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ASSESSING SOCIAL AND ENVIRONMENTAL SUSTAINABILITY OF SONADANGA BUS TERMINAL, KHULNA

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ABSTRACT

For more livable urban places, it is urgently required to change the direction of urban transport development toward a more sustainable future. But sustainability is such a term that can hardly be measured. Properly planned bus transit station would be a better solution for the public transports in cities. In conformity with that perspective; the most common and major topics of the social and environmental sectors can be taken into consideration. This paper focuses on the assessment of sustainability of Sonadanga bus terminal from social and environmental aspects. Based on the secondary and field surveyed data necessary calculations have been performed by using different indices. The result of the analysis indicates moderate sustainability of the terminal from social perspective considering livability, safety, security and accessibility. From the standpoint of HASTA framework, Sonadanga bus terminal is quite sustainable (67.95%). Environmental sustainability has been assessed considering CO_2 emission rate (based on fuel consumption), waste generation and sanitation. All the buses use diesel and it is generating 0.195 mpg/year CO_2 which is greater than the standard value of 0.0264 mpg/year. Dally index shows a poor performance of the bus terminal weighing waste production/year against disposal/year. Regular disposal of waste, proper accommodation of sanitation facilities along with making it comfortable and easily accessible are among the major requirements to be met.

Keywords: *Assessment, Social, Environmental, Bus-terminal, Sustainability*

1. INTRODUCTION

A bus terminal is a facility for passenger boarding and departure and serves as a control point for buses (PIPAF, 2006). It also facilitates ticket counter, waiting room etc. for serving the customers. A properly planned transit station can maximize sustainability of the Transit Oriented Development (TOD).

Khulna is the third largest city of Bangladesh having 15687759 population (Hannan, 2013) and Sonadanga bus terminal is one of the most important transportation nodes of the city. Bus service provided by it connects the city to the whole country. Due to presence of this terminal, bus transit oriented development has been taking place around it. Sonadanga area is flourishing day by day and still has much scope of development. Which means, Sonadanga bus terminal might be able to play a vital role in it from the social and environmental aspects. After the construction of Padma Bridge, vehicular pressure will increase in Khulna city and Sonadanga Bus terminal is going to have to facilitate more services eventually. Evaluation of current social and environmental sustainability can help to identify the lacking and problems of Sonadanga Bus Terminal. Policies can be recommended to overcome the weakness and suggestions for additional improvement can be provided as well. Thus, BTOD can be ensured with maximum level of affectivity and sustainability in terms of social and environmental factors. Recommendations can be made for increasing sustainability of this terminal. Unless assessed, the present condition cannot be identified which will leave no scope for future development. That is the reason behind this project.

2. LITERATURE REVIEW

The term “Sustainability” can be defined as the living process where limited resources are used in a way so that living system can be embedded to thrive. It became a common language at the World’s first Earth Summit in Rio in 1992. Besides, Sustainable developments refers to the development that meets the needs of the present without compromising the ability of future generations to meet their own needs (WCED, 1987). As the perspective of a sustainable urban transport system (i.e. Bus terminal) it requires strengthening various features of that system. It deals with the social, economic and environmental compatibilities in that specific system. The success of bus terminal sustainability depends on how it balance the needs of environmental, social and economic aspects effectively for a long term period with flexibility. So, it may be concluded that sustainable development stand by three important pillars which are economic, social and environmental development.

Different social and environmental indices are used to measure the effectiveness of bus terminal. Among them Customer Satisfaction Index (CSI) measures the social sustainability based on satisfaction score and relative importance score of the attributes (Eboli & Mazzulla, 2009). When the value is closer to 10, it means extreme level of socially sustainability. Environmental sustainability can be calculated through Dally index (comparing demand against supply) and TIGGER sustainability equation (Zhang & Vanasupa, 2009). When demand is greater than supply, it denotes unsustainability.

Through TIGGER (Transit Investments in Greenhouse Gas and Energy Reduction) Sustainability calculation, CO_2 emission rate can be calculated and comparison can be made with standard value of emission rate (Linnertz, 2009). Another weighted average index has been formulated applying the benchmark value of sustainability index. This is used for defining sustainability based on some social and environmental indicators such as CO_2 intensity, waste disposal etc. (Bosello et. al, 2011).

