Evaluation of the implementation of sustainable transportation system in the green city concept in Banda Aceh City

Buraida¹*, R Noer², M Fuady², N Ridwan²

¹Civil Engineering Department, Syiah Kuala University, Darussalam-Banda Aceh 23111, Indonesia
²Architecture Department, Syiah Kuala University, Darussalam-Banda Aceh 23111, Indonesia

*Email: buraida.sipil@unsyiah.ac.id

Abstract. Banda Aceh City has had an expansion and development plan towards a sustainable city with green city concept since 2012. Based on the green city concept, Banda Aceh City is planned to be an environmentally friendly city by utilizing water and energy resources effectively and efficiently, reducing waste, implementing an integrated transportation system, ensuring environmental health, synergizing the natural and artificial environment, based on urban planning and design in favor of the principles of sustainable development. But in reality there are still some problems such as the absence of adequate public transportation, the unbalanced length of the road with the growth in the number of vehicles so that the traffic flow is not smooth and causes traffic jams, pollution and air pollution. For this reason, this research was conducted with the aim of evaluating the implementation of a sustainable transportation system in Banda Aceh City so that achievements can be known by comparing the initial plan and implementation realization. This study uses a qualitative descriptive method with a gap analysis technique to compare the ideal conditions of a sustainable transportation system with the actual conditions in Banda Aceh City. The results show that the level of application has only reached 43.75% where all the models applied have not been implemented optimally.

1. Introduction
The city of Banda Aceh as the capital of Aceh Province, has experienced rapid growth. The population of Banda Aceh City in 2006 was 178,380 people and continued to grow until in 2019 it reached 270,321 people. Such a large increase in population was also followed by growth in housing construction, which in 2006 amounted to 35,676 units, increasing to 54,064 units in 2019 [1]. Furthermore, the Banda Aceh City government has also participated in the green city program since 2012, the green city concept for Banda Aceh City which includes eight supporting attributes of a green city, namely: green planning and design, green open space, green building, green waste, green transport, green water, green energy, and green community [2].

Based on the concept of a green city, Banda Aceh City is planned to be an environmentally friendly city by utilizing water and energy resources effectively and efficiently, reducing waste, implementing an integrated transportation system, ensuring environmental health, synergizing the natural and artificial
environment, based on urban planning and design, side with the principles of sustainable development. However, in reality there are still some problems such as the absence of adequate public transportation, the unbalanced length of the road with the growth in the number of vehicles so that the traffic flow is not smooth and causes traffic jams, pollution and air pollution [3].

2. Materials and methods

2.1. Materials

The definition of sustainable transportation is a concept of developing transportation that does not have a harmful impact on public health or environmental ecosystems. The objectives of this program include directing the development and development of environmentally friendly transportation systems that are human-oriented and the use of alternative renewable energy sources that are free of pollution, to achieve a healthy and comfortable environmental quality [2]. Broadly speaking, to develop green transportation there are three main steps, namely: 1) Identifying and analyzing the status of the existing transportation system, 2) formulating targets for reducing the use of motorized vehicles at and at emission levels, and 3) selecting the appropriate combination of various transportation options. The components of the development of green transportation in a hierarchical order of priority are as follows:

1) Pedestrian Path

Pedestrian paths are convenience facilities that support traffic and road transportation activities inside and outside the road body in the context of safety, security, order and smooth traffic, as well as providing convenience for road users. Pedestrian facilities can be in the form of sidewalks, crossings with road markings (zebra cross), pedestrian bridges and pedestrian crossings (subway). The function of the pedestrian path is:
   a. the vitality of urban space;
   b. reduce the frequency of use of motorized vehicles in city centers;
   c. attractiveness of movement to the downtown area;
   d. create a human-scale atmosphere of space; and
   e. create clean and pollution-free air.

