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Comparative Hospitality Eco-profiles of two Nature-rich Locations of the Indian Sundarbans

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Abstract

The hospitality sector comprising different types of tourist accommodations is an integral part of the tourism industry. In light of climate change concerns, sustainable development, and responsible behaviour, these accommodation establishments like hotels, lodges, and guest houses need to commit to the wise use of environmental resources like land, air, water, and energy. Efficient management of Carbon emissions, consumption of fresh water, and fossil fuel-based energy are imperative to ensure their resilience and acceptable environmental performance. This requires meticulous study and assessment of these parameters leading to the hospitality eco-profiling of a particular destination. This paper aims to present the baseline eco-profiles of the tourist establishments of both Jharkhali and Bakkhali - the two nature-based destinations of the Indian Sundarbans. The result is visualized in the form of a comparative eco-profile diagram for these two locations. The methodology involves the selection of parameters, field data collection through primary survey in the two locations, multi-stage documentation in predefined formats, and finally, computation of the values of the parameters. The seven parameters selected for comparison and their respective units are total bed capacity in numbers, average built-up area/lodge in m^2, user water intensity in litres per head (guest) per day (lphd), water consumption index in kl/m^2/year, energy performance index in kWh/m^2/year, the capacity of captive electricity generator in kVA, and Carbon emission in kgC/m^2/year. It was found that Bakkhali being a more mature destination with greater tourist visitations has much higher values for most parameters than Jharkhali. This first-ever eco-profiling exercise for the hospitality establishments in these two eco-sensitive tourist destinations is expected to help in monitoring the environmental performance of each hospitality unit, and also act as a reference for developing a regulatory framework and environmental management plan for the ecologically fragile Indian Sundarbans by the tourism administrators, planners and managers.

Keywords: *Environmental footprint of hospitality buildings, Carbon emission, energy performance, water consumption index, user water intensity, sustainable development goals*

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Introduction

Travel and tourism are intrinsic human activities that also contribute to local and regional economy. The hospitality sector comprising of lodging and accommodation (NBC, 2016) is a tourism product with significant share in tourism consumption. This sector is also highly resource intensive with substantial use of fossil-fuel based energy and fresh water, causing depletion of finite resources. This turns critical in the context of nature-rich geographical locations that are environmentally sensitive. Understanding the extent of resource usage by the lodging establishments, therefore, becomes an overarching need in such locations. Assessment and monitoring the energy and water consumption scenarios can aid in applying necessary control over tourism growth.

This paper intends to map the energy and water resource consumption patterns of the hospitality buildings in two nature-based tourist destinations in the Indian Sundarbans, named *Jharkhali* and *Bakkhali*. The toponym '*~khali*' is derived from the word '*khal*'- a vernacular word that stands for a creek or canal. Both are set in the island geography of the deltaic region of lower West Bengal in eastern India (fig.1), crisscrossed with tidal creeks. The Indian Sundarbans is a world heritage site of natural category, inscribed in 1987 and has the world's largest mangrove forests traversed by tidal waterways and estuaries (WHC, 1987). *Jharkhali* Island overlooks a tidal river in the interior of the island system while *Bakkhali* directly faces the Bay of Bengal, with its sandy beach as the main tourist attraction. These two locations are marked in figure 2.

Figure 1. Location of the Indian Sundarbans
(Source: World Heritage Convention, UNESCO)

Jharkhali on the other hand draws tourists for the wild animal's park located in the village named Lot no. 126 at the southernmost end of the Island. The lodging facilities and hotels are concentrated well within one km landward from the park and are located within the village, mostly constructed from 2013 onwards. The history of Jharkhali tourism dates back to 1983 when a small wooden cottage was built by the Government as the only accommodation there.

