How to bring "BREEAM" to China

A case study of Zuoling project

Chapter 1. Introduction

In recently years, although Chinese central government and real estate development enterprises have gradually increased the investment in eco-city construction, the deficiency of a unified effective assessment standard is still a problem, which leads to the irregular quality of green buildings. Many buildings or district planning has involved the energy conservation or environmental protection technology, but the concept has not been well conveyed throughout the whole design period, which causes the contradiction between the use of energy-saving technology and the whole project planning.

In most of the urban development projects, the designers, developers, investors, and supervisors are always grouped into the different sides, the design phase is always divorced from financial budget phase, which severely impacts the progress of the whole project. In UK, BRE has developed various BREEAM schemes to cover almost all construction domain. Among them, "BREEAM Communities" is newly launched evaluation system which integrates multiple factors. Through BREEAM Communities, the stakeholders are able to recognize the development projects according to their environmental, social, and economic benefits to the local Communities. (BRE Global Ltd, 2009). Nevertheless, it is difficult to integrate the various local regulations of China and develop a uniformed "Chinese BREEAM". Therefore, in this paper, the authors try to borrow the UK BREEAM Communities' concept and evaluation structure, combine with the Chinese characteristics and Wuhan local regulations, design an initial Bespoke BREEAM Communities for Wuhan City Circle and use this system to evaluate the Zuoling pilot project.

Chapter 2 China's Present Urbanization Patterns

In modern times, the urbanization of China has become the main point of development of the state. The huge domestic demand for construction provides sufficient opportunities to the designers to practice; sufficient funds and vast land enable the developers continually create landmarks for the city.

Referred to the design concept, the indigenous designers can absorb essence from the Chinese classical culture, and also integrate the international design concept as sustainability design or western landscape design. Besides, an increasing number of foreign designers win the bidding in china, through which they bring the western idea and technique to Chinese real estate market. (Wang, 2002)

Owing to the development strategy, Beijing, Shanghai, Guangzhou, and Shenzhen have already reached to the standard of developed country, if only see city scale and degree of modernization. Nevertheless, after the thirty years of development after the "open and reform", most of the suburban areas still stay in the original situation or grow slowly. At the same time, the rapid expansion of urban also brings unprecedented pressure to the people. The four main threats are population explosion, environment deterioration, shortage of resources, and the slum problem. (Hu, Wang, & Shi, 2010)

Chapter 3 Research analysis

In order to improve the living environment of urban, the green building design based on the sustainability concept will become the significant factor of the Communities development. As a consequence, the choice of the green building assessment system will become a significant part of the research.

Among all the assessment systems, there is not a universal standard. Plus with the limitation of technology, economy, resource, social & cultural conditions, the evaluation system of each country has their own constraints. The simplification of evaluation factors and the formulation of quantifiable index weight will be influenced by the regional characteristics. In the assessment of architecture environment, a simply copy of some certain standard will only bring out the distortion.

Considering of the specific state of china, currently there is no complete set of sustainable Communities assessment system, and the involved issues of the development of sustainable Communities are complicated, so a feasible sustainable Communities assessment system should be qualified with the following characteristics:

Flexible

China is a huge country, the policies, regulations, and environment situation diverse in different areas. Owing to a specific state, the assessment system has to be changeable to adapt the local situation and regulations.

Integrating

Except for the construction technical index, there are some invisible elements (e.g. financing, social fabric) which will also affect the final evaluation of the project. As a consequence, the assessment system should be able to coordinate and balance the relations of the different factors.

Explorative

The history of development of real estate in china is less than twenty years; the Chinese developers draw lessons from the western countries and accumulate experience from the real projects. However, there are still some loopholes and specific problems they have to overcome. So the assessment system should stimulate the participants to introduce more significant factors to the system and perfect the system along with the performance of the project.

Currently, the most popular Green building assessment systems in the world are BREEAM and LEED. In China, the Chinese Green Building Label System has been a regular practice. Comparing the three systems, the weighting system of BREEAM is better than the LEED and Chinese Green Building Label System, which enables the assessors to rearrange the criteria and adjust the weighting of each category for a certain project. In this way, the regional characteristics and advantages can be better represented. The covered issues of the three systems are roughly the same, although there are some small differences in specific details. Besides, BREEAM system covers the issues of management which could guarantee the economic feasibility of the project from the start.

To summary, the "Chinese Green Building Label System" is a good start for China's nascent green building; the covered issues can represent the features and state of China, so this system has the reference value. Furthermore, introducing the structure of the

"BREEAM Communities" to the Chinese sustainable Communities construction could provide a comprehensive and scientific guidance for the design and control of the whole project. To conclude, a feasible evaluation method for Chinese sustainable Communities is to integrate the contents of Chinese Green Building Label System to the structure of BREEAM Communities, and combined with the local regulations and policies to design the Bespoke BREEAM Communities for a certain area of China.