In 1993, Calthorpe shows that “Urban TOD” associated with rail stations and a “Neighborhood TOD” associated with bus stations (Calthorpe, 1993). So it can be said that bus terminal can be an effective way to gain sustainability to the zone. Creating economical activities, a bus terminal can create the economic growth and strengthen the economy. It may be added that, a well-functioning bus terminal can attract the community, institutions and industry nearby it. So the pressure on CBD is reduced and employment is decentralized which is important to gain sustainability. For example: 22% of workers in the 100 largest U. S. regions worked within three miles of their respective city centers. But the employment pressure has highly reduced from the CBD by introducing the Bus Transit Oriented Development (BTOD) (Guthrie, 2016).

In Surabaya city, Indonesia the growth rate of vehicles is quite high. To mitigate Green House Gas Effects (GHG) on climate change they used to TOD concept that integrating land use and transportation by creating area around the station. It is found that, trip characteristic in Surabaya was dominated by the private transports (Handayeni, 2014). After the shifting of station, travel behavior change to mode transit and non-motorized usage reduced the number of travel. Policy, institutional and legal aspect support is needed to make TOD successful in Surabaya.

In Italy, a new Customer Satisfaction Index is used for evaluating transit service quality which is based on customers’ perspective (Eboli & Mazzulla, 2009). The methodology adopted in this research aims to obtain a concise indicator by considering different service aspects. The indicators can be calculated on the basis of judgments expressed by a numerical scale from 1 to 10. From the CSI calculation, it is found that services are about

73% successful in satisfying its customers. The attributes with the highest average satisfaction scores are because of ease of purchasing ticket, security against crime and personnel appearance.

3. METHODOLOGY

This section initially briefs the present condition of Sonadanga Bus Terminal. Next the study procedure is explained in detail.

3.1 Study Area

Sonadanga bus terminal is located in Sonadanga, Khulna. The area of this terminal is 12.5 Acres. It is 3.7 kilometers far from Dakbangla More. The terminal is accessible via three streets- M.A Bari Street, Masjid Saroni Road and Sonadanga Bypass Road. These roads crosses by Sonadanga Bus Terminal. Surrounding lands are mainly residential in type. Mixed land use (residential and commercial) characteristics and natural water body exist surrounding the terminal.

