EVALUATION FOR UPGRADATION OF KHULNA AND ISHWARDI RAILWAY STATIONS CONSIDERING WATER AND ENERGY EFFICIENCY

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ABSTRACT

Water and energy efficiency is the practice of reducing water and energy consumption by measuring the amount of water and energy required for a particular purpose that combats climate change, impacts on macroeconomic and reduce costs through application of water-energy saving technologies. Railway is a very important mode of inland transport, linking the entire length and breadth of the country, the healthy grow of railway naturally contributes to the economic development of the country. Railway stations have high occupancy rates and are often open all the time, so it is necessary to save water and energy consumption as it is considered one of the busiest government facilities by increasing the efficiency of environmental architectural design and water-energy conservation requirements. The divisional railway station, Khulna and junction station, Ishwardi among the stations in the West Zone of Bangladesh Railway are selected as study areas which are the most influential stations in the Zone. The aims of the study are to evaluate water and energy efficiency of Khulna and Ishwardi Railway Stations and assess the potentiality of rainwater harvesting and renewable energy options to upgrade those facilities. There are three stages to the analytical methodology of the study: first, an assessment stage of the present situation of availability and adequacy of water supply and sanitation facilities including buildings, service and sustainability through convenience sampling, several respondents' survey and face-to-face interview. Second, present water and energy use efficiency. The third is an upgraded water and energy utilization system for green future of Bangladesh.

Keywords: *Water, Energy, Sanitation, Railway Stations, Environment.*

1. INTRODUCTION

Eco-friendly technical solutions have been introduced in the construction sector to meet the requirements of growing environmental awareness and sustainability concerns in the most cost-effective fashion (Santos, 2020). Railway as a cost-saving, environment friendly, comfortable and safe transport system is playing a important role in passengers and goods transportation. A railway station is the simple to complex and ambivalent element in rail transport. It is trying all over the world to develop a green and sustainable railway stations that reduce emissions, generate energy, improve operational performance (Reham, 2023). A water supply or sanitation system is sustainable when it provides an efficient and reliable service at a level which is desired. The efficient and effective use of water and sanitation facilities is the key dimension in sustainability (Ahmed and Rahman, 2000). The global energy recession is one of the biggest challenges which require the activation of sustainable energy use in the application of the necessary environmental solutions (Reham, 2023). The use of renewable energy and rainwater is immensely important for Bangladesh for its entire development as well as the advancement and accomplishment of the Goals of SDG of the United Nations (UN). The SDG Goal-6 has given importance that substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity by 2030, through integrated water resources management (IWRM) (Islam, 2019). To achieve the Goal-7 of SDG that ensure access to affordable, reliable, sustainable and modern energy for all, the availability of green and affordable energy across the country should be ensured (Razak et al.,2021).

Energy consumption of railway stations is considerably greater than that of conventional buildings due to their high occupational density and need to operate during an extended timeframe (Santos, 2020). Four independent sub-topics: energy, waste, water and air quality influence station management. The water–energy nexus is directly related and impacted by CO_2 emissions and its climate consequences, which calls to a broader approach: energy–carbon–water nexus. The implementation of actions for sustainable use of water and energy is critical for mitigating water and energy supply problems. Energy management systems play a crucial role in optimizing the energy consumption and operational efficiency of railway systems and smart railway networks. With the growing emphasis on sustainable transportation solutions, railway operators are increasingly adopting advanced technologies to reduce energy consumption, minimize environmental impact and enhance overall system performance.

