The evaluation of green open space of disaster prone coastal areas

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Abstract. The utilization of Green Open Space (GOS) is one of the aspects of urban environment that has an important value to the human life in urban areas considering its function in providing benefits ecologically, socially, culturally, aesthetically, and economically. An appropriate utilization aims to improve the quality and quantity of green space, especially in the coastal areas, the use of green space is interesting to study because most of the land planned as green space is considered as a potential land and tends to be often misused on its use. This study aims to identify the existing land use and evaluate the use of GOS to increase the potential development of GOS utilization in coastal areas in Banda Aceh as stipulated in the Regional Spatial Plan (RSP) of Banda Aceh. The evaluation starts from analyzing the existing land use of GOS that has been determined in the SRP of Banda Aceh City through the processing of satellite images in 2016 by using the geospatial information systems application as an analytical aid. The image illustrates the existing land use conditions. The outcome obtained indicates that there is a change in the function of GOS that has been designated as a residential area and trade and services as well as the utilization of GOS that is not optimal yet. The results are expected to be a reference in optimizing the use of green open space in disaster-prone coastal areas in the city of Banda Aceh.

1. Introduction

Post-tsunami spatial use in Banda Aceh has been running rapidly due to high rehabilitation/reconstruction activities, emphasizing the reconstruction of damaged buildings and infrastructure, capacity building and community empowerment, economic, social, and cultural activities [1]. At the beginning of rehabilitation/reconstruction, most of the northern or coastal areas did not allow for the physical development of the City, so development activities tended to develop towards the East and South, which were relatively safe from the tsunami and had the potential to become new development areas. In line with the trend of urban development, the Banda Aceh City Government has stipulated the Regional Spatial Plan (RSP) Regulation Number 4 of 2009 on the Banda Aceh City Regional Spatial Plan 2009-2029 as the basis for implementing development in Banda Aceh City. In the RSP, most of the northern part of the City or coastal area is designated as GOS.

After enacting the RSP regulation, rehabilitation/reconstruction activities continue, housing construction, office buildings, trade, infrastructure, and other urban services began to increase [1]. Increased development activities also occurred in the northern part of the City, a coastal area devastated by the tsunami waves. The utilization of land for these activities changes the natural form of urban land and uses green open space, which has raised concerns that it can make cities less livable [2]. This condition has resulted in changes in spatial use as stipulated in the spatial plan so that the Banda Aceh
Government has revisited the RSP by considering various aspects of urban physical development while continuing to prioritize the sustainability of elements of a sustainable urban environment. Determination of changes in spatial patterns in Banda Aceh is based on considerations to maintain the sustainability of urban protected areas by applying the concept of development based on the arrangement of green cities, sustainable environmental sustainability, optimization and efficiency of spatial use, and disaster mitigation.

Determination of GOS in the RSP is mostly located in the coastal area of the City, which aims as a buffer zone through the development of mangrove and other coastal plants by prioritizing ecological, economic, social, and cultural aspects according to community needs and can be implemented sustainably by not ignoring architectural elements [3]. This is in line with Fuady's opinion that green space has a significant role in tsunami disaster mitigation in the City's coastal areas as a rescue and protector [4].

The coastal area is an attractive area due to natural characteristics, microclimate, and economic factors, which includes the place where the influence of water and land meets, to the land it covers the administrative area of the sub-district while towards the sea as far as 12 (twelve) nautical miles is measured from the coastline towards open ocean [5] so that it can be utilized as a variety of recreational activities [6]. Spatial use in coastal areas as green open space is a step to use as a buffer zone for coastal regions from the tsunami disaster. At the same time, for the tide do the construction of coastal protection in the form of the revetment.

Related to development in coastal areas, coastal cities have city characteristics as a concentration of development activities because of their strategic position; this will affect urban green space [7]. The land ownership that has been determined as a GOS in the RSP is mostly community-owned land. This impacts the limited use of land so that the land seems neglected, and there is no effort to make it have more value. The limited budget of the City Government to conduct the acquisition of community land designated as green space can impact the occurrence of land conversion.