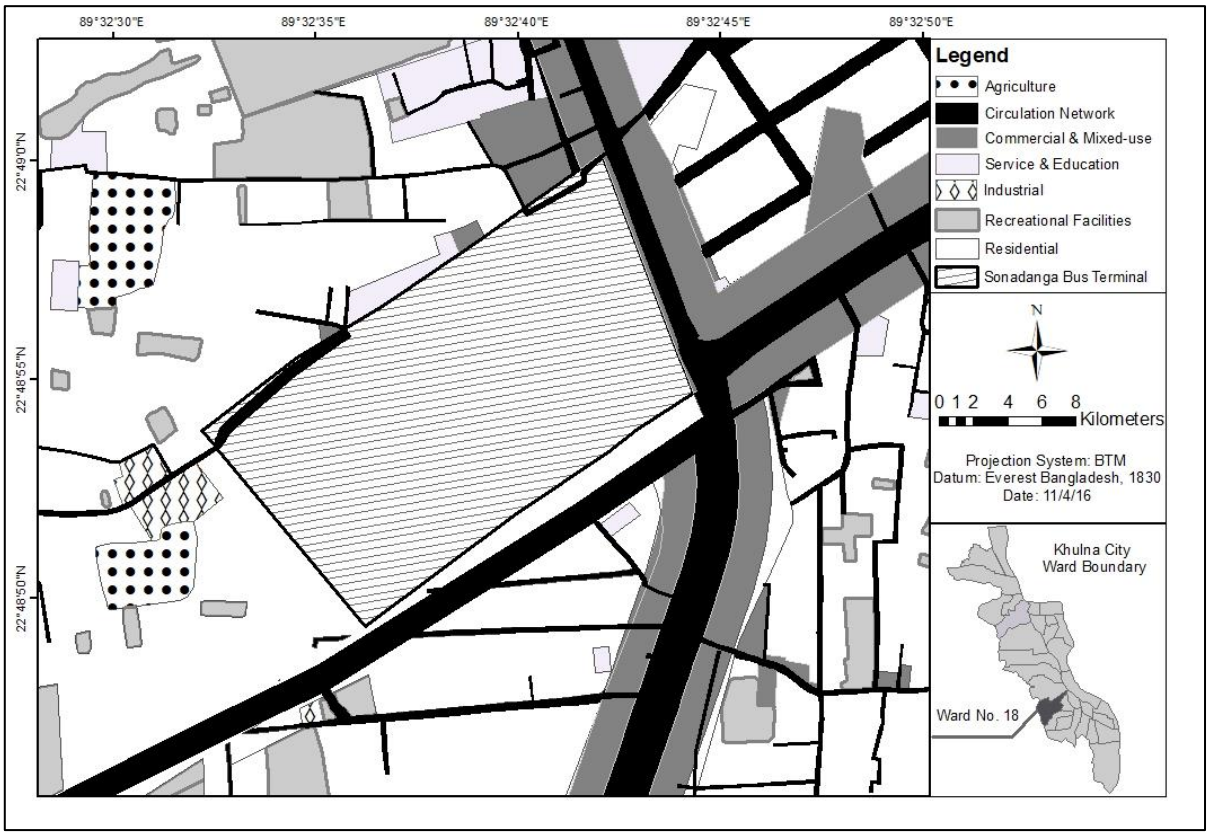

Figure 1: Land-use map of Study Area; the map has been prepared by author (2017)

3.2 Survey Method

The study has been conducted by a group of seven members and focused group of discussions. At first after gathering the conceptual knowledge it had been conducted by means of questionnaire survey and field observation. Probabilistic random sampling has been atopted as sampling method. Sample size for the study has been 117 which has been determined with a z value 1.96 at confidence interval (c) 9.8% by the formula (1) where p is "%" of picking a choice (Freedman et. al, 1997).

$$SS = (z^2 \times p \times (1-p)) \div c^2 \quad (1)$$

Secondary data have been collected using satellite image and GIS software. The collected data have been manipulated and necessary cross tabulation also been done for making the relationships among them and finding the index's values.

Table 1: Benchmark Value for Sustainibility

Value	Indicator	Value	Indicator
0	Extremely unsustainable situation	0.50	a discrete level of sustainability, but still far from target
0.25	indicator is still not sustainable but not as severely as in the previous case	0.75	satisfactory level in the sustainability, yet not on target
		1	target level, fully sustainable

Source: Bosello et. al, 2011

To determine social sustainability, customer satisfaction index has been calculated through the formula (2) (Eboli & Mazzulla, 2009),

$$CSI = \sum_{k=1}^{n} [s_{\bar{k}.} w_k] \quad (2)$$

Here, $s_{\bar{k}}$ the mean of the satisfaction rate of user k attribute and w_k is a weight of k attribute calculated on the basis of the importance rates expressed by users. If the positive response for the taken attributes are greater than 50% in HASTA Indicator Framework, it indicates social sustainability. Environmental Sustainability has been calculated through demand against supply perspective, the score has been derived from the following formula (3) (Zhang & Vanasupa, 2009)-

{(Demand/year) ≤ (Available supply/year)} (3)

Fuel consumption, produced garbage, existing sanitations facilities etc. have been used as demand side indicators.

Table 2: Evaluations and Weighted Transformation

Social		Environment		Weighted transformation
Sub indicators Value		Sub indicator Value		
Worst (0)	Worst (0)	Worst (0)	Worst (0)	Extremely unsustainable situation (0)
Worst (0)	Best (1)	Moderate (0.5)	Sustainable but not on target (0.75)	discrete level of sustainability (0.5<0.56>0.75)

Source: Bosello et. al, 2011

Through TIGGER Sustainability Calculation, diesel consumption (mpg) has been calculated by the following equation-

$$\textit{Diesel used annually} = \frac{\textit{Annual Shuttle Miles}}{\textit{mile per gallon}} \quad (3)$$

The unit here is gallon per year. Only diesel consumption has been considered as all buses use it as for fuel. Produced tons of CO_2 emissions has been compared with standard value 0.0264 mpg (Carbon Independent, 2015). Applying FSI index, social and environmental sub-indicators have been converted into a common benchmark value (Table 1). Finally through evaluations and Mobius transformation method, result is simplified (Table 2).

4. ANALYSIS AND INTERPRETATION

The analysis has been concluded based on the data of the survey conveyed upon 117 user and field observations where 13% are female and most of the respondents are working age people. Among the survey people, 37% has an age ranging between 30 and 44. Around 47% of the respondents have an income below 10000 BDT.

