ECONOMIC VALUATION OF GREEN OPEN SPACE (GOS) AND BIODIVERSITY IN BANDA ACEH

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ECONOMIC VALUATION OF GREEN OPEN SPACE (GOS) AND BIODIVERSITY IN BANDA ACEH

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LIST OF ABBREVIATIONS

C	Carbon
CO	Carbo Monoxide
CO_2	Carbon Dioxide
CVM	Contingent Valuation Method
DKI	Daerah Khusus Ibu Kota
GOS	Green Open Space
GIS	Geographic Information Systems
IVI	Importance Value Index
LULC	Land Use and Land Cover
O_2	Oxygen
POM	Polisi Militer
RF	Relative Frequency
RD	Relative Density
RDo	Relative Dominance
TEV	Total Economic Value
WTP	Willingness To Pay

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PENILAIAN EKONOMI RUANG HIJAU TERBUKA DAN BIODIVERSITY DI BANDA ACEH

ABSTRAK

Faedah ekologi hutan bandar dapat diukur atau dikira secara ekonomi menggunakan pelbagai pendekatan. Oleh itu, keperluan untuk mengetahui harga yang mungkin diperoleh jika faedah hutan bandar diukur atau dikira dalam unit monetari supaya faedah-faedah hutan bandar dapat dilihat. Kajian ini bertujuan untuk menentukan perubahan kawasan tanah terbuka hijau (GOS) di hutan bandar, kepelbagaian vegetasi, burung, mamalia kecil, stok karbon di hutan bandar dan mengukur Total Economic Value (TEV) di hutan bandar. Data penyelidikan yang digunakan dalam kajian ini melibatkan pola perubahan penggunaan tanah dengan menganalisis imej satelit yang diambil pada tahun 2004 (sebelum tsunami), 2005 (selepas tsunami), 2011, 2013 dan 2016. Data biologi diperoleh dengan menganalisis potensi tumbuhan dan haiwan. Jumlah nilai ekonomi sumber asli diperoleh dengan menemuramah orang yang berinteraksi secara langsung atau tidak langsung dengan kawasan kajian. TEV terdiri daripada nilai penggunaan dan nilai tidak digunakan, di mana penggunaan langsung hutan bandar di Banda Aceh menyediakan kayu api dan ekopelancongan. Bentuk penggunaan tak langsung adalah memberikan nilai karbon. Nilai opsyen adalah berupa faedah keanekaragaman hayati, dan nilai kewujudannya ialah keberadaan flora dan faunanya. Perlindungan hutan di hutan bandar di Banda Aceh dikurangkan sebanyak 0.6 ha (1.3%) dari tahun 2004 hingga 2005. Ini disebabkan oleh bencana gempa bumi dan tsunami yang melanda Kota Banda Aceh pada akhir tahun 2004. Walau bagaimanapun, dalam perjalanan masa, penutup hutan

juga terus berubah dan meningkat sehingga 2016. Peningkatan dalam penutupan hutan dari tahun 2005 hingga 2011 berjumlah 2.6 hektar (5.6%), dari tahun 2011 hingga 2013 peningkatan adalah 0.6 hektar (1.3%), dan dari tahun 2013 hingga 2016 ia meningkat sebanyak 4.2 ha (9%). Kajian ini telah mengenal pasti 48 spesies pokok di kawasan hutan di kota Banda Aceh. Daripada 48 spesies pokok, spesies pokok yang mempunyai indeks nilai penting (IVI) yang paling banyak terdapat di hutan Banda Aceh adalah Samanea saman dengan IVI 67,95. Berhubung dengan indeks kepelbagaian spesies, kajian mendapati bahawa hutan Tibang mempunyai indeks kepelbagaian tertinggi 0.37. Dari segi spesies burung, pemerhatian di 10 lokasi hutan bandar hijau terbuka menunjukkan 17 spesies burung dengan 627 individu ditemui di bandar hutan Banda Aceh. Spesies burung *Passer montanus* adalah spesies burung yang paling biasa ditemui. Spesies burung ini mempunyai indeks kepelbagaian tertinggi berbanding spesies burung lain dengan indeks kepelbagaian 0.29. Kajian itu juga mendapati bahawa hutan Tibang mempunyai indeks kepelbagaian burung tertinggi, dengan nilai indeks kepelbagaian 0.32. Hasil kajian ini juga mendapati spesies kelawar yang mempunyai indeks kepelbagaian tertinggi adalah spesies *Brachyotis cynopterus* yang mempunyai nilai 0.36. Tambahan pula, empat kawasan hutan yang mempunyai nilai indeks kepelbagaian tertinggi diperolehi, iaitu hutan Kherkoff, hutan Putroe Phang, hutan Trambesi, dan hutan Tibang. Bagi penyerapan karbon, hasil kajian ini menunjukkan bahawa hutan POM mempunyai nilai stok karbon terbesar penyerapan karbon hutan bernilai 884 tan per ha. Sementara itu, jumlah nilai stok karbon di hutan bandar Banda Aceh berjumlah 3298 tan per ha. Pengiraan jumlah nilai ekonomi (TEV) menunjukkan 10 hutan perkotaan di Banda Aceh adalah Rp6,8 miliar ($ 517.187) per tahun.

