Sustainability Assessment of Fringe Area Development of Dhaka City, Bangladesh

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Introduction

Dominant urban agglomeration by administrative, economic and service sector in the capital Dhaka has resulted in a mono-centric development structure in Bangladesh. Development economics literatures justify further urban agglomeration for continuous economic development and, point out for regional spill-over effects at saturation stages (see Brülhart and Sbergami 2009). Cities are the engines for economic and social development of a country. They harbour tremendous energies and have the potential to generate enormous creativity and significant economic betterment. They provide shelter, jobs and services and are the centres of productivity. For this reason, they attract more and more people and at present absorb two thirds of all population growth while generating over half of the Gross National Product (GNP), even in countries where the majority of the population is engaged in agriculture. This massive agglomeration of population is not only influencing the overall city structure but also causing rapid consumption of environmental resources in the vicinity of the cities; i.e. the fringes. This is where the issue of sustainability of fringe area development comes about, which is the key issue to be investigated through this study (UN-Habitat & UNEP, 2001 p. 2).

Sustainability is not a concept referring to some static paradise, but rather a capacity of human beings to continuously adapt to their nonhuman environment by means of social organizations. This is why sustainable development is essentially not about the environment but rather about the capacity of human society to enact permanent reform in order to safeguard the delicate balance between humans and their natural life support system (Hamm & Muttagi, 1998 p.2). In this study, we try to evaluate the issue of sustainability from all of its social, economic and environmental dimensions in the case of fringe area development.

Definition of Key Terms

In the following sections, the main definitions used are explained in concise manner.

Sustainability: Sustainability has come from a global political process that has tried to bring together, simultaneously, the most powerful needs of our time:

- The need for ***economic development*** to overcome poverty,
- The need for ***environmental protection*** of air, water, soil and biodiversity upon which we all ultimately depend, and
- The need for ***social justice and cultural diversity*** to enable local communities to express their values in solving these issues.

Thus when the issue of sustainability is referred it will be the simple idea that means the simultaneous achievement of social, economic and environmental sustainability. This concept is pictured in Figure 1.

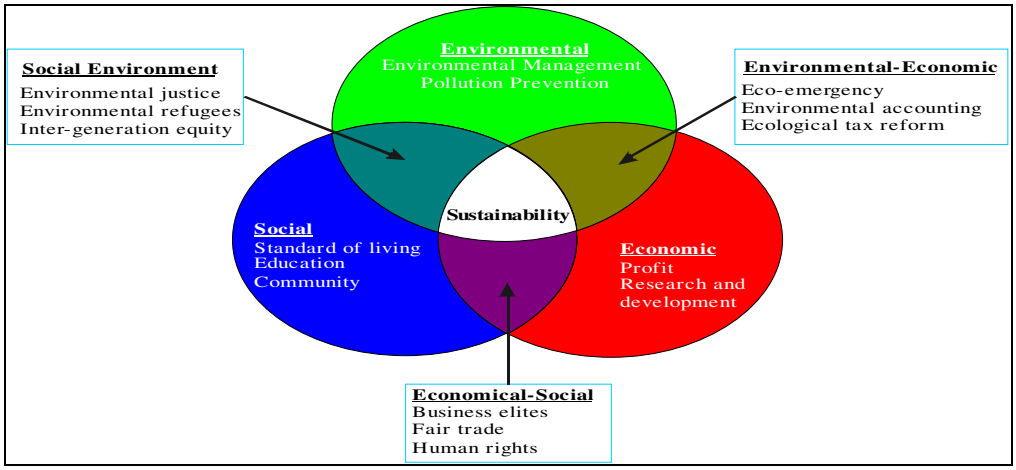

Fig. 1: Issues within three spheres of Sustainability (Sustainability 2002).