Power crises have become a major national problem in Bangladesh. 97.5% of total power, is generating from burning fossil fuels which are polluting air, land, water and damages organic environment gradually whereas, only 2.5%of power is generating from renewable sources (hydro, solar, biogas, biomass and wind) (Ahmed et al., 2020). Bangladesh is now looking forward to develop its renewable energy sources in addition to its traditional sources of fossil fuels as a country of acute power crisis. Bangladesh is such a country which bestowed with solar energy potential which is the largest source of renewable energy. The generation of solar power will not only reduce the grid electricity but also fulfill the government's social commitment. Bangladesh is facing some serious problems in producing solar power for acquiring land to establish solar park because being an agro-based country most of its lands are used for agricultural purpose. It has become necessary to set up renewable energy based local power sources for shopping malls, different large institutions, factories, airports, railway stations rather than depending on national centralized power grid (Laskar, 2017). Bangladesh is a very wet country, receiving on an average about 2,200 millimeters (mm) of rainfall per year. There is a huge scope to insert greener sources of water and energy at rail stations since railway system occupied more land and infrastructures.The acquisition of a photovoltaic system (solar energy) for alternative source of energy and rainwater harvesting for non-contact uses water supply is suitable to meet the goal of reducing water and the energy cost, particularly through more sustainable sources (Carneiro et al., 2022). The rooftops of railway stations (spanning 1.5 million sft.) and other establishments (3.45 million sft.) of Bangladesh Railway across the country may be used to set up solar plants and catchment area for rainwater harvesting. The produced electricity will be consumed by railway for its own purpose first and then sale the extra or unconsumed one to the national grid. Rainwater can be used for different purposes of potable and non-potable applications like drinking, cleaning of trains, flushing toilets, gardening, washing etc. In this research, an attempt will be untaken

to evaluate the existing Water & Energy efficiency of Khulna and Ishwardi Railway Stations and provide some sustainable approaches for its further upgradation. This research will also reviews the platform services of water and sanitation facilities for passengers and other stakeholders at those railway stations.

2. METHODOLOGY

This study is a cross-sectional study conducted at a divisional station in Khulna and a junction station of Ishwardi among the stations in the West Zone of Bangladesh Railway. Both qualitative and quantitative approaches were followed in this study. The selections were made according to the administrative class as the social and economic evaluation.

Figure1: Khulna Railway Station

Figure 2: Ishwardi Railway Station (Junction)

The analytical research was addressed in three stages, as shown in the following Figure 3. First, an assessment of those stations current situation were done considering water and energy efficiency including buildings, service, and sustainability. Second, evaluated the water and energy efficiency of those stations. The third stage, selected measures to upgrade the water and energy efficiency of those stations.