ECONOMIC VALUATION OF GREEN OPEN SPACE (GOS) AND BIODIVERSITY IN BANDA ACEH

ABSTRACT

The ecological benefits of urban forests can be measured or calculated economically using multiple approaches. Therefore, the need to know the price that may be acquired if the benefits of urban forests are measured or calculated in monetary units so that the benefits of urban forest can be seen. This study aims to determine the change of green open space (GOS) land cover in urban forest, diversity of vegetation, birds, small mammals, the carbon stock and measure the Total Economic Value (TEV). Research data used in this study involves the pattern of land use changes by analysing satellite images taken in 2004 (before the tsunami), 2005 (after the tsunami), 2011, 2013 and 2016. Biological data was obtained through analysing the-vegetation and animals. Total economic value of the natural resources was obtained by interviewing people who interact directly or indirectly with the study areas. TEV consists of use value and non-use value, where the direct use of urban forest in Banda Aceh is providing firewood and ecotourism. The form of indirect use is providing carbon value. Option value is in the form of benefits of biodiversity, and existence value is the existence of its flora and fauna. Forest cover in urban forest in Banda Aceh was reduced by 0.6 ha (1.3%) from 2004 to 2005. This was due to the great earthquake and tsunami disaster that struck the City of Banda Aceh in late 2004. However, in the course of time, the forest cover also continued to change and increase until 2016. The increase in the forest cover from 2005 to 2011 amounted to 2.6 ha (5.6%), from 2011 to 2013 the increase was 0.6 ha (1.3 %), and from 2013 to 2016 it increased by 4.2 ha

(9%). The study has identified 48 tree species in the forest area in the city of Banda Aceh. Out of the 48 species of tree, the tree species with the highest importance value index (IVI) was the *Samanea saman* with an IVI of 67.95. With regard to the species diversity index, the study found that Tibang forest had the highest diversity index of 0.37. In terms of bird species, 17 species of birds with 627 individuals were recorded in the forest city of Banda Aceh. The *Passer montanus* bird species are the most commonly bird species with highest index (0.29) compared to other bird species The study also found that the Tibang forest had the highest bird diversity index, with a diversity index value of 0.32. Bat species which had the highest diversity index was the *Cynopterus brachyotis* which had a value of 0.36. Furthermore, four forest areas which had similar highest diversity index value for bats namely Kherkoff forest, Putroe Phang forest, Trambesi forest, and Tibang forest. As for carbon absorption, the results of this research revealed that POM forest has the largest carbon stock value of forest carbon absorption worth 884 tonnes per ha. Meanwhile, the total value of carbon stocks in urban forests of Banda Aceh amounted to 3298 tonnes per ha. The calculation of total economic value (TEV) showed for the 10 urban forests in Banda Aceh is Rp 6,8 billion ($517,187) per year.

CHAPTER 1

INTRODUCTION

1.1 Background

Biodiversity is divided into three levels, namely genetic diversity, species, and community (ecosystem). The diversity of determining the power of adaptation of the population that will be part of the interaction of species. Diversity consists of two different components, namely species richness and evenness (Nahlunnisa, 2016). According to Kartikasari (2015), species diversity can be used to express community structure. The measure of diversity and its causes cover most of the thinking about ecology. That is mainly because diversity can produce stability and thus relates to the ecological center.

Banda Aceh Public Green Open Space (GOS) recorded in Spatial Planning 2009 are found in the forms of city parks (e.g., theme parks, educational garden, garden nursery, and garden monument), urban forests, mangrove forest, sports grounds, and graveyards. Meanwhile, GOS in the form of a link or corridor or green belt at this time is the island roads and green lanes, rivers, and coastal borders. In addition, privately-owned GOS consists of land owned by the Municipal Agriculture farms. Overall, the total area of the existing GOS in Banda Aceh currently comprised of an area of 2077.28 ha, or 33.85% of the area of the city. Generally, that meets the best percentage conditions provided in the Law No. 26 the Year 2007 concerning Spatial Planning and Public Works Minister No.05/PRT/M/2008 Regulation on Guidelines for the Provision and Use of Green Space in Urban Areas.

Green open space is one important element that can control the quality of the urban environment (Handoyo et al., 2016). The proportion of urban green open space is decreasing due to increasing human population growth (Januarisa et al, 2015).

The availability of public green space around the area in the district of Banda Aceh is not optimal according to the greening program, even though additions to city parks, urban forests, city green lanes, have been made to the unequal distribution. The minimum needs of public green space can be achieved by maintaining the existing green space and public open space area and adding to GOS for Agriculture City, addition into Park City and Forest City or by establishing special zones such as water catchment areas, mangrove forests into the Nature Park or Protected Forests. Green open spaces aesthetically function to create comfort, harmony, health, and environmental cleanliness. Green open spaces socially function to create recreational environments and natural education facilities (Putra, 2012).

Increased number of residents in urban areas will cause more and more utilization of natural resources and bring negatives impacts on the environment. The need for infrastructure development and limited land availability become factors of disintegration in urban development. Various activity sectors of urban society often fight over Green Open Space (GOS) in urban areas because of a lack of GOS available. The presence of GOS in urban areas is very important to support the sustainability of a city in terms of ecology and human needs.

Green Open Space (GOS) is one of the important parts of a city. The existence of GOS is very important for the city dwellers. Therefore, it is necessary for the authorities to manage GOS through city landscaping services to ensure the GOS remains to function optimally. A network of open space encourages more active

lifestyles by offering a variety of safe and attractive spaces that are well distributed and accessible throughout a neighborhood to cater for the sporting and recreational needs of the community (Auckland City Council, 2007). Preferably, the public open space should attempt to cater to multiple users. For example, through landscaping and the addition of facilities, a sporting oval could be designed to cater to sportspeople, pedestrians, and children (Giles-Corti et al, 2005).