Pedestrian paths are generally in the form of sidewalks, zebra crossings, plazas, and subways. Sidewalks are pedestrian facilities provided on the roadside with the characteristics of a clear direction, location on the edge of the freeway, and a flat surface (max 5%) with a width of 1.5 – 2 m. A zebra crossing is usually provided on the road. The crossing path aims to avoid conflicts with vehicles. The crossing usually has the characteristics of crossing the road, equipped with traffic lights and has a width of 2-4 m.

2) Bike Path

Bicycle lanes are lanes designated specifically for bicycle users and non-motorized vehicles, and are separated from motorized vehicles to improve the safety of bicycle users. Bike paths have several bicycle lane designs, including:
   - Bike paths, which are bicycle paths that are completely separated from the road and are often combined with pedestrian facilities;
   - Bike line, which is the part of the road marked with a bicycle user marker. Usually made in the direction of the motor lane current, although it can also be designed for two directions on one side of the road.
   - Bike routes are bicycle routes that are designed and can be used in conjunction with motorized vehicles.
The minimum width for a one-way bicycle lane is 1 m, while the minimum width for a two-way lane is 1.8 m. Bike lanes can be separated by physical barriers from motor traffic lanes, and the design allows motorized vehicles to pass through bicycle lanes in case of an emergency. In addition, it is necessary to provide bicycle parking facilities to increase the attractiveness of bicycle transportation.

3) Public transportation
Public transportation or mass transportation is a means of driving for many people to move from one place to another, so that it can provide time and cost efficiency. Public transportation can be divided into several types which include
a. Bus
Bus is a means of land transportation to move someone from one place to another. There is also the Bus Rapid Transit (BRT) which is a development of the bus, which is a transportation system that uses a bus fleet with quality services that are comfortable, safe, fast, and on time. The ideal BRT usually has the characteristics of a special lane so that it is free from congestion on the highway, BRT can use the normal lane on the highway if it is not possible for a special BRT lane, the payment system is carried out at the bus stop, the height of the shelter floor is parallel to the bus door to make it easier passengers board the bus, and the quality of the driver is good so as to create comfort for passengers.
b. Commuter Train
The commuter train is a transportation service that carries a large number of people who travel daily between the city center and the suburbs. The use of commuter trains can reduce congestion on the highway. The characteristics of commuter trains include connecting several stations in urban areas, having close distances or travel times, serving passengers from the suburbs to the city center or vice versa, and having scheduled services.
c. City transport
City transportation is public transportation with the character of small vehicles, mostly owned by individuals, to serve short-distance routes which are determined by the city government. City transportation usually caters to short-distance travel categories, such as trips to school or the market.

4) High Occupancy Vehicle (HOV)
HOV is a high-occupancy vehicle that can be done by implementing ride sharing. Ride sharing is a process where a vehicle driver gives a ride to another person. The form of a ride can be given to friends, family, or it can also be organized from the workplace. In some countries ride sharing can provide a ride in various forms. For example, for the North American region, ride sharing can be in the form of car pooling, and in the UK it can be in the form of car sharing. Car sharing is a form of car rental where someone can borrow a car in the near future or for a long time. The use of ride sharing is usually used by another passenger who has the same purpose. The concept of ride sharing can reduce the number of use of private vehicles.

2.2. Research method
The method used in the implementation of this research is descriptive qualitative through a field survey to determine the application of the attributes of a sustainable transportation system in Banda Aceh City using the gap analysis method and an evaluation using the scoring method. The focus of this approach is to conduct a direct survey in the field to understand the implementation of what has been done in the implementation of a sustainable transportation system and what the ideal and actual conditions are in Banda Aceh City.

2.3. Research Location
This research was conducted in Banda Aceh City, Aceh Province, Indonesia. Based on its geographical location, Banda City is located at the northern tip of Sumatra Island as well as being the westernmost region of Sumatra Island with a city surface area of 61.36 km² [4,5]. The average land surface in Banda Aceh City is 0.80 meters above sea level. In 2020, the population of Banda Aceh City was recorded at around 270,321 people [6].

