MASTER THESIS PROPOSAL

Research on the Resident Perception Rating for Green Building through ESGB in China

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Abstract

Green buildings aim to solve the contradiction between the limited natural resources and the large number of resource consumption requirements. The life cycle of green buildings includes the architectural planning, design,construction,operation and maintenance, which all reflect the rational and effective use of green buildings in energy conservation, land resources and water resources, and the efficient and energy-saving use of materials. At the same time, green buildings adopt high-tech materials and apply the concept of recyclability to the selection and use of materials, which can reduce environmental pollution, maintain an excellent ecological environment, and achieve sustainable development in the construction field. From the perspective of occupants, green buildings can improve the comfort of occupants, provide occupants with a good living and working environment, are conducive to the physical and mental health of occupants, and improve the occupants' quality of life and work efficiency.

This research aims to find to what extent the green building scores match with residents' perceptions about how 'green' the buildings are in China by doing survey in Shenzhen Yantian High School. Several building environmental assessment systems have been developed and applied in some countries, such as America, UK and Germany, which contributes to solving environmental problems related to the buildings. However, the current system can only predict the functions and performance of buildings, not users experience. This research investigates post-occupancy evaluations of green building from six aspects and how the system functions in China. The research mainly focuses on six aspects of the ESGB, including land-use efficiency, energy efficiency, water efficiency, material efficiency and indoor environment quality. After analyzing the data gathered from 500 participants, recommendations are provided to improve the ESGB.

Key words:Green Building, Life Cycle, Evaluation System

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Chapter 1 Introduction

1.1 Background

While enjoying the comfortable life brought about by the rapid development of the economy, modern society has gradually realized that this kind of comfort is based on the prevailing ecological environment, the shortage of natural resources and the instability of climate, making people The demand for harmonious nature is constantly increasing. The construction industry not only occupies huge land resources, but also consumes a large amount of water resources, and has a great negative impact on the city's air quality and urban micro-environment. In recent years, due to the urbanization process in China, a large number of new houses have been built in urban and rural areas across the country. The annual completed housing area is about 20x108 m^2 , and the scale of new buildings exceeds that of developed countries in Europe and America. China's existing building area has reached 420x108 m^2 and continues to increase rapidly (Institute of Climate Change and Low Carbon Economy, Renmin University of China, 2010). Due to unreasonable construction land planning and architectural design, waste is serious. The energy consumption per unit building is 2-3 times higher than that of developed countries in Western Europe. Air pollution is 2-5 times higher than international standards (Institute of Climate Change and Low Carbon Economy, Renmin University of China, 2010). At present, the construction industry is the fastest growing industry in terms of energy consumption and environmental pollution in the national economy. China's construction steel consumption accounts for 50% of the world's total output, and building energy consumption accounts for 30% of the total national energy consumption (Institute of Climate Change and Low Carbon Economy, Renmin University of China, 2010). Based on the contradictions and environmental constraints of the above-mentioned supply and demand, the concept of green building has been proposed in the continuous improvement and innovation efforts. The concept guided the building under construction throughout their entire life cycle (Song, 2013).

In response to China's increasingly severe resources scarcity and environmental issues, the Fifth Plenary Session of the 16th Central Committee of the Communist Party in 2005 clearly stated that it is necessary to build a resource-conserving, environment-friendly society and consider it a national economic and social development plan (Song, 2013). At present, China is in an important period of rapid urbanization. This is a rare opportunity to further promote building energy efficiency and accelerate the development of GB. China's urban and rural construction methods are still lagging behind. China has a large population and more than half of its population lives in rural areas. Many rural houses occupy cultivated land and woodland, and even built places that are not suitable for living. The houses have not been planned and designed, and they are all built by the farmers themselves (Yanyan, 2017). The energy consumption of buildings during construction and use is extremely high, and the resource utilization rate is extremely low (Cong, 2015). Building energy consumption accounts for more than 27% of all energy consumption, and is increasing at a rate of 1% per year. The annual total discharge of construction waste is about 1.55 billion tons to 240 million tons, accounting for about 40% of urban waste, less than 1% of resource utilization, far lower than 90% of Germany and Japan, 80% of the United Kingdom and 70% of the United States (Cong, 2015). Therefore, vigorously developing GB and guiding the construction and development of urban and rural areas with the concepts of green, ecological, and low-carbon cannot only efficiently use resources, but also have a minimal impact on the environment. At the same time, they can also improve people's quality of life and living conditions, and widely establish conservation and environmental protection concepts.In addition, it can also fully bring about innovations in building technologies such as land saving, water saving, material saving, energy saving and environmental protection, promote the transformation of building production methods, and promote the optimization and upgrading of the construction industry, thereby stimulating new energy applications, energy conservation and environmental protection (Yan, 2006).

Meaningful and significant changes are needed to reduce the environmental impacts during a building's life cycle and to give residents an adequate living environment (Cole, 1998). Therefore, many countries and organizations have developed building environmental assessment systems, such as the Building Research Establishment Environmental Assessment Management (BREEAM) in the UK in 1990, the Leadership Energy and Environmental Design (LEED) of the U.S. in 1993, and the Comprehensive Assessment System for Built Environment Efficiency (CASBEE) of Japan in 2001. The purpose of these systems is to assess building performance according to environmental issues.

At the same time, with the development of the society, people's demand for architecture is also constantly developing usability and function to improve the quality of their experience. Many researchers have studied factors related to residential satisfaction. They have concluded that physical, social and management aspects of the living environment are related to their satisfaction (Joo, 2013). Although people are more concerned about their quality of life as well as the physical conditions of architecture, there is limited knowledge about how the systems influence residents. People are not familiar with the systems and they even don't understand the specific items of system because of the complex terms. Therefore, there is an invisible gap between residents and professionals. When the professionals develop evaluation systems, they just follow their experience and ignore residents' suggestions.