The existence of the Green Open Space is an important factor in supporting the ecological sustainability of a city, and the existence of the Green Open Space also influences the comfort of the air. The comfort of the Green Open Space is influenced by the temperature and humidity described in the thermal comfort index. (Asiani, 2007).

The arrangement of green open space is also part of the urban planning strategy to limit development and overcome the ecological impact of various human activities. Green open space as a catchment area, pollution reduction, and decreasing air temperature (Rahmy, et al., 2012). Therefore, environmental management in urban areas needs to be done so that cities have the good spatial quality that can support various activities of urban communities (Lestari, et al., 2013).

The green open space Master Plan is a Green City open space development plan to achieve the target of 30% green open space (Law 26/2007 Spatial Planning) within 20 years (according to District Spatial Plan) targeted in Banda Aceh city, as an alternative effort to minimize the impact of environmental damage by optimizing the ecological function of Green Open Space Urban Area. One of the green open space allocations is the existence of urban forest allocation. Forests area complex community of plants which as a whole is a living community of biological nature and its environment (Paimin 2005).

The urban forest is an abiotic and abiotic environment composed of a series of ecosystems from biological, physical, economic, and cultural components that are related to one another (Farisi et al. 2017). The process of developing a city that is focused on the economic sector can result in the emergence of environmental degradation in the city. Urban development can result in a reduction in the proportion of open space, and result in various disturbances to natural processes in an urban environment (Rawung 2015).

Urban development that is focused on economic activities, and does not pay enough attention to environmental aspects can have an adverse impact on the ecological balance in urban areas because it can cause environmental degradation (Iswari 2012). Therefore, the development of urban forests becomes important, considering the availability of urban forests is expected to represent the sustainability of the ecological function in a city. Ahmad et al. (2016) stated that urban forests have a big role in reducing the maximum temperature to be lower by the mechanism of sunlight through the forest canopy, and through the net energy during the day that is used for the process of evaporation or transpiration so that it causes comfort to shelter under trees compared location without trees. In this case, urban forest management must be carried out in order to obtain the benefits that can be provided from the availability of urban forests.

Livesley et al. (2016) which states that trees in urban forests can be managed to get benefits by reducing negative impacts such as floods, air pollution, and storing carbon stocks with good management. In addition, Farisi et al. (2017) state that planting trees such as trembesi (*Samanea saman*) in urban forest areas can be done to absorb CO_2 well.

Green open spaces also have economic benefits which are expected by the government to develop urban green tourism facilities in order to increase the economic value of the city (Yusmawar, 2016). The management of urban green open space systems is a response to the need for green open space which includes ecological, social and economic aspects.

The ecological benefits of urban forests can be measured or calculated economically using multiple approaches. However, there are obstacles in building urban forest in the form of conflict of interest against the allotment of land to other uses such as the construction of hotels, shopping malls, restaurants and so forth (Dahlan, 2004). This is because the construction of buildings is more profitable than building an urban forest. However, when calculated in monetary terms, damages to urban ecology is very high. Therefore, the need to know the price that may be acquired if the benefits of urban forests are measured or calculated in monetary units so that the benefits of urban forest can be seen.

Economic assessment of natural resources and the environment need doing to give illustrate the importance of urban forests to reducing environmental losses due to the developing city.

1.2 Research Problem

Managing green open space (GOS) in Banda Aceh, faces several problems as follows:

First, there are conflicts of interest between the community and the City Government of Banda Aceh. Geographically, green open space in the city of Banda Aceh plays an important function as a protective area. Nevertheless, now there has been a shift in the process of land use. Most areas designated as open green areas have

been converted into residential and farming areas. Economically, using the green open area for the cultivation area may have a higher economic value, but it endangers the environment.

The city of Banda Aceh is one of the cities hardest hit by the tsunami and being intensively planned for urban spatial changes. Banda Aceh has been targeted to be built as a green city. So, many programs are being planned for Banda Aceh, one of which is to convert it into a green city as a pilot project in the province.

Second, the diversity of vegetation, birds, bats, carbon trade and other living beings are potential biological indicators of the condition of the urban forest that has been allocated to GOS.

Third, the carbon in the ecosystem is the process of using CO_2 in the air for plant photosynthesis, and the formation of CO_2 as a result of the respiration process of living things. This is caused by CO_2 is a major component in the process of plant photosynthesis.

So far, we often do not see that carbon has an economic value in a region. The increasing activity of the city, the more carbon production is expended in the city area. One way to overcome this problem is to maintain and increase green open spaces in the form of urban forests.

Fourth, total economic value for the urban forest in the area of GOS it does not measure yet. It is important to determine the value of GOS as reasonable for the community to protect their area.

1.3 Research Question (RQs)

This study intends to answer the following research questions:

RQ1: What is the change of green open space (GOS) land cover in the urban forest?

RQ2: What is the diversity of vegetation, birds, small mammals (rats and bats) in the urban forest?

RQ3: What is the carbon stock in the urban forest?

RQ4: What is the Total Economic Value (TEV) of GOS provided by urban forest?

1.4 Research Objectives (ROs)

RO1: To determine the change of green open space (GOS) land cover in the urban forest.

RO2: To determine the diversity of vegetation, birds, small mammals (rats and bats) in the urban forest.

