Journal of Civil Engineering, Science and Technology
Volume 12, Issue 2, September 2021

ASSESSING THE FACTORS OF ENERGY CONSUMPTION BEHAVIOR IN URBAN AREA

Md. Nazmul Haque[1*], Arpita Bakshi[1], Fathum Mobin[1]
[1]Department of Urban and Regional Planning, Khulna University of Engineering & Technology, Khulna-9203, Bangladesh

Date received: 15/10/2020 Date accepted: 04/09/2021
[*]Corresponding author's email: nhaque13@urp.kuet.ac.bd
DOI: 10.33736/jcest.3976.2021

Abstract- This paper focuses on delineation of ecological viability due to changes of household energy consumption behavior. Then the research also explored the factors (Environmental resources) behind growing ecological footprint. For having a lot of natural elements and high residential characteristics ward-4 of Khulna city was selected as study area. The research followed a three step approaches. At first, geographical and topographical data are analyzed in geo-spatial environment. Which helped to draw the Environmental Performance framework. Geographical Information system (GIS) helps to evaluate the current scenario and past scenario of the resource compatibility of some existing assets. The second phase is all about assessing the residents' behavior towards energy consumption practice and the influencing factors behind this. The third part showed the environmental performance index (EPI) that include both the socio-economic problems and environmental circumstances using NSA method under the explanatory variables of environmental impact assessment (EIA). Essential natural assets especially water body and the vegetation has decreased at tremendous rate in recent time in Ward-4 with the enhancement of buildup area. This research is totally based on stakeholder perception towards energy consumption pattern and all the further assessment depend on this concept. To assess the behavioral changing factors, it seems that the correlation between income range and energy consumption is positive and linear. It represents that people want to switch high energy consumption appliances with growing wealth. Third phase assess environmental health (measure threat to human health) and ecological vitality (measures ecosystem service and natural resources) under environmental performance index. As the study is mostly involved local residents of study area so the method of neighborhood sustainability Assessment (NSA) is combined with EPI method for scoring the indicators. The approximate score of Environmental Performance Index (EPI) is around 53 percent demarcating the areas existing situation is in moderate rate and diverted from the standard value. This research draw attention to find out environment viability of ward-4 by measuring environmental stress to human health and ecosystem for providing practical guidance to government that aspire to move towards sustainable future.

Keywords: Energy consumption behavior, Energy demand, Environmental Performance Index, Environmental health, Ecosystem vitality.

1.0 INTRODUCTION

According to [1], Intensive pressure of Household energy consumption on atmospheric change will increase at a tremendous rate. Incremental growth of population and their production and consumption pattern make hard the nature to survive aftermath. International Energy Agency claimed that huge change in energy usage is needed to protect the future energy section.

Inefficacious residential energy practices can slow down government's targets, interventions and policies almost in every country [2]. There have several research dealings with potential energy consumption issues but hardly impel over all environmental scenario and trends. Some paper demonstrate various kind of energy consumption pattern that conceive the attitude behind energy consumption depends on the interaction between norms, belief, experience, social aspiration, available technologies and energy practices by measuring ecological footprint [3] [4], [5], [6]. Concerning factors and indicators that emphasis more on consumption pattern of households are pertaining in some papers like

[7]-[11]. But this research rarely addresses the fact why these electric energy consumption behavioral changes are occurred and how environmental viability depends on the energy consumption patterns and socio economic and environmental issues of a particular area.

Factors like income range and building types only demarked the ecological footprint but not consider other ecological factors like water body and greeneries trends of a specific area. In regards to environmental and ecological study, Environmental Performance Index (EPI) is very effective that provides practical guidance for any country desiring for a sustainable future. Its asses some performance indicators that provide a way to identify the environmental health and ecological vitality of a specific region. Environmental health measures the threats to human health and ecosystem vitality measures existing natural resources of a specific region and ecosystem service also [12], [13].

The method of Environmental Performance Index (EPI) is basically large area oriented. So, when it's matter of any small area or neighborhood perspective, Neighborhood Sustainability assessment (NSA) tool can better visualize the local context [14], [15]. The main characteristics of NSA is to allow the participation of stakeholders while assessing the value of variables [16].

Khulna, a coastal zone of Bangladesh having plenty of water bodies, greeneries and natural resources [17]. Although relishing lots of natural amenities, the social, economic, environmental composition is rapidly shifting due to raising population. These enhanced populations assert for more resources and demand for energy that could be rarely restrained. Under the Khulna City Corporation (KCC), the potentiality of Ward-4 is laudable comprising with abundant of viable ecological component as well as has both residential and agricultural land use. It is very prominent in Khulna city that the essential natural assets especially water body and the vegetation have decreased at tremendous rate in recent years [17] as the energy consumption trends and structures are changing day by day due to technological advancement and behavioral change and the Ward-4 is not out of these problems. The current resource can balance the impacts of intensified urban population, their lifestyles and environmental practices.

Behavioral and technological changes along with policy perception are the emergent issues which are not into consideration in Ecological footprint assumption as it is arbitrary [18]. So, interpretation of ecological and carbon footprint of the area, some selected indicators (norms, technological usage, environmental practice) was adopted. The first focus of the study is to identify the environmental viability in the context of behavioral analysis of the people of the study area towards energy consumption. And the second focus is to measure the environmental health and ecological vitality via the combination of EPI and NSA method. The explanatory variables of Environmental Performance Index can address the significance of multiple environmental issues that evaluate the study area circumstances to the standard that promotes sustainable ecosystem [12] [38] - [45].

This paper consists of three main phases. At first, it covers the inventory of the candidate area. The Geographical Information system (GIS) helps to evaluate the current scenario and past scenario of the resource compatibility of some existing assets. The second phase is all about assessing the residents' behavior towards energy consumption practice and the influencing factors behind this. The third phase includes the variables of first phase to assess the environmental viability using NSA method under the explanatory variables of EIA.

2.0 METERIALS AND METHODS

The research is based on questionnaire survey on the households and to fulfill the study objectives the following framework can make a sense of analysis procedure and steps.

2.1. Study Area Profile

There are 31 Wards under Khulna City Corporation and Ward no 04 is one of the most prominent wards affluent with natural riches (figure:1). Mohsin more (22.873420, 89.523242) have enriched with utilities and service facilities that is the starting point of study area and bounded by Moyur river. Total area of this ward is almost 2.93 square kilometers. Ward-4 have basically mixed land use with both residential and agricultural area. But agricultural land use is located far from residential area as well as the periphery of city along with the bypass road [19], [20], [27], [37].