Urban Fringe: Pryor (1968) distinguished 'urban fringe' from 'rural-urban fringe' by narrating 'urban fringe' as, "… that sub-zone that is in context with a contiguous to the central city. Its density of occupied dwellings is higher than the density of occupied dwellings for 'rural-urban fringe' as a whole. It has high proportion of residential, commercial, industrial and vacant land as distinct from farmland. And it has higher rates of increase in population density, of land use conversion from farm to non-farm and of commuting than does the rural-urban fringe as a whole."

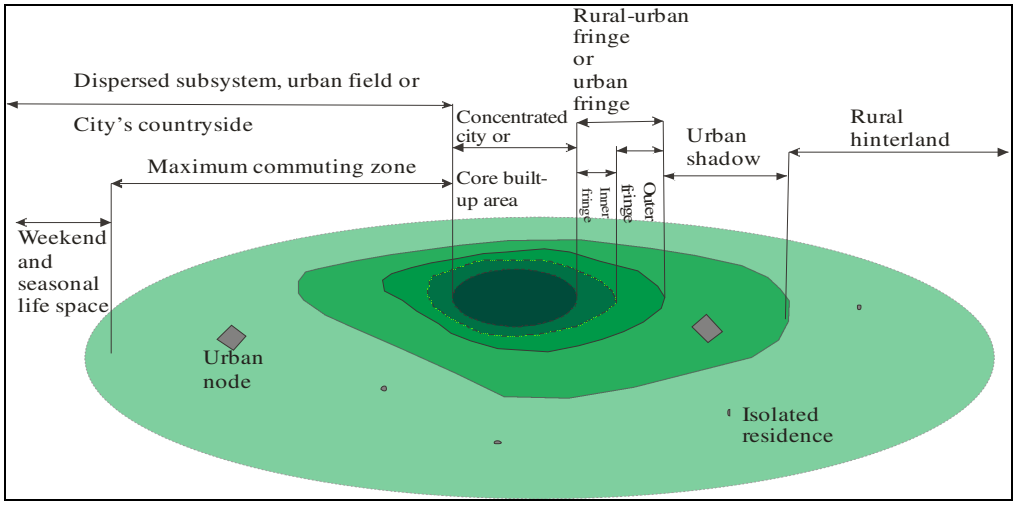

Fig. 2: The form of the regional city (from Bryant et al. 1982).

The urban fringe can also be seen as a multi-functional area. Whilst for many its primary role is seen as rural, in classical green belt terms as stemming the tide of development, it has always accommodated a wide range of activity. It is characterized by diversity, mixes of land use, people, and activities with varied needs fulfilling many social and economic roles (Beesley, 1984). Sinha (1997) classified fringe into two components- rural (outer) and urban (inner). According to his concept, the outer fringe (rural fringe) is more rural than urban areas

whereas inner fringe (urban fringe) is more urban than rural and together may be called rural urban fringe. Sinha's concept can be visualized from Figure 2.

The Study Area: The Dhaka Metropolitan Development Plan (DMDP) was prepared under the project 'Preparation of Structure Plan (SP), Master Plan and Detailed Area Plan (DAP)-Metropolitan development Plan Preparation and Management in Dhaka'. The project was funded jointly by the UNDP and the Government of the People's Republic of Bangladesh. The UN Centre for Human Settlements (UNCHS/ Habitat) acted as the executing agency for UN and Rajdhani Unnayan Kartipakkha (RAJUK) acted as the implementing agency under the control of Ministry of Housing and Public Works. Dhaka Metropolitan Development Planning (DMDP) is a three tier plan package, viz, the Structure Plan and the Urban Area Plan are completed and published in two volumes under the DMDP. The Plan documents are approved and published in the Bangladesh Gazette under the notification of SRO 184-Law/97, dated August 4,1997. However the approved plan (DMDP) indicated that until a Detailed Area Plan (DAP) is prepared for a sub-area, land use management functions will be exercised through the policies, guidelines and principles found in the Structure Plan (SP) and Urban Area Plan (UAP). But without DAP efficient land management would not possible. For the particular case of the study area, some flood retention ponds are dictated in the DMDP within it, which should be preserved for reducing the severity of flood within the FAP proposed embankment protected area.

