The Role of Green Open Space in Palu City's Resilience, Emergency Function Approach

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Abstract*: Green open space in the East Palu and Mantikulore districts, especially in Anjungan Pantai Talise Area, is an open space area that were most affected by the earthquake and tsunami on September 28 2018. Based on the results of observations, the Anjungan Pantai Talise area in the Palu Bay was built of 2.96 hectares. It was destroyed by the earthquake and the brunt of the tsunami waves. The results of the identification show that the Palu Bay area is an area of high potential/prone to earthquakes and tsunamis. So, a natural disaster management in this area is needed. Therefore, with the vulnerability of this region to earthquake and tsunami natural disasters, it is necessary to have an adequate disaster evacuation space. Through ArcGIS analysis, disaster potential analysis is carried out by making overlay maps from secondary data from disaster-prone zone maps and land use maps. The overlay map shows the suitability of the green space location as an evacuation room for the earthquake and tsunami disaster. The results show that an area of 3 hectares which is the Anjungan Pantai Talise Area located on the coast of Palu Bay is an area that is not suitable as an evacuation room because it is located in a disaster-prone zone (ZRB) level 4. And an area of 9 ha is an appropriate green open space as an emergency evacuation room. This green open space consists of public open space, office/school fields, vacant land and shrubs.*

Keywords: Green Open Space, City Resilience, Emergency Function, Palu City

1. Introduction

According to the Rockefeller Foundation 2017, a resilient city is a city with the capacity of individuals, communities, institutions, businesses, and systems within the city to survive, adapt, and grow against the constant stresses and shocks they may face. Related to green open space, the pressures such as air pollution, waste problems, land use changes and access to public spaces, while shocks such as floods, fires, infrastructure damage and earthquakes.

According to the 4th dimensions of urban resilience, green open space is included in the environmental dimension as a medium for providing and increasing natural and artificial assets. Corkery & Marshall, 2018 [1]says that one way to strengthen urban resilience is the application of a green infrastructure system where a green open space system consists of the main dimensions of urban green infrastructure. Environmentally sound urban resilience is intended to create an urban environment that is resistant to disasters and climate change by applying the principles of significant resource use to meet current and future needs [2].

Indonesia itself has a Green City Development Program (P2KH) issued by the Ministry of Public Works in 2016 with the aim of developing cities that are responsive to climate change. This P2KH program has been followed by 165 Regencies/Cities in Indonesia as of 2016 including Palu City. The city of Palu is geographically close to the equator and is located in the Palu valley which is connected to the coast of Palu Bay.

The availability of green open space in Palu City is still poor by only meeting 13% of the 30% minimum requirements for spatial policies from the government. This condition is quite worrying for the fulfillment of the city's green open space. In addition to quantity, the quality of green open space is also important to increase the resilience of urban areas through the development of nature-based solutions. The creation of the quality of public green open space is not only to support public activities and become an ecological space for the city [3] but green open space as a physical natural disaster management through its use as an evacuation space for catastrophe such as earthquake and tsunami [4].

Based on initial observations in 2019, the earthquake disaster of 7.4 Mw (magnitude moment) followed by the Tsunami on September 28, 2018 in Palu City resulted in reduced city open space, especially in East Palu District because it was destroyed and damaged by the tsunami waves. The Anjungan Pantai Talise area in the Palu Bay has an area of 2.96 hectares, which is a water front area with a public open space function that has various facilities and is very crowded by the society [5]. This area is also a city landmark because located with the famous Yellow Bridge (Bridge IV) but was also destroyed by the disaster.

Another result shows that the Palu Bay area is an area of high potential/prone to earthquakes and tsunamis. So it is needed a natural disaster management in this area, especially for the tsunami. One of the physical natural disasters countermeasures that can be done is the use of green open space as an evacuation space. However, with the vulnerability of this area to earthquake and tsunami, it is necessary to have an adequate disaster evacuation space.

Based on this background, the formulation of the problem can be drawn is to see how the green space is suitable as an evacuation room for the natural disasters in the Palu Bay Area, especially on East Palu District and Mantikulore District. This study aims to identify the suitability of green open space as an evacuation space for earthquake and tsunami in the Palu Bay area so that the opportunity for the evacuation process can be easier and not take many lives.