Chapter 4 Bespoke BREEAM Communities for Wuhan City Circle

The ordinary standards of BREEAM Communities are designed for certain areas of UK. Considering of the real situation of Wuhan City Circle, local regulations should be introduced to the BREEAM system. By combining the BREEAM Communities and 《Tentative evaluation standard for green building of Hubei province》,which is modified based on the《Chinese Green Building Label System》, a bespoke system for Wuhan City Circle can be constructed. Especially, if the standard of the theme misfit the Wuhan local regulations, take the Wuhan local regulations as standard. Owing to this situation, some of BREEAM Communities' issues have to be corrected to comply with Wuhan's characteristics and regulations. By realizing this, the determination of the weights of each category should also be based on the local sustainable development strategy.

4.1 Amending of BREEAM Communities issues

To emphasize, Appendix1 enumerates all the "BREEAM Communities" categories, sub categories, issues, and marks if the issue is Mandatory or not. In Appendix 2, a complete BREEAM Communities issue will be presented. In this paper, however, only the corrected issue will be discussed, which will help the project participators to evaluate the program. The amendment from the original BRREAM Communities will be interpreted as following:

CE2-Surface Water Runoff:

Owing to the rich rainfall and dated drainage system of Wuhan, flash flooding accidents happened frequently in this city. (Zhang, 2008). According to the special situation, it is necessary to change the original "No" mandatory to "Yes".

CE4-Heat Island:

Wuhan is located in the Jianghan Plain, and the summer of this area is long, hot and humid. In case the "Heat Island" effect cannot be controlled, the Communities environment will be tough for the residents and workers. For that reason, the original "No" for mandatory has to be changed into "Yes".

COM1- Inclusive Design:

In consideration of the real situation of China, the detailed design will refer to the《Codes for Design on Accessibility of Urban Roads and Buildings》.

COM2-Consultation:

"Remove" is an unavoidable part of urbanization in china. For the sustainable Communities design, it is significant to collect the local residents' idea about the development. And the suggestions from the residents should be synthesized into the final design and written report.

PS1-Sequential Approach:

The detailed design should refer to the《Regulations for gradation and classification on urban land》.

PS2-Land Reuse:

During the urbanization of china, it is common that land status has a fundamental shift. According to the China's national conditions, the assessment criteria have to change to the local regulations.

PS3-Building Reuse:

A considerable ratio of the existing buildings in china were constructed decade years ago, which cannot meet current requirements of quality or function. During the development, a significant proportion of these buildings should be demolished. According to the China's national conditions, the assessment criteria have to change to the local regulations.

PS6-Green Areas:

The detailed design refers to《Code of urban Residential Areas Planning & Design》.

BUS1-Business Priority Sectors:

The establishment of "Wuhan City Circle" is the main strategy of Wuhan municipality. All of the new developed area will be industry orientated. So "Business Priority Sectors" should be mandatory for the design of the project, while the original choice for Mandatory is "No".

BLD1-Domestic:

Based on "Sustainable Homes" or "Eco Homes" are used in some certain districts of UK, while 《Tentative evaluation standard for green building of Hubei province》 are tailor made for Hubei, the latter is more suitable for the local area. Furthermore, original BREEAM criteria require all the domestic buildings to achieve at least CODE 3 Stars (Eco Homes Good). However, this standard is difficult to be met in Hubei. Owing to the market reason and economy reason, a certain percentage of the residential buildings cannot reach the high technique standard. As a consequence, it is more feasible to change the original standard into "The average score of all the domestic buildings achieve at least one star in《Tentative evaluation standard for green building of Hubei province》

BLD2-Non Domestic:

In BREEAM system, there are sufficient themes can be chosen to evaluate the non-domestic buildings. However, just as stated above, these themes are designed for some certain areas of UK. As a consequence, it is more feasible to change the original standard into "The average score of all the non- domestic buildings achieve at least one star in《Tentative evaluation standard for green building of Hubei province》

4.2 Weighting analysis

In the second part of this chapter, the methodology of AHP will be introduced to determine the weighting of each category. Nevertheless, owing to the evaluating mode of BREEAM, the hierarchy evaluating system is not necessary, which means only the eight categories will be compared in pair, while the difference between sub categories or issues can be ignored. As a consequence, only part of the AHP methodology will be adopted in this research.

By comparing the significance of the eight categories in pair, the weights of each category is calculated as:

Climate & Energy: 0.0234; Communities: 0.1401; Place shaping: 0.1602; Ecology &

Biodiversity: 0.0254; Transport: 0.2600; Resources: 0.0647; Business & Economy: 0.2316; Buildings: 0.0945

The calculating process is in appendix 3.

To conclude, combining with the modified issues and newly set weightings, the Bespoke BREEAM Communities for Wuhan has been initially built, and how to use this model to evaluate the sustainability of Zuoling project will be explained in next chapter.

Chapter 5 Case study for Zuoling project

Zuoling is situated at the eastern border of Wuhan, part of "Wuhan East Lake High-Tech Development Zone.' The 30 km^2 area will be transferred into a multi-functional New City, with space for living, working, recreation, nature and infrastructure. Based on the general requirement of the long term planning of Wuhan, three aspects for Zuoling shall be emphasized and implemented.

1. Ecological development and protection
2. Industrial development, including to stop and to clean-up the contamination of the existing industries for soil, water and air.
3. Infrastructure construction to strengthen transport links.