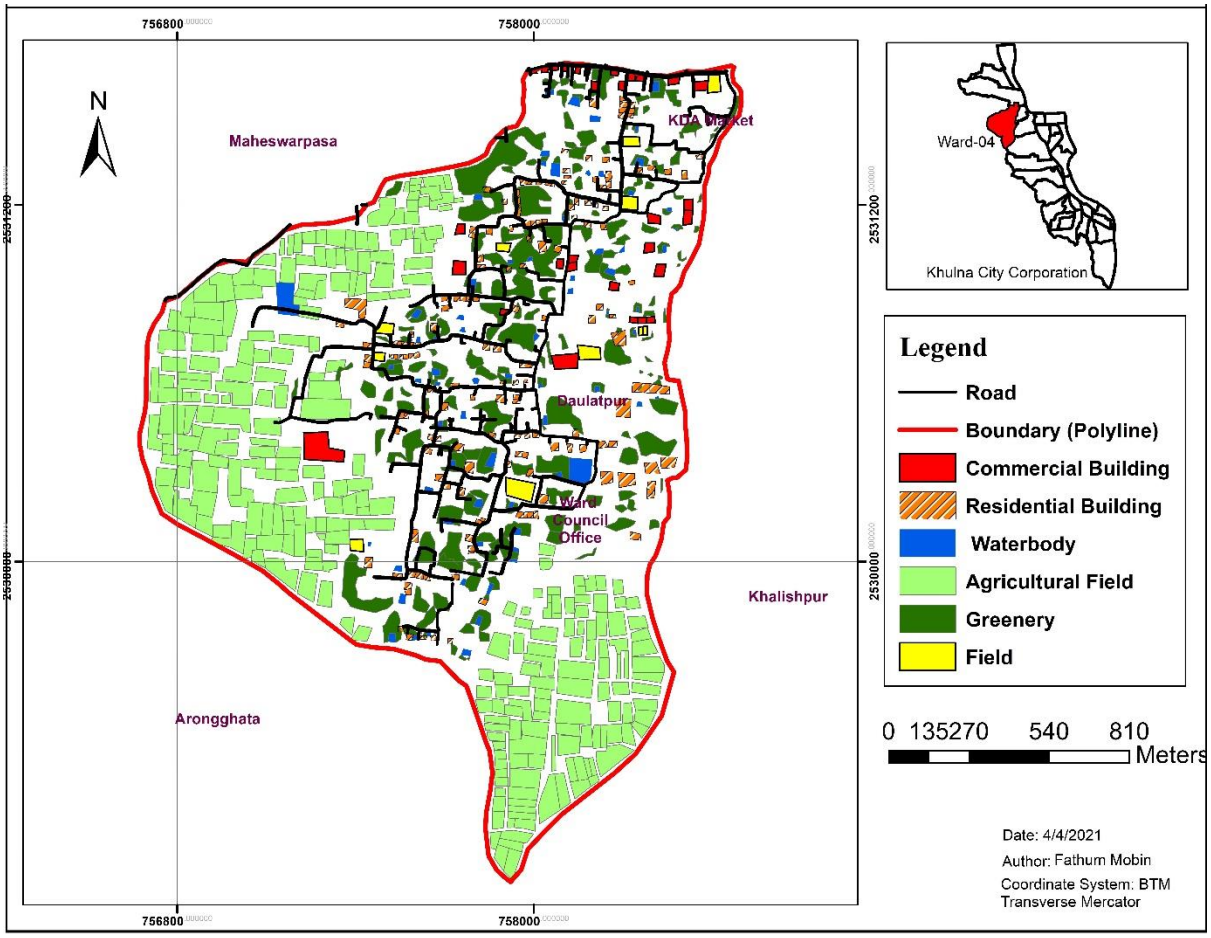

Figure 1 Environmental Components of ward-04.

2.2. Questionnaire Development & Data Collection

This research is mostly based on participation of stakeholder and expert opinion. Urban lifestyle and consumption pattern are relevant to the public point of view of certain study area. And questionnaire survey is one of those which has been developed to gather public information for better understanding the current scenario of study area regarding energy consumption. Primary data was collected using stratified sampling by surveying the citizens of ward-4 that cover all type of income groups in the context of housing types.

To track down the changes in present conditions considering past data was gathered from past research, thesis papers published by NGOs or researchers related to water and sanitation conditions in Khulna region. The demand for water supply and water availability data, demographic data and related GIS shape files was collected from KWASA (Khulna Water and Sewerage Authority), Municipal Office and Khulna Development Authority.

2.3. Sampling

For effective data collection the sample design is necessary. The whole population of the area is 22080. But that huge population need sampling which is the representation of the whole area. As the population is known, the finite sample size estimation for sampling is used [21].

Sample size,

$$n = \frac{\frac{z^2(1-p)p}{e^2}}{\downarrow + \left(\frac{z^2(1-p)p}{e^2 N}\right)}$$

$$= \frac{(1.96^2 * .05 * .05)/.02^2)}{1 + ((1.96^2 * .05 * .05)/.02^2 * 22080)}$$

$$= \frac{456.19}{1.10874}$$

$$= 411$$

$$= (411 * 25)/100$$

$$= 103$$

e= error=2%

N= population=22080

Z=+- 1.96

P= 5%

Percentage of the total sample = (100*100)/ 411 = 24.39 %

As the sample size is very high, have time limitation and COVID-19 situation. So, this huge sample is difficult to survey. Again, as the study was about local level so the sample size taken to 103.

2.4. Selection of Indicators

There are four selection criteria applied in EPI: 1) relevance (the indicator clearly address the concerning environmental issues in wide range circumstances of a region); 2) performance orientation (indicators tracts the best available data); 3) transparency (Indicators have ability to track changes over time and data source transparency); 4) Data quality (the data used by indicators represent the best measurement available) [22], [23]. EPI is relevant to two core underlying indicators and that is environmental health and ecosystem vitality. This environmental health mostly deals with the indicators which can measures threats for human health. In this section, there have some sub section also like water quality, sanitation facility, drainage condition, dwelling density, land use pattern, waste disposal system, Salinity and transport, household solid fuels. If there have occurred some disruptions on these all-sub indicators, it will affect on human health in a long run. The other core indicator is ecosystem vitality related to measure the effects on ecosystem like air pollution, water pollution, biodiversity and habitat, forestry, fisheries, agriculture, climate change [12], [23], [46] - [49].