2. Research Study

The research is located in the city of Palu (Figure 1),

especially in the districts of East Palu and Mantikulore. Administratively, Palu City is the capital city of Central Sulawesi Province, which is located in the Palu valley plain and Palu bay, which is located just below the equator between 0˚.36"-0˚.56" South Latitude and 119˚.45"-121˚, 1" East Longitude.
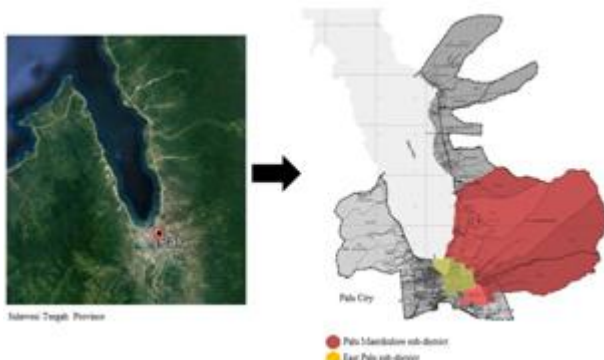

Figure 1: Research study

3. Method

Through ArcGIS analysis, disaster potential analysis is carried out by making an overlay maps by the secondary data from disaster-prone zone maps and land use maps. The overlay map shows the suitability of the green space location as an evacuation room for the earthquake and tsunami disaster. Further steps are as follows:

1) Image Capture
Image retrieval process as initial data in map making, where in this study image retrieval comes from Citra SAS Google Earth.

2) Geometric correction
This geometric correction aims to:
- Perform image rectification (correction) or restoration (recovery) so that the image coordinates match the geographical coordinates
- Register (match) the position of the image with another image that has been corrected (image to image rectification).

3) Area delineation
The results of the image will get an overview of the research area with measurable boundaries.

4) Digitizing
The digitization process aims to determine the existing conditions in the research area based on previously obtained images.

5) Overlay analysis
This stage is the main procedure in GIS (Geographical Information System) analysis. Overlay is the process of combining data from different layers.

6) Visual Interpretation
Then perform the interpretation, namely the interpretation of the elements on the object recorded on the image. These elements include 8 things, namely hue / color, shape, size, shadow, texture, pattern, site and association

7) Ground truth
The classification results are then ground truthed. Ground truth is the process of matching/validating image classification results that have been interpreted with land cover conditions in the field, while field verification is a stage to obtain certainty of classified objects based on secondary data and descriptions/observations.

- After getting the results of land use classification, then create an overlay map from secondary data of disaster-prone zone maps and land use maps. More details can be seen in the following image.
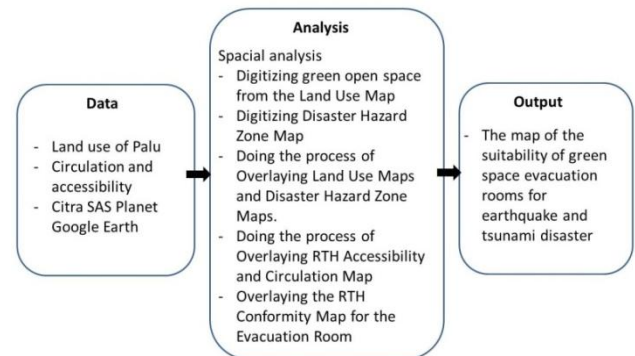

Figure 2: Methodology

4. Result

4.1 Spatial Analysis of the Digitization of Green Open Space from the Land Use Map of East Palu District

Based on land use data from Bappeda 2011, the green open space in East Palu sub-district is divided into active and passive green open space as shown in Figure 3.
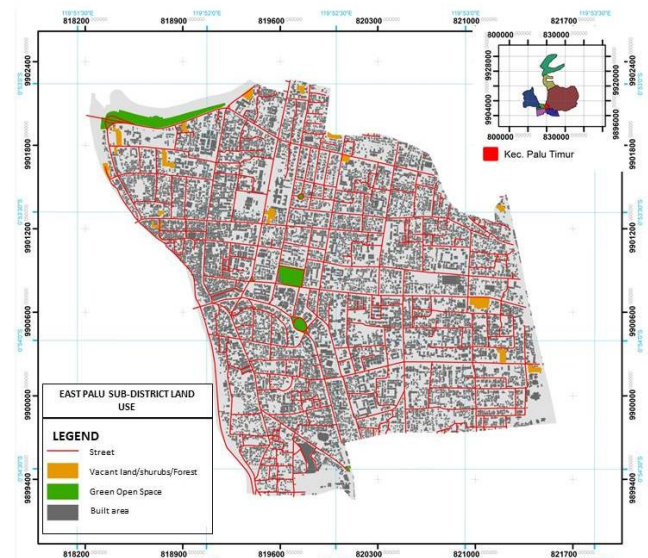