5.1 CSFs for Zuoling

Based on the eight categories of BREEAM Communities, the CSFs (Critical Successful Factors) will be analyzed in "Climate and Energy". "Communities", "Place shaping", "Ecology and Biodiversity", "Transport & Movement", "Resources", "Business and Economy", and "Building". Through this analysis, the significant factors for Zuoling project can be decided.

5.11 Climate and Energy

- Flood risk control:

In recent years, Wuhan has experienced floods many times. The frequent disasters reveal that ecological resources of upper Yangzi River have been severely damaged and the protective measures are not sufficient. (Tan, 2009). And Zuoling area is adjacent to Yangzi River, which causes the flood risk control a severe challenge for this project.

- Urban Heat Island:

Wuhan is one of the hottest cities in China. Owing to the special geographical location, the region's climate is damp and sultry. In addition, Wuhan is located in the fourth wind level of china, which means the natural ventilation of this area is not perfect. In order to provide a suitable living environment, it is significant to control the urban heat island effect by coordinating the building cooling and transportation use.

- Energy management

Ensure certain percentage of buildings in the project will be fitted with the renewable energy as active solar devices or biomass energy.

Part of the Communities internal traffic should use the fuel-cell which can reduce the emission of CO_2.

5.12 Communities

- Keep in touch with the participants:

Pay close attention to the basic needs of the people, along with the design and constructing of the project, consultation from each group of participants and potential final users should be integrated into the design.

- Harmonious Communities:

Since the founding of the People's Republic of China, most of the construction of the Communities is centered on the government agencies or state-owned enterprises. The Communities culture is closely connected to the enterprise culture. Inside the Communities, the residents are not just the neighbors, but also colleagues, friends and relatives. The Communities is also a small society, facilitated with school, hospital, shops. Along with the privatization of housing, the traditional state-owned community has gradually disintegrated, but part of the life style has been preserved. It is feasible to create a harmonious community by integrating the traditional living mode.

- High vacancy:

Owing to the high vacancy of the communities in the suburban, the establishment of owners' committee is in difficulty. So it is a giant challenge for the developer and local authority to control the housing vacancy and stimulate the residents to involve into the Communities activity.

- Gap between the rich and poor. :

The gap between the rich and poor is a serious social problem, how to alleviate the social contradiction must be considered into the design of the Communities. A suitably proportioned social housing should be provided in Zuoling project, and ensure the quality of the housing can approach the level of least. Meanwhile, the social housing should be uniformly distributed in the whole Communities; it is not humanistic to set a special "social housing neighborhood" for the low income people.

- Deal with the removal

After the finishing of the Zuoling project, the original 25.000 residents should have the basic living allowance and employment security.

- Amenities:

The construction of ancillary facility should keep in step with the construction of the main buildings. It is significant to ensure the convenience of the residents' daily life.

5.13 Place shaping

- Reserving:

It is significant to keep the original geography and land features, adapt to the topography. The design of landscape should firstly keep reserving, secondarily renovating. (Lai & Yuan, 2006)

- Identification:

The whole Communities should be divided into grids, which could strengthen the convenience and efficiency of the transportation. Meanwhile, the pattern of each grid should furthest reflect the ecological features of this area and strike up the connection to the Wuhan urban fabric. Each of the "Communities grids" should be organically connected and open to each other.

- Sequential:

The industry park, research & develop center, and residential area should be differentiated clearly. According to the different function, it is necessary to design

harmonious, orderly and clear arranged region for each of the three areas.

- Globality:

As a large-scale Communities which is located at the edge of Wuhan, Zuoling region should not be defined as subordination. Instead, inside this area, developers should establish an integrated system which involves ecology, multilevel transportation, and architectural groups, make Zuoling a new boom city.

5.14 Ecology and Biodiversity

- Biodiversity

It is important to reserve certain land to protect the local animals and plants. The animal corridor should be designed in certain location, the waterfront plants should be protected and some precious trees must be preserved or transplanted to a similar area inside Zuoling region.

- Introduce commercial plants and animals

Conduct field exploration, aimed at the local ecology characters and the needs of life, it is profitable and sustainable to introduce the aquaculture, poultry, and commercial crops, which can optimize the ecology chain.

- Soil protection:

Based on the degree of contamination, the land should be classified into different levels. For the severe contaminated land (which used to be the Heavy metal chemical industry factory), it is necessary to take effective measures to clean the land and avoid planting or living there. (Chen, Kong, & Lu, 2007) For the well preserved land, the removed soil (for construction) should be efficiently reused inside Zuoling region, through which, the project can reduce the dependence of external resources.

- Connecting the lakes

Inside the Zuoling region, there are many natural lakes and rivers, it is important to connect all the water regions together which can ensure the integration of ecology system and strengthen the water holding capacity of the land.

5.15 Transport & Movement

- Efficiency control

Ensure the accessibility of the public transportation node.

Ensure the fluency of each transportation node; reduce the unnecessary congestion and circuitousness.

- Green trip mode

Deploy the bicycle path and footpath, stimulate the green trip mode.

- Distinctive transportation web

The designers should ensure separated network of pedestrian traffic, bicycle path, and motorway. Besides, they should fully consider the overlap and separation of the Communities exterior transportation and Communities inner transportation.

