Sustainability of clean water supply through ecotourism (A Study in Lembang Subdistrict)

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**Abstract.** The growth of tourism in Bandung City is also one of the factors that cause the rapid growth of population in Bandung City. This condition will certainly increase the need for a clean water supply for residents in this city. Fulfillment of clean water needs for inhabitants in the city of Bandung conducted by a regional company that is Regional Water Company TirtaWening Bandung that utilizes several sources of clean water such as surface water, springs, and groundwater that is located in the Cikapundung sub-watershed, which is still very potential for the provision of raw water for the needs of the inhabitants of Bandung and the land-used in the Cikapundung watershed itself is very diverse. Lembang subdistrict as the upstream area in this sub-watershed has a significant role in the water supply condition. This study will create a conceptual framework of sustainable tourism for clean water sustainability using a system dynamics approach that integrating land use, tourism, clean water, and sustainable tourism, and is expected to contribute to be an alternative solution to the problem of water supply in urban areas of Cikapundung sub-watershed, especially Bandung City, in the long run.

1. **Introduction**
West Java province has so abundant natural resources and has the potential to be developed into tourism activities both natural, cultural and artificial tourism. The tourism sector is one of the leading sectors developed in West Java Province. The government's commitment in developing the tourism sector is evident from one of West Java Provincial Government's 2013-2018 mission of improving social life, art and culture, youth and sporting role and tourism development in local wisdom frame. One of the areas in West Java Province which have experienced a fairly rapid development with a mainstay in the tourism sector is North Bandung Area (NBA).

In West Java Provincial Regulation Number 1 the Year 2008 on Control Space Utilization of North Bandung Area mentioned that the area of North Bandung Area is a region that covers most areas of Bandung Regency, Bandung City, Cimahi City, and West Bandung regency. NBA is a very important area because it supplies groundwater for the area of Bandung Basin. However, until now the development in NBA more rapidly, among them the construction of hotels and tourist attractions, and need a supply of clean water. The development can increase the number of tourists coming to the NBA. One of the areas in NBA that experienced rapid growth, especially in the tourism sector, is Bandung City. The number of tourists visiting Bandung in 2016, according to data from [1], is 5 million tourists (shown in Figure 1). But tourists visiting Bandung City trend tends to decrease, one of which is caused by the level of congestion that occurred in the Bandung City [1]. According to
Gösling [2], the need for clean water for tourists of 2,000-7,500 liters/tourists/day. If the tourists who come to the NBA reach more than 5 million tourists, the need for clean water should be provided more than 2,000-7,500 million liters/day. It shows that tourism is very influential on increasing the need for clean water.

![Number of Tourist in Bandung City](image)

**Figure 1.** Number of Tourist in Bandung City.

The growth of tourism in Bandung City is also one of the factors that cause the rapid growth of population in the city of Bandung. Population growth and development of urban activities increase the consumption of land, one of which is for settlement[3]. This condition will certainly increase the need for a clean water supply for residents in this city. According to [4], water requirements can be calculated by multiplying the number of people with per capita water requirements per day, adjusted for urban category classification and non-domestic needs such as commercial, industrial, tourism and other sectors and the volume of water lost. The government of Bandung City has made several efforts to meet the needs of clean water, but there are still failures. Some of the government failures are reflected in the limited availability of water tap service, inadequate quality, quantity, and water continuity, high subscription costs for the poor, illegal connections and low trust in public service providers [5]. According to [6], the development of tourism will require land and water resources and produce waste.

