

## Comparative Analysis of Clean Water Services in Tourism Area: Case Study of Singapore and Lembang, West Java

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### Abstract

The tourism industry influenced by clean water, which impacts service quality, tourist health, and the environment. Clean water crises are occurring in various countries worldwide. The World Bank projects a 40% gap between clean water demand and supply by 2030. The purpose of this study is to analyze clean water management at tourism sites in Singapore and Lembang, West Java. Singapore is a developed country with an integrated system. Meanwhile, Lembang, West Java, is a tourism area that relies on natural resources. The research method is a comparative approach to clean water provision typology based on field surveys consisting of three tourism sites in Singapore: Fort Canning Park, Marina Bay Sands-Merlion Park, and Singapore Zoo. Thus, three tourism sites in Lembang, West Java, are Lawangwangi Creative Space, Floating Market Lembang, and Lembang Park and Zoo. Furthermore, the analysis used a SWOT approach. The results show that Singapore implements water storage and advanced technologies such as water recycling and desalination, supported by strict regulations and high efficiency. Meanwhile, clean water in Lembang comes from springs, private wells, and water subscriptions from the Drinking Water Company (PDAM). This analysis is crucial for uncovering the infrastructure and regulations between the two countries, thus providing an alternative source of clean water for other tourist destinations. This research is also expected to contribute to sustainable clean water management for the tourism sector, particularly within the context of the sustainable development goals (SDGs) on clean water and sanitation.

**Keywords:** Clean Water, Tourism Industry, Water Supply Typology, Singapore, Lembang, West Java.

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### A. INTRODUCTION

Water is essential for sustainable tourism development and ecological health. In various parts of the world, many countries are experiencing a clean water crisis, and the World Bank estimates that the gap between demand and supply of clean water will be as much as 40% by 2030 (World Bank, 2020). On the one hand, tourism is one of the main sources of wealth for many destinations in Asian countries, with a new record of 1.4 billion international tourist arrivals. Tourism continues to maintain its position as one of the fastest-growing economic sectors in the world. The UNWTO report highlights that Asia is the center of tourism growth. In just under two decades, Asia's share of international tourist arrivals increased from 16% of the world total to 25% between 2000 and 2018, with a record 348 million tourist arrivals in 2018, 2019). On the other hand, the tourism industry consumes energy and water, produces waste, and has the potential to damage the environment. As with countries in Southeast Asia with tropical climates, the problem of water scarcity can be a frightening thing during the dry season. Thus, water shortages can also be a direct barrier to future tourism development (del Mar Alonso-Almeida, 2012).

Singapore and Lembang, West Java are two representative models of clean water management in the context of tourism sites. The more tourists visit, the more water is consumed. From April 2024 to April 2025, the number of international tourists visiting Singapore was 1,403,638 (Singapore Department of Statistics, 2025). To collect clean water needs for domestic and non-

domestic consumption, Singapore initially focused on rainwater harvesting and storage. However, due to limited water resources, this method only accounts for half of the country's total water use, and Singapore has become increasingly dependent on the Malaysian state of Johor for its water supply. (*Institutional capacity and policy options for integrated urban water management: a Singapore case study*, 2011; *Singapore's experience with reclaimed water: NEWater*”, *International Journal of Water Resources Development*, 2016)

Lembang is a tourist area in West Java, Indonesia, which has an average number of local and foreign tourists of 2,468,854 people per year. (Dinas Pariwisata Kabupaten Bandung Barat, 2024). This average tourist data has a very large difference with the data on the number of Lembang residents, which only reaches an average of 206,935 people per year (BPS, 2024). Lembang District has rich natural resources, with spring water discharge reaching 31,941,734 liters per day in 2024. Compared to domestic and non-domestic water needs, water needs will be met until 2034. Meanwhile, clean water in Lembang District is of sufficient quality to be consumed, provided it is not consumed directly and is first boiled at 100 degrees Celsius. (Khalifah, 2024). Previous studies on clean water supply in the tourism industry have been carried out extensively (Cole et al., 2021; Cuenca-Martínez et al., 2024; Gonzalez-Perez et al., 2023). The results of a study by Kim and Choi (Kim & Choi, 2023) stated that Singapore has used public-private partnerships (PPP) to build and operate desalination facilities that produce drinking water by processing and filtering brackish water into fresh water. Furthermore, the use of advanced technology for wastewater filtration produces clean, drinkable water. It is different from Lembang, a sub-district in West Java with water sources and river basins that have a fairly large role in the condition of water supply, especially for tourism needs (Wibowo & Karuniasa, 2019). Spatially, the development of ecotourism in the Bukit Lawang area has led to changes in land use, including the increase in settlements, accommodations, parking areas, and supporting infrastructure access (Liyushiana et al., 2023).

This research is important to be carried out for the following reasons: first, to analyze clean water management in supporting the tourism industry using a comparison of supply typologies in Singapore and Lembang. Second, to identify the strengths, weaknesses, opportunities, and challenges faced by tourist destinations with different characteristics in the two countries. Third, to formulate strategies that can improve water management in tourist areas, especially in developing areas such as Lembang. Finally, this research is expected to contribute to sustainable clean water management for the tourism sector, particularly in the context of sustainable development goals regarding clean water and sanitation.

