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ESTABLISHING WEIGHTAGES OF CRITERIA AND KEY ASPECTS FOR QUALITY ASSESSMENT OF BUILT ENVIRONMENT

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Abstract

Everything is being assessed today to know the quality of product. The Built Environment where we live, work and spent our most of the time also needs to assessed for the purpose of quality of built environment which significantly affects our potentials to work and of course the health. It will help to know quality of built environment in terms of planning and design. For the very purpose based on literature study some Criteria and Key Aspects have been identified as an indicators to know the quality of Built Environment.

A questionnaire was formulated having Nine Criteria. These criteria are further divided into thirty six Key Aspects and sent to professionals like Architects, Urban Designer, Landscape Architects, Conservation Architects, Town Planner and Academicians for the purpose of pilot survey. They were asked to gauge these key aspects in the calibrated scale of 1 to 5 from least to most significant. (Pilot Survey of 42 Samples were analysed).This paper basically dealing with to establish weightages of each criteria and key aspects on the basis of percentage of variance of factor analysis.

Key Words: *Factor Analysis, Criteria, Key Aspects, Quality Assessment, Built Environment*

INTRODUCTION

There are thirty six Key Aspects which are grouped into Nine Criteria i.e. Each Criteria has four Key Aspects. These Criteria and Key Aspects are coded as C1k1, C1K2, C1K3, C1K4 and so on for the purpose of calculation. C1K1 be read as Criteria1 Key Aspect1, C1K2 be read as Criteria1 Key Aspect2 and so on. Data is analysed by taking 42 samples with following questionnaire.

Pilot Survey Questionnaire Form for Establishing Criteria and Key Aspects of Qualitative Assessment of Built Environment

	Criteria and Key Aspects	Assigned Key Aspect Grade Points
		1/2/3/4/5
1.0	**Criterion I: Efficiency in Planning and Layout development of Built Environment**	
1.1	Efficiency in Planning and site coverage.	
1.2	Planning and Development of streetscape.	
1.3	Innovation in Planning and design.	
1.4	Visual Appropriateness i.e. three dimensional effect of development in terms height and massing.	
2.0	**Criterion II: Infrastructure available at the Place and Collective Value of the Built Environment**	
2.1	Continuity of streets and enclosure of open spaces.	
2.2	Townscape value i.e. buildings, blocks, sky line, streets and squares that create the urban form.	
2.3	Provision Water Supply, Sewer lines and Electric poles etc. on the site.	
2.4	Public and private areas are clearly delineated and planned.	
3.0	**Criterion III: Planning & designing the External Appearance of Buildings**	
3.1	Identity, character and response to the place.	
3.2	Ambiance creation in context to sense of place.	
3.3	Scale, proportion and building line for articulation of the building facades.	
3.4	Materials and detailing that ensure the quality and finish of the development (buildings / open spaces/streets).	
4.0	**Criterion IV: Legibility of Built Environment**	
4.1	Planning and design of views, vistas and gateways that strengthens people's understanding and use of the place.	
4.2	Planning and design of Edges, Paths, Landmarks and character areas.	
4.3	Provision of way finding signage's.	
4.4	Recognition of Built Environment in context to surrounding.	
5.0	**Criterion V: Streets, Connections and Linkages of the Built Environment**	
5.1	External connections and integration i.e. How well is the place connected with the wider street network.	
5.2	Permeable and internally well linked streets. i.e. ease of movement through and around the area.	
5.3	Planning of off-Street and on street vehicle parking.	
5.4	Pedestrian and cycle consideration in planning to avoiding traffic dominance.	