- Integrated management of the transportation

Rationally allocate the public transportation resources and efficiently set the parking space for both the motor vehicles and bicycles, ensure the convenience for the people to work and live.

- Emergency measure

Fully considering of the possible disasters or incidents, ensure that the people and vehicles can evacuate quickly and efficiently.

5.16 Resources

- Use local materials:

By dealing with the fluvial deposit and demolished plants, it is cost effective and environment friendly to reuse the existing construction materials.

- Use recycled materials:

All the buildings in Zuoling project should be constructed with recycled materials.

- Water treatment:

Establish renewable water systems and rainwater collection systems, ensure certain proportion of the workers can use the drinking water, and most of the domestic water can be provided from Zuoling area itself. Meanwhile, ensure that the development on site does no negative impact upon local groundwater. (Liu, 1999).

- Waste treatment:

A certain proportion of the household garbage should be locally disposed and transformed into the organic fertilizer, which can be provided to the economy growing areas or private gardens.

5.17 Business and Economy

- Business Priority:

Take opto-electronics as the leading industry of Zuoling area, combine "research and development" and "production" together in this region. Meanwhile, vigorously develop the opto-electronics supporting industries.

- Labor and employment

More than 65% of the workers who work in the industry park will live in the Zuoling region. As a consequence, the operation situation of the enterprise will have an enormous influence on the living level of the residents. Meanwhile, through the proper technical training, the local and surrounding residents can be employed to the enterprise, which can strengthen local employment and improve the educational background of the people.

- Industrial layout:

The Zuoling region will be divided into three main areas as ecological industry park, research and develop area, and residential area. It is significant to combine the municipality's strategy of Zuoling and surrounding area, design out layout mode which comply with the development of the core business and ensure that the plant construction and R&D center can meet the development of future.

- Fund introduction

Introduce sufficient initial capital and follow-up funding into this project, ensure the enterprises and supporting facilities can be operated normally.

- Impact to the local economy mode

Actively coordinate the balance between the centered enterprises and existed small and medium-sized private enterprises, ensure the related the tertiary industry can develop normally, and combined with the local characteristics, develop the ecological tourism.

5.18 Building

- Adopt the new building form

For the building design, it is important to break the traditional settlement patterns, combine with the international advanced design concept and local culture characteristics, and design out multiple architecture form.

- Rational density

All the buildings should be set in rational hierarchy, high density area, medium density area, and low density area should be divided clearly. And the whole block should be mainly occupied by medium density area and low density area.

- Renovating

For some of the retained buildings, it is necessary to conduct an evaluation about the quality, energy consumption and function of each building. In the next, according to the plan, the designers should renovate the old buildings to enable them suitable for the standard of sustainable Communities.

- Green building design:

A certain ratio of the buildings in Zuoling region should reach a high quality standard which consume lower energy and produce less waste.

5.2 Pilot project for Zuoling

Fully considering the Bespoke BREEAM Communities for Wuhan and CSFs of Zuoling, the expected score the pilot project can obtain is as shown in the following table. The credit of each issue can obtain is 0,1,2,3 which respectively represent the excellent degree from low to high. In addition, if a certain issue is "Mandatory", that means the issue has to obtain at least 1 credit.

Category	Issue	Credit	Statement/Description
Climate and Energy	CE1-Flood Risk Assessment	2	Introduce the "Urban Drainage" and "Climate Dike" concept to the project, which ensure Zuoling invulnerable to natural hazards.
	CE2-Surface Water Runoff	2	
	CE3-Rainwater SUDS	3	
	CE4-Heat Island	3	
	CE5-Energy Efficiency	2	
	CE6-Onsite Renewable	2	
	CE7-Future Renewable	3	
	CE8-Services	2	
	CE9-Water Consumption	2	
Communities	COM1-Inclusive Design	2	The developers aimed at creating a happy and attractive city, which can provide an identical, healthy, and safety living environment for the residents, and vitalize the sense of belonging.
	COM2-Consultation	2	
	COM3-Development User Guide	3	
	COM4-Management and Operation	2	

