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The Analytic Hierarchy Process (AHP) Approach for Assessment of Urban Renewal Proposals

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Abstract The problem of urban decay in Hong Kong is getting worse recently; therefore, the importance of urban renewal in improving the physical environment conditions and the living standards of the citizens is widely recognized in the territory. However, it is not an easy task for the Hong Kong Government to prepare welcome urban renewal proposals because the citizens, professionals and other concerned parties have their own expectations which are difficult to be addressed all at the same time. Although it is impossible to satisfy all stakeholders concerning urban renewal, it is preferable to have proposals conforming to the interests of the majority and beneficial to the present and future generations. This paper adopts the analytic hierarchy process (AHP) to work out the most sustainable design proposal for an area undergoing urban renewal. AHP is a robust multi-criteria decision making (MCDM) method for solving social, governmental and corporate decision problems. Since there is a lack of published papers demonstrating a systematic and effective way for urban renewal proposal assessment, this paper attempts to fill this gap with the help of AHP.

Keywords AHP · MCDM · Urban renewal · Proposal assessment · Hong Kong

1 Introduction

Urban renewal is a complex process that has been commonly adopted to cope with changing urban environment, to rectify the problem of urban decay and to meet various socioeconomic objectives. In Hong Kong, numbers of urban renewal projects have been conducted but many of them fail to achieve their goals and generate environmental and social problems in the community (Ng et al. 2001; Chui 2003). Some people argue that this phenomenon is probably due to poor quality of the urban renewal proposals. Therefore, the Government and the concerned parties in the territory attempt to improve the design of the proposals by promoting sustainability concept (Fung 2001). They believe that thinking over this concept when preparing the urban renewal proposals can produce positive results

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after projects completion in future such as further economic growth, better quality of the natural and built environment, and increased social well-being. However, it is a hard task for the Government to produce appropriate urban renewal proposals fulfilling sustainable development objectives even it intends to do so and has made a great effort. In view of it, it is necessary to have a tool to assist the Government in working out the most sustainable urban renewal proposal for a renewed area. Determining a sustainable renewal proposal is a difficult and complicated process because a lot of tradeoff decisions have to be made. Parties either affected by or involved in different stages of urban renewal have their concerns and expectations which cannot be satisfied all by a single proposal. In order to ensure that the final proposal is convincing, a more systematic and sophisticated method to make the tradeoff decisions is required. Therefore, this paper encourages the use of analytic hierarchy process (AHP) in dealing with this challenge.

2 What is AHP?

Before discussing AHP, it is necessary to know what multi-criteria decision making (MCDM) method is. MCDM methods are valuable in reaching important decisions that cannot be determined straightforwardly. Nowadays, there are numbers of MCDM methods available for selection. In order to select the most appropriate method for this study, it is necessary to know the general characteristics of different methods. With reference to a study conducted by De Montis et al. (2000), a summary comparing the features of various MCDM methods is produced (Table 1).

From the table, it can be observed that AHP has excellent performance in dealing with interdependent criteria and the local problems involving both quantitative and qualitative

Table 1 Comparison of the general characteristics of MCDM methods

	AHP	NAIADE[a]	MAUT[b]	MOP[c]
Interdependence of criteria	Necessary	Unimportant	Unimportant	Necessary
Transparency of weighting process	Weights given explicitly by mean of pairwise comparisons.	Weights are not set explicitly	Depend on expert decision	Weights given explicitly
Problem solving process	Only experts involved	Only experts involved	Only representatives & experts involved to derive the matrix	No stakeholders included. Problems structured with reference to existing data
Applicability	Used for local scale problem	Used for local scale problem	Used for local scale problem	Used for local scale problem
Types of data used	Quantitative & qualitative data used	Crisp, fuzzy & linguistic data used	Qualitative data used	Fuzzy & linguistic data used

Source: De Montis et al. (2000)

[a] Novel approach to imprecise assessment and decision environments

[b] Multi-attribute utility theory

[c] Multiobjective programming

issues. It is expected that AHP is a suitable method for this study concerning about the urban renewal which is commonly regarded as a social problem (Chan and Lee 2007).