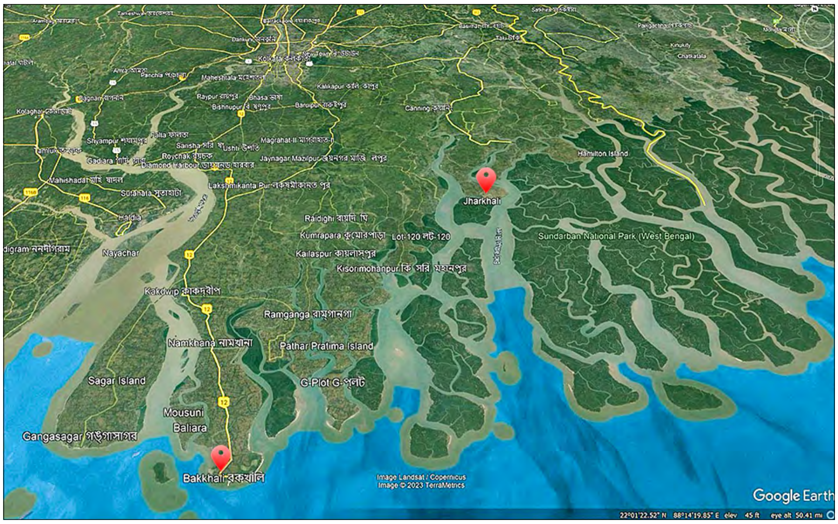

Figure 2. Location of Jharkhali and Bakkhali within the Indian Sundarbans region
(Source: Google Earth)

Unlike *Jharkhali*, Bakkhali started a decade early and 'developed' fast with a higher tourist footfall, reciprocated by a multitude of multi-level accommodations.

The major tourism characteristics of the two locations are given in table 1.

Table 1. *Comparative tourism and hospitality characteristics of Jharkhali and Bakkhali*

Jharkhali	Bakkhali
i. Latitude-Longitude - 22°1'9.18" N and 88°40'59.27" E. ii. Wild-life based tourism, located in a river side village named Lot no. 126, Basanti Block. iii. The wild animal's park is the main attraction, along-with boat ride. iv. Tourism began in 1983 with a small Government lodge. v. Tourism is mostly seasonal and remains active for six months in a year- October to March, peaking up in December-January. vi. There are 16 lodges with a total of 368 bed capacity, as of 2019. vii. Tourist traffic volume and flow as obtained from West Bengal Tourism Development Corporation Limited (WBTDCL) indicate steep rise in visitations and consequently, in the number of lodging facilities. viii. The lodges vary in scale and are mostly small- to medium capacity, with the smallest homestay having six beds, as in 2019. ix. Average built up area of the tourist lodges - 154 m^2 (42.35 m^2 min., 500 m^2 max.) x. The total hospitality building stock is of 5743.78 m^2 built-up area and about a half of the stand-alone lodges are double storied.	i. Latitude-Longitude -21°33'32"N and 88°15'59"E. ii. Coastal tourism, overlooking the Bay of Bengal and located in a sea-side village named Amrabati, Namkhana Block. iii. The sandy beach is the main attraction. iv. Tourism began in the early 1970's with a medium sized Government lodge followed by few private establishments. v. Tourism remains active throughout the year, peaking up during the weekends and holidays. vi. There are 27 lodges of 1705 bed capacity, as of 2019. vii. Tourist traffic volume and flow as obtained from WBTDCL indicate steep rise in visitations and consequently, in the expansion of existing facilities as well as new lodges. viii. Almost all the lodges are medium to high-medium capacity. ix. Average built up area of the tourist lodges- 239 m^2 (70 m^2 min., 659 m^2 max.) x. The total hospitality building stock of Bakkhali is of 16574.5 m^2 built-up area. Majority of the lodges are four to five storied, with large plinth areas and elaborate appearance, lending an urban character to the area.

Source: Field survey

Literature Review

Natural areas possess inherent biotic and abiotic qualities that attract visitors for fulfilling the most common aims of tourism - leisure, recreation, and holidaying. It has been reported that this purpose is the highest among all tourism intents and elicits 55% of tourist visits. Resource management and responsible tourism are critical for sustenance of nature-based locations as these are environmentally sensitive (Han et al., 2016). Farmland or vegetated Greenfield land, freshwater, food systems, and energy are the primary resources that collectively dictate destination attractiveness, which in turn influence favourable tourist experience, satisfaction, and revisit intentions (Chaudhary, Islam, 2020).

Tourist accommodations in natural areas are necessary infrastructure that consume these resources in varying degree. The formal accommodations are designed buildings purpose-built as lodges, guest houses, hotels, and resorts. These are commercial in typology, operating 24x7 and are known to be energy and water intensive, particularly during their operational phase. The World Travel and Tourism Council's Hotel Sustainability Basics Toolkit (WTTC, 2022) has acknowledged these concerns and included measuring and reducing energy (criterion 1), water (criterion 2) and Carbon emissions (criterion 4) in their framework. Mapping the energy and water intensity of these facilities and expressing these in measurable terms constitute the process of eco-profiling. Eco-profiling of hospitality establishments, thus, has dimensions that relate to environmental management (Muhanna, 2006), environmental certification (Bruzzi, 2014), low carbon economy (Legrand et al. 2014), green policy adoption in hotels (Bagur-Femenias et al., 2016), and sustainable development goals as well as practices (Nwokorie, Obiora, 2018).