As land prices continue to rise, rental prices, distance from work locations, and family connections have caused landowners and developers to glance at coastal areas dominated by GOS. The history of the tsunami event is no longer a consideration of the community in choosing the location of residence. This can be a trigger for land conversion from the GOS to the built area.

Based on the above background, it is deemed necessary to evaluate the use of green open space in disaster-prone coastal areas in Banda Aceh City to find out the progress of space utilization activities and potential development of green open space utilization to achieve a balance between economic growth and social welfare with environmental protection and disaster mitigation [8]. This study contributes to information on the utilization and development of the potential of GOS, as a guideline for determining activities in the GOS area and form the basis for policy recommendations for the City Government in determining spatial planning policies, especially for the arrangement and utilization of GOS land use in disaster-prone coastal areas.

2. Materials and methods

2.1. Study area

This research was conducted in Banda Aceh the capital of Aceh Province, a city on the northern tip of Sumatra Island, consisting of 9 districts, 90 Villages with an area of 6,136 ha. The geographical position is flanked by the Malacca Strait on the north side while on the west, east and south sides are limited by the territory of Aceh Besar Regency. Astronomically, Banda Aceh is located between 05°16’15"- 05°36’16" Northern Latitude and 95°16’15"- 95°22’35" East Longitude [3]. The altitude of the urban areas ranges from -0.45 m to +1.00 m above sea level, with an average height of 0.80 m above sea level.

Based on the provisions of the scope of regulation of coastal areas, where in land direction covers the administrative area of the sub-district [5]. The coastal area of Banda Aceh City is in 4 sub-districts, Meuraxa, Kutaraja, Kuta Alam and Syiah Kuala Sub-District, with an area of 3,592.53 Ha (Figure 1).
The research location is focused on the area that has been designated as the designation of green space in the RSP of Banda Aceh City.

![Location of study area](image)

**Figure 1.** Location of study area.

2.2. **Methods**

In this study the research approach used is a combination of quantitative and qualitative with descriptive approaches that describe the relationship between the phenomena under study. The quantitative approach is used in describing existing land-use while the qualitative approach is used in describing the potential development of green space utilization.

2.2.1. **Identification of green open space plans in coastal areas**

Urban GOS is an open space or area within a city planted with trees, shrubs, bushes, and grass [8]. Land planning as GOS aims to present beauty, comfort and safety element for the owner or user which has aesthetic value and functions as an open space with diverse functions [9].

The coastal area of Banda Aceh City consists of low-lying areas and part of it is an area of mangrove forests, water body and ponds. In the RSP, the establishment of GOS in coastal areas is planned to be 992.58 Ha. (Table 1) or 84.07% of the total green space planning in Banda Aceh City (Figure 2).
Figure 2. Map of GOS planning in the coastal area of Banda Aceh City.

Table 1. GOS planning in the coastal area of Banda Aceh City.

| GOS planning          | Kuta Alam | Kutaraja | Meuraxa | Syiah Kuala | Ha  | %    |
|-----------------------|-----------|----------|---------|-------------|-----|------|
| Beach border          | 0.00      | 4.52     | 2.15    | 33.61       | 40.28| 4.06 |
| River border          | 8.67      | 2.48     | 2.08    | 50.87       | 64.10| 6.46 |
| City Forest           | 0.00      | 4.57     | 0.00    | 25.07       | 29.65| 2.99 |
| City Park             | 2.24      | 0.00     | 6.52    | 5.63        | 14.38| 1.45 |
| Mangrove forest       | 32.04     | 87.49    | 162.95  | 29.57       | 312.06| 31.44|
| Cemetery              | 2.01      | 1.63     | 3.56    | 0.88        | 8.08 | 0.81 |
| Sports field          | 2.23      | 0.16     | 1.02    | 17.29       | 20.70| 2.09 |
| Green lane            | 13.44     | 2.48     | 9.80    | 14.36       | 40.07| 4.04 |
| Other open spaces     | 120.52    | 58.58    | 9.75    | 274.40      | 463.25| 46.67|
| Total                 | 181.16    | 161.93   | 197.82  | 451.68      | 992.58| 100.00|