As mentioned, AHP is one of the MCDM methods and the underlying principle of MCDM is that these decisions have to be made by means of sets of criteria. By apply this principle, Saaty (1980) developed AHP which models a hierarchical decision problem framework that consists of multiple levels of criteria having unidirectional relationships. AHP works with such hierarchy that can combine both subjective (intangible) and objective (tangible) criteria.

AHP is a reliable tool to facilitate systematic and logical decision making processes, and determine the significance of a set of criteria and sub-criteria. It is widely applied to construction fields such as resources allocation, project design, planning for urban development, maintenance management, policy evaluation, etc. (Saaty 1980; Cook et al. 1984; Shen et al. 1998; Cheng et al. 2005; Banai 2005). Saaty (1980) laid down the proof and the mathematical calculations of AHP but in this study, the complicated mathematical algorithm is skipped and only a brief description of this method is provided. AHP is composed of eight major steps:

(i) To identify the decision problem—The decision problem has to be stated in the topmost level of a hierarchy that is broken down into different levels in which the final level is usually the scenarios or alternatives to be selected;
(ii) To ascertain that the problem can be solved by AHP—AHP is suitable for the decision problem that can be turned into a hierarchical decision model;
(iii) To structure the decision problem—A hierarchy structure formed for the decision problem consists of several levels. A focus in the topmost level is decomposed into criteria bearing on the focus in the second level followed by sub-criteria in the third level and so forth;
(iv) To determine the raters—AHP solicits expert's judgment and therefore, only experts are eligible to be the raters who are responsible for making the decision;
(v) To collect data from the raters—AHP determines the relative priorities of different criteria in every level of the hierarchy by employing a pairwise comparison. During the process, each expert is required to make judgments on their relative importance in relation to the element at the higher level with reference to a 9-point scale;
(vi) To calculate the priority weights of each criterion—Each decomposed level with respect to a higher level forms a matrix. The pairwise comparison data are summarized in the absolute priority weights on the basis of Saaty's eigenvector procedure; and
(vii) To measure the consistency ratio (C.R.)—This practice is to ascertain that the experts are consistent in rating the relative importance of the criteria. AHP does not demand perfect consistency but a judgment is only considered acceptable when C.R. is of 0.10 or less. If the C.R. value cannot pass such acceptable level, it is certain that the experts make judgments arbitrarily or mistakenly and then they have to do it again.

Pairwise comparison is an important step in AHP to be completed by the experts. However, AHP is widely criticized for such tedious process especially when a large number of criteria or alternatives is involved. Someone may doubt the expert judgments because people are very likely to feel tired and lose patience during this process and therefore, they may not make their judgments conscientiously. They may change their minds frequently in order to ascertain the acceptance of the C.R. value as well as shorten the whole process. To avoid such drawback, only reasonable and manageable amounts of criteria are contained in the model and the author of this study has acted as a facilitator to take over the judgment process.

Although AHP is subject to criticism, it is regarded as the most appropriate method for this study. It is because pairwise comparison form of data input is straightforward and convenient for the users. This method is very suitable for complex social issue in which intangible and tangible factors cannot be separated. Even the hierarchy has not yet been completed, i.e. an element at an upper level do not function as a criterion for all the elements in the lower level, the value of the final output will not be adversely affected. In addition, AHP is flexible to allow revision. The decision makers can expand the elements of the hierarchy and change the expert judgments from time to time.

3 Sustainable Urban Renewal Proposal for Hong Kong

High density urban form of development is commonly found in Hong Kong as a result of limited land supply. Rapid development of Hong Kong without thoughtful planning in early decades leads to under utilization and inefficient use of scarce land resources. In order to deal with the physical constraint on new land production and address numerous urban problems e.g. traffic congestions, lack of amenities, deteriorating urban fabric and substandard living condition, many urban renewal projects have been conducted throughout the years. However, citizens, scholars and other concerned parties criticize that those projects mainly emphasize economic development, and overlook the environmental quality and social needs (Rothenberg 1969; Rapkin 1980; Ng et al. 2001; Chan 2002; Council for Sustainable Development 2004). Therefore, they have suggested considering sustainability concept and taking into account of economic, environmental and social objectives when preparing/designing the urban renewal proposals (Fung 2001; Chan and Lee 2006). In response to this suggestion, this paper intends to highlight six key principles with due considerations to Hong Kong's own attributes and special redevelopment needs in order to ease the design process of urban renewal projects. These six principles were extracted after a review of the foreign literature and the urban design guidelines published by the local government for achieving sustainable development, and the validity and reliability of these principles have been verified and confirmed by more than 70 scholars in a discussion forum (Lee and Chan 2007) and a number of structured interviews.