The energy and water related literature reviews are presented separately in the following sections:

Energy consumption and CO_2 emission:

According to the International Energy Agency (IEA), the operational phase of buildings account for 30 percent of global final energy consumption and 26 percent of global energy-related emissions (8 percent being direct emissions in buildings and 18 percent indirect emissions from the production of electricity and heat used in buildings), where the energy sector CO_2 emissions include emissions from energy combustion and industrial processes (IEA, 2023). The IEA also mentions that globally, the building sector energy use has increased by around 1% in 2022. The United Nations Environment Program (UNEP) had earlier assessed that the building sector in general is responsible for 40 percent of energy use, 30 percent of solid waste generation, 20 percent of fresh water use, and 40 percent of CO_2 emissions in its entire lifespan (UNEP, 2006). Energy monitoring and reporting is the beginning of any energy management plan and a basic requirement for environmental standards (Styles et al., 2013). Lack of understanding in energy performance and management in buildings is a major obstacle in achieving the target of energy efficiency and renewability (SDG 7) of the United Nation's **Sustainable Development Goals** (SDG17 - 1. No poverty, 2. Zero hunger, 3. Good health and well-being, 4. Quality education, 5. Gender equality, 6. Clean water and sanitation, 7. Affordable and clean energy, 8. Decent work and economic growth, 9. Industry, innovation and infrastructure, 10. Reduced inequalities, 11. Sustainable cities and communities, 12. Responsible consumption and production, 13. Climate action, 14. Life below water, 15. Life on land, 16. Peace, justice and strong institutions, 17. Partnerships for the goals) as *'energy is the dominant contributor to climate change,* *accounting for about 60 percent of total global greenhouse emissions'* (United Nations, 2015), which also finds reflection in the United Nations World Tourism Organization (UNWTO)'s Tourism for SDG.s (T4SDG). UNWTO has held hotels and other accommodations accountable for 2 percent of the 5 percent of the global CO_2 emitted by the tourism sector (UNWTO, 2020). To address this challenge, UNWTO's Hotel Energy Solutions (HES) stresses on a hotel's energy usage assessment for effective energy management (HES, 2011) and possible energy solutions (UNWTO, 2020).

Energy required for building operations can constitute as high as 80% of their life cycle energy consumption (Lai et al., 2019) and electricity is the most common source of energy accounting for about 84% of total hotel energy consumption (Wang, 2012), contributing to greenhouse gas emissions. The share of energy sources varies in hotels. A study on hotels in Spain (Perez et al., 2016) reported 67% energy dependence on electricity, 11% on diesel oil, 18% on liquefied petroleum gas (LPG), and 4% solar power. Energy may be sourced from direct on-site fuel consumption and/or purchased electricity to operate its multiple sub-systems such as space conditioning, food preparation, utilities etc. (Bardhan, 2022). These sub-systems as energy end uses and their share in energy consumption reported by some studies are given in table 2.

Table 2. *Share of energy end uses in a hotel*

<table>
<tr><th rowspan="2">Energy end uses</th><th colspan="7">Share in energy consumption as reported by different studies</th></tr>
<tr><th colspan="2">Ivanovic et al., 2015</th><th colspan="2">US Energy Information Administration, 2018</th><th>Patwarya et al., 2020</th><th colspan="2">Orynycz, Tucki, 2021</th></tr>
<tr><td>Heating</td><td>17%</td><td rowspan="3">29%</td><td>32%</td><td rowspan="3">52%</td><td rowspan="3">56%</td><td>33%</td><td rowspan="3">61%</td></tr>
<tr><td>Cooling / Air Conditioning</td><td>6%</td><td>9%</td><td>20%</td></tr>
<tr><td>Ventilation</td><td>6%</td><td>11%</td><td>8%</td></tr>
<tr><td>Lighting</td><td colspan="2">10%</td><td colspan="2">10%</td><td>14%</td><td colspan="2">12%</td></tr>
<tr><td>Refrigeration</td><td colspan="2">16%</td><td colspan="2">5%</td><td>-</td><td colspan="2">-</td></tr>
<tr><td>Office equipment</td><td colspan="2">1%</td><td colspan="2">1%, computing 4%</td><td>5%</td><td colspan="2">4%</td></tr>
<tr><td>Miscellaneous</td><td colspan="2">Water heating 16%</td><td colspan="2">Water heating 5%</td><td>Hot water 3%</td><td colspan="2">Hot water 18%</td></tr>
<tr><td>Other</td><td colspan="2">4%, Cooking 24%</td><td colspan="2">16% , cooking 7%</td><td>Kitchen equipment 11%</td><td colspan="2">Cooking 5%</td></tr>
</table>