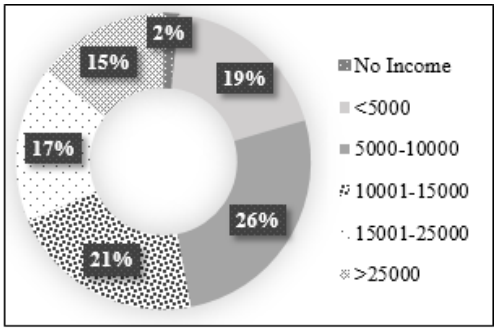

Figure 2: Income distribution
(Field Survey,2017)

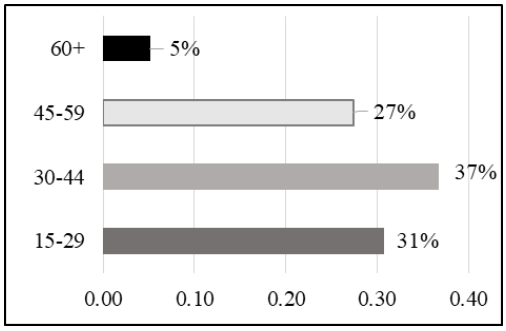

Figure 3: Age distribution
(Field Survey,2017)

4.1 Social Condition

Social sustainability has been assessed in terms of accessibility, safety, security, availability of facilities etc.

4.1.1 Congestion

Due to parking of buses on the roadway for boarding purpose, on an average 3.1m (Arasana & Arkatkar, 2011) effective road width reduces. It gives rise to congestion adjacent to the intersection which hampers social sustainability.

4.1.2 Washroom Facility

Generally, 420 passengers are to be accommodated by the terminal each hour. It is required to have 5 washrooms per 1000 female, 4 washroom and urinals per 1000 male (CED24, 2010). Sonadanga Bus Terminal has two for women and two for men only which are unhygienic as well. 82% of the users are dissatisfied with sanitation facility. This inefficiency to facilitate indicated lack of social sustainability.

4.1.3 User Satisfaction

It can be observed from Figure 2 that above 80% users feel satisfied the availability and ticket price. However, most user are dissatisfied with the existing toilet facility. Their opinion expressed moderate satisfaction for the other facilities.

Figure 3 suggests that most users feel safe in the terminal and most have never faced an accident in the arena and neither harassment. The matter of concern is, though six security guards are being appointed, they are not found to be actively maintaining their duty. So, most of the respondents considers the security level is moderate (59%). When the waiting room is not sufficient for the passengers, they are bound to wait outside which makes them more prone to harassment. This idea has been adopted as the working hypothesis and it has been accepted with 0.014 significance level from the chi-square test

4.1.4 Unpleasant Situations

Often unpleasant situation occurs in the bus terminal and quarrel between passenger and driver or helper breaks out. Such has an occurrence rate of 79% which hampers social sustainability.

4.1.5 Customer Satisfaction Index (CSI)

For assessing customer satisfaction index, ten major attributes are considered. The lowest satisfaction score has been derived for air pollution (2.41) and the attribute (Harassment) with the highest satisfaction score is 9.06 which contributes to the overall weighted score. Waiting room has been rated as the most important attribute (9.5) followed by air pollution

(9). Finally the value of CSI has been determined as 5.33 out of 10 and so, it can be interpreted that Sondanga Bus Terminal is 53.3% successful for being socially sustainable (Eboli & Mazzulla, 2009).

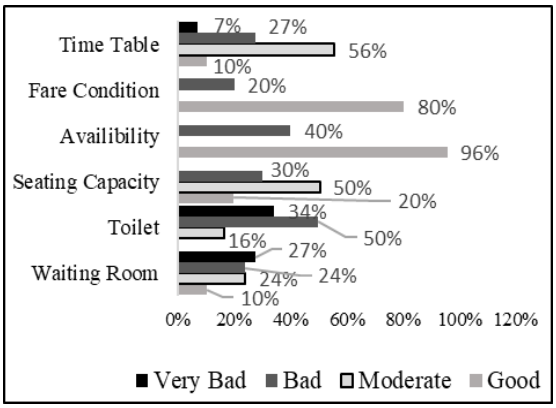

Figure 4: User Satisfaction about Facilities (Survey, 2017)

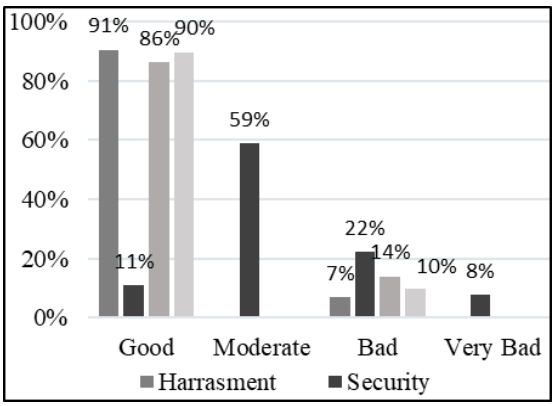

Figure 5: User Opinion about Safety and Security (Survey, 2017)