## **B. RESEARCH METHOD**

### **The Study Area**

Singapore covers an area of 735.7 km<sup>2</sup>, with a population of 6.04 million in 2024, an increase of 2% from 2023 (Singapore Land Authority, 2024). Singapore's population embraces various religions, so the government implements a secularism strategy in Singapore's governance (Abdullah, 2013). As a city-state with scarce natural resources, the Republic of Singapore relies on imported freshwater and rainwater collection and storage to meet domestic and industrial water consumption. By 2060, Singapore's water demand will double, with per capita water consumption of approximately 310 liters per day and domestic water demand of nearly  $1.8 \times 10^6$  cubic meters per day in 2020 (Bai et al., 2020). Meanwhile, in the case of Lembang, West Java, the total area is 95.56 square kilometers. Lembang District has 16 villages, namely: Gudangkahuripan, Wangunsari, Pagerwangi, Mekarwangi, Langensari, Kayuambon, Lembang, Cikahuripan, Sukajaya, Jayagiri, Cibogo, Cijambu, Cikidang, Wangunharja, Cibodas, and Sutenjaya. The population of Lembang was 205,143 people in 2024, with a predominance of Muslims and Sundanese ethnicity (BPS-Statistics West Bandung Regency 2024). Lembang has 72 water sources, but the PDAM service level in the Lembang urban area is 37.62% so it can only serve 930 customers. In order to serve 2,500 customers evenly, PDAM is only able to supply 30.72 liters/day/person. To meet the need for clean

water, the usual effort made by Lembang residents is to reduce clean water consumption (Yanuar, 2016).

**Data Collection**

The primary data based on field surveys of each tourist area from May to June 2025. The first part is about clean water sources channeled from rainwater reservoirs, springs, utilization of desalination systems, and NEWater. The second part is water conservation technology used in the distribution of clean water in tourist areas for drinking and sanitation. The third part is about efficiency indicators in water use. We conducted direct observations of tourism sites, both in Singapore and Lembang. The tourist locations we visited are shown in Figure 1, with a total of fifteen places in Singapore, namely Changi Airport, Fort Canning Park, Sultan Mosque, Kampong Glam and Haji Lane, Robertson Quay Hotel, passing through the Clarke Quay River, Marina Bay Sands, Esplanade Park, Garden by the Bay, Satai Street, Singapore Institute of Technology, Singapore LTA Mobility Gallery, The Little India, Singapore Zoo, and Mustafa Street. In order to make the discussion more in-depth for comparison, we focus on 3 observation tourist attractions, including: Fort Canning Park, Marina Bay Sands-Merlion, and Singapore Zoo. Meanwhile, for the field visit to Lembang, we visited 7 places, starting from the Bandung Institute of Technology, Dago Dreampark, Lawangwangi Creative Space, Lembang Park and Zoo, Lembang Milk Farmhouse, Lembang Floating Market, and Balibu Sundanese restaurant. The focus of the observation of water availability in the tourist areas studied was: Lawangwangi Creative Space, Lembang Floating Market, and Lembang Park and Zoo.