2.5. Scoring and Weighting

There were some limitations in EPI as it is basically used to rank Countries but not for small areas. Because of all the indicators that used in EPI is not feasible for a small area, the experimental factors like measurement of soil texture, air pollution, Ground water contamination is not under the scope of the project [24]. A good NSA tool has some characteristics like adaption to locality (consider the context specific priorities and needs); scoring and weighting (score and weight each and every criteria); participation (mechanisms to involves the perception of different stakeholders) [15]. In this study, scoring and weighting have followed the Neighborhood Sustainability Assessment (NSA) method. The weighting of indicators according to significance is the most difficult tasks and involves subjectivity. This subjectivity also associated with scoring. So, to handle this type of ambiguity in research, NSA promotes expert-led approach for weighting [25]. So, the weight is based on expert suggestion depending upon a specific scale [26] and scoring is based on the public opinion of the concerned area which demarcates the overall environmental condition of that area.

2.6. Calculation of EPI Scores

This study quantifies the environmental performance index where "i" is the ordinal number of an indicator, "n" is total number of the indicators, "Wi" is the weight of the its indicator and "Xi" is the standardized value of each indicator.

$$\text{EPI} = \sum_{i=0}^{n} (WiXi)$$

The numbers of the PARs reaching excellent (EPI score ≥80), good (EPI score: 70–80), general (EPI score: 60–70), poor (EPI score: 50–60) and worst (EPI score). By these EPI measurements, the divided area according to lower and higher value can be ranked [24] .

2.7. Results and Discussions

Assessing and investigating the existing geographical and environmental scenario of the study area is the key consideration for which the finding and analysis are based on. The increasing rate of land use changes as well as declination of natural assets in Ward-04 and relate it to residential energy consumption behavior change is highlighted in this chapter.

3.0 DATA COLLECTION

3.1. Inventory Checklist

This segment represents the overall continuity of the natural and physical structure of the research area and consider the subsist factors considering the entities.

3.1.1. Roads and Transport

In Figure-1 there is road map. The transportation facilities of the ward-04 is good near Mohshin more. The periphery of the ward, basically near the city bypass have rather any kind of transportation. Near the Khulna city bypass road, the land is basically agricultural and so many rivers. Roads are mostly pucca (Concrete Road) in the residential areas and also have some kutcha roads which are unpaved and turn muddy in monsoon season situated in the periphery of the ward boundary. Motorized and non-motorized rickshaw are more prominent in the area [37].

3.1.2. Existing General Land Use

Figure-1 expresses the Land use of the study area. Ward-04 have intensified residential and agricultural land use type and also have some shorts of School side playgrounds used as recreational purposes. About 26% of the total land area of ward 4 is used as Agricultural area. Residential area is about 3% and Greeneries area around 11%. The agricultural land has good transportation facilities but a government project will be implemented in June-July 2020 for an agricultural university. So, the agricultural land mainly converted into a commercial area and land price are increasing due to this government project [27].

3.1.3. Greeneries

In Figure-2 there is existing greenery map and Figure-3 is the greenery map of 2012. There are abandoned of plants and the most noticeable is that every house courtyard have immense number of trees. And in the periphery of the ward and near the bypass road the huge amount of agricultural land are available. In 2012 the number of greeneries covered around 193.60-acre area (26%) and now it is reduced to 84.14 acres area (11%) so about 56% has decreased which is shown in figure 5. Greeneries are the important features of the environment. But the amount now present is the area

not so poor. Due to urbanization the amount is reduced half in 8 years duration. And if it will continue, temperature is increasingly rise [28].

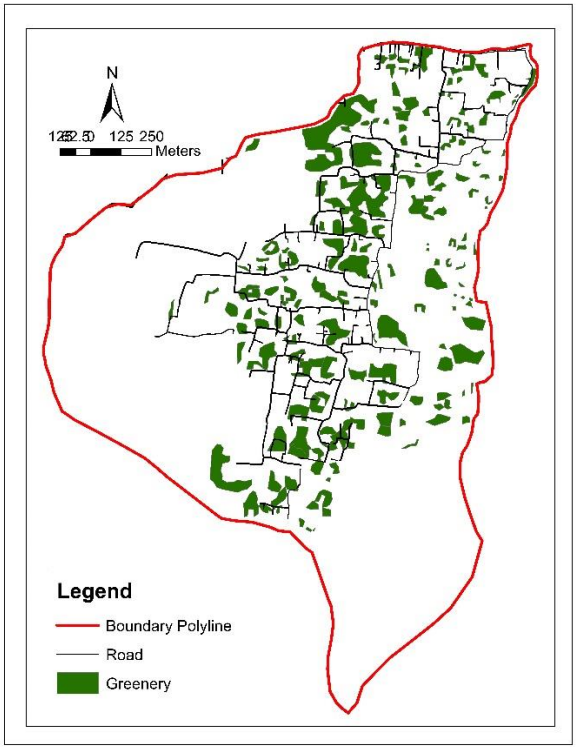

Figure 2 Existing Greenery (2020)

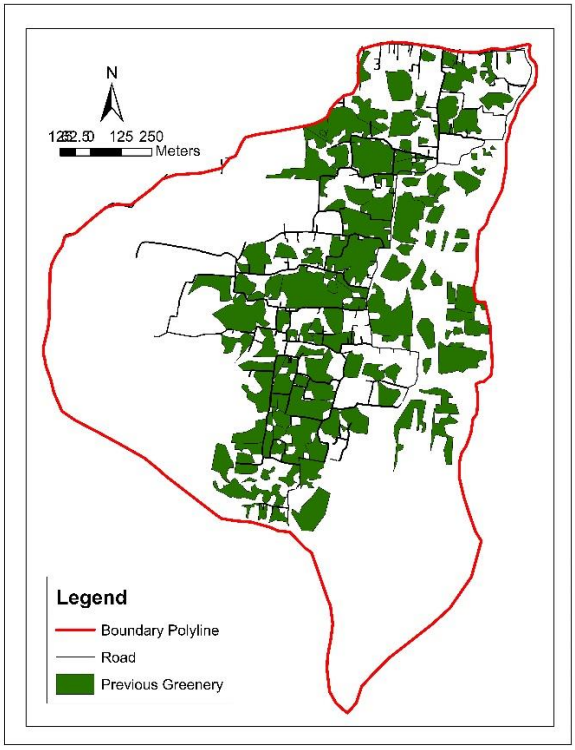

Figure 3 Previous Greenery (2012)

3.1.4. Water Contamination Due to Agriculture Waste

As the area is agriculturally well known, the fertilizer and insecticides can contaminate the nearby water body. According to local people, run-off soil contains toxins that smother and destroy aquatic life. From field surveying the information was gathered that, explosive plant and algae growth produce fertilizers, car exhaust and detergents, which depletes oxygen content, and creates a rotting smell.