Table 3: Customer Satisfaction Index for Different attributes

Attributes	Satisfaction Score	Importance Score	Importance Weight	Weighted Score (CSI)
Air pollution	2.41	9	0.11	0.26
Harassment	9.06	8	0.1	0.88
Waiting room	3.92	9.5	0.12	0.45
ATM Service	2.07	7.5	0.09	0.19
Restaurant	5.45	7.5	0.09	0.5
Parking	6.74	8	0.1	0.66
Luggage carrying	6.53	8	0.1	0.64
Control system	3.92	8	0.1	0.38
Purchase ticket	6.91	8.5	0.1	0.72
Accessibility	6.65	8	0.1	0.65
Total		82		5.33

Source: (Field Survey , 2017)

4.1.6 HASTA Indicator Framework

The percentage of positive responds of relevant indicators have been used in this index. With respect to livability, safety and security and accessibility, social sustainability score has been determined to be 67.95%. This indicates that the terminal is moderately sustainable. However, it is unsustainable to a noticeable degree in terms of livability (39.03%) (Olofsson *et. al.*, 2011).

4.2 Environmental Condition

The environmental sustainability of Sonadanga bus terminal has been identified using air pollution, waste disposal, fuel consumption indicators.

4.2.1 Waste Disposal

Only 18% of the user finds the environment of Sonadanga Bus Terminal tolerable. A majority of 78% user identified it as an unhealthy spot. This represents that most of the respondents

find the environment hazardous. A great amount of waste (33%) generates from food particles and percentage of polythene waste is high too. These indicate environmental unsustainability.
The following table shows that most of the respondents are used to throwing wastes anywhere in the terminal. Huge amount of wastes of all types are disposed on the open ground (44%). Uncovered dustbin turns out to be the next obvious choice. Polythene, food wastes and rotten stuff are never get thrown in the planned dustbin. With increase in waste generation, more waste is dumped on the site clumsily.

Table 4: Waste Disposal according to Waste Types

Types of waste	Open Dustbin	Planned Dustbin	Anywhere	Bucket Dustbin	Total
Others	7%	9%	20%	1%	36%
Polythene	9%	0%	9%	3%	21%
Food Particles	12%	0%	13%	8%	32%
Rotten Particles	5%	0%	3%	2%	10%
Total	33%	9%	44%	14%	100%

Source: (Field Survey , 2017)

4.2.2 TIGGER Sustainability Calculations

Using the index it has been determined that 0.195 mpg CO_2 is emitted annually which is greater than the standard 0.0264 mpg. Hence it can be said that Sonadanga bus terminal is not sustainable environmentally according to CO_2 emission standard (Carbon Independent, 2015).

4.2.3 Dally Index

The average no. of buses departing from the terminal is 130 (6 am- 12pm) and diesel used per day is 60 liters (Field Survey, 2017). From the supply-demand relationship of the sustainability law, 2847 metric tons per year are demanded per year but the supply is short by 547 metric tons per year. It is the result of low amount of buying oil of the filling stations. It is often seen that there is a scarcity of oil if any congestion or hazard occur in supply chain. Besides the filling stations do not reserve any extra amount of oil. They just purchase just to meet the need. So it can be said that there is a fuel unsustainability in the region.
Khulna Development Authority (KDA) has provided 3 vans for waste management which works at once daily. But this can not solve the problem as waste remains in the study area. Assuming 1 kg of waste in 1 square feet, total dumping area, waste per day and cleaning capacity has been calculated as 450 sq. ft., 450kg and 180kg respectively. This implies that the demand is greater than the supply ($\frac{164.5}{1} \not\leq \frac{65}{1}$) which indicates lack of environmental sustainability (Zhang & Vanasupa, 2009).

The terminal has a total number of 4 toilets while it has to serve 420 passengers per hour. As per CEDA standard, 1 toilet can serve 222 people the demand for washrooms while supply permits 250 of them to use one (CED24, 2010). So it can be concluded the sanitary condition is nearly meet the demand. But in future when the population will increase it will be unsustainable.

4.3 Overall Social and Environmental Condition

4.3.1 FSI Transformation

Using all the mentioned indices through FSI transformation the social and environmental sustainability score has been derived 0.58 and 0.13 respectively. In comparison to the benchmark values, finally it can be concluded that Sonadanga bus terminal is

environmentally unsustainable though the condition is not very severe. However the terminal is socially sustainable a moderate condition.