Figure 3: The Map of Land Use in East Palu

Figure 3 shows the distribution of active green open space is a public space which is the focus of research and passive green open space distribution such as vacant land, shrubs and cemeteries. This analysis was conducted to see the suitability of the open space as an emergency evacuation room for natural disasters. After getting the results of the identification of land use, then an overlay process was carried out with a map of the Palu city disaster-prone zone by Bappeda 2019.
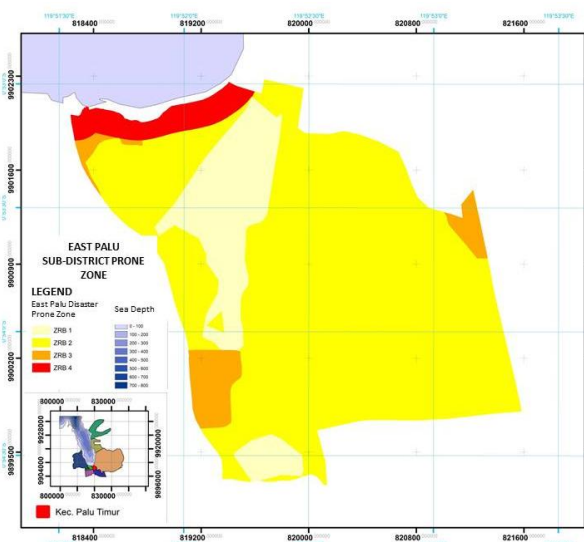
- **East Palu Disaster Prone Zone**

Figure 4: The Map of the East Palu District Disaster Prone Zone

Based on the results of the overlay, it can be seen in Figure 4, the East Palu District is generally included in ZRB 2 (Conditional Zone). However, in the Palu Bay Area, West Besusu Village is included in the ZRB level 4 (forbidden zone) covering an area of 85.7 Ha because of the high potential of tsunami. This disaster-prone zone is followed by South Lolu and East Besusu Villages, which are included in the ZRB level 3 or restricted zone.

Table 1: East Palu District Disaster Analysis

Data	Condition	Analysis
Earthquake	• East Palu District is an area prone to high ground movement disasters • There is an active Palu-Koro fault border 0-10 meters (BPBD, 2020)	The use of green open space as an emergency evacuation room
Tsunami	• West Besusu Village and its surroundings or along the Palu Bay area is a red zone area with a high potential for a tsunami. [6]	Emergency evacuation green open space must be in the vertical direction of the disaster evacuation route to facilitate the evacuation process.

Based on research by Ramadhani, 2011and data from BPBD Palu City 2020, the Palu Bay area is in the Active Fault Fault Zone of the Palu-Koro Fault with high ground movement hazards. Data from the Palu City BPBD shows the magnitude of the earthquake of 7.4 Mw in 2018 sourced in the 80 km northwest of Palu city with a depth of 10 km resulting in underwater cliff landslides and causing a tsunami along Palu Bay, one of which destroyed the public green open space at the Anjungan Pantai Talise.

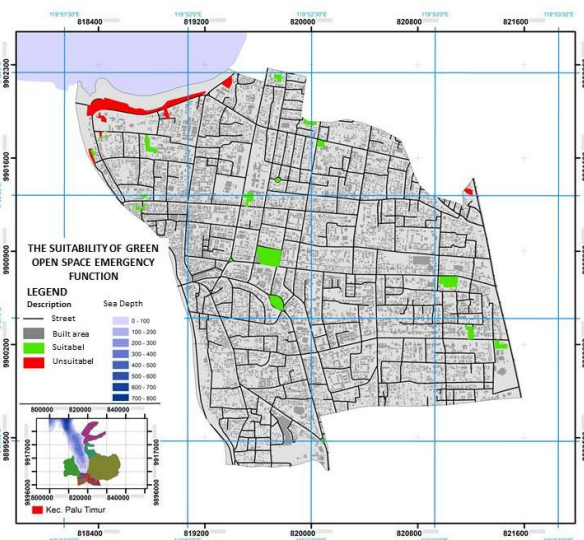- **The suitability of green open space as an evacuation room**