3.1.5. Residential Pollution Source

Mainly the word-04 is a residential and agricultural mixed area. When the term residential pollution source is used, then the waste or the source which are created by household wastage are only considered. Many of the household dump their waste beside their house and the waste collector unload it in an open space and make the air and soil polluted. So, the main pollution sources lie in the open spaces where the waste are dump. Besides, dumping of household wastage here and there specially in ponds, beside roads causes environmental pollution. The main pollution sources in ward-04 are: Poor management of waste collection and dumping system, dumping household wastages by the community people here and there and insane use of open space as a dumping site. The waste dumping situation is shown in figure-4 [29], [30].

3.1.6 Waste Disposal System

In the study it is found that most of the waste collection is conducted by KCC provided van who serve the area by receiving few amounts of money monthly. But the area which close to public bin or have dumping site near their household are not pay money for these and KCC van or any private waste collection agency rarely collect waste in these areas.

a **b**

Figure 4(a &b) Waste dumping site of ward-04.

The main problem of the area is the collected waste of KCC van dump the waste in an open space and insects, bad odor emits from this waste. These dumping sites are not cleaned properly and creates different types of nuisance because of uncovered waste disposal system. In the survey area these types of characteristics occur because of lacking of consciousness of the managerial committee and residents both. The waste collection system is given on table-1.

Table 1 Waste collection system and percentage of usage the process in ward-04

Waste Collection Process			%of people using dumping site
Waste Managerial Committee	Public bin	% of Household using dumping site	10.00
	KCC waste Collection van		50.00
	Open space		40.00
	NGO/public organization		0.00

3.1.8. Salinity

Salinity is one of the most basic problem in Khulna [31] likewise ward-4. From the questionnaire survey, it is clearly visible that the salinity in drinking water is not so much prominent as the water using in household choirs. Because when it is the matter off drinking water, people of the study area use deep tube well mostly. But water used in agricultural purpose and household works have high salinity rate according to local people.

3.2. Demographic Information of the Urban Unit

3.2.1. Education Level

In the measurement of sustainability of an area, education level of the study area is an inevitable factor. Because this factor has potentiality to generate realization of any community or neighborhood. Most of the people

residential area of ward-04 which is directly linked to main road are well educated. Some of them are Teacher, Engineer or government service holder. But considering the overall area people are not so educated and most of the people do small business and many are farmers. Awareness with respect to education is given on table-2.

Table 2 Environmental Activities Based on Education

Awareness related issues (%)	**Education level of the households**			
	Primary	SSC	HSC	Graduate
Throwing waste Haphazardly	43.77%	18.99%	22.22%	15.02%
Using dustbin to throwing waste	1.30%	4.72%	25.8%	68.18%
Planting tress	28.30%	33.70%	29.66%	8.34%
Taking initiatives in environment cleanliness willingly	4.20%	33.80%	20%	42%

3.2.2. Economic Condition

There are four types of housing in ward-04. Such as High income (>30000)**,** middle class (20000-30000)**,** Lower Middle income (10000-20000) and Low class (<10000) residents. Among them majority of the people are in middle class with 37%. High income people are 10%, lower middle income is 22% and low-income people are 31% which is given in figure-7.

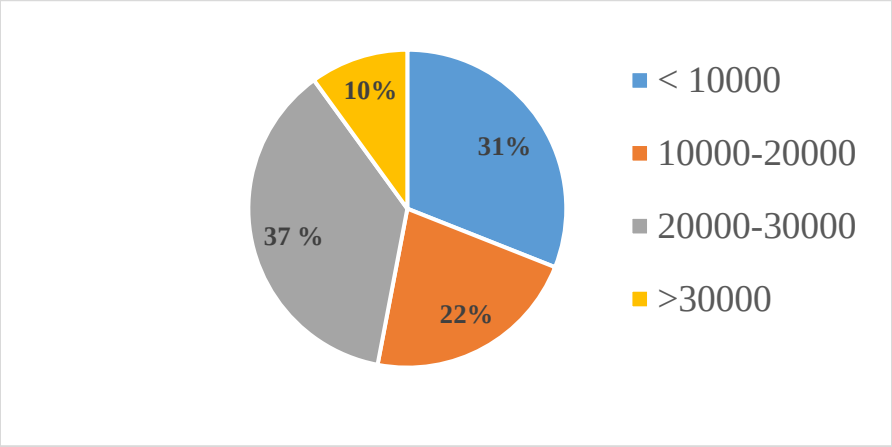

Figure 5 Economic Condition of ward-04.

4.0 RESULT AND DISCUSSION

4.1. Energy Consumption Behavior

Increasing urbanization, lifestyles and consumption behavior is dramatically changing the land use and water body as well as ecological assets. The bio capacity per person, Ecological footprint per person is according to 0.4 gha (Global Hectare) and 0.9 gha [32]. Khulna is the third largest city in Bangladesh and is not exempt from this kind of consequences basically in the wards of Khulna city because of growing rapid amount of buildup areas.

Lifestyle and consumption pattern depend upon the socio economical background of an area like income, educational profile, household size and norms and energy practices. Norms and proper education are the factors which have lack

in the developing countries like Bangladesh. So as the increase of income range effects the consumption behaviors as well as enhance the carbon footprints without aware of the negative impact into environment and natural assets [42].

4.2. Energy Consumption and CFC Emission Rate

CFC gas is one of the green houses that are mostly responsible for global warming as well as chaotic environmental degradation [33]. Unprecedented use of some popular household appliances increases the amount of CFC rate in the atmosphere like aerosol sprays, blowing agents for foams, AC, refrigerator, Residential wall sheathing. There have many CFC containing appliances used in residential areas now a days. But the mostly used appliances are air conditioner (AC), refrigerator and air conditioner (AC) car according to the area profile. By the questionnaire survey, these three appliances are most prominent than others. In table 3, it is visible that mostly the people earning under 10,000 BDT cannot afford such appliances as well as avoid carbon footprint. But the people can earn suitable amount of money, they want to enjoy the comfort of using such technologies. Thus, the encroached level of using these appliances by the high-income people create environmental dilapidation.