2.2.2. Analysis of existing land use
To find out the existing land use, a land use analysis technique is used through satellite image processing in 2016 using the ArcGIS application, the results of field observations are the primary data source and are supplemented by some secondary data as a complement. So that the description of the existing land use of green space has been determined in RSP of Banda Aceh City. The land use classification refers to the Indonesian National Standard (SNI) 7645-1: 2014. The analysis was carried out descriptively by describing the distribution of land uses.
3. Results and Discussion

3.1. Area and GOS plan in the coastal area of Banda Aceh City

Banda Aceh is a very vulnerable city to several types of coastal disasters, such as tsunamis and tidal waves. It is also vulnerable to earthquakes and floods. This is due to Banda Aceh being traversed by two faults which are a branch of the Sumatra Fault, the Aceh Fault and the Seulimum Fault. Both of these faults have the potential to produce an earthquake with the potential for a Tsunami. Determination of GOS plan in tsunami-prone coastal areas is the right step towards disaster mitigation as a rescue and protective area (Figure 3).

![Figure 3. Map of GOS plans in disaster prone coastal areas.](image)

In accordance with the provisions of spatial patterning, in the coastal area a local protected area is planned in the form of a coastal border and river border area. The border area of the coast serves to protect the coastal area from activities that interfere with the preservation of the coast which is located along the banks which width is proportional to the shape and physical condition of the beach, which is 50 m - 100 m from the highest tide point towards the land except for the beach area used for public purposes, such as existing ports/docks, open spaces, public spaces, tourist attractions and fishing settlements [3, 4]. The planned beach boundary covering an area of 40.28 Ha, established along the coast in some village, such as Pande Village, Lampaseh Village, Alue Deah Teungoh Village, Deah Raya Village and Alue Naga Village. The beach borders on the coast of Pande Village which are integrated with the tourism area plan look untreated and the utilization of the coastline has not been maximized, only overgrown with mangroves, shrubs and grass, also the condition of the border beach at other locations. While the river border is planned to be 8 m - 30 m wide to protect the river from activities that can disrupt or damage the river water flow function. The river border in the coastal area
of the city is planned to cover 64.10 ha, which are located along the river Krueng Aceh, Krueng Doy, Krueng Neng, Krueng Titi Panjang, Krueng Lueng Paga, Krueng Daroy, and Krueng Cut.

In the coastal areas, mangrove forest green space is also set as large as 312.06 ha, mangrove forest area is directed at the northern coastal area of Banda Aceh City which is spread in Meuraxa Sub-district as large as 162.95 ha, Kuta Alam Sub-district covers an area of 32.04 ha, Kutaraja 87.49 ha and Syiah Kuala 29.57 ha. This determination is in accordance with the characteristics of the area and city development based on disaster mitigation [4]. The condition of mangrove forests has not been maximally utilized. The utilization of mangrove forest green space is only in the form of mangrove plant growth and utilization as a pond area, so that it only has a limited function to fulfill ecological functions, there is no economic, socio-cultural or architectural function. Furthermore, GOS with other green space designation is set at 463.25 ha, with existing land use dominated by mixed plantations, ponds and vacant land areas that have not been planned, well-maintained, thus creating unattractive visual impressions. For this other green space designation.

3.2. Analysis of existing land use of GOS in the coastal areas

Land use is the result of changes in spatial patterns and the magnitude of human activity which is a dynamic process. Land use is all human activities on the land to use the land to meet all their needs [9]. Analysis of existing land use aims to get a picture of land use and as a basis for evaluating the suitability of spatial use [10].