RO3: To determine the carbon stock in urban forest

RO4: To measure the Total Economic Value (TEV) in urban forest

1.5 Research Scope

The scope of this research is as follows:

a) Analysis of changes in land cover was carried out in 10 urban forests in Banda Aceh, in the period 2004, 2005, 2011, 2013 and 2016

b) To see the diversity of flora and fauna, data collection is carried out on vegetation, birds and small mammals.

c) Measurement of carbon stocks is carried out on surface and subsurface carbon.

d) The total economy is obtained from the use of value and non-use value.

1.6 Research framework

The conceptual framework is a framework that describes the work steps of this research. In this study, the initial step that needs to be taken is to conduct an analysis of the regional spatial plan. To get a green area, an analysis of spatial planning is needed. The next step is to determine the location of the urban forest which is part of this research. Analysis of economic value is done through the study of direct use value, indirect use value, choice-value, and existence value. Pricing is done according to the availability of existing values such as market prices, travel prices and willingness to pay. In determining the price, the total economic value of urban forests in Aceh will be obtained. An overview of the framework of this study is explained in the flowchart of figure 1.1 below.

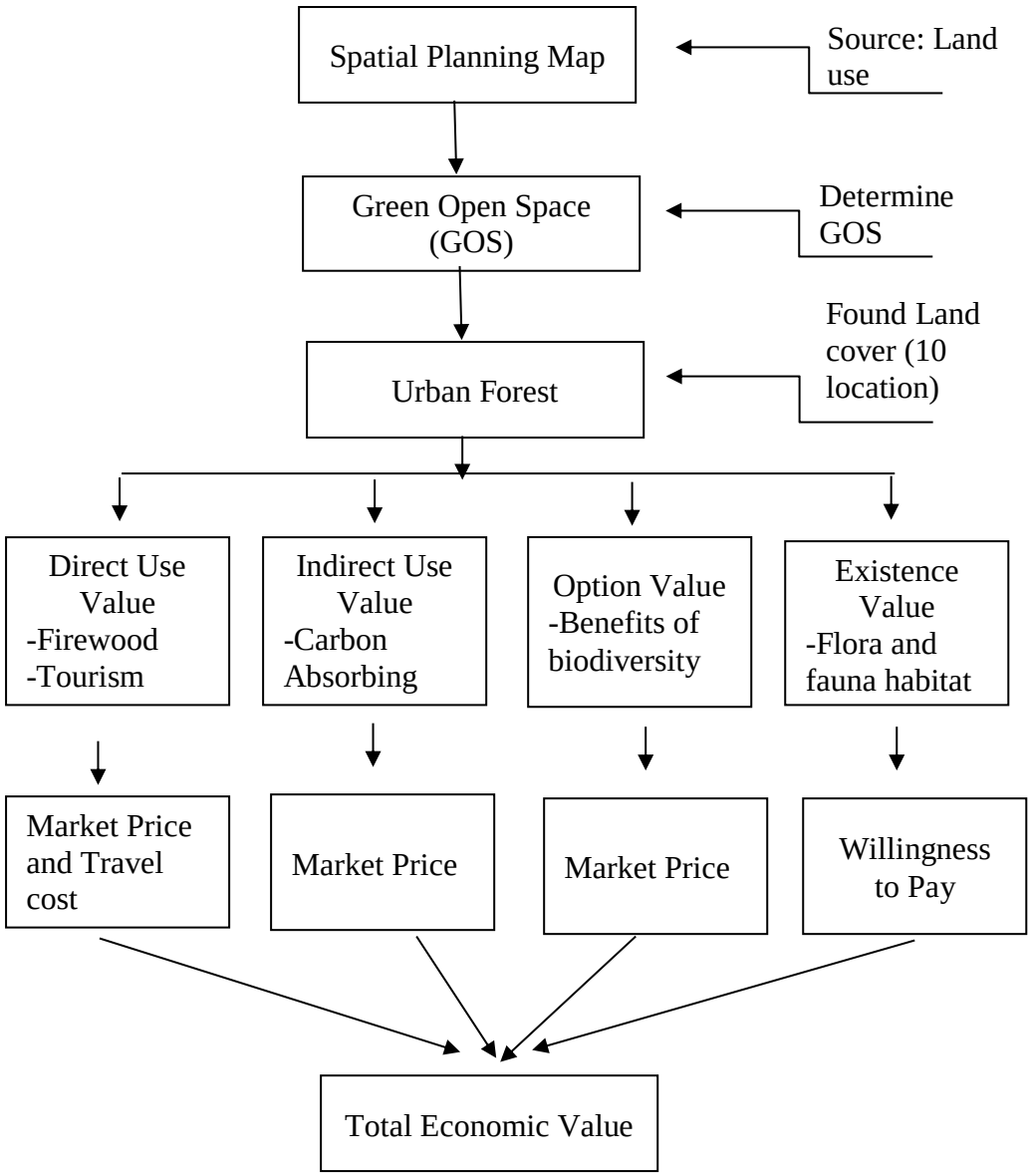

Figure 1.1. Research frame work

1.7 Organisation of the Thesis

The thesis is divided into six chapters. Chapter 1 gives an introduction to this study, which outlines the background of the research, the problem statement, the research questions, the objective of the research studies, scope of research, research framework, and the organization of the thesis. Chapter 2 focuses on a review of existing literature in relation to the research topic. The first section reviews the history and evolution of the spatial plans that affect the planning of GOS and the total

economic value to the region of Banda Aceh. Chapter 3 describes the research methodology used in this study. This chapter is divided into sections that discuss the sampling frame, the sample size, and the research instruments. This chapter was developed based on the literature review provided in Chapter 2. Chapter 4 explains the data result of analysis focuses on the findings and discussion. Finally, Chapter 5 provides conclusion and recommendations of the study.