6.0	**Criterion VI: Planning and Designing of Open Spaces**	
6.1	Streetscape elements such as lighting, building/shop fronts and fences/railings	
6.2	Quality of open spaces in terms of functionality and context.	
6.3	Quality of open spaces in terms of materials, furnishings, landscape specification, detailing and construction.	
6.4	Maintenance and ongoing care of open spaces as well as structures.	
7.0	**Criterion VII: Planning of Safe and Inclusive design for Built Environment**	
7.1	Overlooking and natural surveillance, from nearby uses.	
7.2	Physical security measures provided in an area / scheme.	
7.3	Lighting and the evening environment creating a safer place after dark.	
7.4	Accessible and inclusive planning and design.	
8.0	**Criterion VIII: Planning of Space and Use Attributes in Buildings**	
8.1	Land Use in terms of mix and tenure i.e. supporting an appropriate mix of uses and tenures through planning and design.	
8.2	Land Use in terms of density & intensity i.e. appropriate for context, vitality and sustainability.	
8.3	Response of open spaces with ground floor units/building/street.	
8.4	Flexibility and adaptability of planning and design.	
9.0	**Criterion IX: Sustainability aspects in planning & design of Built Environment**	
9.1	Sustainability of the location in respect of accessibility and the nature of uses.	
9.2	Provision of waste water treatment plant, renewable source of energy and rain water harvesting.	
9.3	Local resource used in the development of place.	
9.4	Environmental performance of the Built Environment as a whole.	

Table.1: Pilot survey Questionnaire Form

FACTOR ANALYSIS

The Correlation among the Key Aspects and Correlation among the Criteria analysed and results show that there is no significant correlation among the Key Aspects and Criteria. This means all the variables have their individual importance in the planning and designing of quality assessment of Built Environment.

Since all the Criteria and Key Aspects has their own importance in the matrix therefore Factor Analysis is to be carried out for producing the percentage of variance in each Criteria in the matrix which will also determine the percentage of variation of Key Aspects within the Criteria. This will further provide the weightage of Each Criteria and further the weightage of each Key Aspect within the Criteria. Generally Factor Analysis is done to reduce the variables and percentage of variance in the matrix so the main purpose would be to know the percentage that each criteria and key aspects contributing in the matrix. Criteria and key aspects identified for quality assessment is not too large therefore it is not required to reduce the criteria and key aspects.

Measure of Appropriateness of factor Analysis

The Factor Analysis is applied as a data reduction or structure detection method.. Interpretive adjectives for the Kaiser-Meyer-Olkin Measure of Sampling Adequacy are: in the 0.90 as marvellous, in the 0.80's as meritorious, in the 0.70's as middling, in the 0.60's as mediocre, in the 0.50's as miserable, and below 0.50 as unacceptable.

Bartlett's test of sphericity tests the hypothesis that the correlation matrix is an identify matrix; i.e. all diagonal elements are 1 and all off-diagonal elements are 0, implying that all of the variables are uncorrelated. If the Sig value for this test is less than our alpha level, we reject the null hypothesis that the population matrix is an identity matrix. The Sig. value for this analysis leads us to reject the null hypothesis and conclude that there are correlations in the data set that are appropriate for factor analysis. This analysis meets this requirement.

The Principal Components Method of Factor Analysis

Principle Components (PC) analysis is a procedure to convert a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables called principal components. This transformation is defined in such a way that the first principal component accounts for the largest variability in the data, and each succeeding component in turn has the highest variance possible under the constraint that it is uncorrelated with the preceding components.

FACTOR ANALYSIS OF CRITERIA

Factor Analysis of all Nine Criteria i.e. C1, C2, C3, C4, C5, C6, C7, C8andC9 was carried out with the following hypothesis

H_0: All the criteria are equally important in assessing quality of built environment.

H_1: All the criteria are not equally important in assessing quality of built environment

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.628
Bartlett's Test of Sphericity	Approx. Chi-Square	116.337
	df	36
	Sig.	.000

Since the KMO Measure of Sampling Adequacy meets the minimum criteria, we do not have a problem that requires us to examine the Anti-Image Correlation Matrix.

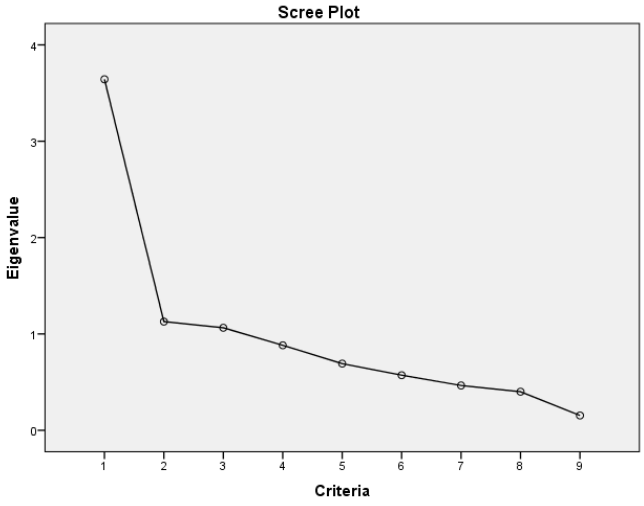
Rotated Component Matrix[a]