Table 3 Uses of CFC containing appliances based on income profile

Income Information			Percentage of Electric appliances used				Total
			Refrigerator	**AC Containing car**	**Refrigerator and AC**	**Have not any**	
Income of Earning Members	below 10000	**% of Electric Appliances which contain CFC**	0%	0.00%	0.00%	100.00%	100%
	10000-20000		37.60%	2.00%	0.00%	60.4%	100%
	20000-30000		67.10%	5.10%	22.10%	5.7%	100%
	>30000		55.26%	10.34%	34.40%	0.00%	100%

4.3. Mobility of Footprint

In most of the development countries is suffering much for lacking of efficient transportation for accessibility. Mobility is a vital part of ecological footprint; but it can be reduced if the use of public transport is increased rather than private transport [34].

Table 4 Connectivity to the important point from ward-04

Connectivity to the important point	Distance
Growth center (Shibbari more)	7.3 km
Fire service	2.2km
Market	3.8 Km
Railway station (Daulatpur)	2.2km
Nearest park (Linear park)	12km

Source: Google map, 2020

Here the connectivity between important points of the study area is given in table-4 where the most reasonable transport is motorized. And major public transport like bus is not so popular for these services.

4.4. Energy Appliance Usage Vs Income Level

Lifestyle and consumption pattern depend upon the socio economical background of an area like income, educational profile, household size and norms and energy practices. Norms and proper education are the factors which have lack in the developing countries like Bangladesh. So as the increase of income range effects the consumption behaviors as well as enhance the carbon footprints without aware of the negative impact into environment and natural assets [50], [51].

There are some kinds of electric appliances which are prominently used in urban residential area. Qualitative data are collected by people perception about energy consumption ability of each of these appliances via electricity bills of each household. Likewise, refrigerator, washing machine, micro-oven, air conditioner (AC) is high energy consumption product as the household having these appliances get high electricity bills.

The score of energy appliances is given in table-5 depending on the perception of people about increasing electricity bills due to usage of appliances. The score of the appliances which consume greater energy given as 1 to 5 range (1= very low electricity bill; 2= low electricity bill; 3= Moderate electricity bill; 4=high electricity bill; 5= very high electricity bills). And the average answer of the responded is putting in table-5. Here the AC, Refrigerator, washing machine, micro-oven has greater energy consumption intensity so that they are to give greater energy consumption value. The scores are given below:

Table 5 Energy appliances score due to energy consumption ability

Appliances	Score	Appliances	Score
Fan	2	Light	2
Television	3	Induction cooker	3
Air Conditioner	5	Heater	3
Refrigerator	5	Micro oven	4
Washing machine	4	Others	5

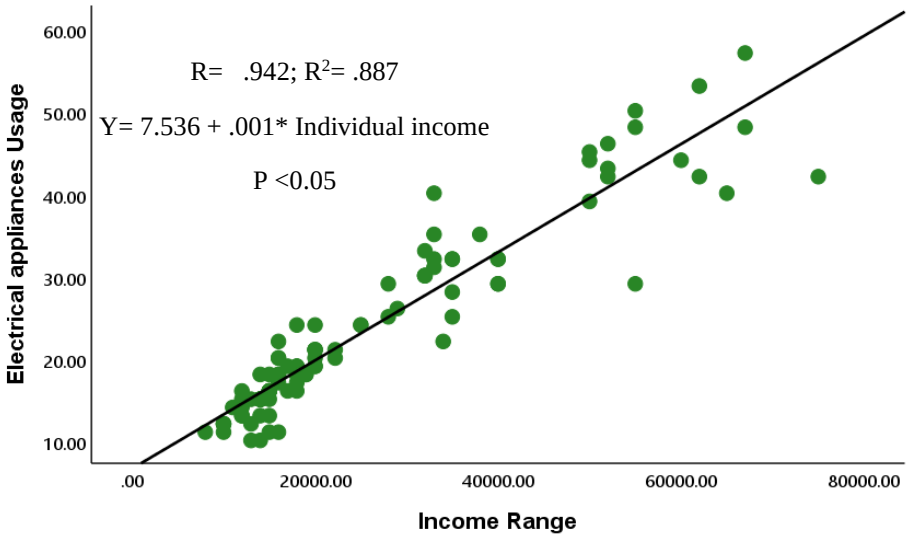

Figure 6 Electrical appliances Usage and individual income level relationship.

The findings of the study mainly based on the definite relationship between income level and usage of energy appliances in figure-6. Here the percentage of energy appliances usage refers the percentage of income spending on energy appliances usage. The level of significance is less than 0.05. So, the income level has significant and positive relationship with the percentage of energy appliances usage. That means, the household income improves the choice of energy appliances. Enhancement of income ability force people to invest more on buying high energy consuming appliances. Here energy price may be good variable but cannot considered to a good predictor of selecting appliances. When people's income capability is increased, it hardly matters for getting better energy choices. Here R is the correlation between two variables and R^2 depicts that the independent variable (income level) can describe 81% of the percentage contributing in usage of home appliances. The trend of using more energy appliances depends on increasing of income of people.

4.5. Choice of Cooking Energy Based on Building Type

The building type significantly affect the household energy choices which is in table-6. Normally the thatched house hold is well habituate to use hearth and cooking heater as the other sources of energy they cannot easily afford. It is observed in table 4.7 that 38.50 percent people depends on heater rather than rice cooker and induction cooker.

But most often, it is a tendency in the household with one and more than one story that they want to use source cannot pollute their indoor environment. So, they use mostly rice cooker, induction and LP gas rather than using hearth or heater. The household having more than one story have significant change in energy consumption behavior and the use of hearth and cooking heater is decreased in high rise buildings.