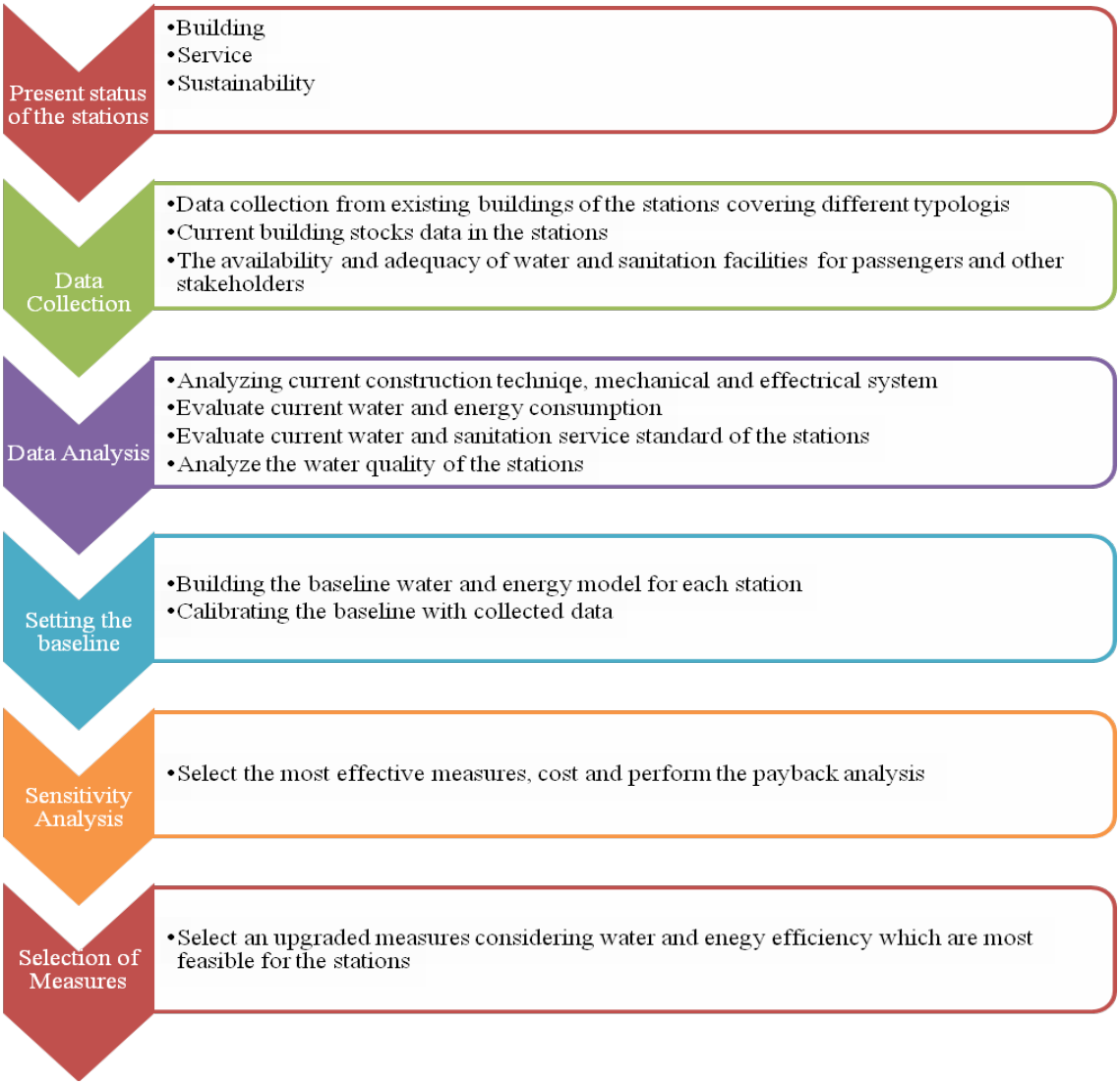

Figure 3: Flow chart of Methodology

To evaluate the water quality at stations, water samples from available sources were collected to analyze for Arsenic, Manganese, Iron, Total coliform, Faecal coliform, Hardness, pH, Conductivity, Color, Turbidity and Chloride according to standard procedures. For the validity of the study, people concerned with rail stations of different aged, professions, passengers were selected for conducting the survey. The physical specifications of both of the stations were taken. For the qualitative part, Key Informant Interview (KII) of high-level personnel of Bangladesh Railway, expertise on alternative sources of water and renewable energy options were done using the purposive sampling method. The primary data were collected through a semi-structured questionnaire. The physical data of both stations were also collected. Economic and social data were collected through face to face structured questionnaire survey. Additionally, the existing environmental and technological condition through the analysis of the present condition of engineering facilities and energy sources and consumption for power supply at those stations were observed. Whereas, the secondary data were collected from the Head office of West Zone, Rajshahi, journal papers and relevant literature. To evaluate the stakeholders' satisfaction with water use and sanitation service of railway stations a hybrid approach combing SERVQUAL and Analytical Hierarchy Process (AHP) was used (Alam and Mondal, 2019). The collected data were also analyzed using Microsoft Excel and then were presented in tables, figures, graphs, and charts as well as a written script. To analysis the water quality in laboratory, Weighted Arithmetic Water Quality Index method were used for Water Quality Index (WQI) value.