2.4. Research variable

According to Notoatmodjo [7] the definition of variables is distinguished as follows:

- Variables contain an understanding of the size or characteristics possessed by members of a group that are different from those of other groups.
- A variable is something that is used as a characteristic, trait or measure that is owned or obtained by a research about a certain concept of understanding.

The following is a table of research variables and indicators

| Variable                          | Indicator                                                                 | Data source                      | How To Pick Up                  |
|-----------------------------------|---------------------------------------------------------------------------|----------------------------------|---------------------------------|
| Sustainable Transportation System | Development of sustainable transportation systems, such as public transportation, bicycle lanes, etc. | Banda Aceh City Spatial Planning, Interview, Literature Study related agencies, Banda Aceh City planning documents | Survey, Interview, Literature Study related agencies, Banda Aceh City planning documents |

2.5. Method of collecting data

There are several data collection techniques used in this study, namely:

2.5.1. Primary Data

1. Field Observation/Survey

The type of observation carried out in this study is direct observation, namely observations or observations made by the researchers themselves to the research location by observing directly into the
field and taking primary data which is realized through an image recording device (photography) to record images of physical data and phenomena that exist in the location. The purpose of observation is to obtain concrete data directly. The thing that is examined by this observation method is the application of the attributes of the green city concept in Banda Aceh City according to data from the city government offices and agencies. Observations that have been made are visiting the Aceh Transportation Service, and BAPPEDA Banda Aceh City.

2. Interview
In this interview process, the researcher tried to gather information and opinions from respondents about the application of the green city concept in Banda Aceh City. During the interview process, the researcher can add some questions outside the context of the existing questions. The type of interview used is included in the in-depth interview where the purpose of this interview is to find problems more openly. The informants chosen to be interviewed are from government agencies because they are people who have extensive knowledge about various problems that exist in a community and society. Interviews that have been conducted visiting the Aceh Transportation Service, and BAPPEDA Banda Aceh City.

2.5.2 Secondary data
Secondary data is obtained through the inventory stage or data collection from other sources used for research in library research, namely previous research reports, data collection methods in the form of papers, and other necessary auxiliary data. The data collected can be seen in the following table.

| No  | Data                        | Data Type          | Data source          | How To Pick Up |
|-----|-----------------------------|--------------------|----------------------|----------------|
| 1   | General Condition of Banda  | Location, area, footprint | Secondary RTRW and BPS for Banda Aceh City | Literature review |
|     | Aceh City                   | Land use, Population |                      |                |
| 2   | Green City Attributes       | The implementation of a sustainable transport system, | Primary and secondary Surveys, personal documentation, and the Banda Aceh City Service | Field surveys, interviews with related offices |

2.5.3 Analysis
The analysis stage begins with formulating the ideal concept of a green city from the results of a desk study with a green city attribute (indicator) approach, which is followed by identifying the existing conditions of the attributes of a sustainable transportation system in Banda Aceh City using descriptive gap analysis. In this study, gap analysis is an analytical method used to compare the ideal conditions of a green city with the actual conditions of Banda Aceh, so that it can be seen the implementation of the plan for implementing a sustainable transportation system that has been achieved by the City of Banda Aceh and described descriptively.

According to Parasuraman [8], gap analysis is one of the tools that can be used to evaluate the performance of government agencies, especially in providing services to the general public. The results of the analysis can be a useful input for planning and determining budget priorities in the future. Gap analysis is a very important step in the planning and performance evaluation stages.

2.5.4 Evaluation
This study resulted in an evaluation of the implementation conditions of the green city concept in Banda Aceh City. At this stage an assessment or scoring is carried out to find out what and how to achieve the application of the green city attributes. Scoring is done using a modified scoring table from Desdyanza's research [8] to evaluate the implementation of the attributes of the green city concept that has been applied. The limitations of the program assessment are based on the Green City Development Program (P2KH) document in Indonesia by the Ministry of Public Works and Public Housing, as well as other supporting literature adapted to the physical condition of Banda Aceh City and the literature on the ideal concept of a Green City. Assessment is done by giving a score of 0, 1, 2, 3, and 4.