The study area falls in SPZ 13.2 of the DMDP that include Uttara in its middle part. DMDP identifies following major issues/problems, opportunities and actions for the study area within the broader area of this SPZ. Two sample sites within the study area were selected for achieving the best result from the analysis. Between these two sample sites one was in inner fringe area and the other was in outer fringe area. Through extensive field visit these two sites were randomly selected considering their location within the fringe area (distance from the core urban area), and their present physical characteristics (land use pattern). The site which was found to be not far from the urban core, had most of its land area covered by residential or non-residential structures and had got the character of urban area (although in a scattered manner) was selected to be inner fringe area. The site which was found in longer distance from the urban core, had most of its land area covered by agricultural land and had got the character of rural area was selected to be outer fringe area.

Methodology

Identification of Sustainability Criteria for MCA: In this study, Multi Criteria Analysis (MCA) technique for quick appraisal of the sustainability of development trends in the fringe area has been used. For conducting MCA it has identified 3 Primary Tier Criteria (PTC), namely Environmental, Social and Economical. Under these PTC, 28 Secondary Tier Criteria (STC) have been identified. The Environmental PTC contains 10 STC, Social PTC contains 9 STC and Economical PTC has got 9 STC. These PTC and STC are listed in Table 1.

Table 1: Primary Tier Criteria (PTC) and Secondary Tier Criteria (STC) for MCA of sustainability

Primary Tier Criteria (PTC)	Secondary Tier Criteria (STC)
Environmental Sustainability (PTC-1)	Air Pollution (STC 1-1)
	Loss of wetland (STC 1-2)
	Water Pollution (STC 1-3)
	Noise Pollution (STC 1-4)
	Waste Management (STC 1-5)
	Agricultural Productivity (STC 1-6)
	Fisheries Production (STC 1-7)
	Ground water extraction (STC 1-8)
	Deforestation (STC 1-9)
	Sanitation (STC 1-10)
Social Sustainability (PTC-2)	Public Participation (STC 2-1)
	Housing Quality (STC 2-2)
	Education Facility (STC 2-3)
	Healthcare Facility (STC 2-4)
	Access to safe drinking water (STC 2-5)
	Recreational Facility (STC 2-6)
	Gender equity (STC 2-7)
	Public security/ crime (STC 2-8)
	Disaster Management (STC 2-9)
Economical Sustainability (PTC-3)	Increase of income (STC 3-1)
	Employment opportunity (STC 3-2)
	Increase of property value (STC 3-3)
	Economic equity (STC 3-4)
	Development of Industries (STC 3-5)
	Economic return of agricultural products (STC 3-6)
	Transport Facility (STC 3-7)
	Electricity Supply (STC 3-8)
	Gas Supply (STC 3-9)

Weighting of the Criteria by AHP: Analytical Hierarchy Process (AHP) was applied for weighting the STC. A brief discussion on AHP is provided in the following page in Box-1. All of the PTC was given with the value of 1 which was distributed among their STC in the form of Sustainability Weight (SW) on the basis of AHP.

Box 1: Analytical Hierarchy Process

The Analytic Hierarchy Process (AHP) is a multi-attribute modelling methodology, which was first developed and applied by Saaty (1980). The Analytical Hierarchy Process (AHP) is a systematic method for comparing a list of objectives or alternatives.

We begin by assuming that a set of objectives has been established and that we are trying to establish a normalized set of weights to be used when comparing alternatives using these

objectives. For simplicity, we assume that there are 4 objectives: O1, O2, O3, andO4.

We form a pair-wise comparison matrix *A*, where the number in the *i*th row and *j*th column gives the relative importance of O*i* as compared with O*j*. We use a 1–9 scale, with *aij* = 1 if the two objectives are equal in importance, *aij* = 3 if O*i* is weakly more important than O*j*, *aij* = 7 if O*i* is very strongly more important than O*j*, and *aij* = 9 if O*i* is absolutely more important than O*j* (these are explained in detail in Section 7.5.1, p.7-21).