(1) Compact Design and Intensive Development

Compact design and intensive development are regarded as a more efficient form of urban development especially for urban renewal in Hong Kong. Urban renewal usually takes place in dilapidated urban areas with dense population and concentrated properties. During the urban renewal process, certain amounts of existing properties in a confined site are demolished and significant amounts of citizens are affected. In order to fill in the gap in the urban fabric, utilize the renewed area and satisfy the needs of both affected citizens and the outsiders, infill development with compact land use has to be conducted. Of course, the scale and density of infill development has to be well-decided and proper controlled with reference to the carrying capacity of the renewed areas, otherwise negative impacts e.g. congestion, dangerous traffic, air and noise pollution, and social and family problems may be generated.

(2) Proper Mix and Balance of Land Uses

A renewed area should has a wide mix of uses including office, residence, retail, entertainment, etc. performing in mutually supportive manner in order to establish a vibrant living, business and leisure environment. A lively region can generate pedestrian activities, facilitate social interactions and stimulate local economy by attracting citizens to visit frequently and stay for a longer period during each visit. However, offering a variety of uses without proper balancing the activities during daytime and nighttime is not recommended. A commercial area with a disproportionate high amount of offices leaves the renewed area empty after office hours; therefore, a mix of shops, visitor attraction points and/housings should be provided in order to bring the region alive.

(3) Establishment of Inter and Intra-regional Linkage

Different uses in a renewed area should be linked with safe, comfortable and convenient pedestrian walkways, and the renewed area should be connected to other regions with streets, and convenient and efficient vehicular access. Since the location of the region undergoing urban renewal is fixed and its development is subject to various site constraints, provisions of large scale public infrastructure such as carriageway, bridge, Mass Transit Railway or Kowloon-Canton Railway stations and public transport terminal in the renewed area may not be feasible. Therefore, the common ways to increase the accessibility of the renewed area from and to other districts are by connecting internal streets with the main road outside the renewed area, and providing parking spaces, bus or mini-bus stops, taxi stands, various lay-bys or direct access to mass transit.

(4) Respect for Positive Identity

Every area undergoing urban renewal has its own identity and recognizable image. Architectural forms, materials used, colour scheme selected, etc. determine visual qualities while development patterns and human activities establish image and orientation of the renewed areas. In order to retain original positive identity of a renewed area, existing land uses, properties and features significantly contributing to the image of the area and truly reflecting the community's past achievement have to be preserved provided that conservation and restoration only require reasonable efforts and affordable expenses. During the urban renewal process, new development is inevitable. New development in the renewed area has to reinforce or complement such positive identity. For instance, new signs and landmarks can be provided to reinforce sense of identity, and new structures have to blend well with existing elements.

(5) Plan for Comfort and Quality Living

The majority of people living in the areas in urgent need of urban renewal suffer some sorts of social problems. Therefore, guaranteeing the physical and psychological well-being of the citizens in the urban renewal process is paramount. Social well-being is affected by numbers of factors e.g. micro-climate in terms of temperature, relative humidity, ventilation flow and air quality; living condition; public safety; regional security, etc. in which all these factors would be influenced by urban design. For example, proper separation of tall buildings, multi-level building pattern or low density development can reduce heat island effect, contaminations of pollutants and wind-tunnel effects on streets and in public spaces. Improving linkage between properties by pedestrian walkways instead of vehicular travel lanes can enhance the air quality of the renewed areas by reducing emission of air pollutants from automobiles. The living condition of the citizens can be significantly improved when quality buildings with adequate amenities and green spaces are constructed. In addition, proper streetscape design, building and street pattern, arrangement of pedestrian walkway and roadwork, management of public spaces etc. also increase the feelings of safety and security of the citizens.