5. RECOMMENDATION

On the basis of analysis, some recommendations have been made which would be effective from social and environmental concerns.

1. KDA can install waste bins beside the waiting room, entrances and canteen is essential for keeping the environment cleaner. This would prevent the users from throwing wastes anywhere.
2. Providing one more toilet for both male and female can ensure supply-demand equivalence. Regular toilet cleansing and supplying water in toilets all day is complusury.
3. To make the terminal environmentally compatible, it is required to ban the buses from the terminal physical life of which have expired. Buses which are not used any longer should be removed from the terminal parking lot to increase the parking capacity for other vehicles. They can be recycled for other purposed or shifted to a salvage yard.
4. Security cameras and emergency call boxes are recommended in the main terminal office for monitoring the role and performance of the terminal continuously.
5. Plan of the terminal should be incorporated with the provision of adequate arrangement for drainage of all sewage and waste water to ensure rapid drainage, even during peak rainfall events.

Naturally, all of these proposed changes and improvements will result in heavy expenditures. The bus terminal improvement plan organizes a budget based on the proposed improvements and amenity changes. In order to implement these changes, formulating a plan is necessary. By following the implementation guidelines and utilizing the proposed funding strategies, it is possible to accomplish the required improvements as per Bus Terminal Improvement Plan in reality. As a result, Sonadanga bus terminal would serve as a safe, accessible, and identifiable transit facility.

6. CONCLUSIONS

The study result shows moderate level of social sustainability and environmental unsustainability for the Sonadanga bus terminal. Sanitary condition, waste management and drainage system are needed to be modified significantly. If these sectors are not properly maintained, it would be a great threat for the terminal to achieve sustainability. Moreover terminal authority allows old and poor conditioned buses to access in it which generates huge amount of CO_2. The terminal also has some operational and maintaining drawbacks which must be modified. Finally, it can be concluded that the terminal has some major environmental drawbacks that should be resolved as soon as possible. Otherwise the terminal will lose its acceptability and will become a threat for surrounding environment. In that respect this study can serve as a guideline for the concerning authorities and people associated with it.

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APPENDIX

Table 1: HASTA Indicator Framework

Category	Indicators	Sub- Indicators	Positive Response	Score	Interpretation
Social	Livability	Waiting Room	30.77%	39.03%	The terminal is not sustainable in terms of livability
		Toilet	16.24%		
		Sitting Capacity	70.09%		
	Safety & Security	Harassment	90.60%	84.19%	The terminal is sustainable in terms of safety and security
		Security	70.09%		
		Accidents	86.32%		
		Safety	90%		
	Accessibility	Availability	95.73%	80.63%	The terminal is sustainable in terms of accessibility
		Fare Condition	80.34%		
		Time Table	65.81%		

Source: (Field Survey , 2017)

Table 2: Filling Stations Data Near Sonadanga Bus Terminal

Station	Capacity (L)	Supply Frequency (/day)	Supply Amount (L)	Availability for bus (L)
Maniktala	27000	3	6000	2400
Religate	20000	3	4000	1500
New Road	30000	3	8000	4000
Boikali	25000	3	6000	3000
Joragate	25000	3	6000	2500
Powerhouse	20000	3	4000	1500
Gollamari	27000	3	6000	3000
City Bipass	15000	3	3000	1000
Total				18900

Source: (Field Survey , 2017)

Table 3: Waste Management Scenario in Sonadanga Bus terminal

Total Dumping area (formal & Informal)	Garbage waste (daily) (assume 1 sq.ft = 1kg)	Total cleaning capacity per day
450 sq. ft.	450 kg	3 van of 50 kg per =180 kg

Source: (Field Survey , 2017)

Table 4: Evaluations and Mobius transformation

Environmental Indicator	Benchmark value for Sub-indicator	CO2 Emission	Not Sustainable (0)	
		Fuel Management	Fuel unsustainability (0)	
		Sanitary Condition	just meet the demand (0.5)	
		Waste management	opposite to sustainability (0)	
	Decision	(0+0+0.5+0)/4	= 0<0.13<0.25	Environment is not very sustainable, but not severely unsustainable
Social Indicator	FSI Benchmark value for Sub-indicator	CSI Index	0.53	
		HASTA Indicator	0.67	
	Decision	(0.5+0.67)/2	=0.58	A discrete level of sustainability, but still far from target

Source: (Bosello et. al, 2011)