Fulfillment of clean water needs for inhabitants in the city of Bandung conducted by a regional company that is Regional Water Company TirtaWening Bandung. The company utilizes several sources of clean water such as surface water, springs, and groundwater. The utilized surface water is sourced from the Cisangkuy River, Cikapundung River, Cibeureum River, and Cipanjalu River. The rivers are located in the Cikapundung sub-watershed which administratively covers 12 sub-districts with the upstream of the river located in northern Bandung and become part of the North Bandung Area [7,8]. Land use in the Cikapundung watershed, especially in the upper reaches of the river, results in a large degree of damage to the soil, or more than 75% of the top layer is lost [7]. The Cikapundung sub-watershed, as part of the Citarum watershed, is still very potential for the provision of raw water for the needs of the inhabitants of Bandung and the land-used in the Cikapundung watershed itself is very diverse among others settlements, plantations, tourism, and other land uses include protected areas [8,9]. Cikapundung sub-watershed, which also serves as a source of raw water for the Regional Water Company, is the largest river in Bandung with upstream in the Lembang Subdistrict and downstream in the Dayeuh Kolot Subdistrict, so it will likely greatly determine the quantity and quality of clean water supply in Regional Water Company TirtaWening Bandung [10]. Lembang Subdistrict has a significant role for the water supply in Cikapundung sub-watershed.
because of its location as the upstream and also as the catchment area. In 2011-2017, the growth of not only the population density but also the lodge showed positive trends (7% for population density and 26% for lodge) [30]. The minimum standard of clean water service in Bandung is 120 liters/person/day or 296.5 million liters/day with a population of 2.5 million inhabitants, but Regional Water Company TirtaWening Bandung only has a production capacity of 2,478 liters/second or 214.1 million liters/day [5].

Based on the background discussed in the previous section, the conversion of land from urban green space into constructed land (hotels, tourist sites, and settlements) in Cikapundung sub-watershed is thought to have an impact on the supply of clean water for daily needs of people in Bandung City for several years upcoming. The impact began to be seen in the gap that arose between the production capacity of Regional Water Company TirtaWening Bandung with the minimum requirement of clean water in Bandung City. As shown in Figure 2, the population in the city of Bandung tends to increase, but the effectiveness of clean water production in the Bandung City tends to decrease during 2011-2015 [1]. Moreover, the needs of clean water used by hotels and tourist attractions in Bandung City is expected to increase every year so as to make the gap the amount of clean water distributed to the public will be even greater. If the conversion of land is not controlled, it can have a major impact on the decrease of water resources available for the subordinate area or the so-called water scarcity. In addition, land conversion can also affect socio-economic conditions such as livelihoods and income changes [11].

![Figure 2. The Effectiveness of Clean Water Productivity in PDAM TirtaWening.](image)

Potential water scarcity in the city of Bandung due to land conversion in Cikapundung sub-watershed can be minimized through environmentally friendly tourism called sustainable tourism. Sustainable tourism is a positive approach to reduce the tension and friction created by the complex interaction between the tourism industry, visitors, the environment and the communities which are host to holidaymakers [12]. Sustainable tourism focuses on three areas: 1) quality: valuable experience for visitors and increased life quality for host communities through cultural identity, poverty reduction, and environmental quality; 2) continuity: exploitation is made at the optimum level that allows the preservation and regeneration of the natural resources; and 3) balance between the needs of tourism industry, environmental protection, and local communities by an equitable distribution of benefits among stakeholders.
2. The Development of Sustainable Tourism and Land-Use Concept

One component of sustainability according to Miller & Spoolman [13] is to recognize the large number of human activities that can reduce the availability of natural resources through the normal utilization of renewable natural resources, such as trees and soil surface, faster than natural ability to restore its availability and normally give overload to the water and air systems with pollution and waste. Such conditions may cause hazards to the environment where nature must meet the needs of the amount of land and water to supply the population, absorb and recycle waste and pollution resulting from the use of natural resources or called ecological footprints.