Figure 1. Three Sites in Singapore and Lembang

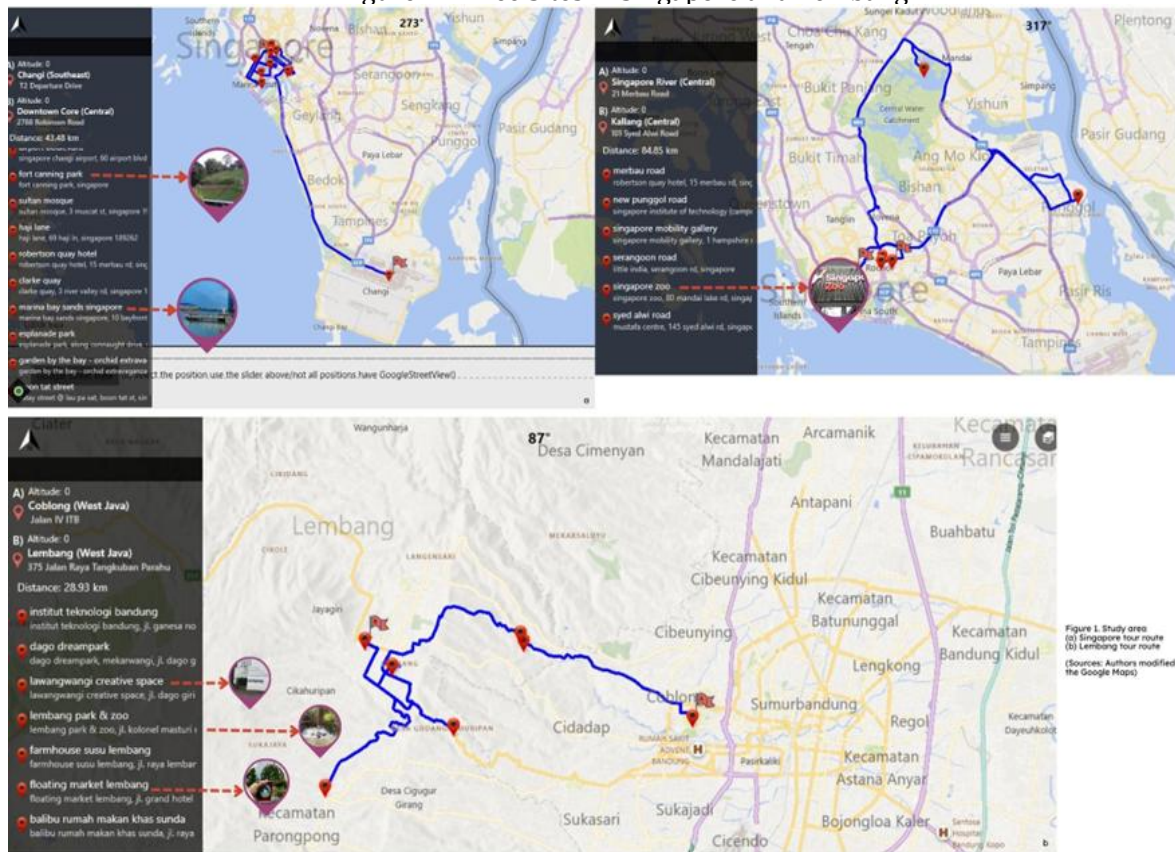


Figure 1. Study area (a) Singapore tour route (b) Lembang tour route (Sources: Authors modified the Google Maps)

Consideration of three tourist sites in Singapore and Lembang at Figure 1 through an approach to each destination's characteristics. First, we visited a destination in Lembang similar to Fort Canning Park: Lawangwangi Creative Space. The art gallery in Lawangwangi is open to tourists without an entrance ticket, but to get food and drinks, visitors can pay from Rp. 50,000, painting activities are charged Rp. 53,500 per person, and the paintings can be taken home. Tourists can also

enjoy the garden surrounding the gallery with its beautiful mountain views and cool atmosphere. Lawangwangi Artspace was founded by PT Buni Siliwangi in 2010. Essentially, the creative Space accommodates various creative ideas and innovations from works that combine art, crafts, culture, and science and technology (Sitorus, 2018). Second, the Lembang Floating Market has an attraction similar to Marina Bay Sands-Merlion in terms of water tourism activities. Tourists can find a variety of delicious local culinary delights typical of Bandung. Floating boats lined up on the lake sell traditional snacks such as batagor, cilok, siomay, to heavy meals such as nasi timbel, satay, and grilled fish. In this tourist area, there are also stalls selling food, souvenirs, and local products typical of Lembang, such as tempeh chips, dairy products, and various handicrafts (Sitorus, 2018). Third, Lembang Park and Zoo, which promotes zoo tourism, has many similarities with the tourism activities at Singapore Zoo. This zoo was designed to become an educational tourism destination targeting families. However, the ownership of Lembang Park and Zoo, which is a combination of private stakeholders, has an impact on the planning and design process, which emphasizes aesthetic and business economic functions rather than animal welfare and landscape ecology functions (Salim, 2024).

### **Data Analysis**

By the cross-national comparative case study approach in the field of clean water supply services in the tourist areas of the two countries, the data were analyzed exploratively in the form of a typology of water supply, with categories of site type, provider, clean water source, water quality, service coverage, price, clean water distribution, and person in charge. Finally, a SWOT (strengths, weaknesses, opportunities, threats) analysis was used to produce the clean water provision typology.

## **C. RESULTS AND ANALYSIS**

### **Case 1: Typology of Water Provision in Singapore**

#### *Fort Canning Park Site*

The Fort Canning Park tourism site has a special place for Singaporeans. Fort Canning Park has four main attractions, including the historical place, the first flower garden, the spice gallery, and the Fort Canning Heritage Gallery. As a historical place, Fort Canning Park was the control of the ancient Malay kingdom in Singapore around 1300. By Sir Stamford Raffles, this park became a residence in 1819. Then, this area was known as Government Hill. In 1822, Singapore's first flower garden was built in the Fort Canning Park area. In the 1970s, it was used as a military base by the British colonialists, the Japanese Army during World War II, and by the Republic of Singapore Army. Today, Fort Canning Park is a must-visit for tourists to enjoy the beauty of the gardens and the rich history of Singapore. It also offers a blend of art, heritage, and a meticulously landscaped natural panorama.

The development of Fort Canning Park cannot be separated from the consumption of clean water used for park hydration, tap water for drinking refills, which can be found at several points in the park. Tourists can relax, jog, and enjoy the beautiful panoramic views of the plants. Apart from that, there is a museum gallery in the Fort Canning Park area. Other activities in the heritage gallery include visiting the museum's collections, painting, and planting spice seeds. Clean water in the museum gallery can be consumed for drinking with a sophisticated tap water machine, and used for sanitation such as washing hands and toilet needs. There is also bottled mineral water sold together with other drinks in the refrigerator. The irrigation source in the Fort Canning Park area comes from the Fort Canning Service Reservoir, which was built during the British colonial era in 1929. The clean water service coverage in this area covers several urban areas such as the Central Business District, Bugis, Lavender, and Boon Keng (Kow, 2021). Clean water facilities in the Fort Canning Park area are free because it is a state-owned tourism site. Distribution of clean water from the Fort Canning Service Reservoir to the Fort Canning Park tourist area through water installations, distributed through a network of pipes so that it can be consumed by tourists. In terms of responsibility for clean water services, it is held by the Public Utilities Board (PUB) under the auspices of the Ministry of the Environment and Water Resources.