The share of space-conditioning ranges from 29%- 61%, food preparation ranges from 5%-24%, refrigeration varies between 5%-16%, water heating between 3%-18%, while lighting energy requirement is more or less consistent between 10%-14%. These variations are due to differences in location, climatic factors, user preferences, behaviour, and awareness, and in-house energy management strategies.

The energy consumption in hotels can be stated as energy consumed per unit built-up area of the building in one year (Styles et al., 2013, 36). This is the annual operational energy giving a measure of the building's energy performance and, hence, is termed as Energy Performance Index (EPI) or the Energy Use Intensity (EUI), expressed as kilowatt-hour per metre-square per year or 'kWh/m^2/year'. Energy consumed may also be assessed in relation to a tourist staying overnight at the hotel instead of its built-up area and may either be expressed as kWh/guest-night (one guest for one night) or as kWh/guest room/year (Wang, 2012).

Water consumption

Fresh water is a crucial resource that aligns with SDG 6 (Clean water and sanitation for all) as well as public health (SDG 3- good health and well-being). Water consumption in hotels is still not considered as seriously as its energy counterpart (Pure Blue, 2020) and studies in this field are relatively at nascent stage. A UAE study assessed the daily average water usage per hotel room to be ranging from 100-400 gallons (100 gallon = 378.54 litre), which is many times the domestic water consumption standard (Pure Blue, 2020). Water usage is more commonly expressed as litres per person per day and may vary from 150 litres to 780 litres per person per day (Orynycz, Tucki, 2021), varying with the location, the climate characteristics, and the star category of the hotel.

The percentage break-up of water consumption of different activities in a hospitality set-up as reported by two studies have been represented in table 3. The study of a large-scale five-star city hotel in Central Europe (Orynycz, Tucki, 2021) assigned 30% of total water usage on account of guest rooms and 45% together for laundry and kitchen services. Another study by a European plumbing corporate (IDRAL, 2022) shows that the guest room water usage (54%) in a medium sized hotel substantially surpasses its laundry and kitchen services (33%).

Table 3. *Share of water end uses in a hotel*

Water end uses	Share in water consumption as reported by different studies	
	Orynycz, Tucki, 2021	IDRAL, 2022
Heating/ steam generation	18%	4%
Cooling		9%
Guest rooms + restrooms	30%	(37%+17%) = 54%
Laundry/ cleaning	20%	12%
Kitchen/ Dishwashing	25%	21%
Landscaped gardens	7%	(Pool 2% + others 7%)= 9%

Although there are multiple factors influencing the share of water end use in a tourist accommodation, the table 3 indicates that it is possible that the share of the services and utilities (kitchen, laundry, and others) increases with its star-category, number of guest rooms, and high occupancy rate as the demands on the quantity and quality of services also rises.

Sustainable Hospitality Alliance (2021) has devised a toolkit to assess the water consumption under its Hotel Water Measurement Initiatives (HWMI) and considers metered and unmetered water supply. The unit of measurement is litres. It covers both direct building uses and ancillary activities such as restaurants, laundry, back of house, landscaped garden areas, and outsourced operations, such as laundry, if any. The metrics are total water withdrawn (in litres), total guest room use (in litres per year), total water use per occupied room (in litres per room per night), and water use per guest (in litres per guest per night (guest-night)). The exclusions are bottled water, recycled water, and harvested water, among some more. In India, the National Building Code (NBC), 2016 recommends 180 litres per head per day (lphd) for hotels of up to three-star and 320 lphd for four-star and above, excluding the water used for staff, kitchen, laundry and water features. NBC also specifies water requirement standard for restaurants as 70 litres per seat, including that of kitchen. The NBC standards help to estimate the water demand in a 'proposed' hotel and design its water infrastructure accordingly.

In all the literature studies, water is expressed in terms of litres per guest or guestroom, and either per day (or night) or per year basis.

Aim, objectives, and scope

The aim of the paper is to compare the environmental footprint of the ever-expanding hospitality sectors in Jharkhali and Bakkhali of the Indian Sundarbans for the larger purpose of examining their SDG alignment or lack of it.