3. RESULTS AND DISCUSSION

3.1 Information of Khulna and Ishwardi Railway Stations

Bangladesh railway sector is important to the country's economy and its infrastructures are developing day by day through huge investment to improve its operational efficiency, safety and to make the railway system sustainable. Recently, with the rapidly growing awareness of achieving environmentally sustainable development, railway stations have played a crucial role in the operation of country's transport systems. The information of infrastructures of Khulna and Ishwardi railway stations are given in table 1.

Table 1: Information of Khulna and Ishwardi Railway Stations

Particular	Khulna Railway Stations	Ishwardi Junction Stations
Station building	03 storied building, constructed in 2018, has area of 33,250 sft. (approximately)	01 story ancient buildings, has area of total 7,200 sft. (approximately)
Platform	03 nos. platform, each area 36000 sft. (1200' x 30') (approximately)	04 nos. platform, each area 21000 sft. (approximately)
Workshop	02 nos. workshop covered by steel sheet, area 5700 sft.	Yes
Parking	Yes, more than 150 nos. car can park	Yes
Park/Recreational area	Yes	Yes
Open area	Yes	Yes

3.2 Water Consumption Scenario

It is the responsibility of Railway authority to arrange supply adequate quantity of water of acceptable quality to the Railway station premises for passengers and stakeholders. To discharge this responsibility, it is essential to assess the requirements of water supply. As per Indian Railways Works Manual (IRWM), the sector wise total requirement of water are given in table 2.

Table 2: Sector wise Water Requirement at Station as per IRWM

Particulars	Demand (liters per day)
Office and workshop	
Office	45 per capita
Workshops	30 per capita
Station and Platform	
Platform washing	5 per m^2
Passengers on Railway station	25 per Passerger
Washing of Carriages on washing line	3600 per carriage Broad Gauge
Cleaning of Carriages on Platform	500 per carriage
Carriage watering	As per actual

As per Indian Standard, (Code of Basic Requirements for Water Supply, Drainage and Sanitation, 4th Revision, IS 1172 : 1993), the requirements for water supply at terminal stations is 45 lpcd without bathing facilities and at junction station and intermediate station where mail or express trains stop is 45 lpcd without bathing facilities.

Table 3: Water Scenario at Khulna and Ishwardi Stations

Particular	Khulna Railway Station	Ishwardi Junction Station
Sources of water	Ground water	Ground water
Treatment plant for drinking water	Available (established by WaterAid, an international NGO)	No
How does water store	Overhead tank	Overhead tank
Capacity of ovehead tank	2,00,000 liter	2,00,000 liter
Supply system	Pumping and piping	Pumping and piping
Waste water disposal system	Drain to Municipal line	Drain to Municipal line
Availability of septic tank	Available	Available

As water has become a limited resource, it is required to evaluate the water being consumed by all types of the buildings including railway station. Total 11 nos. of trains (6 nos. Intercity and 5 nos. Mail/Express) departs and arrives daily at Khulna station. If it is considered 10 nos. carriages (coach) per train, 105 seat per carriages, then the total requirement of water at Khulna station per day as per Indian Standard (IS 1172 : 1993) is 5,19,750 liters (105 seats x 10 carriages x 45 lpcd x 11 nos. passenger train x 01 way). Simillarly, the total requirement of water at Ishwardi Junction Station per day as per Indian Standard (IS 1172 : 1993) is 9,45,000 liters (105 seats x 10 carriages x 45 lpcd x 20 nos. passenger trains that passes Ishwardi Junction Stations everyday).