CHAPTER 2
LITERATURE REVIEW

2.1 Green City

According to Wildsmith (2009), the green city can also be called a sustainable city or eco-city, that is, a city which carries out development, designed by taking into consideration the environment so that its functions and benefits can be sustainable. Green City can be realized if the people living in it save or minimize the use of energy and water. Besides, they also minimize the exhaust of gasses that cause heat and prevent water and air pollution. Furthermore, Wildsmith (2009) also added social and cultural elements to these points. Thus, the green city is a city that conducts sustainable development in terms of economic, social, and ecological development to create a balance between humans and nature.

Some notions of Green City in the 2013 Green City Programme Guidelines included (Ministry of Public Works, 2013):

(a) Green City is an environmentally friendly city that uses water and energy resources effectively and efficiently, reduces waste, implements an integrated transportation system, ensures environmental health, synergizes natural and artificial environments, based on urban planning and design in favor of sustainable development principles.

(b) It is a city designed taking into consideration the environmental impacts, populated by conscious people who minimize their consumption of energy, water, and food resources; they also minimize waste disposal, air pollution, and water pollution.

(c) It is a city that prioritizes the balance of the living ecosystem with a built environment to provide comfort for the dwellers of the city and visitors to the city.

(d) It is a city built by maintaining and fostering city-territory assets, such as human assets and organizes citizens, built environment, uniqueness, and cultural creativity and intellectual life, natural resources, the environment and quality of urban infrastructure.

2.2 Green Open Space (GOS)

The green open space is an important natural and cultural entity for a city (Yuhong et al., 2014). Green open space has an important role in sustainable urban development and urban ecology. It provides environmental, social and economic benefits (Zhou et al, 2011). GOS has an important role in meeting the non-material and non-consumption needs (Chiesura, 2004). Chiesura (2004) maintained that green open spaces play a role in the building of a sustainable city and they have a positive social impact. In addition, the wide and green conditions of GOS have a positive effect on health (Paquet et al., 2013).

Non-green open spaces are open spaces in urban areas not included in the GOS category. They are in the form of hardened land or in the form of water bodies (Ministry of Public Works, 2008). Private green open spaces (GOS) owned by institutions or individuals. They are used for limited purposes such as a home garden or in buildings owned by the community or owned by private owners and planted with plants. Public green open spaces are GOSs owned and managed by a city or county government and are used for the benefits of the society in general. According to Paramesti (2016), it is emphasized that the provision of Green Open Space in urban

areas is faced with limited government-controlled land, whereas, land that is not developed must be purchased by the government in stages at a high price, this is due to inadequate government budget, and the existence of the sector others that also require financing.

Public GOSs are green areas that a city must provide. This is in line with the provisions outlined in Law No. 26 of 2007 on Spatial Planning Article 29 stating that the proportion of GOS in the city area must at least be 30% of the city area. GOS is divided into public and private GOSs. The area for a public GOS is 20% while a private GOS is 10% of the city area (Ministry of Public Works, 2007).

The types of GOS can be physically distinguished into natural GOS in the form of habitat for natural wild species, protected areas, and national parks, and non-natural or constructed GOS such as parks, sports fields, cemeteries or green paths. In terms of spatial structure, GOS can follow its ecological patterns (clumped, elongated, or scattered), or it can follow its planological patterns that follow the hierarchy and structure of urban space structure (Ministry of Public Works, 2008).

2.2.1 Ecological Benefits from Green Open Space (GOS)

Parks and other green spaces provide many ecosystem benefits, such as regulating ambient temperatures, filtering air, reducing noise; sequestering carbon and attenuating storm-water (Bolund and Hunhammar. 1999). Aside from these human benefits, carefully designed urban green spaces can also protect habitats and preserve biodiversity (Wilby and Perry 2006). Green spaces that feature good connectivity and act as wildlife corridors or function as urban forests, can maintain viable populations of species that would otherwise disappear from built environments (Fernández-Juricic, 2000).

2.2.3 Economic Benefits from Green Open Space (GOS)

Finally, researchers have found that parks and greenways provide significant economic benefits. These include promoting tourism, lessening environmental impacts (e.g., carbon sequestration, storm-water attenuation), reducing pollution through decreased car-dependence by providing alternative transportation corridors, and reducing health care expenses by fostering healthy living (e.g., promoting regular exercise) (Sherer, 2006). Parks exert a significant beneficial impact on nearby property values (Bolitzer and Netusil, 2000). Properties located near parks and greenways have been found to have higher resale value and homeowners value these spaces as important attributes when making decisions about residential location and housing choice (Bolitzer and Netusil, 2000). Finally, a likely future economic benefit of urban green space is in adapting cities to the anticipated impacts of climate change such as higher temperatures, increased flooding, increased storminess and the like. Green space that is well integrated into urban environments will likely lessen the severity of many of these anticipated problems, providing significant economic benefits (Byrme, 2009).