(6) Maximization of Community Participation

Compared to previous decades, the Hong Kong society nowadays becomes more democratic, and the local citizens become more educated. The well-educated citizens tend to pay more attention to the government policies and aspire to have more chances to express their views on the strategies especially those affecting their living environment and standard of living. That explains why the general public would like to be actively involved in making decisions about current urban (re)development in Hong Kong. Community participation is very important to urban renewal in Hong Kong not only because it can ensure that the constraints, challenges, interests, and needs, etc. of the affected parties and concerned groups in both public and private sectors are taken into account before preparing and implementing the renewal proposals but also because it can reduce confrontation between decision makers and local citizens, and social opposition to the finalized urban renewal proposals.

The above mentioned principles have provided clear directions for the urban design practitioners preparing sustainable urban renewal proposals but they still have to make an effort to work out the detailed design based on the resources available for the renewal projects and site constraints of the areas to be renewed. During the design process, they have to balance the interests of different parties and make a lot of tradeoff decisions as it is impossible for an urban renewal proposal to satisfy all affected citizens and concerned groups having their own desire and expectations in which some of them may contradict one another, violate the principles of sustainable development or cannot be fully met with existing resources. In order to ensure that appropriate tradeoff decisions are made and sustainable urban renewal proposal is prepared, the urban design practitioners have to think over different design criteria and identify those that can effectively contribute to sustainable development and satisfy the majority. This paper has identified major objectives and corresponding design criteria for producing sustainable urban renewal proposal (Table 2). Although this is not an exhausted list of relevant criteria, they are expected to be critical design factors applicable to local context for creating sustainable community in renewed area (Chan and Lee 2007; Lee and Chan 2006a, b). Other corresponding design criteria can be integrated when they are relevant to renewed areas with specific requirements or deemed to be necessary by individual urban practitioners.

Table 2 Objectives and design criteria for sustainable urban renewal proposal

Objectives	Design criteria
Economic sustainability	Access to public facilities
	Green design
	Provisions for establishment of different businesses
	Community involvement
	Compatibility with neighborhood
	Convenience, efficiency & safety of pedestrian & public transport users
Environmental sustainability	Access to work
	Sense of community
	Green design
	Building form
	Provision of open spaces
	Rehabilitation of repairable properties
Social sustainability	Provisions for disabled, elderly or children
	Green construction
	Conservation of local distinctiveness
	Availability of local employment
	Access to open spaces
	Adaptability of development to the changing needs