3.3 Rainwater Harvesting System: an Upgraded, Water Efficient and Sustainable Approaches

Water efficiency refers to the decrease in the usage of water as well as decrease in the wastage of water. Wastage of water or its extra usage leads to drawing out of more water from the fresh water resources, resulting in their depletion. Thus, water efficient technologies have been developed to conserve potable as well as non-potable water and to ultimately save the already limited fresh water resources. Water efficient technologies in buildings include rain water harvesting, recycling and reuse of grey water and water saving fittings and fixtures. The major water saving is done by rain water harvesting. Traditionally, rainwater harvesting systems have been used in arid and semi-arid areas for

Figure 4: The simplified path of rainwater harvesting

potable and nonpotable use of water. Bangladesh is a very wet country and there is a great opportunity to harvest rainwater as greener source since rail stations have huge catchment area. Rainwater can be used at railway station for different purposes of potable and non-potable applications like drinking, flushing of toilets, platform washing, carriage watering for train's toilet, washing of carriages on washing line, cleaning of carriages on platform, gardening, fire fighting, cooking at restaurants and other use at shops, etc.

3.4 How Much Water Can Be Harvested?

The quantity of water that runs off a roof is usually calculated using the following equation (Ahmed and Rahman, 2000):

$$Q = C \times I \times A,$$

where Q is the quantity of rainwater that runs off in m^3/year, C is the runoff coefficient of available runoff, I is the total rainfall intensity (m/y) and A is the roof area or the catchment area (m^2). Since C is 0.8 (as adopted for this study), I is 1809 mm/y (1.809m) (for Khulna district) and A is 13,587 m^2 (33250 sft.+36000 sft. x 3 nos. +5700 sft. = 1,46,200 sft. = 13,587 m^2), the quantity of water (Q) that runs off (supply) at Khulna station is 19,663 m^3 /y (≈1,96,63,000 L/y). Thus the amount of water that can be harvested is 53,871 L/day. Similarly, the amount of water that can be harvested at Ishwardi station is 37,912 L/day. As per Indian Standard (IS 1172 : 1993) the total requirement of water at Khulna and Ishwardi station per day is 5,19,750 liters and 9,45,000 liters respectively. However, assuming four months as the rainy season, the amount that can be harvested during this period is

53,871 × 30 × 4 = 64,64,520 L for Khulna station and 45,49,440.00 L for Ishwardi station which is enough to use water as alternative source.

Average Normal Rainfall in mm

St_name	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Dhaka	7.7	28.9	65.8	156.3	339.4	340.4	373.1	316.5	300.4	172.3	34.4	12.8
Ishurdi	8.1	21.5	30.8	95.0	206.3	288.6	335.6	261.2	282.8	98.1	17.4	10.8
Bogra	8.7	15.2	20.1	80.5	222.0	343.8	406.1	285.3	310.1	126.9	13.1	11.3
Rangpur	9.3	11.8	24.5	104.0	294.4	417.4	464.8	376.1	383.0	132.1	10.5	7.9
Dinajpur	12.3	10.5	11.3	67.1	232.5	335.3	433.6	387.7	383.8	115.1	7.0	10.2
Sayedpur	12.6	6.5	22.7	94.1	221.7	435.2	350.0	350.0	456.3	139.7	11.8	6.7
Khulna	13.3	44.4	52.1	87.5	200.0	335.6	329.8	323.5	254.7	129.8	32.1	6.6
Country	9.0	25.5	52.4	130.2	277.3	459.4	523.0	420.4	318.2			

Figure 5: Average monthly rainfall data in Bangladesh (Source: Bangladesh Metarological Department, cited on 02.01.2024).

3.5 Energy Consumption Scenario

The concept of energy efficiency refers to the ability to get the best results in any given activity by utilizing the least amount of energy resources possible. It enables us to reduce the consumption of any type of energy including the associated environmental impacts. This is applicable from production to consumption of energy. Energy (Electricity) required at a railway station are lighting of stations, offices, platform, parking, workshop and other areas; Pumping, Communication system; Sign and Signaling; Activation of different manchine, Air conditioning etc.