### *Marina Bay Sands-Merlion Site*

The second discussion is about the Merlion tourism site, which is located in the Marina Bay Sands area. The iconic Merlion of Singapore is inspired by the mythology of a creature with the head of a lion and the body of a fish. The design of the Merlion statue was created in 1964 for the Singapore Tourism Board, and it was inaugurated on 15 September 1972. With the completion of the Esplanade Bridge in 1997, the Merlion statue is no longer clearly visible from the waterfront. In 2002, the Singapore Tourism Board decided to move the statue to a new, purpose-built pier across the Esplanade Bridge facing Marina Bay. The relocation and expansion of Merlion Park began on April 23, 2002, and was completed on April 28, 2002 (Yong, 2016). As is known, the water source in Marina Bay is salty, so the Singapore Government uses desalination technology, which is stored in a water reservoir (Marina Reservoir). Tourists can enjoy walking, cycling, jogging, and taking photos near the Merlion. They can even take a boat to explore Marina Bay with the River Cruise by Water B.

The Marina reservoir was built in 2004 by the Singapore government in collaboration with Koh Brothers Building & Civil Engineering Contractor Pte Ltd, a public-private partnership. Initially, the reservoir was filled with seawater. But in November 2010, rainwater gradually replaced seawater. Rainwater in the reservoir is channeled to a water treatment plant to be processed into drinking water (Chew, 2019). Clean water consumption from the Marina reservoir to Marina Bay Sands-Merlion is used for park hydration, fire hydrants, cafes, and sanitation, as well as tap water for drinking. Clean water coverage is distributed to the areas of Ang Mo Kio, Queenstown, Eunos, and the Central Business District. Meanwhile, the distribution process involves collecting rainwater and then channeling it to a water treatment plant to be processed into drinking water. Access to clean water in the area is free, except in the cafes. However, based on the price set by the Singapore government (PUB, 2025) for domestic needs it reaches \$4.39 per month, while the pricing for non-domestic (business) per cubic meter or the equivalent of 1000 liters of water varies, starting from the price of drinking water at \$3.24 for drinking water, NEWater \$2.50, industrial water \$1.75, and customer delivery \$4.50.

### *Singapore Zoo Site*

The third tourism site that is the focus of discussion is the Singapore Zoo. The Singapore Zoo is part of the Mandai Wildlife Group. Home to 4,200 animals, the zoo operates daily from 8:30 a.m. to 6:00 p.m. Tourists can do walking tours or use buggies to explore this area. After activities and interacting with animals, tourists can shop for souvenirs and food at this place. We also learned about sustainability at Mandai, focusing on eight key objectives: 1). 100% electricity consumption generated from renewable sources through on-site solar power, Renewable Energy Certification, and/or Virtual Power Purchase Agreements, by 2030; 2). The intensity of drinking water use for Singapore Zoological Gardens, Night Safari, and River Wonders is reduced by 25% from 2020 to 2030 (target: 0.21 cubic meters per guest); 3). The internal fleet consists of 100% electric vehicles or vehicles with low-carbon emission fuels by 2030; 3). 60% of waste will be diverted from incineration by 2030; 4). 100% of palm oil and its derivatives used in all products come from certified sustainable sources (Roundtable on Sustainable Palm Oil) by 2025; 5). 100% Mandai-produced paper-based products, FSC (Forest Stewardship Council) certified or 100% recyclable by 2025; 5). All fossil-based single-use plastics used by guests must be eliminated by 2023; 6). 2.7 hectares of degraded land in buffer zones, protected areas, and protected forests will be restored and improved by 2030.

The consumption of clean water at the Singapore Zoo includes: tap water for drinking is available near the toilets (six points), for sanitation, even used for animal habitat purposes, and water transportation. The water source in this area comes from the Upper Seletar Reservoir, which was built during the British colonial period in 1920, and recycled wastewater with high-quality technology that is suitable for non-drinking use in the wildlife park. The Upper Seletar Reservoir's clean water service covers Mandai Road, Seletar Expressway (SLE), the Singapore Zoological Garden, and the Bukit Timah Nature Reserve. The distribution of water is obtained from imported water from the Gunong Pulai and Pontian reservoirs in Malaysia, and then stored in the Upper Seletar Reservoir. To further clarify the results of observations on clean water availability facilities

at three Singapore tourism sites, namely Fort Canning Park, Marina Bay Sands-Merlion, and Singapore Zoo, are shown in Figure 2.

Figure 2. Singapore Destination

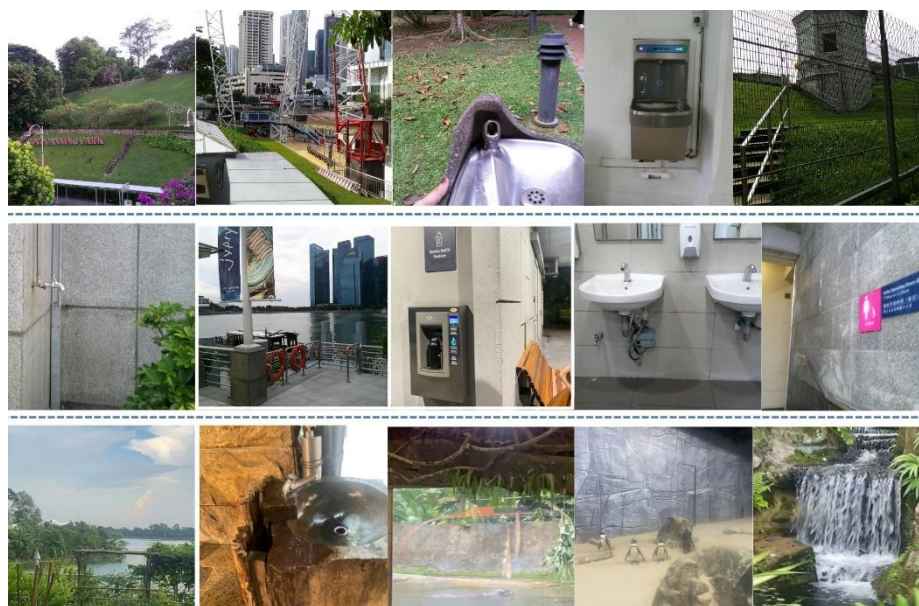


Figure 2. Singapore destinations  
(Sources: Authors)