Place Shaping	PS1-Sequential Approach	2	The architecture and public space are in harmony, every subarea has an own style. A clear hierarchy also contributes to orientate through the city: traffic, density and public space operate on city, district, neighborhood and block level.
	PS2-Land Reuse	1	
	PS3-Building Reuse	1	
	PS4-Landscaping	3	
	PS5-Design and Access	3	
	PS6-Green Areas	3	
	PS7-Local Demographic	3	
	PS8-Affordable Housing	2	
	PS9-Secure by Design	2	
	PS10-Active Frontages	3	
	PS11-Defensible	3	
Ecology and Biodiversity	ECO1-Ecological Survey	2	A full ecological survey and action plan will be carried out to protect existing natural habitats.
	ECO2-Biodiversity Action plan	2	
	ECO3-Native Flora	2	
Transport and Movement	TRA1-Location/Capacity	3	This project will fully consider of the integrated transportation and take the lead in China to design cycle way which will cover the entire area of Zuoling. The different areas or functions are connected with each other by a main infrastructure axis, with metro and bus. This main internal Zuoling connection follows the same direction of the same direction of the old north-south roads.
	TRA2-Availability/Frequency	3	
	TRA3-Facilities(for public transport)	2	
	TRA4-Local Amenities	2	
	TRA5-Network	3	
	TRA6-Facilities(for cycling)	2	
	TRA7-Car Clubs	1	
	TRA8-Flexible Parking	2	
	TRA9-Local Parking	3	
	TRA10-Home Zones	0	
	TRA11-Transport Assessment	2	
Resources	RES1-Low Impact	3	A large proportion of the building materials that are needed to construct the public spaces and infrastructure can have a low environmental impact. In addition, high efficient water treatment and water treatment system will be applied.
	RES2-Locally Sourced Materials	3	
	RES3-Road Construction	2	
	RES4-Composting	2	
	RES5-Masterplanning Strategy(to develop a sustainable water efficiency strategy)	3	
	RES6-Groundwater	1	
Business and Economy	BUS1-Business Priority Sectors	3	The Zuoling project will strive to develop new business areas and protect agricultural businesses. In addition, the
	BUS2-Labor and Skills	3	
	BUS3-Employment	3	

	BUS4-New Business	2	urban design of Zuoling has room for social amenities.
	BUS5-Investment	2	
Buildings	BLD1-Domestic	2	80% of the buildings will be green sustainable buildings.
	BLD2-Non Domestic	2	

As calculated in the appedix4, the total BREEAM Communities Score is 75.6%. If the designers and developers can finish the project in accordance with the above standards, the Zuoling project will turn out to be "excellent" in rating benchmarks.

Chapter 6 Conclusion

In this paper, a quantitative method has been adopted to analyze the significance of each category of the Bespoke BREEAM Communities for Wuhan City Circle. Simultaneously, the CSFs analysis for Zuoling area is a qualitative method which integrates conceptual factors. By combining the quantitative evaluating structure and qualitative issue analysis, the Zuoling project can be evaluated during the design period. With the guidance of Bespoke BREEAM Communities for Wuhan City Circle, the stakeholders would be in a stronger position to weigh the factors involved in the sustainable design. Through testing the total BREEAM Communities Score, the decision maker can effectively adjust the master plan and work out the most sustainable project.

Meanwhile, the development of such a large scale Communities is complicated and long-period. As a consequence, some unpredictable elements will reduce the reliability of the assessment system. In the further studies, more works have to be focused on the analysis of each issue in Bespoke BREEAM Communities, ensure the criteria are suitable for the local regulations. Besides, more experts will be invited to judge the weights of each category, which can effectively reduce the bias from subjective consciousness.

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Introduction of the regulation

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And this regulation is modified based on the Chinese Green Building Label System, GB/T 50378, (2006).

Codes for Design on Accessibility of Urban Roads and Buildings, JGJ50-2001, (2001).

Regulations for gradation and classification on urban land, GB/T 18507-2001, (2001).

Code of urban Residential Areas Planning & Design, GB50180-93, (2002).