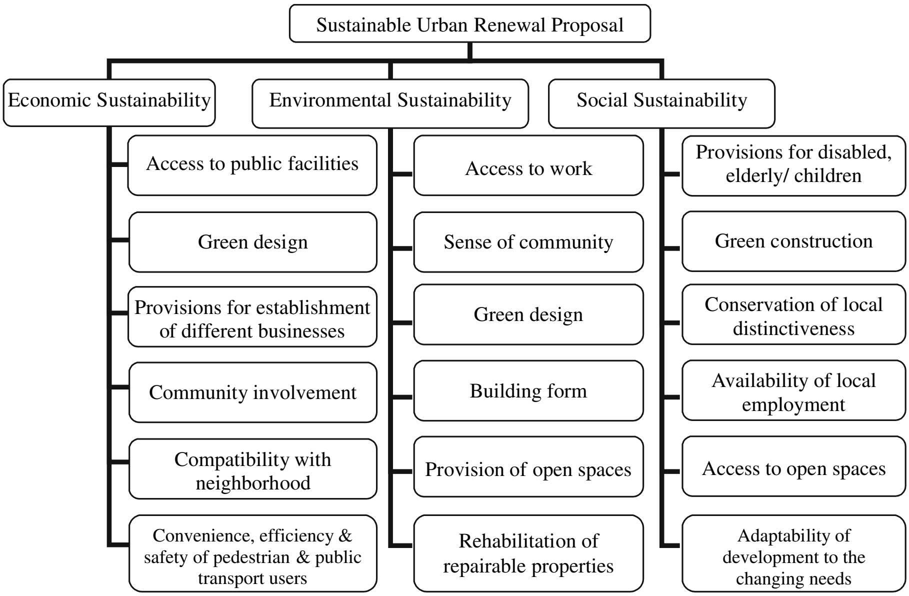


Fig. 1 AHP decision model for producing sustainable urban renewal proposal

4 Development of a Hierarchical Decision Model

As mentioned before, this paper adopts AHP to work out sustainable urban renewal proposals for renewed areas. Before data collection, it is necessary to develop a hierarchical decision model for the decision problem. The decision model of this study illustrated in Fig. 1 is broken into three major levels including *goal* level, *objectives* level and *design criteria* level. The goal level is the topmost level which describes the decision problem. This study attempts to work out the most sustainable urban renewal proposal for a renewed area and therefore, the topmost level is to "design the best proposal". The second level is the objectives level comprised of three aspects: economic sustainability, environmental sustainability and social sustainability while the third level consists of various design criteria. In order to identify the priorities of three sustainable development objectives in the second level, and the relative importance of different design criteria in the third level, a series of pairwise comparisons have to be performed by the experts. The elements in both levels are then weighted and the final score for each potential renewal proposal is based on the composite view of a group of experts engaging in the judgment process.

5 Data Collection

In order to have a representative result, 40 experts were invited to participate in the judgment process. They can be divided into two groups with 20 experts each. Group 1 is experienced urban design practitioners i.e. architects, town planners and property development managers having more than 10 years' working experiences in the construction industry and concerning about the sustainable development in Hong Kong. Group 2 is the people who are impartial and usually dealing with the affected parties in urban renewal e.g. local scholars, people working in non-government organizations (NGOs) and district councilors. They know the needs and wants of citizens well and therefore their views can represent the citizens' thinking to a large extent. When conducting AHP, all experts are required to make judgments on the relative standings of different criteria in the matrices with reference to a 9-point scale as shown in Table 3.

According to Saaty (1995), making group decision is more preferable to relying on single decision maker as brainstorming, ideas sharing and discussion within the group can improve representation of the final results and reduce bias against/towards particular group of criteria. However, it is very difficult to gather 40 experts in a single occasion and reach consensus in a group of experts with different preferences or levels of status and expertise in a short period of time. Therefore, this study has invited 40 experts to make judgments in the interviews on the same hierarchy separately. The judgments from individual experts are then synthesized into a single judgment through geometric mean in order to get an overall estimate of the priorities for each criterion in every level of hierarchy. The geometric mean for synthesizing individual judgments is expressed in Eqs. 1 and 2.

$$(a_1, a_2, \ldots, a_{\mathrm{n}}) \equiv \left(\prod_{i=1}^{\mathrm{n}} \quad a_i\right)^{1/\mathrm{n}} \tag{1}$$

Thus,

$$G\ (a_1,\ a_2,\ a_3) = (a_1 \times a_2 \times a_3)^{1/3} \tag{2}$$

where G = Geometric mean, a = Pairwise comparison scale given by an expert, n = Number of experts

Table 3 9-point scale for pairwise comparisons in AHP

Intensity of importance	Definition	Explanation
1	Equal importance	Two criteria/sub-criteria contribute equally to the level immediately above
3	Moderate importance	Judgment slightly favours one criterion/sub-criterion over another
5	Strong importance	Judgment strongly favours one criterion/sub-criterion over another
7	Very strong importance	One criterion/sub-criterion is favoured very strongly over another
9	Absolute/extreme importance	There is evidence affirming that one criterion/sub-criterion is favoured over another
2, 4, 6, 8	Immediate values between above scale values	Absolute judgment cannot be given and a compromise is required
Reciprocals of above	If element *i* has one of the above non-zero numbers assigned on it when compared with activity *j*, *j* has the reciprocal value when compared to *i*	A reasonable assumption

Source: Saaty 1980

6 Priority Weights of the Criteria

During the interview, each expert is requested to take part in AHP judgment process with the aid of a computer software called Expert Choice. By using this software, the relative weights of the objectives and corresponding criteria, and the consistency ratios of the matrices can be calculated. If there is any matrix with an unacceptable C.R. value i.e. >0.10, the expert is required to make judgement on that matrix again. In order to improve the consistency in ratings, the experts can be explained about the concept of pairwise comparison. Figures 2–5 show the relative weights and C.R. values for the objective matrices and design criteria matrices. In Figs. 2 and 4, three sustainable development objectives (level 2 of the decision model) were rated pair by pair with respect to the decision problem (topmost level of the decision model). In Figs. 3 and 5, the design criteria (level 3 of the decision model) were rated pair by pair in relation to their respective objective (level 2 of the decision model). However, Figs. 2 and 3 are matrices synthesizing the judgments from individual experts in Group 1 while Figs. 4 and 5 are the matrices containing the judgments from the experts in Group 2. The C.R. values of all matrices are less than 0.10 and therefore accepted. The last column of each matrix shows the eigenvectors indicating the absolute priority weight of each rated criterion.

