions. This chapter explains the methodology used in this study which are: 1) literature reviews and secondary data documents; 2) analytic hierarchy process (AHP) technique; and 3) GIS technique. All the techniques supplement and validate each other for analytical purposes. In the second methodology which is AHP technique, 5 criteria were identified for selection of the environmental condition of forestry area and the AHP hierarchy model for this study is constructed. The process in the third methodology is also enlightened whereby the criteria were classified in the form of over layering maps using the GIS technique. Other than that, this chapter also discussed about the study area of this research in details which is Forest Research Institute Malaysia.

Chapter Four presents the data analysis and its results based on the objective and research questions. This chapter discusses the analysis process and the results of the study based. The AHP decision support model that have been constructed in chapter three will generates eigenvalue and priority weightage which will be used as followed in the GIS technique. In the GIS technique, all plans with its classifications measurement and eigenvalue are overlaid to produce a composite map. The final composite map result will shows the areas that are classified as the healthiest, moderately healthy and less healthy condition. Thus, the result of the analysis will determined the current condition of forest reserve in FRIM Campus. Eventually, the findings of the analysis will also be discussed.

Chapter Five summaries the research findings and presents the conclusion based on those findings. It is followed by the recommendations and suggestion that could be offered for the improvement of the environmental condition of FRIM Campus in the future.

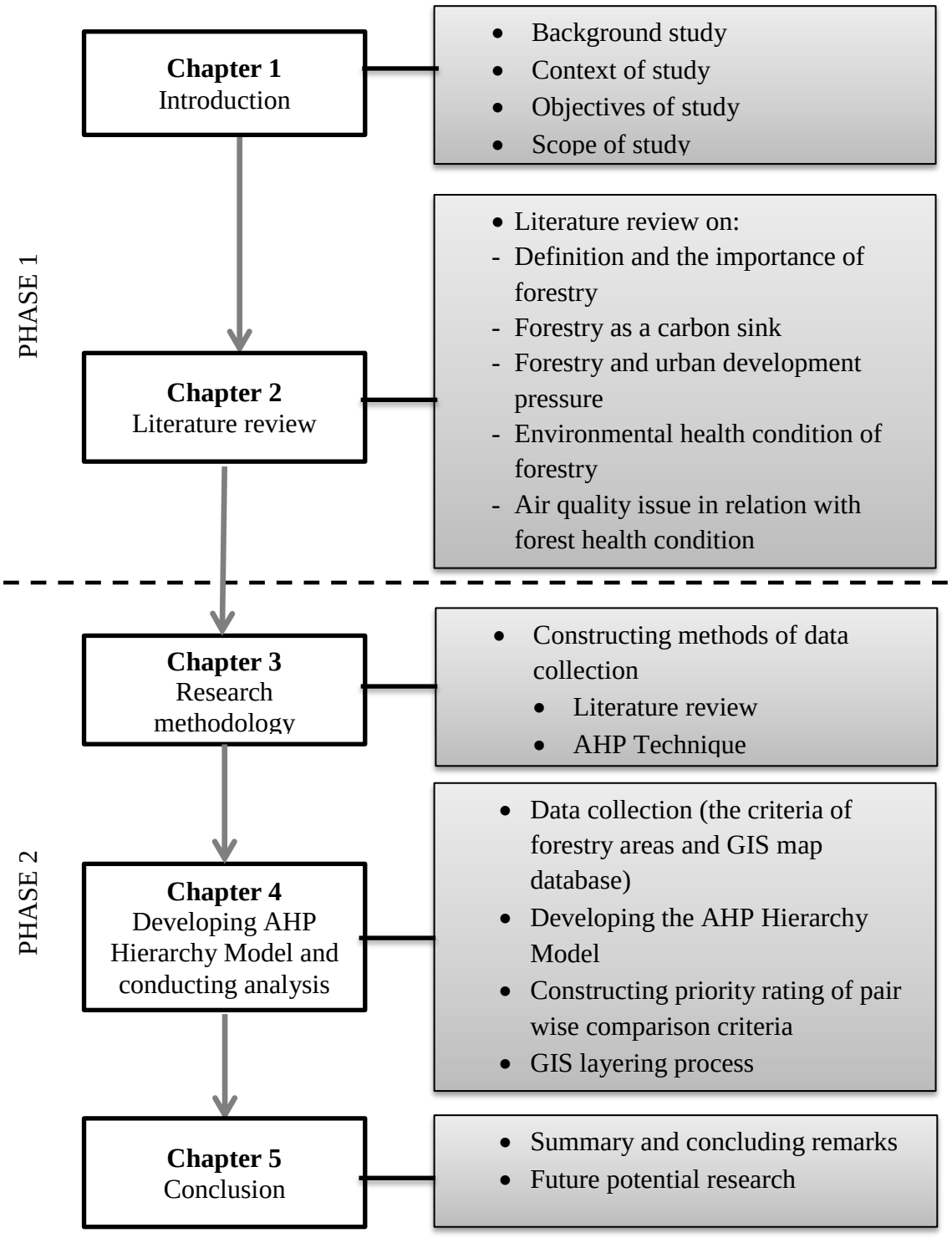

Figure 1.2 Flowchart of the Study Process