## Case 2: Typology of Water Provision in Lembang, West Java

### *Lawangwangi Creative Space Site*

We now turn to a discussion of tourist destinations in the Lembang area of West Java at figure 2, Indonesia. Our first focus of study is the Lawangwangi Creative Space tourist site. Geographically, it is not too far from the bustling city of Bandung, and can be reached in 10 minutes, covering a distance of 2.6 kilometers. The temperature in this area is also very cool, reaching 22°C at night. To reach this location, tourists can use online motorcycle taxis, as there is no public transportation. Once there, tourists can enjoy the natural beauty of Dago Hill in the Lawangwangi Creative Space park. Furthermore, tourists can explore the art gallery, showcasing paintings and sculptures, and experience hands-on painting at the Lawangwangi Creative Space restaurant. Regarding clean water services in this area, the gallery owner provides tap water for handwashing, toilets, and tap water for ablution before prayer. Drinking water can be purchased at the restaurant.

In this area, there are two sources of clean water used for the gallery's operations. The first comes from a well dug for sanitation purposes, through a groundwater distribution process at a depth of at least 20 meters. After the water comes out, an electric water pump is used to fill the water tank. The water can then be used for sanitation and garden hydration. The cost of obtaining well water involves labor for digging, pumping, and maintenance. Secondly, for kitchen use, the water is supplied by the Tirtawening Water Company (PDAM) through a standard raw water treatment distribution process. This involves purifying river water with a certain chlorine content, followed by storage and distribution through pipes to homes and industries. The subscription fee depends on location, customer class, and usage volume. On average, the cost per cubic meter of water in Indonesia ranges from Rp 2,000 to Rp 6,500, with progressively higher rates for larger water usage. For the tourism industry, which includes the business sector, starting from 0-10 m<sup>3</sup>: Rp9,000/m<sup>3</sup>, 11-20 m<sup>3</sup>: Rp11,000/m<sup>3</sup>, 21-40 m<sup>3</sup>: Rp12,500/m<sup>3</sup>, >40 m<sup>3</sup>: Rp13,000/m<sup>3</sup>. The water quality from these two sources is very good, but is not directly drinkable; but is heated first to reach a temperature of 100°Celsius. This clean water service is only for one area of Lawangwangi Creative Space because it is owned by a private company, PT Buni Siliwangi.

### *Floating Market Lembang Site*

The Floating Market Lembang site is one of the tourist areas under the auspices of PT Perisai Group, a private company engaged in the development of other tourist destinations such as Farmhouse Susu Lembang, The Great Asia-Africa, and many more. The entrance ticket is IDR 40,000 per person, and can be exchanged for one drink, such as coffee or milk. Floating Market tourists reached 3,500 people throughout 2023, facilitated by 183 employees and vendors. The price range for food at the Floating Market starts from IDR 20,000, while the rides range from IDR 5,000 to IDR 200,000. The newest attraction currently is that visitors can explore the lake with the Royal Cruise for larger and more luxurious boats and the Floating Cruise for regular rowing boats. The area of the Floating Market Lembang reaches 7.2 hectares, so a lot of clean water is used for operations. Tourist facilities that require water in this area include: garden watering, sanitation, restaurants, shopping centers, and souvenirs. The area's water source is an artificial lake, known as Situ Umar, used for water tourism activities and watering gardens, flowers, fish, and swan ponds, artificial fountains, and a small water market. Other water sources include water supplied by the Tirta Raharja Water Company (PDAM) for restaurants and sanitation, such as handwashing facilities and toilets.

#### *Lembang Park and Zoo Site*

The Lembang Park and Zoo educational tourism site is still within the Lembang sub-district, but borders the Parongpong sub-district of West Bandung Regency. This area covers 25 hectares and has more than 850 species of animals managed by a private company owned by Agus Wiediyanto. However, the permit for the establishment of the area still involves the West Java Provincial Tourism Office. Opened in 2019, Lembang Park and Zoo has 200 employees with operating hours from 9:00 a.m. to 5:00 p.m. Monday through Friday, and 8:00 a.m. to 6:00 p.m. on Saturdays, Sundays, and holidays. Tourists can enjoy walking or using buggies to see the animals here, and even feeding the tigers with the guidance of zookeepers. Meanwhile, there are recreational facilities such as water boats, rest areas, a restaurant, a prayer room, and a cat cafe. Tourists can chat with cute cats while enjoying food and drinks. The cool mountain atmosphere certainly makes visiting with families comfortable, with affordable rates starting at IDR 60,000 per person. Wheelchair and baby stroller facilities are available near the entrance. As a large zoo, water consumption is significant, including for the habitats of hippos, crocodiles, fish, and other animals. The clean water source comes from groundwater wells and a spring (Ci Irung-Irung). Despite the long dry season, this spring never dries up and is considered a sacred spring within the Lembang Park and Zoo area. The existence of Ci Irung Irung is believed to be a legacy from previous ancestors. The clean water from this spring is so clear that you can even drink it directly. Piping is used for the distribution of toilet sanitation, hand washing, restaurants, and animal pens, which are first stored in large water tanks. The costs charged for water consumption include the installation of an electric water pump, a water pipe network, as well as maintenance. The documentation of the observation results of clean water availability facilities at three tourism sites in Lembang, West Java, both at Lawangwangi Creative Space, Floating Market Lembang, and Lembang Park and Zoo, is shown in Figure 3. We realized that these three tourist destinations in Lembang do not provide water taps for drinking refills, but tourists can buy mineral water at cafes or restaurants available at each site at affordable prices starting from IDR 4,000 per 600 milliliters.