Based on the results of the analysis, land use in the designation of GOS in the coastal area of Banda Aceh City in 2020 consists of built areas namely residential and trade areas and services, mangrove forests, urban forests, city parks, green lanes, cemeteries, sports fields, green open spaces others, grass/vacant land, ponds, swamps, riverbanks, coastal banks and water bodies (Figure 4) with the area of each sub-district use shown in Table 2.

![Figure 4. Map of existing land use in coastal areas.](image-url)
Table 2. Land use exists in the coastal areas of Banda Aceh City.

| Existing land use | Area | Kuta Alam | Kutaraja | Meuraxa | Syiah Kuala | ha | % |
|-------------------|------|----------|----------|---------|-------------|----|---|
| Settlement        |      | 0.28     | 1.28     | 1.76    | 9.13        | 12.44 | 1.25 |
| Trade             |      | -        | -        | -       | 0.47        | 0.47  | 0.05 |
| Mangrove forest   |      | 22.12    | 71.05    | 34.75   | 10.80       | 138.71 | 13.98 |
| City forest       |      | -        | -        | -       | 13.63       | 13.63 | 1.37 |
| City park         |      | 1.28     | 5.46     | 5.91    | 13.78       | 26.43 | 2.66 |
| Green lane        |      | 10.85    | 0.64     | 9.79    | 9.41        | 30.68 | 3.09 |
| Cemetery          |      | 2.06     | 1.63     | 3.56    | 0.87        | 8.12  | 0.82 |
| Sports field      |      | 1.67     | -        | -       | 5.98        | 7.65  | 0.77 |
| Mixed plantations |      | 0.29     | 2.16     | 2.62    | 5.07        | 1.52  |     |
| Grass / vacant land|   | 9.76     | 3.54     | 3.86    | 63.01       | 80.18 | 8.08 |
| Pond              |      | 111.36   | 9.32     | 95.34   | 205.17      | 420.97 | 42.41 |
| River border      |      | 2.69     | 0.42     | 0.21    | 46.37       | 49.68 | 5.01 |
| stretch of beach sand | | -        | 3.19     | 6.50    | 22.16       | 31.85 | 3.21 |
| water body        |      | 18.78    | 65.23    | 33.63   | 38.82       | 156.47 | 15.76 |
| total             |      | 162.37   | 96.51    | 163.82  | 413.40      | 992.58 | 100.00 |

The results of the analysis between the existing land use and the green space plan shows that 12.91 ha of GOS plan has changed its function as a built area such as a residential area and a trade and service area. The existing land use that is appropriate for the allocation of GOS covering an area of 225.22 ha consists of mangrove forests, urban forests, city parks, green lanes, cemeteries and sports fields. While other land area of 754.45 ha which consists of mixed plantations, grass/vacant land, ponds, riverbanks, coastal banks and water bodies has not been used optimally according to its purpose.

3.3. Potential utilization of GOS in disaster prone coastal areas

GOS is an important component of urban landscape and provides many benefits as a city lung, improving physical, psychological and increasing social harmony through social interaction and recreation. Meanwhile, unplanned expansion and development have directed the city to risky hotspots from various environmental, social and disaster perspectives. In this situation, urban green space is considered an important natural contributor that supplies a variety of ecosystem services to the humanity who live in cities and can be an important part of achieving sustainable development goals [11].

The existence of GOS is not only has an ecological function, but also have an additional function, namely as a social and cultural, economic, aesthetic and the function of tsunami disaster mitigation in the coastal areas of the city [4, 12]. This is a consideration in determining the potential types of utilization of GOS. Utilization of GOS should be in accordance with the conditions and characteristics of a city and provide an effective impact according to the purpose and function of allocating space for GOS so that it provides benefits of comfort, security, beauty and prosperity [13].