The objectives to fulfil this aim are:

- To understand the hospitality scenario at these two locations by recording the number, size, and scale of the lodges, their area data, and guest-nights
- To assess and generate baseline data on energy consumption of the lodges with respect to electricity and on-site fuel consumption
- To assess and generate baseline data on fresh water consumption of the lodges in these two locations
- To present the aforementioned assessments in the form of environmental footprints for these two locations, termed as their eco-profiles
- To compare the eco-profiles of these two locations

The scope of the paper:

The environmental footprint will give an idea of the eco-profile of the hospitality establishments in Jharkhali and Bakkhali operating as in 2019 in these two tourist destinations and is based on the following seven chosen parameters:

i. total bed capacity in numbers,
ii. average built-up area of the hospitality establishments in m2,
iii. energy performance index (EPI) in kWh/m^2/year,
iv. Carbon footprint in kgC/m^2/year
v. capacity of diesel generator in kVA, and
vi. water consumption index (WCI) in kl/m^2/year,
vii. user water intensity (UWI) in litres per head (guest user) per day (lphd),

Electricity and on-site fuel consumption based EPI and their corresponding CO_2 emissions have been assessed. Use of other energy sources in the accommodations such as liquefied petroleum gas (LPG) has not been considered here. Natural gas supply is not applicable in these locations.

Drawing parallels with the EPI/ EUI calculations, this paper has expressed the water consumption in two different ways:

i. Water Consumption Index (WCI)

Water consumed per unit built-up area of the building in one year. This is the annual operational water consumed by the hotel and the term Water Consumption Index (WCI) has been used to describe this metric. It is expressed as kilolitres per metre-square per year (kl/m^2/year).

ii. User Water Intensity (UWI)

Water consumed per tourist per day for overnight stay in the hotel, i.e. for a guest-night and may be expressed as kl/guest-night. In this paper, the unit of daily water consumptions by guests is taken as litres per head per day (lphd) for easy comparability with the National Building Code of India, 2016 standards and termed as User Water Intensity (UWI). This UWI may be used across all building typologies in other water related research works.

Methods and methodology

The methodology involves field data collection through primary survey in both the locations of *Jharkhali* and *Bakkhali*, for multi-stage documentation in predefined formats, including questionnaire survey and interviews with the lodging staff. The required information comprised of area and capacity data, energy data and water data, as shown in figure 3.