Figure 5: The Map of the Suitability of Green Open Space as a Disaster Evacuation Room in

Through an overlay with ArcGIS 10.4, Figure 5 shows that green open space along Palu Bay is included in the red zone category, so that there is a high potential for a tsunami disaster to occur. Earthquakes in Palu City and its surroundings are highly correlated with the possibility of tsunami waves due to seismic activity often originating under the sea. Therefore, it is necessary to carry out emergency mitigation efforts for the earthquake and tsunami disaster in this region.

Disaster mitigation efforts are carried out by determining the appropriate and inappropriate green open space zone as an evacuation room through the results of the overlay map of the distribution of green open space and a map of the disaster-prone zone of the city of Palu. The overlay results show that 9 ha of green open space is a suitable green open space as an emergency evacuation room including Taman Gor. This green open space consists of public open space, office/school fields, vacant land and shrubs. Then the unsuitable green space of 3 hectares is the Anjungan Pantai Talise Area located on the coast of Palu Bay.

The Anjungan area as well as the Yellow Bridge which is a city landmark. As an active public green open space area, according to the city spatial plan, this area is included in the waterfront green open space area as a means of community recreation (Figure 6). However, after the disaster on September 28, 2018, this area was destroyed by an earthquake and tsunami (Figure 7).

Figure 6: The Visual of Anjungan Pantai Talise in 2017 before the disaster

Figure 7: The Visual of Anjungan Pantai Talise in 2021 after the disaster East Palu District

In 2020, the Palu City Spatial Planning and Defense Office issued a revision of the Palu City Regional Regulation where the Anjungan Pantai Talise area is on a level 4 natural disaster-prone zone (ZRB). ZRB level 4 is a conditionally prohibited zone with various development provisions and is prioritized as an open space function just. It can be seen in Figure in 2021, there has been a 3 meter high embankment as a solution to re-planning the platform area to be more disaster-resilient.
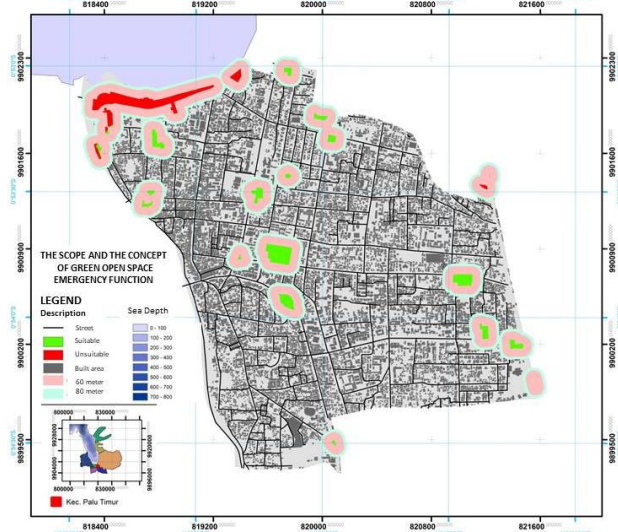

Figure 8: The Map of the Range of Evacuation Green Space and the Concept of Evacuation Room in East Palu District

According to research conducted by Rashifah et al., 2019 [7] the minimum evacuation green open space distance is 60-80 m based on the assumption that everyone has a different reaction when an earthquake or tsunami occurs. Figure 8 shows the coverage of the evacuation green open space within a radius of 60 and 80 m.

The standard of human motion according to Ching, 1996 [8] is 1.35-1.62 m². If the population in East Palu District is 57, 479, it requires 93, 116 m² or 9, 3116 Ha to accommodate residents in green open space as an emergency evacuation site. The total area of suitable green open space is 99, 203 m²2 or 9, 9203 ha, so the capacity of the evacuation green open space in East Palu has been fulfilled.