**Table 3.** Limitations for determining scoring attributes for a Sustainable Transportation System (Green Transport).

| Program         | Score |
|-----------------|-------|
|                 | 0     | 1       | 2       | 3       | 4       |
| Pedestrian Path | 1. There is no pedestrian path development plan listed in the RTRW. | 1. There are directions for the development of pedestrian paths, but they are not listed in the RTRW. | 1. There is already a pedestrian path development plan listed in the RTRW. | 1. There is already a pedestrian path plan listed in the RTRW. | 1. There is already a pedestrian path plan listed in the RTRW. |
|                 | 2. No implementation. | 2. There has been implementation of pedestrian paths but not yet in accordance with the standards. | 2. Has an ideal pedestrian path dimension. | 2. Has an ideal pedestrian path dimension. | 2. Has an ideal pedestrian path dimension. |
| Bike Path       | 1. There is no bicycle lane development plan listed in the RTRW. | 1. There is already a direction for the development of bicycle lanes, but it has not been stated in the RTRW. | 1. There is already a bicycle lane development plan listed in the RTRW. | 1. There is already a bicycle lane development plan listed in the RTRW. | 1. There is already a bicycle lane development plan listed in the RTRW. |
|                 | 2. No implementation. | 2. There is already an implementation of bicycle lanes but they do not meet the standards. | 2. Has ideal bike path dimensions. | 2. Has ideal bike path dimensions. | 2. Has ideal bike path dimensions. |
|                 | 3. Separate bicycle lanes from motorized vehicles. | 3. Connect one place to another. | 3. Connect one place to another. | 3. Connect one place to another. | 3. Connect one place to another. |
|                 | 4. Placement of site furniture in accordance with the pedestrian path. | 4. Placement of site furniture in accordance with the pedestrian path. | 4. There are supporting facilities for cycling (shelters). | 4. There are supporting facilities for cycling (shelters). | 4. There are supporting facilities for cycling (shelters). |
### Mass Public Transport

1. There is no public transportation development plan listed in the RTRW.
2. No implementation.

1. There is a directive for the development of public transportation, but it has not been stated in the RTRW.
2. There has been an application in the use of public transportation, but it has not met the existing standards (not paying attention to the ideal aspects of using public transportation).

1. There is already a public transportation development plan listed in the RTRW.
2. Public transportation has not been integrated with each other.
3. There is already a directive on the use of alternative fuels.

1. There is already a public transportation development plan listed in the RTRW.
2. Public transportation is integrated with each other.
3. Has a city strategic zone integration.
4. Use of alternative fuels in (min. 2 types) public transportation.

### High Occupancy Vehicle (HOV)

1. There is no HOV development plan listed in the RTRW.
2. No implementation.

1. There is already a directive for the development of HOV, but it has not been stated in the RTRW.
2. There is already an application with one HOV application (for example in the scope of the agency).

1. There is already a HOV development plan listed in the RTRW.
2. There is already an application with one HOV application (for example in the scope of the agency).

1. There is already a HOV development plan listed in the RTRW.
2. There is already an implementation with two HOV implementations.
3. Not yet integrated with the public transportation system.

1. There is already a HOV development plan listed in the RTRW.
2. There are already implementations with > two HOV deployments.
3. Have integration with the public transport system.

After scoring the application model of each attribute to determine its achievement in Banda Aceh City, the next step is to determine the percentage of each attribute with the formula:

\[ \text{Total application value} (X_t) = X_1 + X_2 + \ldots + X_n \]

Where:  
- \( X_1 \) = percentage of application form attribute 1
- \( X_n \) = percentage of the nth attribute application form
- \( X_t \) = the total application value of the application form of each attribute

Furthermore, the calculation of the maximum value of each attribute and calculates the percentage of the implementation of each attribute with the following formula:
Maximum Score (Xmax) = number of implementation models \( \times \) maximum scoring points

Percentage of application of attributes (%) = \( \frac{\text{implementation value} - \text{total (Xt)}}{\text{maximum score (Xmax)}} \times 100\% \)

After this scoring stage is carried out, it can be seen whether these attributes have been implemented properly or not in Banda Aceh City. So that it can be seen the treatment or plan that will be carried out next to create an ideal green city in Banda Aceh City. The following is a table of the limitations of each attribute that can be used as a reference to determine the score of each implementation model.