Figure 3. Lembang Destinations

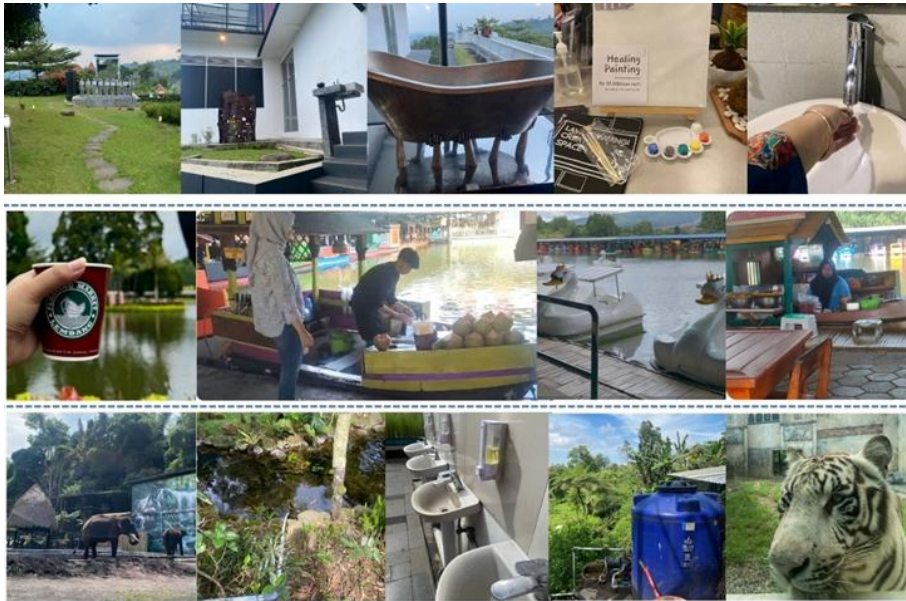


Figure 3. Lembang destinations  
(Sources: Authors)

### SWOT Analysis

Based on the findings of the case study of clean water services in Singapore, we identified the internal factor analysis strategy (IFAS) of the service strengths and weaknesses. In terms of strengths include Singapore has advanced systems such as NEWater (recycled wastewater) and desalination plants to reduce dependence on imported raw water. Furthermore, the implementation of a balanced combination of local water catchments, imported water, NEWater, and desalination meets water needs on a national scale. The effective DBOO (Design, Build, Own, Operate) model accelerates the development of clean water service infrastructure. Proactive policies by PUB (Public Utilities Board) ensure long-term water security. Weaknesses include: limited land for rainwater harvesting, resulting in reliance on imports and advanced technology. Droughts and intense rainy seasons disrupt supplies (rain-dependent water sources), and desalination/NEWater requires significant investment, increasing water prices. Next, we identify the external factor analysis strategy (EFAS) of opportunities and threats. Opportunities in clean water provision include: Singapore could sell its filtration/desalination expertise to areas like Lembang or promote itself as a leader in sustainable water use for tourism. The expansion of NEWater and desalination could meet growing demand (projected to double by 2065). Meanwhile, threats facing Singapore include: climate change, such as longer droughts reducing rainwater supplies; rising sea levels could impact desalination; and dependence on Malaysian water imports could re-emerge if the technology fails. Meanwhile, the pressure on water demand in the tourism sector, such as the current usage of 430 million gallons/day, may become unsustainable.

Figure 4. Cartesius Diagram SWOT Analysis of Singapore`s Clean Water Services

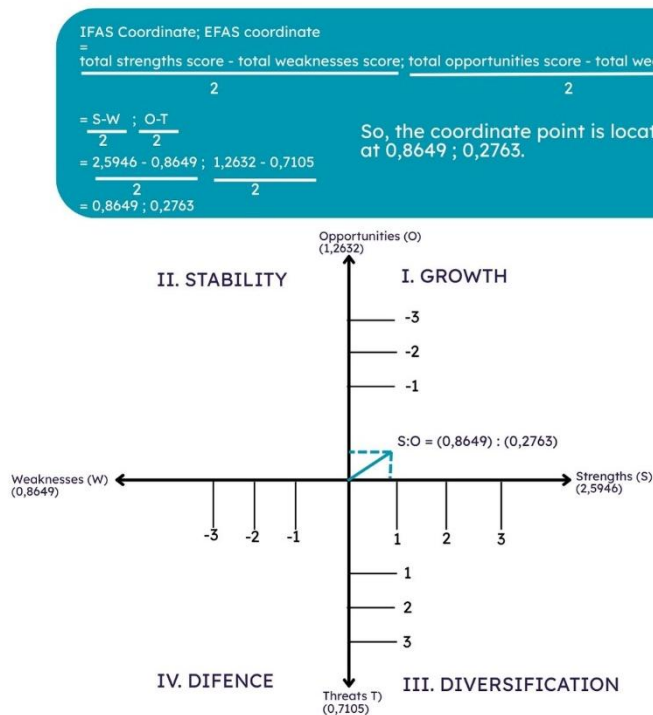


Figure 4. Cartesius Diagram SWOT Analysis of Singapore's Clean Water Services (Sources: Authors)