4.2 Spatial Analysis of the Digitization of Green Open Space from the Land Use Map of Palu Mantikulore District

Based on land use data from Bappeda 2011, the green open space in Mantikulore sub-district is divided into active and passive green open space. Figure 9 shows the distribution of active green open space is public green open space which is the focus of research and the passive green open space distribution such as protected forest areas, vacant land, shrubs and cemeteries.
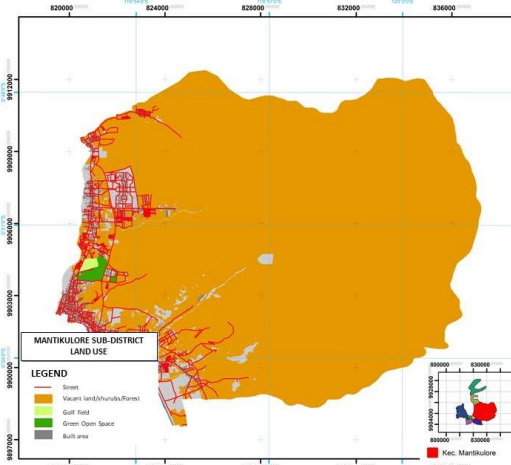

Figure 9: The Map of Land Use in PaluMantikulore District

This analysis was conducted to see the suitability of the open space as an emergency evacuation room for natural disasters. After getting the results of the identification of land use, then an overlay process was carried out with a map of the Palu city disaster-prone zone by Bappeda 2019.

- **Palu Mantikulore Disaster Prone Zone**

The overlay results in Figure 10 shows that Palu Mantikulore District is generally included in ZRB 2 (Conditional Zone). However, the coastal areas of Talise, Tondo and Layana Indah villages are included in the ZRB level 4 (forbidden zone) covering an area of 37.6 hectares because they have a high potential for a tsunami disaster. This disaster-prone zone is followed by Poboya, Lasoani and Kawatuna sub-districts which are included in the ZRB level 3 or restricted zone.
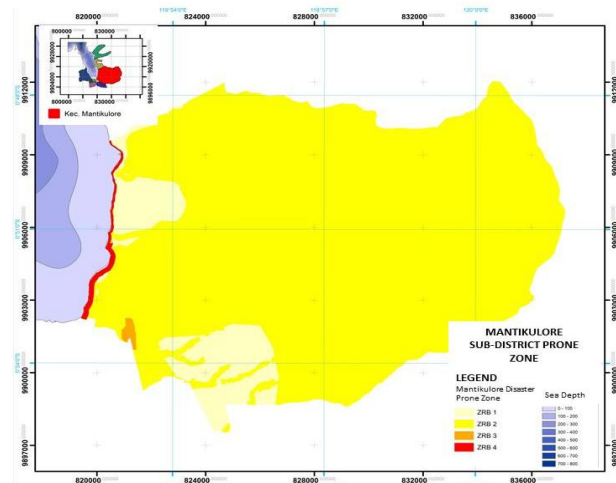

Figure 10: The Map of Palu Mantikulore Disaster Prone Zone

Table 2: Disaster Analysis in Palu Mantikulore District

Data	Condition	Analysis
Earthquake	East Palu District is an area prone to medium ground movement disasters (BPBD, 2020)	The use of green open space as an emergency evacuation room
Tsunami	The coastal border or along the coast is a medium tsunami hazard zone (BPBD, 2020)	Emergency evacuation green open space must be in the vertical direction of the disaster evacuation route to facilitate the evacuation process. .

Based on research by Ramadhani, 2011 [6]and data from BPBD Palu City 2020, the coastal area of Palu Bay is in the Palu-Koro Fault Active Fault Zone with high ground movement hazard. Data from the Palu City BPBD shows the magnitude of the earthquake of 7.4 Mw sourced in 80 km northwest of Palu city with a depth of 10 km that occurred in 2018 resulting in underwater cliff landslides and a tsunami along Palu Bay.