Ecological footprints can increase as a result of the construction taking place where the construction requires land and water. In addition, the development that occurred in modern times today cannot be separated from technology development. In Miller & Spoolman [13] it is explained a simple model for calculating the environmental impact called IPAT model. The IPAT model shows that population (P), prosperity (A), and technological effects on environmental benefits and hazards (T) help determine the impact on the environment (I). In this paper, the author argues that the IPAT model can be used to control the development that occurs so that development can still be done using the principles of sustainability or known as sustainable development. Sustainable development is a development that meets the needs of the present without compromising the ability of future generations to meet their own needs [33]. One of the developments undertaken by many countries today, both developed and developing countries is the development of tourism.

2.1. Sustainable Tourism

Tourism by the World Tourism Organization (WTO) [14] is a social, cultural and economic phenomenon which entails the movement of people to countries or places outside their usual environment for personal or business/professional purposes. One type of tourism is nature-based tourism. Nature-based tourism is often described as one of the largest rapidly growing industrial sectors in the world and is vital to conservation, but also adds significant weight to economic cases for biodiversity conservation, and seems to contradict the widely-people are increasingly isolated from nature [15]. Environmental issues are critical to tourism management as illustrated in the Buttler tourism life cycle model [16]. Activities of the tourism sector will be closely related to the carrying capacity of the environment in which the tourist area is located. Application of carrying capacity has the greatest potential, one of them, infrequently visited cultural and natural attractions, and can be done, in tourism, by preparing for the influence caused by an external factor (e.g. by educating local community), by planning tourism infrastructure (its size, location, type, etc.), by optimizing visitor flows and visitor concentration (optimizing paths and trails – their location, type of surface, etc.) [17].

According to [18], dependent on using natural resources in a relatively undeveloped state, ecotourism is based on natural features like scenic vistas, wild rivers, pristine forests, and abundant wildlife and necessitates the high-quality maintenance of these resources or in other words represents a potentially low-consumption use of natural resources that may generate substantial economic return, thus playing a role in the sustainable management of resources. Ecotourism is a component of sustainable tourism because often located in highly sensitive and vulnerable environments, but also is one of the fastest growing industries in the world, because this type of tourism is a responsible business opportunity, resulting in environmental and community benefits [19-21,34]. In an increasing number of cases, natural areas worth protecting are under development as ecotourism attractions due to the growing perception of the positive economic impacts of ecotourism in both the public and private sectors [22]. Sustainable tourism, or even more specifically on ecotourism, can be an alternative solution to environmental problems because of the rapid growth of tourism around the world, both in developed and developing countries. The results of this research paper will show a conceptual framework of sustainable tourism for clean water problems.
2.2. Land-Use
Land use can change because of urbanization that makes the rural area to be an urban area where the land cover increasing. The adaptation of land-use patterns is an essential aspect of minimizing the inevitable impact of climate change at regional and local scales, for example, adopting watershed land-use patterns to mitigate the impact of climate change on a region’s hydrology [36, p. 4083]. The land use, in the Cikapundung Hulu Sub-watershed for example, is currently causing disruption of the ecosystem interaction process in the watershed, thus reducing the quality level of the upstream of the watershed [37]. Urban development can cause land use change that can reduce the capacity to absorb water and increase the surface run-off water [38,39]. Continuous land use changes, that can greatly influence the surface runoff into water bodies, without proper development plan and law enforcement may critically threaten the sustainability of river network in the highlands area as it happened in highlands area, Malaysia [40]. An exhaustive analysis of land-use change should be done at regional and local spatial scales as it can contribute to finding alternative policies for land-use efficiency and long-term environmental sustainability [41]. In Jiangsu Province, for example, the policies also had significant impacts on land use change, where development policies usually had indirect impacts, particularly economic development policies, which promote the economic development to cause land use change, while land management policies had direct impacts [42].