Thus we might arrive at the following matrix:

$$A=\begin{bmatrix}1 & 1/5 & 1/3 & 1/7\\ 5 & 1 & 3 & 5\\ 3 & 1/3 & 1 & 3\\ 7 & 1/5 & 1/3 & 1\end{bmatrix}=\begin{bmatrix}1.000 & 0.200 & 0.333 & 0.143\\ 5.000 & 1.000 & 3.000 & 5.000\\ 3.000 & 0.333 & 1.000 & 3.000\\ 7.000 & 0.200 & 0.333 & 1.000\end{bmatrix}$$

To normalize the weights, we compute the sum of each column and then divide each column by the corresponding sum. Thus, using an overbar to denote normalization, we get:

$$\bar{A}=\begin{bmatrix}0.063 & 0.115 & 0.071 & 0.016\\ 0.313 & 0.577 & 0.643 & 0.547\\ 0.188 & 0.192 & 0.214 & 0.328\\ 0.438 & 0.115 & 0.071 & 0.109\end{bmatrix}$$

The next step is to compute the average values of each row and use these as the weights in the Objective Hierarchy. Thus, for this example, the weights would be:

$$w=\begin{bmatrix}0.066 & 0.520 & 0.231 & 0.183\end{bmatrix}^T$$

Note that by construction, $\sum_{i=1}^{4} W_i = 1$, These weights would be used in summing the measures as required in the evaluation of the Objective Hierarchy.

Saaty TL, 1980, The Analytic Hierarchy Process, NY, McGraw Hill.

Ernest H. Forman, *Decision by Objectives*, http://mdm.gwu.edu/Forman/DBO.pdf;

Collection of Data and Information: Data and information regarding the selected STC about these two sample sites were collected both from primary and secondary sources.

Primary Sources: Primary sources of data and information can be further classified as focal group meetings, personal interview and questionnaire survey that were conducted during field visit in both the inner and outer fringe areas.

Some focal group meetings were arranged in the sample sites comprising local political leaders, respected persons from different professional and social groups and peoples who are residing for more than 10 years in the study area. Through these focal group meetings it was tried to evaluate the perception of the local people regarding the selected STC as to what extended these criteria have improved or deteriorated in the past 10-15 years.

In addition to focal group meetings, the view of the local people regarding the sustainability criteria was also evaluated through personal interview with people from different strata. As the presence of women was almost zero in the focal group meetings, it was tried to have their perception about the STC through these personal interviews.

Based on the selected PTC and STC a close-ended questionnaire was prepared to identify the perception of the local residents regarding the positive or negative change of these criteria

within the last 10-15 years in the study area. The respondents were asked to answer about the level of change of each criterion as shown in Figure 3. Sample questionnaire surveys of 100 respondents were conducted in each of the two sample sites.

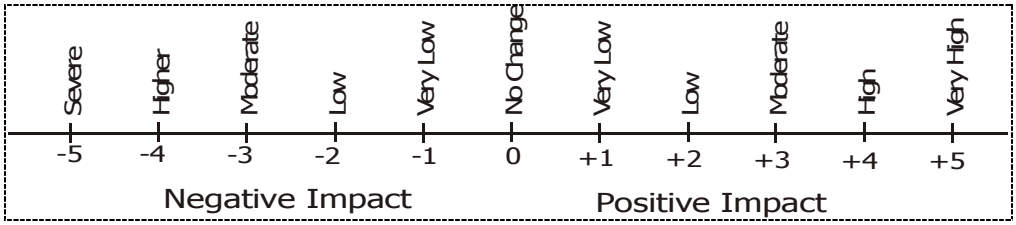

Fig. 3: Sustainability Impact Level (SIL) for different STCs

Calculation of Sustainability Impact Value (SIV) for Each Criterion: The criteria, which were not possible to evaluate through questionnaire survey, was assessed through focal group meetings, personal interviews and analysis of secondary data. For calculating Sustainability Impact Value (SIV) of each of the STC from questionnaire survey, following formula was used:

$$SIV_{ji} = \frac{\sum (SIL \times X)}{\sum X}$$

Here,

SIV_{ji} = Sustainability Impact Value of i-th STC of j-th PTC

SIL = Sustainability Impact Level (SIL) assigned by the respondent

X = No. of respondent

Determination of Sustainability through MCA: After providing SW to all of the STC, these SWs were then multiplied by SIVs of the respective STC. In this process the following formula was used to calculate Primary Sustainability Level (PSL) of each of the PTC:

$$PSL_j = \frac{\sum_{j=1,i=1}^{n} \left(SW_{ji} \times SIV_{ji} \right)}{\sum_{j=1,i=1}^{n} SW_{ji}}$$

Here, PSL_j = Primary Sustainability Level of j-th Primary Tier Criteria (PTC)

SW_{ji} = Sustainability Weight of i-th Secondary Tier Criteria (STC) of j-th Primary Tier Criteria (PTC) (here, $SWj_1+SWj_2+SWj_3+\text{---------}+SWj_n=1$)

SIV_{ji} = Sustainability Impact Value of i-th STC of j-th PTC

(here $-5 \leq SIV_{ji} \leq +5$)

Identified PSL of the three PTC were then calculated to identify Site Sustainability Level (SSL) of each of the sample sites using the following formula:

$$SSL = \frac{\sum_{j=1}^{n} (PSL_j \times SSV_j)}{\sum_{j=1}^{n} SSV_j}$$

Here, SSL = Site Sustainability Level

PSL_j = Primary Sustainability Level of j-th PTC

SSV_j = Sustainability Significance Value of j-th PTC

Here, Sustainability Significance Value (SSV) for different PTC are applied depending on the relative importance of the PTC on the total sustainability of the area. SSV is an arbitrary value depending on its significance. For this particular study, it was assumed that all the PTC are equally important for the overall sustainability of the fringe area and hence all the SSVs were equally valued (=1).

In this way SSL_1 and SSL_2 can be calculated for site-1 (inner fringe) and Site-2 (outer fringe) respectively. SSLs were then used to identify Generic Sustainability Level (GSL) of the study area according to following formula:

$$GSL = \frac{\sum_{k=1}^{n}(SSL_k \times SSV_k)}{\sum_{k=1}^{n} SSV_k}$$

Here, GSL = Generic Sustainability Level of the study area

SSL_k = Site Sustainability Level of k-th Site (here, site-1 is inner fringe and site-2 is outer fringe)

SSV_k = Sustainability Significance Value of k-th site

In this case, Sustainability Significance Value (SSV) was applied for the two sample sites based on their relative locational importance on the overall sustainability of fringe area. These SSVs are arbitrary values depending on their significance. In this case, two of the sample sites were in inner fringe and outer fringe and sustainability of both of these sites were assumed to be equally important for the sustainability of whole fringe area.

Results and Discussion

Before identifying GSL of the study area, it identified Site Sustainability Level (SSL) for the two sample sites (termed as Site-1 'inner fringe' and Site-2 'outer fringe'). On the way to identifying SSL it also calculated Primary Sustainability Level (PSL) for each of the Primary Tier Criteria (PTC) of both of the sample sites.

Sustainability Level of Site-1 (Inner Fringe)

Environmental Sustainability: Table 2 shows the Sustainability Impact Value (SIV) of different Secondary Tier Criteria (STC) under the Primary Tier Criteria of Environmental Sustainability (PTC-1). It shows that only STC 1-5 (waste Management) and STC 1-10 (sanitation) of site-1 are in a positive state of sustainability although with a very low value of SIV. All the other STC of this PTC are in a negatives state where STC 1-2 (Loss of wetland) is in the worst position, which is followed by STC 1-9 (Deforestation). STC 1-3 (Water Pollution), STC 1-7 (Fisheries Production) and STC 1-8 (Ground water extraction) are also in highly negative state as can be seen from Table 2.