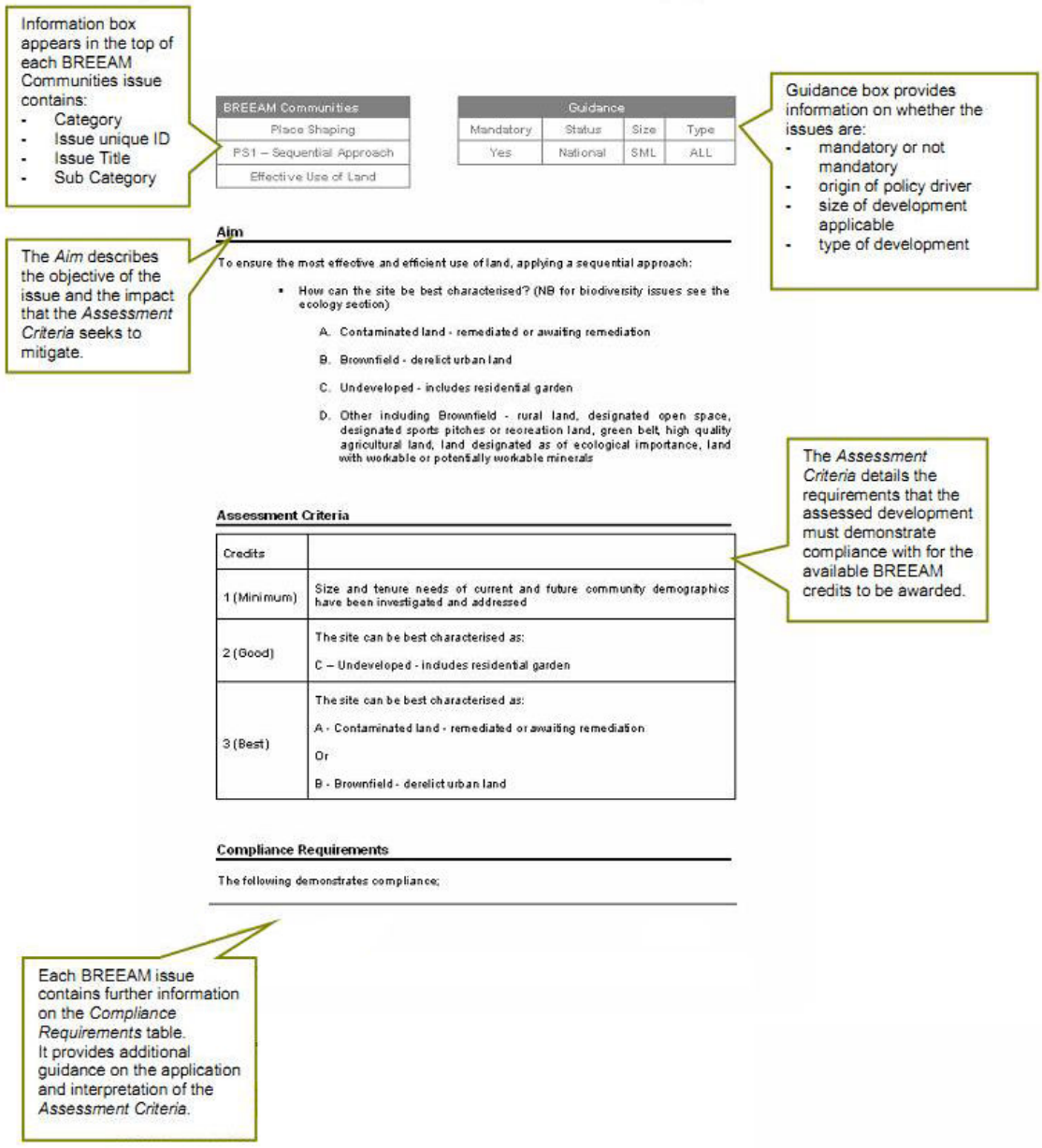
Appendix1

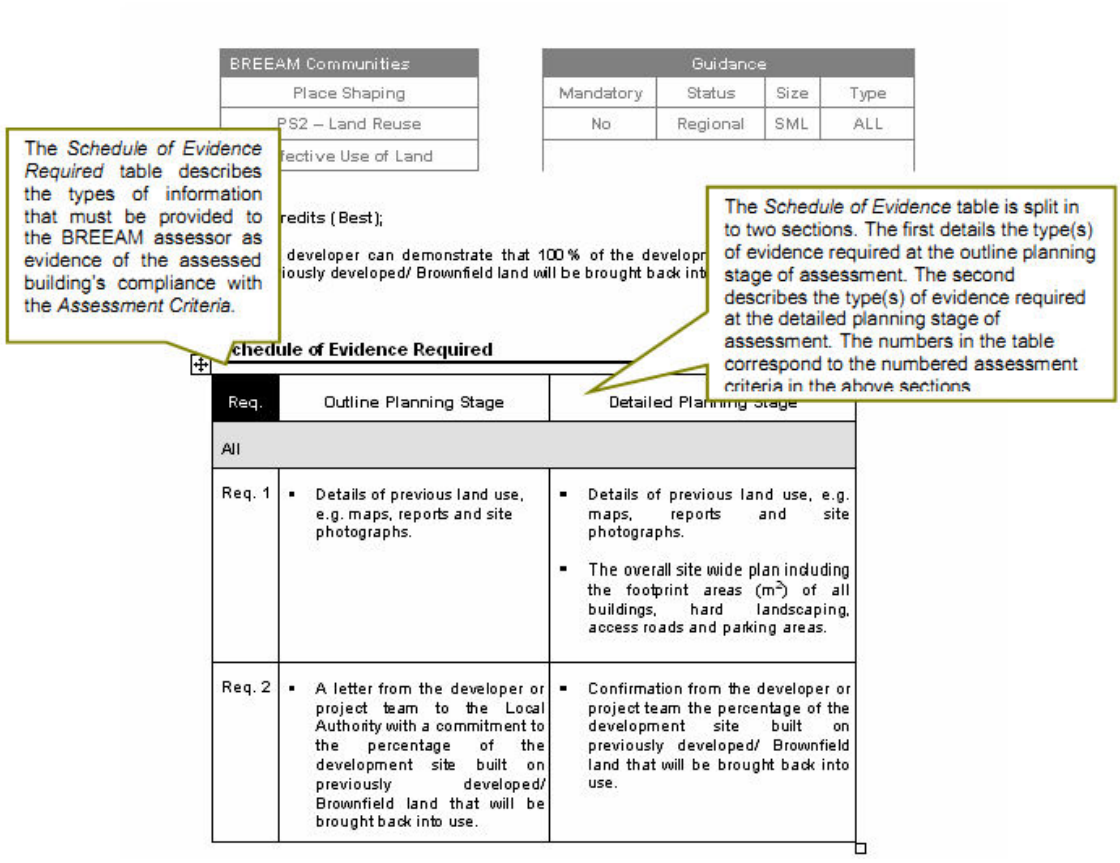
Category	Sub Category	Issue Title	Mandatory
Climate	Water Management	CE1-Flood Risk Assessment	No
		CE2-Surface Water Runoff	Yes
		CE3-Rainwater SUDS	No
	Design Principles	CE4-Heat Island	No
	Energy Management	CE5-Energy Efficiency	Yes
		CE6-Onsite Renewable(s)	Yes
		CE7-Future Renewable	Yes
	Infrastructure	CE8-Services	Yes
	Water Resources Management	CE9-Water Consumption	Yes
Communities	Inclusive Communities	COM1-Inclusive Design	Yes
		COM2-Consultation	Yes
		COM3-Development User Guide	Yes
		COM4-Management and Operation	No
Place Shaping	Effective Use of Land	PS1-Sequential	Yes
		PS2-Land Reuse	No
		PS3-Building Reuse	No
	Design Process	PS4-Landscaping	No
		PS5-Design and Access	Yes
	Open Space	PS6-Green Areas	No
	Inclusive Communities	PS7-Local Demographics	Yes
		PS8-Affordable Housing	Yes
	Form of Development	PS9-Secure by Design	No
		PS10-Active Frontages	No
		PS11-Defensibel Spaces	No
Ecology & Biodiversity		ECO1-Ecological Survey	Yes
		ECO2-Biodiversity Action Plan	Yes
		ECO3-Native Flora	No
Transport	Public Transport	TRA1-Location/Capacity	No
		TRA2-Availability/Frequency	No
		TRA3-Facilities	Yes
	General Policy	TRA4-Local Amenities	Yes
	Cycling	TRA5-Network	No