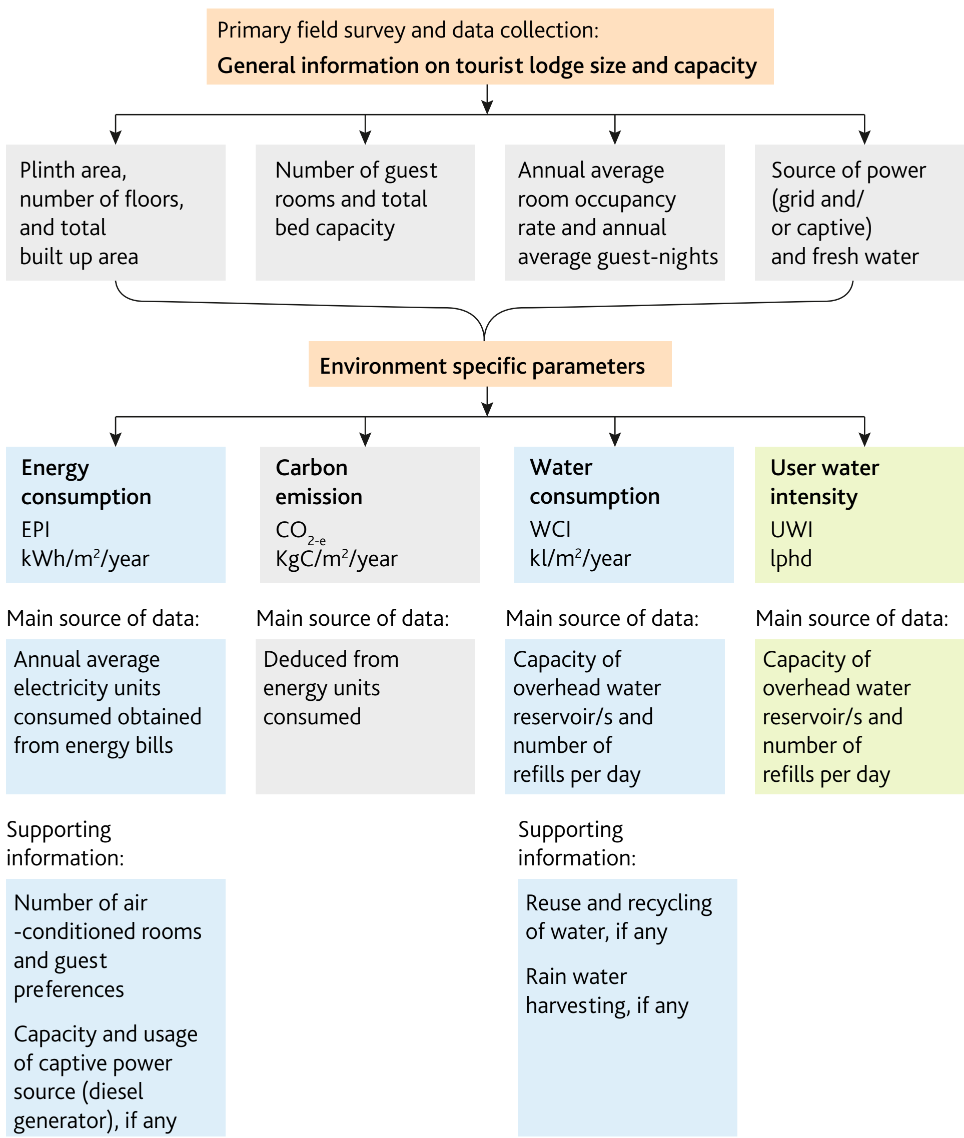

Figure 3. Methodology flow diagram

Computational steps for energy, Carbon emission, and water intensity assessments

The area and capacity data, energy data and water data for the 16 tourist lodges of Jharkhali and 27 tourist lodges of Bakkhali were collected, classified, and analysed using spreadsheets based on field visit and inspection, observation, and questionnaire survey. The data was cross-verified and validated from multiple sources.

As evident from the methodology flow chart, 14 set of information for 43 different tourist lodges generated a large amount of data. This required a structured step-by-step approach for assessing the environmental performance of the hospitality segment in the two locations. The detailed methods used for calculation of the four basic environmental parameters- energy, CO2e footprint, water footprint for building, and water footprint per guest are explained in the computational steps below.

The hospitality establishments or tourist lodges in both Jharkhali and Bakkhali are connected to electrical grid but switch over to diesel generators (DG) during disruptions. The total EPI has been computed by summing up the two components of energy consumption in the lodge in a typical year:

i. Electrical energy supplied through grid – information sourced from their energy bills
ii. Direct on-site use of diesel as back-up energy supply – information on power rating of diesel generators and hours of operation collected through primary survey. This diesel-oil based energy was calculated by applying a Power Factor of 0.8 (Bose, Bardhan, 2021)

Step 1-A: Calculation of the total annual energy consumption by a lodge (kWh/year)

Electrical $En_{lodge\text{-}1}$ = annual electricity-based energy as per energy bills (1a)

Diesel $En_{lodge\text{-}1}$ = average annual electrical units generated in the diesel generator (1b)

Total annual energy consumed by lodge-1:

ΣEn_1 = (Electricity $En_{lodge\text{-}1}$ + Diesel $En_{lodge\text{-}1}$) (1c)

Step 1-B: Calculation of the Energy Performance Index of the lodge (kWh/m²/year)

∴ Energy Performance Index (EPI) of lodge-1:

$$EPI1 = \frac{\sum En1}{A_1} \quad (1d)$$

Where EPI_1= Energy Performance Index of lodge-1,
$\Sigma En1$ = Total annual energy consumed by lodge-1, and
A_1= Total built up area of lodge-1

Step 1-C: Calculation of the Mean EPI of all the lodges (mean kWh/m²/year)

∴ Mean Energy Performance Index of N number of lodges:

$$EPI\ Mean = \frac{\sum_{n=1}^{n=N} EPIn}{N} \quad (1e)$$

Step 2-A: Calculation of the total annual Carbon emission of the lodge (kgC/year)
The corresponding Carbon dioxide equivalent (CO_2e) or the amount of CO_2 which would have the equivalent global warming impact for any quantity and type of greenhouse gas, is also assessed against the tourist lodges' respective EPI.s based on the following:

- Greenhouse gas emission is 900 grams per kilowatt-hour of CO_2 equivalent for coal-based fossil fuel form of energy supply (IEEE, 2008).
  Electricity-based emission $CO_2e_{1\underline{E}}$ = (Electricity $En_{lodge\text{-}1}$ × 0.9) (2a)
- Greenhouse gas emission is 850 grams per kilowatt-hour of CO_2 equivalent for oil-based fossil fuel form of energy supply (*ibid*).
  Diesel-based emission $CO_2e_{1\underline{D}}$ = (Diesel $En_{lodge\text{-}1}$ × 0.85) (2b)

∴ Total annual Carbon emission by lodge-1:
$$\Sigma CO_2e_{lodge1} = (CO_2e_{lodge1\underline{E}} + CO_2e_{lodge1\underline{D}}) \quad (2c)$$

Step 2-B: Calculation of the annual Carbon footprint of the lodge (kgC/m²/year)

$$CO_2eFP_1 = \frac{\sum CO_{2e1}}{A_1} \quad (2d)$$

Where = CO_{2e} footprint of the lodge-1,
ΣCO_{2e1} = Total CO_{2e} emission by the lodge-1 in a year, and
A_1= Total built up area of the lodge-1

Step 2-C: Calculation of the Mean Carbon footprint of all the lodges (mean kgC/m²/year)
∴ Mean CO_{2e} footprint of N number of lodges:

$$CO_2eFP\ Mean = \frac{\sum_{n=1}^{n=N} CO_2eFPn}{N} \quad (2e)$$

Step 3-A: Calculation of the water consumption index of the lodge (kl/m²/year)
Fresh water is scarce in the Sundarban region and is availed by extracting ground water through bore wells from a depth of about 300-400 m. All the tourist lodges are dependent on such deep tube wells. The capacity of the overhead reservoir and the number of refills were noted for each lodge through the survey questionnaire. The volume of water used per day was calculated based on this and then translated into annual consumption.

Water Consumption Index (WCI) of lodge-1:

$$WCI_1 = \frac{V1 \cdot nR \cdot gN}{A_1} \quad (3a)$$

Where

- WCI_1= Water Consumption Index of lodge-1,
- V_1 = Total volume of the over-head reservoir/s of lodge-1,
- nR = average number of refills of the tank per day in lodge-1,
- gN = annual average guest-nights (Bakkhali-330 guest-nights/year; Jharkhali-220 guest-nights/year), and
- A_1= Total built up area of lodge-1

Step 3-B: Calculation of the Mean water consumption index of the lodge (kl/m²/year)
∴ Mean *WCI* of N number of lodges:

$$WCI\ Mean = \frac{\sum_{n=1}^{n=N} WCIn}{N} \tag{3b}$$

Step 4-A: Calculation of the user water intensity of a lodge (lphd)
User Water Intensity (UWI) of lodge-1:

$$UWI_1 = \frac{V_1 \cdot nR}{nG} \tag{4a}$$

Where
- UWI_1 = User Water Intensity of lodge-1,
- V_1 = Total volume of the over-head reservoir/s of lodge-1,
- nR = average number of refills of the tank per day in lodge-1, and
- nG = number of guests per day, based on average room occupancy rate of lodge-1

Step 4-B: Calculation of the Mean user water intensity of the lodge (lphd)
∴ Mean *UWI* of N number of lodges:

$$UWI\ Mean = \frac{\sum_{n=1}^{n=N} UWIn}{N} \tag{4b}$$

Results and Discussions

Since Jharkhali is relatively less frequented, guest nights were considered to be about 60% in a year, i.e., rounding it to 220 days/year. Bakkhali, as a popular and established destination with low seasonality, annual average guest nights were taken as 330 days/year. Annual average room occupancy rate of 60% was considered for Jharkhali, while the same for Bakkhali was taken as 80%.

Energy Performance Index of each of the lodges for the two locations were separately calculated following computational steps 1-A and 1-B. Corresponding annual CO_2e footprints were worked out following steps 2-A and 2-B. Water related footprints were assessed following steps 3-A and 4-A. The Mean values were computed by following steps 1-C, 2-C, 3-B, and 4-B. The results thus obtained against these metrics for Jharkhali and Bakkhali are presented in table 4 indicating their comparative eco-profiles.