Table 6 Household energy source (for cooking) behavior based on building type

Types of Houses		**Consuming Appliances Usage percentage**				
		Rice cooker	**Induction Cooker**	**LP Gas**	**Hearth**	**Cooking Heater**
Thatched House	% within Type of building	0.00%	0.00%	30.80%	30.80%	38.50%
Single Detached House		12.20%	35.70%	16.40%	14.30%	21.40%
One Story House		10.50%	31.60%	26.30%	5.30%	26.30%
More Than One Story		40.00%	40.00%	15.50%	0.00%	4.50%
Above 5 Story		33.30%	25.00%	41.70%	0.00%	0.00%
Total		17.60%	26.50%	26.50%	10.30%	19.10%

4.6. EPI Assessment Method

For computing matrix, EPI needs an organizing output. This group's indicator for issuing category, problem category to policy goals, policy goals to index overall. The EPI focuses on two key environmental objectives: Reducing environmental stress on human health and Promoting sustainability of the ecosystem and effective management of natural resources.

Scoring: Scoring is given based on their derived using. Each indicator scores ranges from 0 to 1 where 0 defines the lowest condition and 1 defines the best condition.

Normalization of score: The indicator scores were normalized based on the categorical normalization technique [35] through which each indicator score was transformed into a numerical scale ranging from 1 to 5. The normalized value is given in table-7.

Table 7 Conversion process of normalized value

Scoring percentage	Normalized value	Attribute
0-30%	1	Very low
30%-50%	2	Low
50%-70%	3	Acceptable
70%-90%	4	Good
90%-100%	5	Very good

Weighting: The level of importance of each indicator will be given, according to the expert opinion, on a scale of 7points (from "1 = very low" to "7 = very high"). The weight variation is given depending on the number of selected indicators. The number of measures increased then there will be more variability. As there were no expert opinion, the generalized opinion of local people can be used and weight the indicators. If the number of measures increased then there will be more variability. In table-4 the assessment method is shown. Here the weighted score refers multiplication between normalized score (X) and weight (W). And the aggregated sum was the result of sum of weighted score and categorical weight. Standard score is assumed to five to take along that all indicators remain in a standard state. In the context of standard weight, Standard score is used as X and weight (W) was as same as before. For getting standard aggregated value, multiplication between standard weight and categorical weight was operated.

Table 8 Showing assessment tools through EPI Index

Category	Given categorical weight	∑weighted score	Aggregated sum	Standard aggregated
Environmental Health	40	∑W*X	(∑W*X) *40	(∑W*X) *40
Ecosystem Vitality	60	∑W*Y	(∑W*Y) *60	(∑W*Y) *60
			Total sum	**Standard sum**

Here from table-9 the standard composite or benchmark is 25562.5 and calculated composite score according to local context is 13616.25. From composite score it is clear that the experimented value dispersed about:

((25562.5-13616.25) *100)/ 25562.5

=46.73% = 47% from the standard value.

Hence the evaluation process will be established by taking difference in percentage

= (13616.25 / 25562.5) *100= 53. 26%

In the criteria of environmental health, it is observed that drainage condition, waste disposal system is in the worst condition. But in ecosystem vitality, the energy consumption condition is quite acceptable but the greeneries are reduced. From the GIS shape file, it is depicted that in 2012 the amount of vegetation is covered around 193.60-acre area and now it is reduced in 84.14 acres area. And the total amount of water body is 71 acres.

Table 9 Calculation through Environmental Performance Index

Criteria	Indicator	Score	Normalized score	weight	Weighted score	Standard score	Standard weight
Environmental health (42.50)	Household Solid Fuels	0.55	3	4	12	5	20
	Water Quality (fresh drinking water)	0.50	2	5.5	11	5	27.5
	Sanitation	0.40	2	5	10	5	25
	Drainage condition	0.30	1	4.5	4.5	5	22.5
	Dwelling density	0.70	3	4.5	13.5	5	22.5
	Land use concerns	0.65	3	5	15	5	25
	Waste disposal system	0.20	1	4.5	4.5	5	22.5
	Salinity	0.45	2	5	10	5	25
	Transport	0.75	4	4.5	18	5	22.5
	Weighted sum of Environmental Health indicators				98.5		212.5
Ecosystem vitality (57.5)	Tree cover	.65	3	5.5	16.5	5	27.5
	Agricultural	.55	3	4.5	13.5	5	22.5
	Fish availability in water body	.45	2	4	8	5	20
	Water body humidity	.75	4	5	20	5	25
	Residential water consumption	.55	3	5	15	5	25
	Residential Energy consumption	.50	2	4.5	9	5	22.5
	CFC gas emission rate	.55	3	4.5	13.5	5	22.5
	Open space provision	.55	3	5	15	5	25
	Impervious surface	.65	3	4.5	13.5	5	22.5
	Solar Orientation	.55	3	4.5	13.5	5	22.5
	Strom water runoff	.45	2	5	10	5	25
	CO_2 emission rate	.60	3	5.5	16.5	5	27.5
	Weighted sum of Ecosystem vitality Indicators				164		287.5
Total =100	**Composite weight sum score=**						
	(weighted score*categorical weight)				13616.25		25562.5

As the calculated value cover the 53% feature of environmental component according to local context, it can be said that the area condition is moderate or acceptable but not so good. Hence, it can be said that the area of ward 4 is in a poor condition following Eco-friendly neighborhood perspective as it is covering only 53% from the standard of environmental features.

According to the EPI result, the area has diverted around 50% of the standard value, that's mean the area is not so environmentally or ecologically healthy. Basically, the growing urban population declining the bio capacity and newly developed areas are expanding. The ward-04 have both residential and agricultural land uses. The agricultural fields are under the government project where these lands are used for making build up area instead of promoting vegetation. The intensity of changing the vegetation coverage due to meet up existing demand decline the production of biological materials.

The result of the regression analysis shows that increase amount of income can enhance the amount of ecological footprint. Though the area has not very serious amount of ecological footprint according to their consumption but the matter of concern that the vegetation and water body is decreasing day by day. And it is well known that these two components of nature can balance the raising temperature and humidity. The green design features have potential to save energy around 30% and shorten CO_2 emission rate to 35% [25]. To control the environmental degradation, it is these elements have greater significance. As the agricultural land acquisition could not stop now, because it is under government project, Rooftop gardening will have to be generated to tackle the scarcity of vegetation. Low hanging fruits and vegetables can be generated so that it can return some monetary value and have required less maintenance. To make this more popular, government can reduce tax for the house which practice roof top gardening.