		TRE6-Facilities	Yes
	Traffic	TRE7-Car Clubs	No
		TRE8-Flexible Parking	No
		TRE9-Local Parking	Yes
		TRA10-Home Zones	No
		TRA11-Transport Assessment	Yes
Resources	Materials	RES1-Low Impact	Yes
		RES2-Locally Sourced Materials	No
		RES3-Road Construction	No
		RES4-Composting	No
	Water Resources	RES5-Masterplanning Strategy	No
		RES6-Groundwater	No
Business and Economy		BUS1-Business Priority	No
		BUS2-Labour and Skills	No
		BUS3-Employment	No
		BUS4-New Business	No
		BUS5-Investment	No
Buildings	Code for Sustainable Homes/Eco Homes	BLD1-Domestic	Yes
	BREEAM	BLD2-Non Domestic	Yes

Appendix2

In the following two pages is the example of a BREEAM Communities Issue. These materials are directly quoted from the SD5065B Technical Guidance Manual of BRE Global.





BREEAM Communities
Place Shaping
PS2 – Land Reuse
fective Use of Land

Guidance			
Mandatory	Status	Size	Type
No	Regional	SML	ALL

redits (Best);

developer can demonstrate that 100% of the developr
iously developed/ Brownfield land will be brought back int

The *Schedule of Evidence Required* table describes the types of information that must be provided to the BREEAM assessor as evidence of the assessed building's compliance with the *Assessment Criteria*.

The *Schedule of Evidence* table is split in to two sections. The first details the type(s) of evidence required at the outline planning stage of assessment. The second describes the type(s) of evidence required at the detailed planning stage of assessment. The numbers in the table correspond to the numbered assessment criteria in the above sections

chedule of Evidence Required

Req.	Outline Planning Stage	Detailed Planning Stage
All		
Req. 1	▪ Details of previous land use, e.g. maps, reports and site photographs.	▪ Details of previous land use, e.g. maps, reports and site photographs. ▪ The overall site wide plan including the footprint areas (m^2) of all buildings, hard landscaping, access roads and parking areas.
Req. 2	▪ A letter from the developer or project team to the Local Authority with a commitment to the percentage of the development site built on previously developed/ Brownfield land that will be brought back into use.	▪ Confirmation from the developer or project team the percentage of the development site built on previously developed/ Brownfield land that will be brought back into use.

Additional Information

Peer review: Is defined as the process employed by a professional body to demonstrate that potential or current full members maintain a standard of knowledge and experience required to ensure compliance with a code of conduct and professional ethics.

Full members of the following organisations, who meet the above requirements, are deemed suitably qualified ecologists for the purposes of BREEAM:

A. Association of Wildlife Trust Consultancies (AWTC)

B. Chartered Institution of Water and Environmental Management (CIWEM)

C. Institute of Ecology and Environmental Management (IEEM)

D. Landscape Institute (LI)

E. Institute of Environmental Management and Assessment (IEMA)

The *Additional Information* section contains definitions of terms used in the *Assessment Criteria* and *Compliance Notes* section. This section will also contain further information relevant to the issue e.g. assessment guidance and relevant websites

Appendix 3

AHP (The Analytic Process) is to decompose a complicated problem into component factors. By comparing each of the two factors, the relative importance of each factor will be decided.