GOS of beach border which has the main function as a barrier to the growth of settlements or other activities so as not to interfere with coastal sustainability, can be utilized for non-green activities by 10% of the planned area This refers to the stipulation that the area planted with plants (green space) on the coastal boundary is at least 90% of the planned beach border areas. Provision of activities and facilities in the coastal boundary area should not cause disturbance to the sustainability of the coastal ecosystem, including disturbance to visual quality, planting vegetation prioritizes local vegetation with a cropping pattern aimed at preventing abrasion, erosion, protecting against the threat of tidal waves, and reducing...
strong winds. The potential for developing the utilization of coastal borders can be in the form of planting mangrove vegetation, as well as the development of ecotourism integrated with the planned tourism area in Pande Village and GOS mangrove forests in Syiah Kuala Sub-District. Ecotourism is a form of natural-based sustainable tourism with a primary focus on nature conservation, learning and education as well as locally oriented [14].

River border areas can be used for outdoor activities that are recreational in nature which can increase the intensity of community socio-cultural interactions and limited use for activities that function as utility buildings and infrastructure related to river management [3]. The GOS for mangrove forests has the potential to be used as a mangrove conservation area that can be combined with other plants as a buffer zone, tourist area [8] and the development of a Silvofishery pond system. Silvofishery or also known as Wanamina is a system of aquaculture which is a combination of aquaculture with the activities of planting, maintaining, managing and conserving mangrove forests that can reduce negative impacts on the environment [15]. The pattern of this technical approach seeks to overcome the problem of mangrove forest sustainability and community welfare. Fishery activities can continue to be carried out in the mangrove forest without disturbing its function as a natural coastal protector from waves. This pond system has a simple technology that can be operated without damaging existing mangrove plants and can be done as an activity to reforest coastal areas. The development of the concept of ecotourism and Silvofishery pond system in the green open space plan of the mangrove is expected to have a positive impact on the community, especially in the economic, socio-cultural, educational fields and the development of the concept of ecotourism will present the aesthetic impression of the area by not reducing the main function of green space as a provider of ecological functions.

For another GOS dominated by existing land use as ponds and empty land area, this GOS can be developed to the maximum with a variety of potential uses that can provide more value to the environment and society. Several potential uses that can be developed in other GOS, those are: as an ecotourism area, especially in some villages, such as: Deah Raya, Tibang and Alue Naga in Syiah Kuala sub-district. in Pande Village and Jawa Village Kutaraja sub-district which is directly adjacent to the mangrove forest GOS. The utilization as a breeding ground for fauna, especially birds, plantations with the concept of tourism in Blang Oi Village Meuraxa sub-district, Lambaro Skep Village Syiah Kuala sub-district and in Peulanggahan Village, Kutaraja sub-district. Besides that, it can also be used as a pond with Silvofishery system, especially in areas bordering the mangrove forest GOS in Lambaro Skep Village Syiah Kuala Sub-district and the development of thematic GOS such as City Forest, City Park, Sports Field, under the potential of the area. allocating space for GOS so that it provides benefits of comfort, security, beauty and prosperity [10].

4. Conclusion

GOS in the coastal area of Banda Aceh which has been set in the Banda Aceh City Spatial Plan is dominated by green space borders of the coast, river borders, mangrove forests and other open green areas as a whole are still not optimally utilized yet, not treated properly and presents a less attractive visual impression, this is illustrated from the existing land use and visual impressions that are present at the site.

The potential use of GOS in coastal areas that can be applied include development of mangrove forest conservation, development of ecotourism areas, development of Silvofishery system ponds, fauna breeding sites and tourism-based plantations and thematic green space development including city forests, city parks, sports fields following the characteristics and potential of the green space.

GOS will be valuable in every part of the urban area, if it can be planned for the welfare of urban residents, both from ecological, economic, socio-cultural functions and aesthetically designed through architectural touches that are responsible and responsive to disasters to create a balance of the environment and environment the ongoing development.
5. Acknowledgement
Thank you to Syiah Kuala University and all parties who have contributed to this writing, so that it can be well done.

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