Table 4. *Comparative mean values of the selected parameters for Jharkhali and Bakkhali*

Parameters	Jharkhali	Bakkhali
Average number of beds/ tourist lodge	23	63
Average built up area per tourist lodge	154 m^2	239 m^2
Mean Energy Performance Index (EPI) - energy footprint per lodge	65.46 kWh/m^2 /year	104.53 kWh/m^2 /year
Mean annual CO_2e emission –Carbon footprint per lodge	16.85 kgC/m^2 /year	59.2 kgC/m^2 /year
Maximum capacity of DG	10 kVA	162 kVA
Mean Water Consumption Index (WCI) - water footprint per lodge	2.59 kl /m^2/year	3.03 kl /m^2/year
Mean User Water Intensity (UWI) - water footprint per tourist	126.2 lphd	91.8 lphd

Source: Computation by authors based on primary survey data

Both EPI and WCI were found to be independent of the building area, making appliance efficiency and user behaviour more important for better environmental management. About 25% of the lodges in Jharkhali displayed higher user water intensity compared to the NBC standards. These lodges do not have elaborate kitchen and laundry facilities, hence the high water foot-print is a cause of concern and indicates fair scope and potential for better water management.

EPI studies of lodges in Bakkhali had earlier reported a range of 107.17 kWh/m^2/year and 198.68 kWh/m^2/year (Bardhan et al, 2010; Bardhan, 2012a) that support the present findings. Deployment of renewable energy, particularly, solar photo-voltaic and solar water-heating have immense potential in bringing down fossil-fuel based energy consumption and existing lodges would benefit from retrofitting (Bardhan, 2012b).

The comparative eco-profiles of Jharkhali and Bakkhali's hospitality segments are given in figure 4.

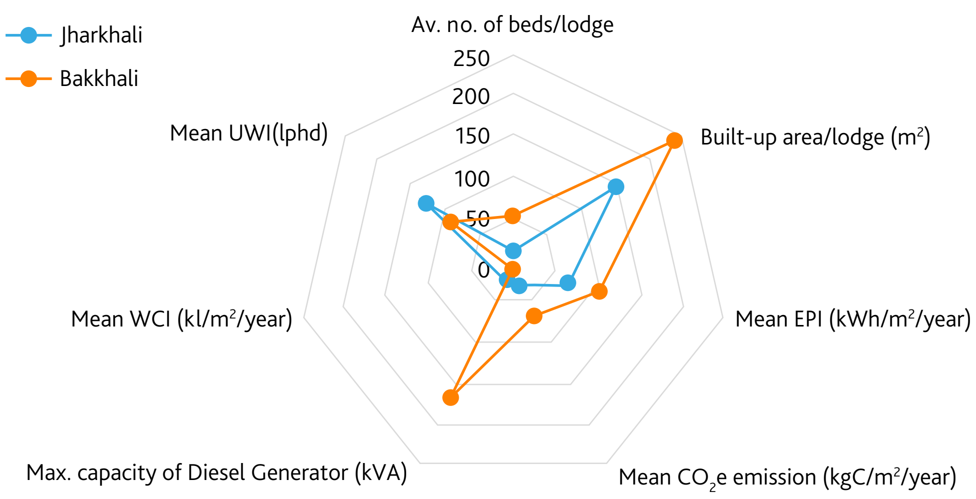

Figure 4. Comparative hospitality eco-profiles of Jharkhali and Bakkhali

Conclusion

The hospitality sector is known to be resource intensive, particularly during their operational period. For nature-based tourism in sensitive ecological belts, these twenty-four-hour operational buildings run additional risk of exceeding the sustainable limits of the region and degrading the inherent natural qualities leading to poor visitor experience. This paper presented the energy and water consumption patterns of the 16 tourist lodges in Jharkhali and 27 lodges in Bakkhali. The purpose is to inventorize the hospitality sector's eco-profile for long-term sustainable tourism. As expected, the hospitality's environmental footprint was found to be much intense in Bakkhali than in Jharkhali. The relatively dismal environmental performance of the Bakkhali facilities rests mainly in its higher tourist volume and guest nights consistently throughout the year. The warm humid weather conditions of this sea-proximal destination further aggravate the cooling energy demand.

This first-ever eco-profiling exercise for the hospitality establishments in these two eco-sensitive tourist destinations is expected to help in monitoring the environmental performance of each hospitality unit, and also act as a reference for developing a regulatory framework and environmental management plan for the ecologically fragile Indian Sundarbans by the tourism administrators, planners and managers. Appropriate building bylaws and design control rules need to be put in place so that energy and water- the two scarcest resources, are used wisely while keeping the emission under check. All proposed tourist accommodations should be strictly regulated and scrutinized before approval. For the existing ones, installing certified energy-efficient appliances and water-efficient fixtures, followed by regular energy and water auditing are recommended measures for lowering the environmental foot-prints.

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