	Component								
	1	2	3	4	5	6	7	8	9
c1	.922 **1**	.004	.041	.081	.166	.176	.127	.029	.256
c2	.324	.947 **2**	.114	.195	.124	-.020	.013	.259	.146
c3	.083	.038	.143	.934 **5**	.126	.154	.154	.108	.157
c4	.171	.098	.008	.132	.917 **6**	.172	.179	.170	.109
c5	.182	.135	.148	.166	.178	.905 **7**	.156	.153	-.013
c6	.036	.262	-.014	.126	.192	.169	.146	.876 **9**	.245
c7	.008	.860 **3**	.078	.036	.089	.118	.136	.207	.112
c8	.131	.154	.184	.166	.185	.155	.906 **8**	.133	.016
c9	.039	.072	.965 **4**	.129	.007	.123	.152	-.008	.083

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 7 iterations.

The above table of Extraction Method: Principal Component Analysis, shows that all the 9 Criteria lies in PCI to PC9. Therefore no criteria is being eliminated and are important for evaluating the Quality Assessment of Built Environment of any place.

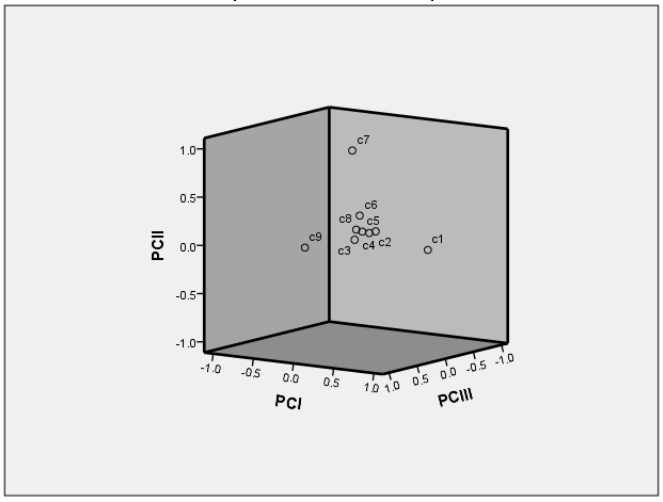


Total Variance Explained

Component	Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1 C1	3.643	26.476	26.476	1.045	11.614	11.614
2 C2	1.128	18.535	45.011	1.045	11.610	23.224
3 C7	1.064	11.822	56.833	1.028	11.425	34.649
4 C9	.882	9.800	66.633	1.023	11.362	46.011
5 C3	.692	7.688	74.321	1.011	11.229	57.240
6 C4	.572	7.355	81.676	.986	10.957	68.197
7 C5	.465	7.166	88.842	.981	10.896	79.093
8 C8	.400	6.449	95.291	.960	10.665	89.758
9 C6	.154	4.709	100.000	.922	10.242	100.000

Extraction Method: Principal Component Analysis.

Component Plot in Rotated Space



Result of Factor Analysis of Criteria

The above table of Total Variance Extraction Method of Principal Component Analysis with Sums of Squared Loadings and the above graph of Principle Component clearly shows the all the Criteria taken for analysis are very closely bonded and are having values of percentage relatively equal in matrix. This percentage of Nine Criteria will help in providing the numbers to each Criteria for the Assessment of Built Environment of any place.

The **Null Hypothesis H_0** is accepted on the basis of above analysis carried out.

FACTOR ANALYSIS OF INDIVIDUAL CRITERIA FOR ANALYSING THE WEITAGE OF KEY ASPECTS

The above Factor Analysis was done to understand the weightage of each criteria. Now the Factor Analysis of individual criteria has been done to get the weightage of individual key aspects in each of the nine criteria.