The strategy at figure 4 used in Singapore's clean water management is SO towards quadrant 1, which means emphasizing growth that takes into account strengths and opportunities (see figure 4). Strengths-Opportunities (SO) aims to maximize Singapore's strengths to seize external opportunities to achieve sustainable growth. In SO (quadrant 1), Singapore becomes a major player in the global water management industry by combining technological strengths and market opportunities. This step not only covers domestic needs but also creates economic and geopolitical value.

We also identified EFAS and IFAS in a case study of clean water services in Lembang, West Java. Lembang's strengths as a cool mountainous area include: abundant water sources from groundwater basins with an area of 209 km<sup>2</sup> supporting tourism needs. Furthermore, the potential for tourism growth, with 36 tourist destinations, can drive economic benefits if water is managed properly. Ecotourism opportunities are closely related to the natural attractions that can encourage sustainable tourism. Lembang's weakness in providing clean water is the excessive exploitation of groundwater through unregulated pumping processes that drain the aquifer. This also risks causing long-term shortages. Furthermore, weak infrastructure development is characterized by a lack of sophisticated processing facilities compared to Singapore. Poor regulatory implementation is demonstrated by inefficient water governance, leading to an imbalance between tourism and local needs. We identified opportunities for Lembang in clean water management, including adopting the Singaporean public-private partnership model, by partnering with private companies to improve water infrastructure. Developing ecotourism by promoting water-friendly tourism (e.g., natural springs, eco-friendly resorts, and sustainable theme parks). For improvements in government policy by implementing integrated water management strategies to prevent excessive groundwater extraction.

The SO strategy (quadrant 1) in Lembang has the potential to create sustainable clean water management while simultaneously encouraging local economic growth through ecotourism and simple technological innovation (see figure 5). By harnessing the power of nature and opportunities for collaboration, Lembang can become an example of community-based water management in Indonesia. The benefits of the SO strategy for Lembang include: long-term water security by utilizing local resources, economic growth through water-based tourism and sustainable management, and strengthening community participation in environmental protection. This requires attention to the risks faced, such as development pressures, with the threat of conversion of green land to housing/commercial use. Adapting to climate change during long dry seasons can reduce water availability, and funding constraints require initial investment in clean water infrastructure in the tourism sector.

Figure 5. Cartesius Diagram SWOT Analysis of Lembang's Clean Water Services

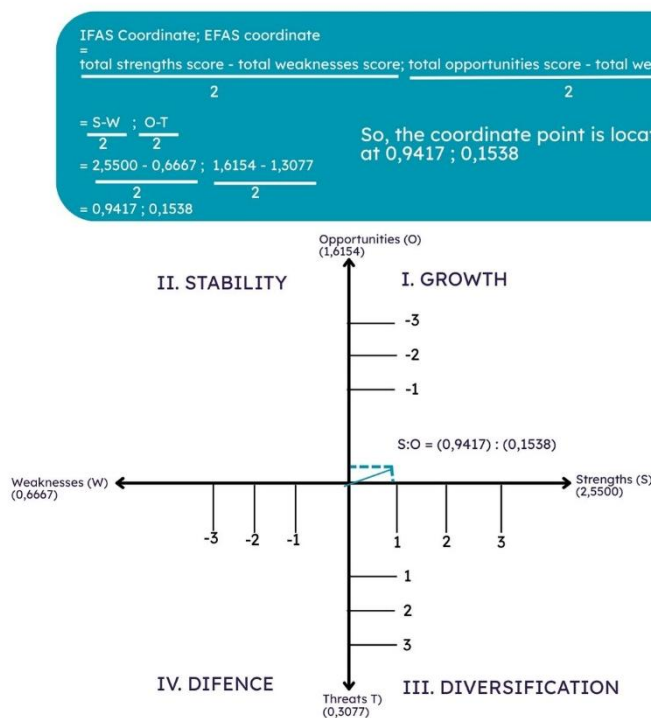


Figure 5. Cartesius Diagram SWOT Analysis of Lembang's Clean Water Services  
 (Sources: Authors)

## Discussion

Since becoming a British colony in the 1920s, Singapore has been heavily dependent on water imports from the Malaysian state of Johor, which lies north of Singapore. In 1961 and 1962, Singapore signed two separate water import agreements with Malaysia to address the lack of adequate water supply systems (e.g., underground water reserves) due to its own geographical constraints (Centre for Liveable Cities, 2020; Chew, 2019). Singapore initially focused on rainwater harvesting and storage, but due to the country's limited surface area, harvesting methods account for only half of the country's total water use, and Singapore has become more dependent on the state of Johor for the remaining supply (Chen, 2011; Lee, 2016). Therefore, to reduce dependence on water imports from Malaysia and neutralize the water issue as a political threat, the Singapore Government is developing two new water sources by collaborating with local and international private water/energy companies to develop and advance filtration/treatment technologies that enable desalinated water and recycled wastewater to be suitable for both industrial and domestic use, referred to as NEWater Public Utilities Board (PUB, 2024).