After synthesizing the judgments from individual experts in both groups separately, it is time to decide whether it is appropriate to combine these results to exhibit the final weights of the sustainable development objectives and the design criteria for developing the assessment model. In order to find out the answer, Kendall's *W* was proposed to be generated. Kendall's *W* is useful to evaluate the degree of agreement between three or more sets of ranks for numbers of subjects/objects (Sheskin 2004). The possible value of *W* ranges between 0 and +1. It the value of *W* is zero, that means there is no pattern of agreement among those sets of ranks, vice versa. Converting the priority weights of individual design criteria produced from each of 40 experts' judgements into 40 sets of ranks is a prerequisite for calculating the Kendall's *W*.

The Kendall's *W* for the rankings of individual design criteria among all respondents, and between two expert groups i.e. Group 1 and Group 2 was 0.261, 0.276 and 0.311 respectively (Table 4). The null hypothesis, the experts' ratings in a group are unrelated to each other, was rejected at a 0.05 significance level. That means there is substantial agreement among the experts in each of three groups on the rankings of the design criteria for sustainable urban renewal projects.

Since the respondents in both groups having different background and expertise more or less admitted the priority weights of the design criteria generated from AHP, the judgments of 40 experts were combined to produce the final weights of the sustainable development objectives and the design criteria. Table 5 presents the absolute weights of the sustainable development objectives, and the relative importance and final weights of the criteria after combining the judgements from two expert groups.

Fig. 2 Comparisons of three sustainable development objectives for Group 1

Matrix 1: Objectives with respect to the decision problem

	EcS	EnS	ScS	EV
EcS		1.08	1/1.11	0.329
EnS			1/1.44	0.285
ScS				0.387
			C.R.	0.000

Note: EcS = Economic Sustainability; EnS = Environmental Sustainability; ScS = Social Sustainability; EV = Eigenvector

Matrix 2: Design Criteria with respect to EcS

	AF	GD	EB	CI	CN	CT	EV
AF		1/1.39	1/2.54	1/1.24	1/2.30	1/2.14	0.094
GD			1/2.19	1.16	1/1.68	1/1.53	0.128
EB				2.08	1.28	1.26	0.256
CI					1/1.66	1/1.42	0.122
CN						1.05	0.207
CT							0.194
						C.R.	0.000

Note: AF = Access to public facilities; GD = Green design; EB = Provisions for establishment of different businesses; CI = Community involvement; CN = Compatibility with neighborhood; CT = Convenience, efficiency & safety of pedestrian & public transport users

Matrix 3: Design Criteria with respect to EnS

	AW	SC	GD	BD	PO	RP	EV
AW		1.26	1/1.15	1/1.21	1.45	1.20	0.175
SC			1/1.60	1/1.56	1.33	1.13	0.143
GD				1/1.16	1.82	1.57	0.209
BD					2.07	1.35	0.220
PO						1/1.08	0.115
RP							0.138
						C.R.	0.000

Note: AW = Access to work; SC = Sense of community; GD = Green design; BD = Building design; PO = Provisions of open spaces; RP = Rehabilitation of repairable properties

Matrix 4: Design Criteria with respect to ScS

	PD	GC	CL	AE	AD	AO	EV
PD		1.21	1/1.54	1/1.80	1/1.03	1.16	0.146
GC			1/1.39	1/1.69	1/1.17	1/1.04	0.133
CL				1/1.23	1.08	1.40	0.192
AE					1.21	1.62	0.228
AD						1.20	0.166
AO							0.136
						C.R.	0.000

Note: PD = Provisions for disabled, elderly/ children; GC = Green construction; CL = Conservation of local distinctiveness; AE = Availability of local employments; AD = Adaptability of development to the changing needs; AO = Access to open space

Fig. 3 Comparisons of design criteria for Group 1

Fig. 4 Comparisons of three sustainable development objectives for Group 2

Matrix 5: Objectives with respect to the decision problem

	EcS	EnS	ScS	Eigenvector
EcS		1/1.31	1/1.53	0.261
EnS			1/1.09	0.349
ScS				0.390
			C.R.	0.000