Factor Analysis of Criterion I: Efficiency in Planning and Layout development of Built Environment

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.609
Bartlett's Test of Sphericity	Approx. Chi-Square	19.468
	df	6
	Sig.	.003

Component Matrix[a]

	Component			
	1	2	3	4
C1K1	.799 2	-.190	.321	-.471
C1K2	.109	.937 4	.329	.051
C1K3	.805 1	-.226	.184	.516
C1K4	.706 3	.329	-.624	-.063

Extraction Method: Principal Component Analysis.

a. 4 components extracted.

Component	Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %
1 C1K3	1.798	38.938	38.938
2 C1K1	1.073	32.827	71.765
3 C1K4	.634	15.859	87.624
4 C1K2	.495	12.376	100.000

Result of Factor Analysis of Criteria I

The two tables of Principal Component Analysis shows the percentage of variation of Key Aspects and the sequence of Key Aspects in the Criteria1.Therefore it is to be used to take percentage of variance for the decision of weightage of individual Key Aspects of this Criteria

Factor Analysis of Criterion II: Infrastructure of a Place and Collective Value of the Built Environment:

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.583
Bartlett's Test of Sphericity	Approx. Chi-Square	8.704
	df	6
	Sig.	.191

Component Matrix[a]

	Component			
	1	2	3	4
C2K1	.752 1	.150	-.314	-.560
C2K2	.749 2	-.152	-.336	.551
C2K3	.460	-.699 4	.536	-.109
C2K4	.458	.705 3	.526	.129

Extraction Method: Principal Component Analysis.

a. 4 components extracted.

Component	Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %
1 C2K1	1.548	38.692	38.692
2 C2K2	1.031	25.766	64.458
3 C2K4	.776	19.403	83.861
4 C2K3	.646	16.139	100.000

Result of Factor Analysis of Criteria II

The two tables of Principal Component Analysis shows the percentage of variation of Key Aspects and the sequence of Key Aspects in the Criteria- II. Therefore it is to be used to take percentage of variance for the decision of weight age of individual Key Aspects of this Criteria.

Factor Analysis of Criterion III: Planning & designing the External Appearance of Buildings:

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.584
Bartlett's Test of Sphericity	Approx. Chi-Square	4.922
	df	6
	Sig.	.554

Component Matrix[a]

	Component			
	1	2	3	4
C3K1	.629 **1**	-.459	-.381	.498
C3K2	.558 **4**	.612	.431	.359
C3K3	.582 **3**	-.475	.546	-.372
C3K4	.629 **2**	.356	-.505	-.472

Extraction Method: Principal Component Analysis.
a. 4 components extracted.

Component	Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %
1 C3K1	1.441	36.022	36.022
2 C3K4	.937	23.433	59.456
3 C3K3	.883	22.085	81.541
4 C3K2	.738	18.459	100.000

Result of Factor Analysis of Criteria III

The two tables of Principal Component Analysis shows the percentage of variation of Key Aspects and the sequence of Key Aspects in the Criteria- III. Therefore it is to be used to take percentage of variance for the decision of weight age of individual Key Aspects of this Criteria.

Factor Analysis of Criterion IV: Legibility of Built Environment:

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.584
Bartlett's Test of Sphericity	Approx. Chi-Square	22.786
	df	6
	Sig.	.001

Component Matrix[a]

	Component			
	1	2	3	4
C4K1	.779 **1**	-.277	.430	-.363
C4K2	.700 **3**	-.516	-.084	.487
C4K3	.760 **2**	.312	-.524	-.224
C4K4	.416	.817 **4**	.293	.270

Extraction Method: Principal Component Analysis.
a. 4 components extracted.

Component	Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %
1 C4K1	1.847	46.186	46.186
2 C4K3	1.109	27.714	73.900
3 C4K2	.553	13.817	87.718
4 C4K4	.491	12.282	100.000

Result of Factor Analysis of Criteria IV

The two tables of Principal Component Analysis shows the percentage of variation of Key Aspects and the sequence of Key Aspects in the Criteria- IV. Therefore it is to be used to take percentage of variance for the decision of weight age of individual Key Aspects of this Criteria.

Factor Analysis of Criterion V: Streets, Connections and Linkages of the Built Environment:

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.573
Bartlett's Test of Sphericity	Approx. Chi-Square	6.552
	df	6
	Sig.	.364

Component Matrix[a]

	Component			
	1	2	3	4
C5K1	.441	-.714 **3**	.511	.186
C5K2	.432	.682 **4**	.589	.033
C5K3	.715 **2**	.116	-.458	.515
C5K4	.764 **1**	-.082	-.200	-.608

Extraction Method: Principal Component Analysis.

a. 4 components extracted.