5.0 CONCLUSION

To assess the environmental viability, existing condition of the explanatory indicators portray overall scenario of ward-04. Water body and greeneries, the most vital indicators under ecological viability have had in tremendous change in eight-year gap (2012-2020) as increasing rate of urbanization. Greeneries are reduced from 26% (2012) to 11 % (2020) of total land use. The situation is almost same for agriculture area. The residual agricultural area will be diminished soon by implementation of governmental projects. As a result, carbon-di-oxide could not absorb properly due to reduction of greeneries and agriculture. Secondly, the energy consumption pattern and energy choice of people increase usage of electric energy appliances. According to the perception of people, refrigerator, air conditioner, micro-oven, computer have high energy consumption ability as per high electricity bills. These energy appliances usage mostly depends on income range of people. In the study area, it is most prominent that the people having much income and delicate housing patterns have more willing to lead expedite life. And as income is increasing per year, the percentage of income mostly contributed in energy appliances usage. Besides income ability, household types are another dominant factor to avail high energy consumed appliances. These ruling factors run the Environmental Performance Index (EPI). The composite score of EPI is 47% (less than the standard benchmark). That means that the area is covered with 53% of environmental component. The worst situation of the area is seen on Drainage and waste disposal system. The vegetation of the area has reduced to more than half from 2012. Again, increased income is cause of increase in electric appliance which causes ecological footprint. But the number of greeneries is decreasing day by day. Here CFC rate and carbon-di-oxide emission rate have used in household modern appliances that are not in a good position. To tackle this devastation, the effectiveness of greeneries is desiderating as the number of greeneries is declining over the years whatsoever. Similarly, land use patterns and landscape dynamics changes are also a matter of concern. This study evaluates the feasibility of Ward-4's climate by evaluating environmental stress on human health and the ecosystem, with the intention of offering practical advice to governments trying to move toward a more sustainable future.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

Acknowledgement

The authors would like to thank the citizens of KCC ward-04 who participated in the survey. Also, the special thanks go to Mr. Sharfan Upaul for helping to find out the factors in scoring and weighting and also thanks to F.M. Rezvi Amin and Md. Abdul Fattah who helped to survey in ward-04.

Reference

[1] OECD (2007). Instrument Mixes for Environmental Policy, Paris, France.

[2] EECA (2006). Situation Assessment Report on the National Energy Efficiency and Conservation Strategy. Energy Efficiency and Conservation Authority, Wellington.

[3] Hubacek K., Guan D., Barrett J. & Wiedmann T. (2009). Environmental Implications of Urbanization and Lifestyle Change in China: Ecological and Water Footprints. Journal of Cleaner Production,17(14), 1241-1248. DOI: 10.1016/j.jclepro.2009.03.011.

[4] Moore J., Kissinger M. & Rees W. E. (2013). An Urban Metabolism and Ecological Footprint Assessment of Metro Vancouver. Journal of Environmental Management, 124, 51-61. doi: 10.1016/j.jenvman.2013.03.009.

[5] Scotti M., Bondavalli C. & Bodini A. (2009). Ecological Footprint As a Tool for Local Sustainability: The Municipality of Piacenza (Italy) As a Case Study. Environmental Impact Assessment Review, 29(1), 39-50. DOI: 10.1016/j.eiar.2008.07.001

[6] Stephenson J., Barton B., Carrington G., Gnoth D., Lawson R. & Thorsnes P. (2010). Energy Cultures : A framework for understanding energy behaviours. Energy Policy, 38(10), 6120-6129. DOI:10.1016/j.enpol.2010.05.069

[7] Asici A. A. & Acar S. (2015). Does Income Growth Relocate Ecological Footprint? Ecological Indicators, 61, 707-714.

[8] Danish &Wang Z. (2019). Investigation of the ecological footprint's driving factors: What We Learn From The Experience of Emerging Economies. Sustainable Cities and Society, 49. https://doi.org/10.1016/j.scs.2019.101626

[9] Duro J. A. & Figueras J. T. (2013). Ecological Footprint Inequality Across Countries: The Role of Environment Intensity, Income and Interaction Effects. Ecological Economics, 93, 34-41. https://doi.org/10.1016/j.ecolind.2021.107439

[10] Rashid A., Irum A., Malik I. A., Ashraf A., Rongqiong L., Liu G., Ullah H., Ali M. U. & Yousaf B. (2018). Ecological Footprint of Rawalpindi; Pakistan's First Footprint Analysis from Urbanization Perspective. Journal of Cleaner Production, 170, 362-368. DOI: 10.33687/008.03.3438

[11] Zhang J., Teng F. & Zhou S. (2020). The Structural Changes and Determinants of Household Energy Choices and Energy Consumption in Urban China : Addressing the Role of Building Type. Energy Policy, 139. DOI: 10.1016/j.enpol.2020.111314

[12] Conrad E. & Cassar L. F. (2019). The Environmental Performance Index.Routledge Handbook of Sustainability Indicators, 10(5), 294-307. https://doi.org/10.3390/su10051688

[13] Esty D. C., Kim C., Srebotnjak T., Levy M. A., Sherbinin A. D. & Mara V. (2008). Environmental Performance Index. Center for International Earth Science Information Network, Columbia .

[14] Kamble T. & Bahadure S. (2019). Neighborhood Sustainability Assessment In Developed And Developing Countries. Environment, Development and Sustainability, 22(6), 4955–4977. https://doi.org/10.1007/s10668-019-00412-6

[15] Yigitcanlar T., Kamruzzaman M. & Teriman S. (2015). Neighborhood Sustainability Assessment: Evaluating Residential Development Sustainability In A Developing Country Context. Sustainability, 7(3), 2570-2602. https://doi.org/10.3390/su7032570

[16] Shari A. & Murayama A. (2013). A Critical Review Of Seven Selected Neighborhood Sustainability Assessment Tools. Environmental Impact Assessment Review, 38, 73-87. DOI: 10.1016/j.eiar.2012.06.006

[17] Haque M. N., Mamun M. A., Saroar M. M. & Roy T. K. (2019). Application Of "DPSIR" Framework To Assess The Status And Role Of Blue Ecosystem Services (BES) In Khulna City. Journal of Engineering Science, 10(2), [26] -60. http://www2.kuet.ac.bd/JES/images/files/v102/06_JES_234_28-10-2019.pdf

[18] Simion I. M., Ghinea C., Maxineasa S. G., Taranu N., Bonoli A. & Gavrilescu M. (2013). Ecological Footprint Applied in The Assessment of Construction and Demolotion Waste Integrated Management. Environmental Engineering & Management Journal, 12 (4),779-788.