Using the values of SIV for all the STC of PTC-1 (environmental sustainability) the Primary Sustainability Level (PSL) for this PTC was calculated as shown in Table 2. It indicates that PSL_1 (Primary Sustainability Level of PTC-1) is –1.52. It means Site-1 (inner fringe) is in a 'Low Negative State' of Environmental Sustainability (as per Figure 3). If the negative impact though loss of wetland, deforestation, water pollution and ground water extraction can be minimized, the overall level of environmental sustainability of this area can be improved.

Table 2: Calculation of PSL_1 for Site-1 (Environmental Sustainability)

Secondary Tier Criteria	SW	SIV	SW× SIV	PSL= $\frac{\sum(SW \times SIV)}{\sum SW}$
Air Pollution (STC 1-1)	0.07	-0.87	-0.06	-1.52
Loss of wetland (STC 1-2)	0.20	-3.00	-0.59	
Water Pollution (STC 1-3)	0.15	-2.01	-0.30	
Noise Pollution (STC 1-4)	0.04	-0.79	-0.03	
Waste Management (STC 1-5)	0.10	0.84	0.08	
Agricultural Productivity (STC 1-6)	0.05	-0.81	-0.04	
Fisheries Production (STC 1-7)	0.06	-1.83	-0.11	
Ground water extraction (STC 1-8)	0.14	-2.00	-0.27	
Deforestation (STC 1-9)	0.13	-2.23	-0.28	
Sanitation (STC 1-10)	0.08	1.06	0.08	
Total	1.00		-1.52	

Social Sustainability: Table 3 shows the Sustainability Impact Value (SIV) of different Secondary Tier Criteria (STC) under the Primary Tier Criteria of Social Sustainability (PTC-1). It shows that site-1 (inner fringe) is in a positive state of sustainability in terms of Public Participation (STC 2-1), Housing Quality (STC 2-2), Education Facility (STC 2-3), Healthcare Facility (STC 2-4), Access to safe drinking water (STC 2-5) and Gender equity (STC 2-7) although all of them contains a low positive value of SIV. In terms of Recreational Facility (STC 2-6), Public security/ crime (STC 2-8) and Disaster Management (STC 2-9) this site is in a negative state of sustainability, as can be seen in the figure.

Table 3: Calculation of PSL_2 for Site-1

Secondary Tier Criteria	SW	SIV	SW× SIV	PSL= $\frac{\sum(SW \times SIV)}{\sum SW}$
Public Participation (STC 2-1)	0.14	0.47	0.07	0.43
Housing Quality (STC 2-2)	0.06	1.20	0.07	
Education Facility (STC 2-3)	0.12	1.48	0.18	
Healthcare Facility (STC 2-4)	0.15	1.41	0.22	
Access to safe drinking water (STC 2-5)	0.19	1.11	0.21	
Recreational Facility (STC 2-6)	0.05	-1.11	-0.05	
Gender equity (STC 2-7)	0.11	0.49	0.06	
Public security/ crime (STC 2-8)	0.06	-1.70	-0.10	
Disaster Management (STC 2-9)	0.11	-2.00	-0.21	
Total	1.00		0.43	

Using the values of SIV for all the STC of PTC-2 (Social Sustainability) the Primary Sustainability Level (PSL) for this PTC was calculated as shown in Table 3. It indicates that PSL_2 (Primary Sustainability Level of PTC-2) is 0.43. It means Site-1 (inner fringe) is in a

'Very Low Positive State' of Social Sustainability (as per Figure 3). If the negative impact though loss of recreation facility, increase of crime and inadequate disaster management can be minimized the overall social sustainability of this area can be improved. Again, if public participation, education facility, healthcare facility and gender equity can be improved further, it would surely attain a satisfactory level of social sustainability.