2.2.4 Reasons for Providing Green Open Space

Parks and other open green spaces play multiple roles in making cities more sustainable (Chiesura, 2004). These include nature's services or ecological benefits (e.g., biodiversity), social benefits (e.g., socialization and healthy living) and economic benefits (e.g., tourism). While identifying all these benefits could rapidly become a "laundry list," it is useful to briefly list an overview of the major benefits here because it helps us to better appreciate the taken-for-granted services, that urban green space provides benefits to urban residents, and to counter myopic perspectives

that suggest that green open space is a liability because of its maintenance costs. A proper cost-benefit analysis of providing an urban green open space must factor in the wider variety of benefits that green space confers savings to its users and the sometimes less tangible savings that green space affords (Chen and Jim, 2008). For example, current research shows that green open space provides considerable benefits in terms of potential cost-savings to local authorities (e.g., preventing health problems, increasing worker productivity, lessening damages to infrastructure, attenuating the phenomena of flooding, cooling heat islands, etc.) (Sherer, 2006). While this cost-saving is not immediately obvious, translating these them into monetary values shows that urban green space can save municipalities millions of dollars annually – money that would otherwise have to be spent on flood barriers, air-conditioning, sick days, stress leave, and the like (Byrne, 2009).

2.3 Land Use and GOS Changes

Green open space is one important element that can control the quality of the urban environment (Handoyo et al., 2016). Within the framework of international relations, especially on climate change and reductions of greenhouse gas emissions, the Government of Indonesia has given its commitment to reduce greenhouse gas emissions by 26% by 2020. Hence, issues related to land use are important. The land-use allocation has been presented to regional planning, and the plan is to reduce ecological damage from the social and economic factors that affect land-use change. The land is a physical environment comprised of climate, relief, soil, water, and vegetation, as well as objects on it, so long as they influence land use. It includes the results of human activities whether in the past or the present (Sitorus, 2003). Land use is the physical manifestation of objects that cover a plot of land and are linked to

human activities (Lillesand and Kiefer. 1990). According to Sitorus (2003) land use is any form of human intervention to the land to meet the needs of their material and spiritual life. In general, land use is a general classification of land use such as rainfed agriculture, irrigated agriculture, grasslands, forestry or recreation areas (Hardjowigeno and Widiatmaka. 2007).

2.3.1 Land Use

According to Lillesand and Kiefer (1990), the term land use pertains to human activities on certain plots of land. Information about the land can be obtained directly by using remote sensing techniques. Meanwhile, information about human activities on land use cannot always be predicted directly from the closure of the terrain. According to Aldrich (1981), as cited in Lo (1995), land constitutes the materials incorporated of a site. The environment is defined in terms of the number of natural characteristics, namely climate, land geology, topography, hydrological, and biological characteristics. According to Lillesand and Kiefer (1990) land is a term relating to a type that can be seen on the surface of the earth. Understanding Similarly, Burley (1961), as cited in Lo (1995), added that the cover shows the vegetation and artificial construction that cover the surface of the land. In general, there are three classes of data, on land coverage which include the following: (a) the physical structure built by humans (b) biotic natural phenomena, which are the natural vegetation, the crops, and the animal life, and (c) types of development.

Land change is the change in the state of land because of human activities at different times (Lillesand and Kiefer, 1990). Detection of the change can be traced by the use of successive aerial photography in the specific region. The proportion of urban green open space is decreasing due to increasing human population growth (Januarisa

et al, 2015). Then photographs that show the map on land use for the various times can be mapped and compared (Lo, 1995). Campbell (1983, as cited in Lo, 1995) added that map changes on the use of land between two different periods usually can be produced. Factors that cause the change of land use have been discussed in some literature elaborated that some kind of activity that can be characterized due to changes in the land. For example, the activities causing disorders against forest, land occupation, and shifting cultivation.

2.3.2 Land Use Change

Recently, issues related to land use and land-use change have attracted attention in various fields of research. Industrialization, population growth, and population movement to cities are believed to be the components that contribute most to global land-use change (Long et al., 2006). Nevertheless, there is no concrete agreement related to the causes of land-use change in Indonesia. Naiman (1992) concluded that forest resource management is complex and full of uncertainty, because of changes in democratic systems, socio-political forces, and community expectations. Furthermore, decisions and pressures on land use are increasing due to widespread economic and social factors. Likewise, in Uganda, this decision is also strongly influenced by political factors and development policy (Tukahirwa, 2002).

Serial analysis of land-use change and identification of the causal factors of these changes are needed, not only in the sustainable management of land resources but also for future land use projections (Alig et al., 2004). In general, the factors affecting deforestation vary widely. Changes in state forests in the period of 1990-2000 were influenced by infrastructure development, subsidies, employment opportunities and population pressures (Vanclay, 2005). In theory, economic

instruments to regulate natural resources have led to market failures and policy failures that eventually led to deforestation (von Amsberg, 1998).

In addition, wage rates and risks in agriculture also determine the decision (Upadhay et al. 2006). Prices of wood and agricultural products are market signals that directly influence and encourage deforestation. Trade-in forest products, agricultural products, especially plantations, in international and domestic markets determine the direction of land use. Tropical timber trade in Indonesia encourages deforestation (Barbier et al. 1995). This is in line with findings by Sunderlin et al. (2001) which stated that the reduction of trade barriers by the government has integrated the domestic market with international markets. An increase or decrease in the price of agricultural exports may encourage forest clearance.