2.3. Land-Use, Water Resource, and Sustainable Tourism
Almost every human activity involves land use and as the amount of human activity increases rapidly, so the land becomes a scarce resource so that the decision to change the land use pattern can provide great advantages and disadvantages, both in terms of economic terms and environmental changes [23]. In general, advantages are more visible and measured from economic aspects, while disadvantages are
more to the environmental aspect. The main drivers for land use changes in the Baltics have been both political and economic, and on the one hand, climate-and land use-induced changes in precipitation and evaporation directly affect the amount of available water, which can theoretically be used for hydropower production or for other uses of water resources [24]. From this statement, we can see another aspect or factor, that can affect the environment directly at the same time with the land use changing happened, is climate change. But in this research paper, the author excludes climate change from the conceptual framework because of the reason there are so many indirectly activities make climate change happened that not easy-counted value.

Moreover, if we get more focusing to the watershed, it can be explained that urban land, in the watershed, had the strongest impact on water quality, shown by one of the causal factors for that impact, that domestic sewage discharge had greater impacts on river ecosystem health than industrial activities [25]. This paper was conducted to see the impact of land use change on the sources of clean water in Cikapundung sub-watershed, one of which is caused by tourism, can be minimized by tourism development approach that is sustainable tourism. There is an idea of economically efficient resource use, which is eco-efficiency, that suggests increasing the efficiency in the use of nature for economic production [31]. The land-use in the Cikapundung sub-watershed is very diverse, as described in the previous section, so it is necessary to manage the proper land use. For example, we can take one research of it, that is the removal of native vegetation accompanied with the decrease of soil qualities induced by land use change from rangeland to the rainfed farming and finally can make the soils more susceptible to soil erosion [26]. From that research, it tells us, erosion can cause the loss of soil to a certain volume which will also affect the loss of the water catchment area because the soil quality, which can absorb water initially, will decrease also. The availability of clean water, as the main factor of life support, becomes important in tourism. Water affects a wide range of environmental resources that can be the main attraction for tourism including wildlife, biodiversity, snow regions and health spas [27]. On the other hand, healthy tourism development can stimulate local economic growth, create jobs, and facilitate other positive spillover effects accompanied by the effective use of resources while minimizing the effects on the local environment [28]. For example, ecotourism development in Yunnan and Sichuan has an economic impact where the most significant impacts are felt on wholesale and retail, transport, agriculture, transportation and other services and his trend is consistent in both provinces and the country as a whole [29].

3. Conclusion
Research on land use in the Cikapundung sub-watershed has been widely used, as well as research on how tourism affects land use change, how land use and tourism affect clean water, and research on how sustainable forms of tourism developed. The authors see that those studies were still partial or not yet in a unified whole system so that a conceptual framework that integrating land use, tourism, clean water, and sustainable tourism should be created. Furthermore, researchers will create a conceptual framework of sustainable tourism for clean water sustainability using a system dynamics approach (shown in Figure 3). This approach has evolved since the decade of the 50s, first developed by Jay. W. Forester in 1961 [35]. System dynamics are a method that has been used to model systems that are complex enough to understand behavior patterns at different stages over time. A system dynamics is a methodology that looks at the problem thoroughly. System dynamics try to explain the behavior of various actions in some systems. Such a system is called a closed system (inherent/closed system). The dynamics of the behavior of a system is largely determined by the feedback loops structure.

In a closed system, there are dynamic character traits of a system, therefore in the System Dynamics method, the focus of attention is more on the closed system or feedback system. This feedback system is a model-forming block expressed through closed circles. The feedback loop represents the causal relationship of the circular variables, rather than expressed relationships due to the correction of the statistical correction. There are two kinds of causal relationships, namely "positive" causal relationships and "negative" causal relationships. Negative feedback is a goal-seeking process. According to the author, tourism development is also a system that has feedback
between stock and flow in it. The relationship between stock and flow existing in the system needs to be described in a system dynamic model to be able to analyze the main factors affecting the development of tourism over time. The results of this study will be elaborated more deeply, in further research conducted by the author, and is expected to contribute to be an alternative solution to the problem of water supply in urban areas of Cikapundung sub-watershed, especially Bandung City, in the long run. Furthermore, the results of this study can be applied in various locations in Indonesia that have similar issues.

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