Component	Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %
1 C5K4	1.477	36.932	36.932
2 C5K3	.995	24.867	61.799
3 C5K1	.858	21.452	83.251
4 C5K2	.670	16.749	100.000

Result of Factor Analysis of Criteria V

The two tables of Principal Component Analysis shows the percentage of variation of Key Aspects and the sequence of Key Aspects in the Criteria- V. Therefore it is to be used to take percentage of variance for the decision of weight age of individual Key Aspects of this Criteria.

Factor Analysis of Criterion VI: Planning and Designing of Open Spaces:

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.513
Bartlett's Test of Sphericity	Approx. Chi-Square	12.131
	df	6
	Sig.	.059

Component Matrix[a]

	Component			
	1	2	3	4
C6K1	.624 **3**	.217	-.750	.039
C6K2	.813 **1**	-.034	.296	-.500
C6K3	.644 **2**	-.594	.181	.446
C6K4	.330	.834 **4**	.336	.287

Extraction Method: Principal Component Analysis.

a. 4 components extracted.

Component	Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %
1 C6K2	1.575	39.381	39.381
2 C6K3	1.097	27.436	66.818
3 C6K1	.795	19.868	86.686
4 C6K4	.533	13.314	100.000

Result of Factor Analysis of Criteria VI

The two tables of Principal Component Analysis shows the percentage of variation of Key Aspects and the sequence of Key Aspects in the Criteria- VI. Therefore it is to be used to take percentage of variance for the decision of weight age of individual Key Aspects of this Criteria.

Factor Analysis of VII: Planning of Safe and Inclusive design for Built Environment

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.577
Bartlett's Test of Sphericity	Approx. Chi-Square	10.925
	df	6
	Sig.	.091

Component Matrix[a]

	Component			
	1	2	3	4
C7K1	.866 1	.441	-.054	.230
C7K2	.666 3	-.413	-.471	.406
C7K3	.575 4	.002	-.138	-.574
C7K4	.807 2	-.189	.780	.160

Extraction Method: Principal Component Analysis.
a. 4 components extracted.

Component	Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %
1 C7K1	1.620	40.510	40.510
2 C7K4	.956	23.896	64.406
3 C7K2	.851	21.284	85.690
4 C7K3	.572	14.310	100.000

Result of Factor Analysis of Criteria VII

The two tables of Principal Component Analysis shows the percentage of variation of Key Aspects and the sequence of Key Aspects in the Criteria- VII. Therefore it is to be used to take percentage of variance for the decision of weight age of individual Key Aspects of this Criteria.

Factor Analysis of Criterion VIII: Planning of Space and Use Attributes in Buildings

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.494
Bartlett's Test of Sphericity	Approx. Chi-Square	19.031
	df	6
	Sig.	.004

Component Matrix[a]

	Component			
	1	2	3	4
C8K1	.616 2	-.622	-.147	.461
C8K2	.780 1	-.354	.306	-.416
C8K3	.612 3	.563	-.539	-.133
C8K4	.422	.744 4	.431	.288

Extraction Method: Principal Component Analysis.
a. 4 components extracted.

Component	Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %
1 C8K2	1.539	38.483	38.483
2 C8K1	1.382	34.561	73.044
3 C8K3	.592	14.798	87.841
4 C8K4	.486	12.159	100.000

Result of Factor Analysis of Criteria VIII

The two tables of Principal Component Analysis shows the percentage of variation of Key Aspects and the sequence of Key Aspects in the Criteria- VIII. Therefore it is to be used to take percentage of variance for the decision of weight age of individual Key Aspects of this Criteria.

Factor Analysis of Criterion IX: Sustainable Planning & design Aspects of Built Environment:

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.503
Bartlett's Test of Sphericity	Approx. Chi-Square	13.423
	df	6
	Sig.	.037

Component Matrix[a]

	Component			
	1	2	3	4
C9K1	.804 **2**	-.340	-.022	.487
C9K2	.835 **1**	-.182	.181	-.487
C9K3	.224	.777 **3**	.574	.130
C9K4	.396	.634 **4**	-.663	-.037

Extraction Method: Principal Component Analysis.

a. 4 components extracted.