Green open space is one important element that can control the quality of the urban environment (Handoyo et al., 2016). Within the framework of international relations, especially on climate change and reductions of greenhouse gas emissions, the Government of Indonesia has given its commitment to reduce greenhouse gas emissions by 26% by 2020. Hence, issues related to land use are important. The land-use allocation has been presented to regional planning, and the plan is to reduce ecological damage from the social and economic factors that affect land-use change. The approach taken is to formulate causal relationships and field surveys followed by an analysis of the relationships and interactions of each factor with land-use change. The relationship between these factors and changes in land use is applied to examine land-use change and the nature of these relationships.

Geist and Lambin (2002) suggested that one of the main causes of global environmental change is tropical deforestation. The analysis of 152 case studies in

their study showed that factors that encourage tropical deforestation include economic, institutional, national policies, agricultural development, logging, and infrastructure development. In addition, they stated that population growth and changes in agricultural patterns are the two main causes of deforestation in addition to human activities.

2.3.3 Definition of Cover and Land Use

Many authors distinguish between land cover and land-use. According to Lambin and Geist (2001), land cover is a bio-attribute of the earth's surface in a region (such as grass, plants, and buildings) whereas land use is the actual use of land by humans (e.g., pasture for livestock grazing, housing areas, and so forth). Meanwhile, Dewi (2011) stated that the term land cover refers more to the type of vegetation that exists on a particular land, while land use refers to human activities on the land. Furthermore, the land use system is a combination of both including vegetation change cycle and management activities (planting, harvesting). The term land use is often used for certain formal purposes such as agriculture and plantations expressed in terms of planting and harvesting areas.

The presentation of available statistical data is often less able to describe real land use. This condition can be overcome by the use of Geographic Information Systems (GIS), which is capable of interpreting and processing satellite images or other remote sensing media. GIS has been widely used and is expressed as a useful and effective tool in detecting spatial-temporal dynamics from land use and land cover (LULC). GIS techniques can analyze and map out real forms of land-use change (Zhang et al., 2002).

2.4 Urban Forest

The urban forest is a a piece of land usually planted with trees, to cope with harsh environments to qualify in the city's development plan. The urban forest is a field grown with woody vegetation in urban areas that provides the greatest environmental benefits for urban dwellers with other special uses (Faculty of Forestry IPB, 1987).

The urban forest as a catchment area, pollution reduction, and decreasing air temperature (Rahmy, et al., 2012). The urban forest will be felt incomplete if a city forest is not able to bring wildlife, especially birds because their presence provides a jaunty atmosphere with their chirping sound. The presence of birds can add to the aesthetic and ecological value of an urban forest. At present, birds in urban areas are increasingly being pinched by rapid development. The opening of an area for human settlement indirectly can change or reduce the composition of plants making the area unsuitable to be used as a bird sanctuary. Such conditions can cause the population of birds in urban areas to decrease in number. Yet according to studies conducted, the real city is still able to be inhabited by various species of birds (Janala, 1995).

Livesley et al. (2016) which states that trees in urban forests can be managed to get benefits by reducing negative impacts such as floods, air pollution, and storing carbon stocks with good management. In addition. According to Dahlan (1992), urban forests can play a role as city identity, germplasm conservation, retaining and filtering solid particles from the air, as an absorbent that absorbs lead particles, absorbers and adsorbers of cement dust, noise reducers, reducing the danger of acid rain, carbon dioxide absorber, Oxygen, windbreaker, absorber, and odor remover, overcoming inundation, overcoming seawater intrusion, climate amelioration, waste management,

preservation of groundwater, glare filter, enhancing beauty, as bird habitat, reducing stress, safeguarding beaches from abrasions, improving the tourism industry, as a hobby and time filler. The urban forest is an abiotic and abiotic environment composed of a series of ecosystems from biological, physical, economic, and cultural components that are related to one another (Farisi et al. 2017).

Ahmad et al. (2016), states that urban forests have a large role in reducing the maximum temperature to be lower, by the mechanism of sunlight reduction through the forest canopy, and through net energy during the day, which is used for the evaporation or transpiration process, thus, causing a comfort to take shelter under a tree compared to a location without trees.

According to Rachman (1996), the use of flower-producing plants in urban forest areas will provide its charms as a flamboyant. Colors of the flowers will be an attraction for birds and butterflies and provide a cheerful atmosphere. The presence of these animals will add to the natural-looking atmosphere surrounded by high rise buildings and the bustle of transportation activities. The presence of birds will add to the beauty of the area. The use of vegetation that has flowers or fruits will be an attraction for the bird to live and stay in the area.

Various species of birds require various types of food such as fruits, seeds, honey from flowers and insects. Vegetation composition is achieved by planting various types of trees, shrubs, vines, cover crops or food-producing grasses (Hails et al., 1990).

In addition to producing food, the plants in the urban forest must produce nesting materials and provide a nesting place for birds. Some bird species use a straw, cobwebs, mosses, feathers, and other materials to nest on trees and tree branches (Hails

et al, 1990). Some bird species need certain types of trees as a source of feed or a place of life and the species will be lost if these trees are not found. Therefore, the number of bird species depends on the profile of the vegetation layer (Grubb, 1979).

The diversity of vegetation structures and vegetation closure is an important factor affecting the diversity and populations of birds in urban areas (Hails et al., 1990). The type of plants favored by birds for nesting or foraging is related to plant height, leaf cover structure, crown diameter, foliage structure, foliage leaf, crown cover, branch free height and tree architecture (Pakpahan, 1993). The importance value index (IVI) is a measure of how dominant a species is in a given forest area. The importance value index (IVI) of tree species was determined as the sum of relative frequency, relative density, and relative dominance (Curtis and McIntosh, 1950).