Based on the DBOO model, the construction of the Tuas desalination plant (2001–2005) near the coast became the first water infrastructure project driven by a public-private partnership in Singapore (Kim and Kwa, 2020). Indeed, the launch of NEWater in 2004 was a significant milestone in Singapore's systematic approach to providing water services. To date, water resource management in Singapore has been based on the “Four National Taps” strategy: local catchment water, imported water from Malaysia, NEWater, and desalinated water (Chen, 2011; PUB, 2023).

Singapore is located along the equator as the smallest country in Southeast Asia with a limited land area, a tropical climate year-round, and continues to face the challenge of finding sufficient catchment areas to capture and store rainwater. In recent years, this situation has been exacerbated by intensifying climate change (e.g., more violent monsoon storms and floods, and longer hot and dry periods due to lower rainfall). PUB, the Ministry of Environment and Water Resources, has projected that Singapore's total water demand is likely to almost double by 2026, with the non-domestic sector contributing 60%. Singapore's water demand is approximately 440 million gallons per day (mgd), which is equivalent to the capacity of 800 Olympic-sized swimming pools, and most of Singapore's fresh water needs are met through NEWater and desalination (PUB, 2025).

In the Lembang area, groundwater basins require sufficient groundwater resources to support sustainable tourism activities. The tourism sector is a growing sector in this city, with over 36 tourist destinations. With increasing tourism activity, the need for water resources, particularly groundwater, to support these activities increases (Nugraha et al., 2023). Water resource management aims to maintain a balance between water availability and demand. Water availability is largely determined by the spatial and temporal hydrological cycle, while water demand often increases and varies with use. Integrated water resource management is necessary to improve community welfare. The magnitude and distribution of water scarcity have increased over time, while rapid population growth and water demand to meet human needs have put pressure on water availability. Water from public services such as the Regional Water Company (PDAM) has been provided for domestic needs, especially in cities, but appears insufficient to meet all needs. The use of groundwater by pumping has become popular, leading to a decline in the groundwater table (Subagyono and Pawitan, 2008). The availability of clean water, a key life-sustaining factor, is crucial for tourism. Water impacts a variety of environmental resources that can be key tourism attractions, including wildlife and biodiversity. Furthermore, healthy tourism development can stimulate local economic growth, create jobs, and facilitate other positive spillover effects, coupled with effective resource utilization while minimizing impacts on the local environment. For example, the development of ecotourism at Lembang Park and Zoo has had the most significant economic impact, felt through the addition of tourism, transportation, and trade workers.

#### **D. CONCLUSION**

There are several things that Lembang needs to adopt from Singapore in managing clean water in the tourism sector, including strengthening technology-based water infrastructure, with strategies: building a water recycling system (such as NEWater) to reduce dependence on groundwater sources, improving the PDAM distribution network to reduce leaks and increase service capacity. The stakeholders involved are the West Bandung district government, in collaboration with PDAM Tirtawening and Tirtaraharja (Public-Private Partnership model). The PPP formation process can be carried out with the following strategies: opening invitations to interested private companies, pre-qualifying bidders, making proposals from selected bidders (invitation to tender), market feedback period, issuing final tenders, closing tenders, awarding contracts, or closing Finance.

In optimizing local water sources with an integrated approach, mapping and protecting natural springs in Lembang through the implementation of strict regulatory strategies (for example: prohibiting the conversion of infiltration land), developing rainwater harvesting systems in hotels, restaurants, and tourist destinations, and creating artificial wetlands for processing tourism liquid waste. Furthermore, conventional water channels in tourist areas (e.g., the Lembang Floating Market) can be transformed into infiltration areas with biofiltration gardens. The stakeholders involved include the government, environmental services, local communities, and tourism businesses.

In terms of sustainable policies and regulations, progressive water tariffs can be implemented for tourism industry players (the higher the usage, the higher the tariff), and water conservation requirements can be included in tourism business permits (e.g., a mandatory water recycling system). Lembang can emulate the Tuas Desalination Plant project by involving the private sector in building water infrastructure (e.g., a water filtration plant in Lembang). In terms of stakeholders involved, the West Bandung Regency Government, through the tourism office, can be involved. For educational tourism, the Lembang regional government can create a "Water Source Adoption" program involving schools, residents, and tourism actors (e.g., regular river cleaning), and conduct sustainable water management training at tourist attractions, particularly Lawangwangi Creative Space, Floating Market Lembang, and Lembang Park and Zoo. The stakeholders involved include managers, academics from the Bandung Institute of Technology, Padjajaran University, and community groups. Furthermore, water-friendly tourism can be developed by designing water conservation-based tourist attractions (e.g., educational ecotourism with water recycling at Farmhouse Lembang), and by creating "Green Tourism" certification for businesses that meet sustainable water management standards.

Priority actions to integrate clean water sustainability strategies in Lembang, West Java, can be carried out in the short term (one to two years) by auditing water sources and PDAM leaks, and implementing rainwater harvesting pilot projects at 10 tourist locations. Long-term implementation (five to ten years) can involve the construction of tourism wastewater recycling installations, as well as integrating water policies into the Regional Spatial Planning Plan. The hope is that Lembang, West Java, can become an example of a sustainable tourism destination that combines economic growth and water sustainability, while reducing the risk of future water crises.

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