### 3. Results and discussion

#### 3.1. Features extracted

The following is an evaluation table for the implementation of green transport in Banda Aceh City (Table 4)

| Model                  | Evaluation                                                                 | Score (a) |
|------------------------|-----------------------------------------------------------------------------|-----------|
| Pedestrian Path        | Generally, the main roads in Banda Aceh City already have pedestrian paths, but the main problem is that supporting facilities are not well available such as facilities and infrastructure so that pedestrian paths are not comfortable and safe for road users. | v         |
| Bike Path              | The city of Banda Aceh already has bicycle lanes, but they are still very limited, such as on Jln. Mr. Chik Ditiro Kec. Lueng Bata. | v         |
| Mass Public Transport  | Trans Koetaradja has been operating on five corridors out of 6 planned since 2016. Buses running on diesel and electricity are currently being tested. | v         |
| High Occupancy Vehicle (HOV) | Currently, the concept of ride sharing has not been developed in the city of Banda Aceh, both for communities and individuals. | v         |

| Total Deployment Value | 7(b) |
|------------------------|------|
| Maximum Value          | 16(c) |
| Percentage of application of Green Transport attribute | 43.75%(d) |

From the evaluation results above, it shows that the achievement of the green transportation attribute in Banda Aceh City has only reached 43.75%. This value indicates that the condition of implementing green transportation in Banda Aceh City is not good enough. The model that has been implemented is limited to pedestrian paths, bicycle lanes, and mass public transportation, while the High Occupancy Vehicle (HOV) has not been planned at all.

### 4. Conclusions

The results of the evaluation using gap analysis and scoring show that the level of implementation of the green transportation attribute in Banda Aceh City has only reached 43.7%. There are already planning models that support the green transportation attribute, but not all of them have been implemented optimally. The model that has been implemented is limited to pedestrian paths, bicycle
lanes, and mass public transportation, while the High Occupancy Vehicle (HOV) has not been planned at all. Currently the city of Banda Aceh is still in the development stage, which can be seen from the planning and implementation of the green city attributes that are applied.

References
[1] BPS 2020 Banda Aceh City in Figures 2020 Central Bureau of Statistics Banda Aceh City
[2] P2KH 2017 Guidelines for the Implementation of the Green City Development Program of the Ministry of Public Works and Public Housing
[3] Dishubkominfotel Aceh 2016 Final Report on Planning for Advanced Transportation Services Corridor I Mass Transportation in Banda Aceh City. Aceh Transportation Service
[4] Fitri I, Aulia T B, Fuady M 2020 The effect of public space availability on children's creativity (case study: Taman Sari kota Banda Aceh). IOP Conf. Series: Materials Science and Engineering 933:1-5
[5] Fuady M 2015 Disaster Mitigation Approach of Urban Green Structure Concept in Coastal Settlement, Journal of Architecture and Built Environment Dimensi 42, 2: 51-58 [3] Asian Development Bank, Cities Development Initiatives in Asia 2017 Improvement of BRT-Based Transportation Network in Banda Aceh
[6] Pemko Banda Aceh (2009). Regional Spatial Plan (RTRW) for Banda Aceh City 2009-2029.
[7] Notoatmodjo S 2002 Definition of Variables According to Experts and in General. https://www.zonareference.com/pengertian-variabel/ (accessed November 29, 2020 at 15.34)
[8] Desdyanza N A 2014 Evaluasi Penerapan Konsep Kota Hijau di Kota Bogor Skripsi Departemen Arsitektur Lanskap Institut Pertanian Bogor