7 Discussion

Figure 6 has provided a finalized hierarchical decision model for producing sustainable urban renewal proposal. From the figure, it can be observed that the weight of socially sustainable objective is slightly higher than the others. Not surprisingly, both expert groups emphasize more on social sustainability because urban renewal is often beset with social problems such as destruction of existing social networks, expulsion of vulnerable groups and adverse impacts on living environments (Rothenberg 1969; Couch 1990; Ng 2002; Lee 2003) and this phenomenon has instigated urgent need for substantial improvement in the performance of local urban renewal projects especially for social realm (Ng et al. 2001; Lai 2002).

Compared to other criteria, the absolute weight of design criterion GD is the highest because both expert groups believe that this criterion can significantly contribute to economic and environmental sustainability. This finding is in line with the view of Chartered Institute of Housing (2000) and Corbett and Corbett (2000). Green design can reduce consumption of natural resources in an effective way. Proper building orientation and

Matrix 6: Design Criteria with respect to EcS

	AF	GD	EB	CI	CN	CT	EV
AF		1/1.37	1/2.14	1/1.46	1/1.38	1/1.70	0.109
GD			1/1.80	1.09	1/1.16	1/1.63	0.141
EB				1.69	1.57	1.24	0.245
CI					1/1.13	1/1.52	0.141
CN						1/1.25	0.158
CT							0.205
						C.R.	0.000

Matrix 7: Design Criteria with respect to EnS

	AW	SC	GD	BD	PO	RP	EV
AW		1.26	1/1.77	1/1.33	1.26	1/1.08	0.152
SC			1/1.56	1/1.39	1.17	1/1.04	0.141
GD				1.18	1.41	1.30	0.221
BD					1.47	1.32	0.197
PO						1/1.04	0.135
RP							0.153
						C.R.	0.000

Matrix 8: Design Criteria with respect to ScS

	PD	GC	CL	AE	AD	AO	EV
PD		1.82	1.065	1.01	1.49	1.39	0.207
GC			1/1.68	1/1.37	1/1.13	1.07	0.127
CL				1.23	1.44	1.50	0.207
AE					1.49	1.32	0.186
AD						1.08	0.139
AO							0.134
						C.R.	0.000

Fig. 5 Comparisons of design criteria for Group 2

Table 4 Ranking and Kendall's *W* for design criteria

Design criteria	All respondents		Group 1		Group 2	
	FW	Rank	FW	Rank	FW	Rank
1. AD	0.058	7	0.064	6	0.054	7
2. EB	0.068	4	0.084	3	0.064	6
3. AE	0.072	2	0.088	2	0.072	4
4. AW	0.053	11	0.050	12	0.053	10
5. CT	0.058	8	0.064	7	0.054	8
6. AF	0.037	17	0.031	17	0.029	17
7. PD	0.064	5	0.056	9	0.081	3
8. PS	0.045	15	0.052	10	0.047	14
9. AO	0.054	10	0.033	16	0.052	11
10. GD	0.109	1	0.101	1	0.114	1
11. GC	0.053	12	0.051	11	0.050	12
12. RP	0.049	13	0.039	15	0.054	9
13. BD	0.063	6	0.063	8	0.069	5
14. CN	0.055	9	0.068	5	0.041	15
15. CL	0.070	3	0.074	4	0.081	2
16. CI	0.044	16	0.040	14	0.037	16
17. SC	0.048	14	0.041	13	0.049	13
Number (N)	40		20		20	
Kendall's *W*	0.261		0.276		0.311	
Level of significance	0.000		0.000		0.000	

Where FW = Final weights of the design criteria, H_0 = The experts' ratings in a group are unrelated to each other