The establishment of the model is based on the structure of "BREEAM Communities", there are eight categories of BREEAM COMMUNITIES, define all the categories as C1, C2 …C8. The research method is described as following:

Step1: Construct Paired comparison matrix

Each of the categories contains several issues, which are impossible to evaluate in quantitative way. By comparing the significant level of factor C_i and C_j, in the following table, the meaning of 1-9 scale has been explained:

Scale	Meaning
1	Comparing two factors, they have the same significance
3	Comparing two factors, the former is slightly more important than the latter.
5	Comparing two factors, the former is obviously more important than the latter
7	Comparing two factors, the former is sharply more important than the latter
9	Comparing two factors, the former is extremely more important than the latter
2,4,6,8	The significance is the median of the above
Reciprocal	If the significance ratio between C_i and C_j is a_{ij}, then significance ratio between C_j and C_i is $a_{ji}=1/a_{ij}$

So through comparing the relative importance between the eight factors, a Paired comparison matrix can be described as:

$$A=(a_{ij})_{8\times 8}$$

$$a_{ij} = \begin{bmatrix} a_{11}, a_{12}, \ldots a_{18} \\ a_{21}, a_{22}, \ldots a_{28} \\ \ldots \ldots \\ a_{81}, a_{82}, \ldots a_{88} \end{bmatrix}$$

a_{ij} is the significance ratio scale for factor C_i and C_j relative to the sustainability.

Paired comparison matrix is as following:

	Climate & Energy	Communities	Place shaping	Ecology & Biodiversity	Transport	Resources	Business	Buildings
Climate & Energy	1	1/7	1/7	1	1/9	1/3	1/7	1/5
Communities	7	1	1	5	1/3	3	1/3	3
Place shaping	7	1	1	5	1/3	3	1	3

Ecology & Biodiversity	1	1/5	1/5	1	1/7	1/5	1/7	1/5
Transport	9	3	3	7	1	3	1	3
Resources	3	1/3	1/3	5	1/3	1	1/5	1/3
Business	7	3	1	7	1	5	1	3
Buildings	5	1/3	1/3	5	1/3	3	1/3	1

The significance ratio scale made by the author is based on the analysis of the CSFs of Wuhan City Circle. (Due to limitations on space, not described in this paper)

Step 2: Calculating for relative weighting
Geometric mean method

$$\omega_1 = \frac{(\prod_{j=1}^{n} a_{ij})^{\frac{1}{n}}}{\sum_{k=1}^{n}(\prod_{j=1}^{n} a_{kj})^{\frac{1}{n}}} \qquad i = 1, 2, \cdots, n$$

In this formula, n=8. And ω_i represent the weighting of each factor from C1 to C8.
With the calculation from Excel, the weighting of each factor is:
ω_1: 0.0234 (Climate & Energy)
ω_2: 0.1401 (Communities)
ω_3: 0.1602 (Place shaping)
ω_4: 0.0254 (Ecology & Biodiversity)
ω_5: 0.2600 (Transport)
ω_6: 0.0647 (Resources)
ω_7: 0.2316 (Business)
ω_8: 0.0945 (Buildings)

Step3: Consistency check
In the Paired comparison matrix, when appeared a result as "C_i is more important than C_j, C_j is more important than C_k, and C_k is more important than C_i", this situation is obviously contrary to the logic. Accordingly, the weighting of each factor is less reliable. Consistency check is to help avoid logic confusion.
The formula is as following:

$$C.I. = \frac{\lambda_{\max} - n}{n - 1}.$$

$$C.R. = \frac{C.I.}{R.I.}.$$

In these formula, ω_i and ω_j represent the weighting of each factor as calculated from the previous step; R.I (random index) can be checked from the existing calculation results. And in this research, the Paired comparison matrix is 8×8, so relevant R.I is 1.41(as shown in the following table). When C.R.＜0.1, the consistency of the Paired comparison matrix is acceptable. By calculating from Excel, the λ_{max} is 8.4976, so the C.R is 0.0711, which is less than 0.1. This means the Paired comparison matrix as described above is logical.

R.I (Random Index)

Size of the matrix	1	2	3	4	5	6	7	8
R.I	0	0	0.52	0.89	1.12	1.26	1.36	1.41

9	10	11	12	13	14	15
1.46	1.49	1.52	1.54	1.56	1.58	1.59

(Liang & Cao, 2007).

Appendix4

Development Performance by Section					
	Regional Weighting	Credits Available	Scores Available	Credits Expected	Scores Expected
Climate & Energy	0.0234	27	0.6318	21	0.4914
Place making	0.1401	12	1.6812	9	1.2609
Communities	0.1602	33	5.2866	26	4.1652
Transport	0.0254	9	0.2286	6	0.1524
Ecology	0.2600	33	8.58	23	5.98
Resources	0.0647	18	1.1646	14	0.9058
Business	0.2316	15	3.474	13	3.0108
Buildings	0.0945	6	0.567	4	0.378
		Summation	21.614		16.345
				Total BREEAM Communities Score	75.6%

In this table, Regional Weighting of each category is calculated from Appendix 3, Credits Available=3×issue number of each category,

Scores Available=Regional Weighting×Credits Available.

And the Credits Expected is the summation of each issue credits in certain category as shown in page 10-12.

Scores Expected=Regional Weighting×Credits Expected.

The Total BREEAM Communities Score = Summation of Scores Expected/Summation of Scores Available.

BREEAM Communities rating benchmarks

BREEAM Communities Rating	% score
UNCLASSIFIED	<25
PASS	⩾25
GOOD	⩾40
V GOOD	⩾55
EXCELLENT	⩾70
OUTSTANDING	⩾80

(BRE Global Ltd, 2009)