Carbon is a chemical element that has the symbol C and atomic number 6 on the periodic table. Carbon is a non-metallic element, divalent 4, and has several allotropes, including graphite and diamond. Carbon is present in all living things and is the basis of organic chemistry. This element also has its uniqueness in its ability to form chemical bonds with fellow carbons as well as many other types of elements, forming nearly 10 million known types of compounds (Libretexts, 2019). The urban forest is a land that contains vegetation dominated by trees in urban areas. Lubis et al. (2013) argue that urban forests were developed to reduce environmental pollution in urban areas. Vegetation in urban forests can naturally absorb CO_2 that will be stored in the form of carbon compounds. The existence of forests in the city is considered important to balance activities in a city.

In nature, carbon elements circulate following the biochemical cycle, the

carbon exchange that occurs between the biosphere, geosphere, hydrosphere, and Earth's atmosphere. In this cycle, there are four main carbon reservoirs connected by the exchange path. These reservoirs are atmospheric, terrestrial biosphere (usually including freshwater systems and organic non-biological materials such as soil carbon, including dissolved inorganic carbon and biodiversity and non-biological biota), and sediments (including fuel Fossils.) The annual carbon exchange movement between reservoirs occurs due to various chemical, physical, geological, and biological processes. The oceans contain the largest carbon-active pools near the Earth's surface, yet the ocean in this part of the pool experiences a slow atmosphere (Houghton, 2005).

According to Houghton (2005), the amount of carbon entering and leaving each reservoir is in a dynamic balance, known as the carbon balance. The global carbon budget is the balance of carbon exchanges (between the entry and exit) between the carbon reservoirs or between one specific round of the carbon cycle (e.g., atmosphere - biosphere). The carbon balance analysis of a pond or reservoir can provide information about whether the pond or reservoir functions as a source or substrate of carbon dioxide.

2.4.1 The Forest Transition

Population growth, urbanization, and industrialization contribute substantially to the decline of forest areas in some areas. On the contrary, the increase of forest area in some other areas forms a general pattern of changes in the area of forest cover in line with economic development (Rudel et al. 2005). The Kuznets environmental curve hypothesizes an inverted, non-linear form describing the relations of economic development and environmental degradation. Initially, degradation increases then decline as the rate of economic development increases. Other forms of relationship

show that the transitional patterns occur; if environmental indicators are represented by forest area, economic development tends to cause a decrease in the forest area.

As development progresses, the decline in forest area can be stopped, and in fact, the forest cover can be made to grow again. This can occur if the rate of reforestation is higher than the rate of deforestation (Mather, 1992). Urban development can result in a reduction in the proportion of open space, and result in various disturbances to natural processes in an urban environment (Rawung 2015). Environmental problems have many dimensions. So, the selection of indicators itself is a challenge. Some of the indicators are air quality, forest stocks and recovery rates, biodiversity levels, and carbon emissions. Indonesia's forest resources are rich in forest products; timber and non-timber have various functions, tangible and intangible, such as the potential of environmental services with enormous economic value, as well as water services and carbon services. The emphasis of the management of forest resources in the future is to improve the quality and extent of the remaining forest cover. This situation encourages the dynamics of forest cover (Zhang, 2000).

In line with the development process, changes in forest cover represent a transitional process that illustrates the dynamics of forest cover over the long term. Various literature related to forest transition theory has used the spatial approach at a particular point in time (cross-sectional approach). However, the process of forest transition is also highly dependent on time (Rudel et al. 2010). The socio-economic dynamics described above should form the basis for policy formulation regarding efforts to avoid deforestation and forest degradation, in addition to the objectives of forest resource management in the relevant location. Prevention of forest cover reductions can be made through political policies and by providing appropriate incentives (Angelsen and Rudel, 2013).

The forest transition theory focuses on the understanding related to the factors driving the transition. Theoretically, the increase in forest cover is influenced by social, economic and biochemical factors such as industrial development, increased agricultural efficiency, international trade, urbanization, changes in energy sources and overall economic development. As development continues to progress, the decline in forest area could be halted, in fact, even the forest cover can be made to grow again. The key to this transition is to make the rate of reforestation becomes higher than the rate of deforestation (Mather, 1992).

Studies on changes in forest cover in Indonesia should be done based on identifiable causes and dynamics of forest transitions. Various literature has suggested that the causality relationship between socio-economic conditions and forest resources needs to be analyzed. In general, factors such as economic development, demographic conditions, institutions, and geographical factors are used because they are suspected to affect forest resources (Zhang, 2000).

2.5 Carbon Sources in Nature

According to Banuwa (2013), the amount of carbon stored per land-use varies, depending on diversity, plant density, soil type, management method, and others. Most CO_2 in the air are used by plants during photosynthesis and enters the ecosystem through fallen plant litter and accumulation of C in plant biomass (canopy). Half of the amount of C absorbed from the free air is transported to the roots of carbohydrates and into the ground through dead roots. There are three main sources of C supplies in the soil: (a) canopy of trees and seasonal crops entering as litter and crop residue; (b) root crops, dead, root tips, root exudation, and root respiration; and (c) biota. Litter and roots that enter the soil will soon be overhauled by the heterotrophic biota, and