[19] Haque M. N., Sresto M. A. & Siddika S. (2020). Nexus Between Urban Green Streets And The Sustainability: Case on Khulna City Corporation (KCC) Area, Bangladesh.THE CREATIVITY GAME – Theory and Practice of Spatial Planning,8, 37-45.

[20] Haque M. N., Sresto M. A. & Siddika S. (2021). Suitable Locations for Industrial Setup in Urban Context: Way Forward To Meet the SDGs for Khulna City, Bangladesh," International Journal of Built Environment and Sustainability (IJBES), 8(2). [Accepted]

[21] Israel G. D. (1992). Determining Sample Size. Institute of Food and Agriculture Sciences, Florida.

[22] Esty D., Kim C. & Srebotnjak T. (2008) . Environmental Performance Index.

[23] Emerson J., Levy M. A., Esty D. C., Mara V., Kim C. & Sherbinin A. D. (2010). Environmental Performance Index. Center for International Earth Science Information Network, Columbia.

[24] Wendling Z. A., EmersonJ. W., Esty D. C. & Sherbinin A. D. (2020). Environmental Performance Index. Yale Center for Environmental Law & Policy, New Haven.

[25] Pan Y., Yin R. & Huang Z. (2008). Energy Modeling of Two Office Buildings With Data Center for Green Building Design. Energy and Buildings, 40(7), 1145-1152. DOI: 10.1016/j.enbuild.2007.10.008

[26] Dobbie M. J. & Dail D. (2013). Robustness and Sensitivity of Weighting and Aggregation in Constructing Composite Indices.Ecological Indicators, 29, 270-277. DOI: 10.1016/j.ecolind.2012.12.025

[27] Haque M. N., Saroar M., Fattah M. A., Morshed S. R. & Ishra A. K. (2020). Environmental Risk Zone Identification of An Urban Unit Using GIS and Remote Sensing. BAUET Journal, 2(2), 25-39.

[28] Haque M. N., Rahman N. & Nanjiba M. (2020). Geospatial Monitoring on Land Surface Temperature and Vegetation Dynamics: A Case of a City Area. Trends in Undergraduate Research, UNIMAS, Malaysia, 3(2), 35-43.

[29] Haque M. N., Fattah M. A., Morshed S. R. & Saroar M.(2020). Public-Private Partnership for Achieving Sustainable Development Goals: A Case Study of Khulna, Bangladesh.Public Administration and Policy: An Asia-Pacific Journal, 23(3), 283-298.

[30] Morshed S. R., Fattah M. A., Rimi A. A. & Haque M. N. (2020). Surface Temperature Dynamics in Response to Land Cover Transformation. Journal of Civil Engineering, Science and Technology, 11(2), 94-110.

[31] Ahsan M. and Bhuiyan M. R. (2010). Soil And Water Salinity , Their Management In Relation To Climate Changes In Coastal Areas Of Bangladesh..Khulna University Studies Special Issue (SESB), 31-42.

[32] "Global Footprint Network," 2016. [Online]. Available: https://data.footprintnetwork.org/#/.

[33] Dieckmann J., Little A. D. & Magid H. (1999). Final Report to the Alliance for Responsible Atmospheric Policy," Global Comparative Analysis of HFC and Alternative Technologies for Refrigeration, Air Conditioning, Foam, Solvent,Aerosol Propellant,and Fire Protection Applications, Cambridge, Massachusetts.

[34] Muller R. & Howe M. (2017). Small Farm Permaculture And Sustainable Living.[Online]. Available: https://small-farm-permaculture-and-sustainable living.com/ecological_footprint_components/.

[35] Hassan S., Hotlz W., Tansey J. & Whitelaw G. (2017). Sustainability Assessmet : Criteria and Processes., Perth: Murdoch University.

[36] Singh B., Roy P., Spiess T. & Venkatesh B. (2015). Sustainable Integrated Urban & Energy Planning, the Evolving.The Centre for Urban Energy,01-41.

[37] Kabir, A. (2019). Report on Sustainable Urban Transport Index for Khulna, Bangladesh. ESCAP. Khulna University.

[38] Moore J., Kissinger M. & Rees W. E. (2013). An Urban Metabolism And Ecological Footprint Assessment Of Metro Vancouver. Journal of Environmental Management, 124, 51-61. doi: 10.1016/j.jenvman.2013.03.009.

[39] Wackernagel M. & Rees W. E. (1996). Our Ecological Footprint: Reducing Human Impact on the Earth.

[40] Srinivas H. (2015) "GDRC". [Online]. Available: http://www.gdrc.org/uem/disasters/disenvi/tools/index.html. [Accessed 23 2 2019].

[41] Fabien D. (2006). Environmental Profile Of Rwanda. European Commission, Kigali.

[42] Das P. K. (2016). An Introduction to The Concept of Environmental Management: Indian Context. International Journal of Innovation and Economic Development,2(4), 25-34.

[43] Twidell J. & Weir T. (2015). Renewable Energy Resources, New York: Routledge.

[44] Wackernagel M. (1998). The Ecological Footprint of Santiago de Chile. Local Environment,3(1), 7-25. https://doi.org/10.1080/13549839808725541

[45] Chambers N., Simmons C. & Wackernagel M. (2000). Sharing Nature's Interest: Ecological Footprints as an Indicator of Sustainability, London: Earthscan.

[46] Levett R. (1998). Footprinting: A Great Step Forward,But Tread Carefully. Local Environment, Santiago de Chile, 3(1), 7-26.

[47] Wiedmann T. & Barrett J. (2010). A Review Of The Ecological Footprint Indicator Perceptions And Methods. Sustainability, 2(6), 1645-1693. https://doi.org/10.3390/su2061645

[48] Fare R., Grosskopf S. & Sancho F. H. (2004). Environmental Performence: An Index Number Approach. Resource And Energy Economics, 26(4),343-352.

[49] Stern N. H. (2007). The Economics of Climate Change: the Stern Review. Cambridge: Cambridge University Press.

[50] Hubacek K., Guan D., Barrett J. & Wiedmann T. (2009). Environmental Implications Of Urbanization And Lifestyle Change In China: Ecological And Water Footprints. Journal of Cleaner Production,17(14), 1241-1248. DOI: 10.1016/j.jclepro.2009.03.011.

[51] Bisset R.(1996). Environmental Impact Assessment: Issues, Trends and Practice.United Nations Environment Programme (UNEP).