- **The suitability of green open space as an evacuation room**

Through an overlay with ArcGIS 10.4, based on Figure 11, the analysis results show that green open space along Palu Bay is included in the red zone category, so there is a high potential for a tsunami to occur. Earthquakes in Palu City and its surroundings are highly correlated with the possibility of tsunami waves due to seismic activity often originating under the sea. Therefore, it is necessary to carry out emergency mitigation efforts for the earthquake and tsunami disaster in this region.
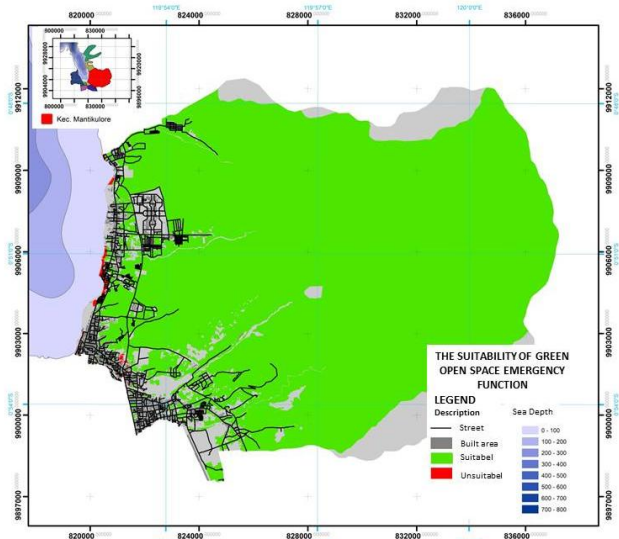

Figure 11: The Map of the Suitability of Green Open Space as a Disaster Evacuation Room in Palu Mantikulore District

Disaster mitigation efforts are carried out by determining the appropriate and unsuitable green open space zone as an evacuation room through the results of the overlay map of the distribution of green open space and a map of the disaster-prone zone of the city of Palu (Figure 11). The results of the overlay show that an area of 15, 862 Ha is a suitable green open space as an emergency evacuation room. This green open space consists of public open space,

office/school fields, Protected Forest Area, vacant land and shrubs. Then the unsuitable green space covering an area of 37.6 Ha is an empty land in the Warehousing Area and a park in the Citra Land Housing Complex.
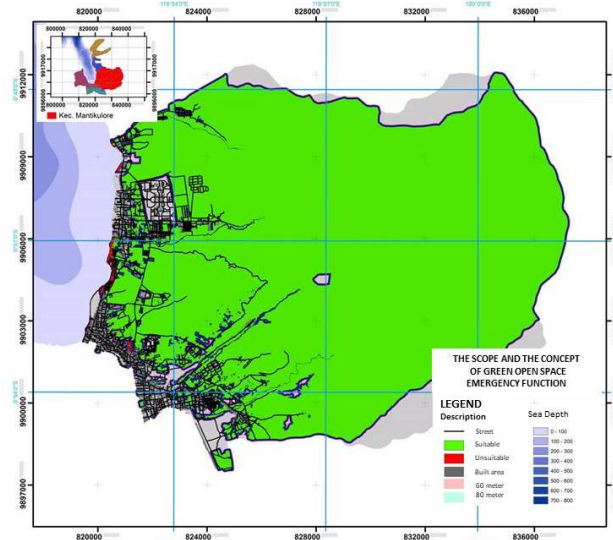

Figure 12: The Map of the Range of Evacuation Green Space and the Concept of Evacuation Room in Palu Mantikulore District

According to research conducted by, the minimum evacuation green open space distance is 60-80 m based on the assumption that everyone has a different reaction when an earthquake or tsunami occurs. Figure 12 shows the coverage of the evacuation green open space within a radius of 60 and 80 m.

The standard of human motion according to Ching, 1996 [8] is 1.35-1.62 m². If the population in Palu Mantikulore District is 15, 826 people, it requires 25, 638.12 m² or 2.5638 Ha to accommodate residents in RTH as an emergency evacuation site. The total area of suitable green open space is 158620000 m² or 15, 862 ha, so the capacity of the Palu Mantikulore green open space has been fulfilled.

5. Conclusion

The suitability of green open space as a disaster evacuation room in East Palu District shows an area of 3 hectares which is the Anjungan Pantai Talise area located on the coast of Palu Bay is not suitable as an evacuation room because it is in a level 4 disaster prone zone (ZRB) and green open space with a total area of 9 Ha **is** a suitable green space as an emergency evacuation room including Taman Gor. This green open space consists of public green open space, office/school fields, vacant land and shrubs.

The suitability of green open space as a disaster evacuation room in Palu Mantikulore District shows that the distribution of green open space covering an area of 15, 862 ha is suitable green open space as an emergency evacuation room. This green open space consists of public green open space (including Kaombona City Forest and Vatulemo Park), office/school fields, Protected Forest Area, vacant land and shrubs.

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