Component	Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %
1 C9K2	1.551	32.763	32.763
2 C9K1	1.154	26.840	59.603
3 C9K3	.803	20.083	79.686
4 C9K4	.493	20.314	100.000

Result of Factor Analysis of Criteria IX

The two tables of Principal Component Analysis shows the percentage of variation of Key Aspects and the sequence of Key Aspects in the Criteria- IX. Therefore it is to be used to take percentage of variance for the decision of weight age of individual Key Aspects of this Criteria.

Key Aspects and Weight ages

Criteria	Key Aspects	Weight ages (W)
I: Efficiency in Planning and Layout development of Built Environment	1.1 Efficiency in Planning and site coverage.	90
	1.2 Planning and Development of streetscape.	40
	1.3 Innovation in Planning and design.	120
	1. 4 Visual Appropriateness i.e. three dimensional effect of development in terms height and massing.	50
	Total	**300**
II: Infrastructure available at the Place and Collective Value of the Built Environment	2.1 Continuity of streets and enclosure of open spaces.	85
	2.2 Townscape value i.e. buildings, blocks, sky line, streets and squares that create the urban form.	55
	2.3 Provision of Water Supply, Sewer lines and Electric poles on the site.	35
	2.4 Public and private areas are clearly delineated and planned.	45
	Total	**220**
III: Planning & designing the External Appearance of Buildings	3.1 Identity, character and response to the place.	35
	3.2 Ambiance creation in context to sense of place.	20
	3.3 Scale, proportion and building line for articulation of the building facades.	20
	3.4 Materials and detailing that ensure the quality and finish of the development (buildings / open spaces/streets).	25
	Total	**100**
IV: Legibility of Built Environment	4.1 Planning and design of Views, vistas and gateways that strengthens people's understanding and use of the place.	40
	4.2 Planning of Edges, Paths, Landmarks and character areas.	15
	4.3 Provision of way finding sign ages.	25
	4.4 Recognition of Built Environment in context to surrounding.	10
	Total	**90**

V: Streets, Connections and Linkages of the Built Environment	5.1 External connections and integration i.e. How well is the place connected with the wider street network.	20
	5.2 Permeable and internally well linked streets. i.e. ease of movement through and around the area.	15
	5.3 Planning of off-Street and on street vehicle parking.	25
	5.4 Pedestrian and cycle consideration in planning to avoid traffic dominance.	30
	Total	**90**
VI: Planning and Designing of Open Spaces	6.1 Streetscape elements such as lighting, building/shop fronts and fences/railings	15
	6.2 Quality of open spaces in terms of functionality and context.	25
	6.3 Quality of open spaces in terms of materials, furnishings, landscape specification, detailing and construction.	20
	6.4 Maintenance and ongoing care of open spaces as well as structures.	10
	Total	**70**
VII: Planning of Safe and Inclusive design for Built Environment	7.1 Overlooking and natural surveillance, from nearby uses.	55
	7.2 Physical security measures provided in an area / scheme.	30
	7.3 Lighting and the evening environment creating a safer place after dark.	20
	7.4 Accessible and inclusive planning and design.	35
	Total	**140**
Criterion VIII: Planning of Space and Use Attributes in Buildings	8.1 Land Use in terms of mix and tenure i.e. supporting an appropriate mix of uses and tenures through planning and design.	25
	8.2 Land Use in terms of density & intensity i.e. appropriate for context, vitality and sustainability.	25
	8.3 Response of open spaces with ground floor units/building/street.	10
	8.4 Flexibility and adaptability of planning and design.	10
	Total	**70**
IX: Sustainable planning & design aspect of Built Environment	9.1 Sustainability of the location in respect of accessibility and the nature of uses.	30
	9.2 Provision of waste water treatment plant, renewable source of energy and rain water harvesting.	40
	9.3 Local resource used in the development of place.	25
	9.4 Environmental performance of the Built Environment as a whole.	25
	Total	**120**
	Grand Total	**1200**

Conclusion:

Factor Analysis were carried out for the purpose to know the percentage variation of each Criteria and Key Aspects and accordingly weightage of each Criteria and Key Aspects are established.

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