Table 4: Energy Scenario at Khulna and Ishwardi Stations

Particular	Khulna Railway Station	Ishwardi Junction Station
Main Sources of Energy	Electricity	Electricity
Alternate source of energy supply	Generator	Generator
Availability of Solar panel	No	No

3.6 Solar Power, a Renewable Energy Resource at Railway station

Obviously, the sun is the ultimate source of energy. Solar energy is available everywhere in the planet. The rapid decline of hydrocarbon fuels which is being used for power production forces us to find an alternative and effective source for electricity generation. However, achieving such a significant generation of power from hydrocarbon fuels like gas, coal or oil is also challenging due to their high cost, limited availability and environmental concerns and including the effect of rapid depletion of foreign reserves due to purchase those fuels.

Figure 7: Bangladesh largest solar power plant, 200 megawatts (MW) at Sundarganj in

Gaibandha district on a 650-acre plot of infertile land inaugurated in 2023

While electricity can be produced from non hydrocarbon fuels sources like solar power as renewable resources due to their wide availability in Bangladesh. As railway stations acquire more land and have also more infrastructures, so there is as great scope to insert solar power at station in order to mitigate land problem to establish solar park, being an agro-based country most of its land is used for agricultural purpose. Once such rooftop solar power projects are implemented at railway stations in Bangladesh huge amount of electricity will be produced annually which create station energy efficent and sustainable.

3.7 How Much Energy Can Be Generated?

There are two ways to use solar energy. The first is photovoltaic, while the second is solar thermal power. The power of the Sun on the Earth, per square meter is called the solar constant. Bangladesh is one of the country where the sun heats the surface all the year round and hence has a large solar power capacity. The average value of solar constant in Bangladesh is 4.36 Kwh/m^2. Solar panels are rated by the amount of power they can produce in ideal conditions, typically around 1,000 watts per square meter per hour. However, in real-world conditions, they usually only produce 200 to 300 watts per square meter per hour considering all types of losses. The total roof area of Khulna railway station is 13,587 square meter, once solar panels are installed at the roof, total 3.39 MW/h electricity will be generated (considering solar panel production capacity 250 W/m^2) daily. Similarly, the total roof area of Ishwardi railway station is 8,476 square meter, total generated electricty will be 2.11 MW/H daily which is much more enough to use solar power as alternative source.

4. CONCLUSIONS AND RECOMMENDATION

This paper presented a methodology to implement a sustainable consumption approach of water and energy in the railway stations. Water and energy is a finite resource. With the increasing population and living standards, water and energy issues are becoming more crucial and challenging throughout the world with passage of time, but the resources are remains constant. Water and energy efficiency may helps us to preserve our resources alive for future generations. The per capita consumption of water and energy will be reduced signigicant amount by harvesting rainwater and using solar energy at railway stations. Switching to renewables is not a matter of ideology; it can offer a wide range of benefits including improving ‘Green’ credentials; lowering energy bills; introducing the possibility of selling electricity back to the national grid; increasing the security of energy supply by minimizing the reliance on fossil fuel. The implementation of rainwater harvesting can help to meet new standards of energy and water efficiency ratings and codes that are being developed in communities and also help to gain the water-energy nexus benefit in railway stations.

This research can be used as a starting point towards more detailed research in the development of energy efficient and fresh water resourceful railway stations. As technologies improve from day to another, there is always room for improvement, the investigation could be further extended to investigate the impact of

- The need for a long term commitment from the Government to promote energy efficient and water resourceful railway stations
- Better end-use analysis needs to be undertaken in order to know what progress is being made on improving those provisions
- Certification needs to be implemented in parallel with effective information campaigns to explain to the wider public
- The certification programme should be designed to help construct and maintain end-use databases to help in the policy analysis.

The findings of this paper may be useful to the railway authoirty, public or other private institutions for future study in order to establish more efficient railway stations considering water and energy cosnsumption. Finally, this work may contribute to achieve the goals of UN agenda

2030, mainly to the Sustainable Development Goals 6 (Clean water and sanitation) and 7 (Affordable and Clean Energy).

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