Economic Sustainability: Table 4 shows the Sustainability Impact Value (SIV) of different Secondary Tier Criteria (STC) under the Primary Tier Criteria of Economic Sustainability (PTC-1). It shows that site-1 (inner fringe) is in a positive state of sustainability in terms of increase of income (STC 3-1), employment opportunity (STC 3-2), increase of property value (STC 3-3), development of Industries (STC 3-5), economic return of agricultural products (STC 3-6), transport Facility (STC 3-7), electricity supply (STC 3-8) and gas supply (STC 3-9) although all of them contains a low positive value of SIV. But, in terms of economic equity (STC 3-4) this site is in a highly negative state of sustainability, as can be seen in the figure below.

Table 4: Calculation of PSL_3 for Site-1

Secondary Tier Criteria	**SW**	**SIV**	**SW× SIV**	**PSL=** $\frac{\sum(SW \times SIV)}{\sum SW}$
Increase of income (STC 3-1)	0.15	0.81	0.13	0.95
Employment opportunity (STC 3-2)	0.15	0.98	0.14	
Increase of property value (STC 3-3)	0.08	3.10	0.24	
Economic equity (STC 3-4)	0.17	-3.00	-0.52	
Development of Industries (STC 3-5)	0.07	2.26	0.17	
Economic return of agricultural products (STC 3-6)	0.10	1.25	0.13	
Transport Facility (STC 3-7)	0.12	1.99	0.23	
Electricity Supply (STC 3-8)	0.08	2.89	0.23	
Gas Supply (STC 3-9)	0.08	2.68	0.21	
Total	1.00		0.95	

Using the values of SIV for all the STC of PTC-3 (Economical Sustainability) the Primary Sustainability Level (PSL) for this PTC was calculated as shown in Table 4. It indicates that PSL_3 (Primary Sustainability Level of PTC-3) is 0.95. It means Site-1 (inner fringe) is in a 'Very Low Positive State' of Economical Sustainability (as per Figure 3). If the negative impact though economic equity can be minimized the overall economical sustainability of this area can be improved.

***Primary Sustainability*:** The Site Sustainability Level of Site-1 (SSL_1) was calculated using the Primary Sustainability Level (PSL) of all the Primary Tier Criteria (PTC). Here, all the PTC were given same significance (=1) to achieve improvement in overall sustainability of inner fringe of the study area. The SSL_1 was calculated in the following manner:

$$SSL_1 = \frac{-1.52 \times 1 + 0.43 \times 1 + 0.95 \times 1}{3}$$

$$= -0.05$$

Here we found SSL of Site-1 (inner fringe) is –0.05 that indicates the site is in a 'low negative state' of sustainable development (as per Figure 3).

Sustainability Level of Site-2 (Outer Fringe)

By applying the same method, we find the PSL for Environmental, Social and Economic sustainability as -1.47, 0.34 and 0.86. Thus the SSL_2 is:

$$SSL_2 = \frac{-1.47 \times 1 + 0.34 \times 1 + 0.86 \times 1}{3}$$

$$= -0.09$$

Here we found SSL of Site-2 (outer fringe) is –0.09 that indicates the site is in a 'low negative state' of sustainable development (as per Figure 3).

Conclusion

Generic Sustainability Level (GSL) of the whole study area was calculated by using the Site Sustainability Level (SSL) of the two sample study sites. It was found that both of the sample sites are in 'very low negative state' of sustainability that is mainly due to their deteriorated environmental conditions. Both the sample sites were provided equal significance (=1) for calculating Generic Sustainability Level (GSL) of the study area. The GSL was calculated in the following manner:

$$GSL = \frac{-0.05 \times 1 + -0.09 \times 1}{2}$$

$$= -0.07$$

As can be found from the above calculation, the study area has got a GSL value of '-0.07'. It indicates that the study area is in a 'very low negative state' of sustainability in its development process. It means that, if the development trends of the study area continue in the same manner as it occurred for last 10-15 years, it would proceed further towards an unsustainable situation.

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