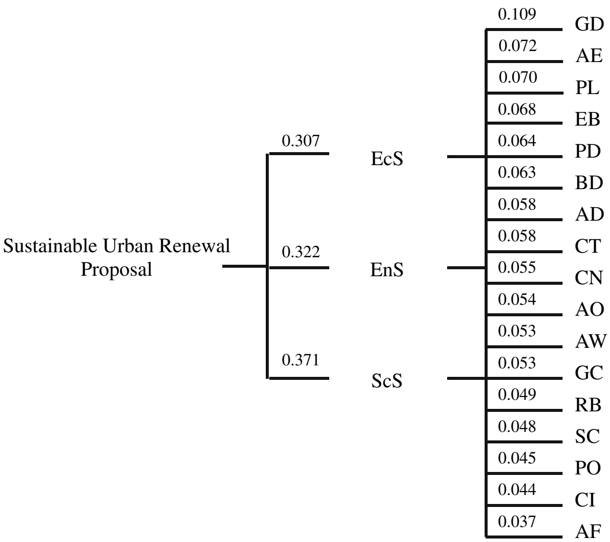
façade design to maximize the ingress of sunlight and facilitate natural airflow, installation of insulation systems, selection of light coloured materials, use of low emission glazing, provision of external shading devices such as fins and balconies, etc. regular heat entering

Table 5 The final weights of the sustainable development objectives and design criteria

	Final weights of objective	Relative weights of criterion	Final weights of criterion
EcS	0.307		
AF		0.121	0.037
GD		0.146	0.045
EB		0.221	0.068
CI		0.144	0.044
CN		0.178	0.055
CT		0.190	0.058
EnS	0.322		
AW		0.165	0.053
SC		0.151	0.048
GD		0.199	0.064
BD		0.194	0.063
PO		0.138	0.045
RP		0.153	0.049
ScS	0.371		
PD		0.172	0.064
GC		0.142	0.053
CL		0.189	0.070
AE		0.193	0.072
AD		0.158	0.058
AO		0.146	0.054

and leaving the buildings without inducing excessive solar heat gain and heat lost. As a result, only a reasonable amount of energy is required to be used for providing artificial lighting, and additional cooling and heating (Chartered Institute of Housing 2000). The

Fig. 6 Finalized AHP decision model for producing sustainable urban renewal proposal



reduction in energy consumption through proper green design not only benefits the physical environment but also saves the electricity expenses for artificial lighting and cooling (Corbett and Corbett 2000).

8 The Way Forward

For further study, we could select several urban renewal proposals appropriate for evaluation of the AHP decision model. Suppose that there are three potential renewal proposals (A, B & C) for a renewed area. All proposals are included in an *alternative* level (the forth level), the lowest level added to the captioned decision model. By using this model to calculate the score for each proposal, the person in charge can identify the best option for the area. The score is calculated using the formula as shown in Eq. 3.

$$P_k = \sum_j \mathrm{W}_j \times \mathrm{S}_{kj} \tag{3}$$

where P_k = Urban renewal proposal k, W_j = Final weight of criterion j in level 3, S_{kj} = Score of proposal k on criterion j, j = 17 design criteria

For example, the final score of proposal A (P_A) is equal to $W_1 \times S_{A1} + W_2 \times S_{A2} + \ldots + W_{17} \times S_{A17}$. After calculating the scores of three renewal proposals, the most sustainable urban renewal proposal for a particular area can easily be identified. Based on the final score, design criteria that have been overlooked can also be highlighted and further improvement can then be made. It is believed that putting forward this model for local urban renewal can create more and more sustainable communities in the foreseeable future.

9 Conclusion

Due to the complexity of the real life, every person has to solve a lot of decision problems in their daily life. For the Hong Kong Government, preparing appropriate urban renewal proposals is one of the major decision problems because it is very difficult to make tradeoff decisions based on the resources available and divergent opinions of different concerned parties, and to ascertain that the renewal proposals are sustainable and good for the present and future generations. Therefore, this paper intends to use AHP to facilitate such problem solving process. Although AHP is not the only one or the best method for solving all daily decision problems, it is widely recognized that AHP is an effective tool to provide a reasonable and logical solution for the decision makers. It focuses on how to structure a hierarchical decision model (by breaking down the decision problem into levels) and how to weight the decision criteria (by means of pairwise comparisons). In order to illustrate how AHP is put into practice, this paper has presented a decision model for producing the most sustainable urban renewal proposal for a renewed area in detail. By adopting AHP judgement process, relative importance of the sustainable development objectives and design criteria can be identified. The decision model consisting of the final weights of the design criteria is very useful for assessing the sustainability level of the potential urban renewal proposals in future.

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