1.2 Problem Statement

There is limited knowledge for residents about how the system influences their daily life. Improved satisfaction and awareness can help spread GB. But in most cases, resident opinions are ignored. Most researches and professionals have not examined the relationship between the system standard and resident perception. Therefore, more research concerning this relationship should be done, which can link professionals with occupancy. By promoting their communications, professionals can improve the quality for living by assessing resident opinions.

1.3 Research Objectives and Research Questions

The research objective is to find out to what extent the green building scores match with residents' perceptions about how 'green' the buildings are. After a brief introduction about background and current problem statement in chapter 1, the chapter 2 provides literature review about the global development of green building and international building environmental assessment systems. Then methodology of this research is presented in chapter 3. Chapter 4 covers data analysis and discussion based on the data collected from Shenzhen Yantian High School. Recommendations are offered in chapter 5. Chapter 6 provides the conclusion of the entire study.

The main research question and sub-research question are:
To what extent, the rating of green buildings through ESGB is consistent with residents' perceptions on the "green" degree of buildings?

1. What are the current green building assessment standards in China?
2. How do residents rate green buildings?
3. How to improve the ESGB in the case of considering residents' perception?

Chapter 2 Literature Review

From 1969, the concept of ecological building was first proposed, and nowadays, the green building is widely promoted, and the green building rating system has also moved from the burgeoning stage to the mature stage. In the following literature review, the development history of domestic and foreign architecture and the environmental assessment system will be discussed in different parts of the world including China.

2.1 The Concept of Green Building

Green Building (GB) (also known as green construction or sustainable building) refers to both a structure and the application of processes that are environmentally responsible and resource-efficient throughout a building's life-cycle: from planning to design, construction, operation, maintenance, renovation, and demolition. The GB process requires close cooperation of the contractor, the architects, the engineers, and the client at all project stages. The GB practice expands and complements the classical building design concerns of economy, utility, durability, and comfort (U. S. Environment Protection Agency).

International GB perspective will be explained in section 2 and 3. In China's GB Evaluation Standards, GB is defined as: to maximize the conservation of resources (energy saving, land saving, water conservation, and material saving), protect the environment, and reduce pollution throughout the life cycle of the building. It provides people space that are healthy, applicable, and efficient and lives in harmony with nature. Actually, GB is a climate adaptive building, which requires adopting appropriate technology as much as possible to reduce energy consumption, meanwhile materials should be recycled and fully localized to achieve the lowest cost of energy and comfort (Yanan, 2014).

This research focuses on the relationship between the scores of green building criteria and residents' perceptions, which refers to sustainability and user experience, e.g. the social aspects of convenience, proximity to transportation, etc. People can also intuitively realize whether it consumes less energy and improve the indoor air quality compared to non-green building.

2.2 Characteristics of Green Building

GB has several characteristics as here above indicated, most of them focus on ways to become more efficient with material resources and energy consumption. In the following sections, energy saving, environmental protection and livable will be elaborated.

A. Energy saving

GB has the characteristics of reducing resource consumption from planning , design and construction to operation and demolition (Fig.1.). On the one hand, in the processes of planning and construction,GB tries to reduce the waste of resources as much as possible and completes construction with minimal resources. For example, the design uses natural wind to reduce the dependence on building air conditioning; strengthen the light environment design of green building interior, try to use natural lighting; pay attention to the thermal insulation design of green building and enhance its energy saving effect (Song, 2013). On the other hand, during the operation and use of GB, various energy-saving technologies need to be used to reduce the building energy consumption by directly utilizing the natural energy or indirectly utilizing the bio-energy. For example, solar energy and wind energy are directly used to convert natural energy into energy for use within a building. Through greening and other means of cultivation, the building will function as a winter water-saving and heat-retaining system, and in summer it will strengthen thermal insulation and regulate indoor climate (Song, 2013).

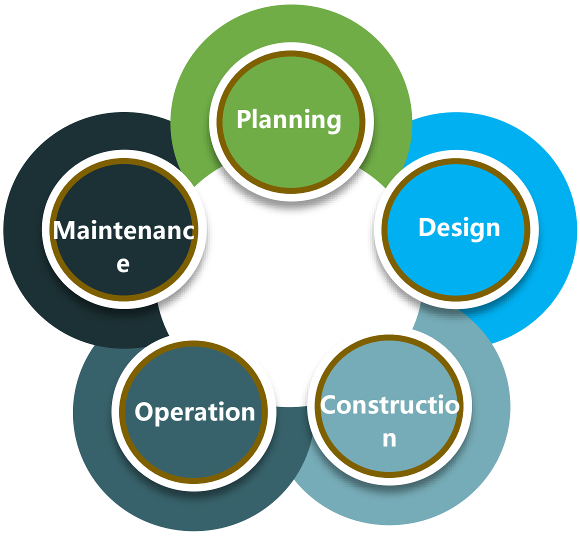

Fig.1. Life cycle of green building (Song Ding, 2013)

B. Environmental protection

GB has always adopted the concept of environmental protection in the processes of urban planning, design, construction and use. First of all, in the planning and site selection, it must consider the coordination with the surrounding environment, it should not damage the surrounding environment and it should use clean, renewable energy and materials. During the construction process, the use of advanced construction technology and scientific management will reduce energy consumption and avoid interference and pollution of the natural environment.It will control the damage to the environment from various aspects of ventilation, lighting, and drainage, and reduce pollution emissions (especially carbon dioxide emissions). Thirdly, environmental protection is reflected in the operation stage. Solar energy, wind energy, geothermal energy and other energy sources are used more and more, effectively reducing building energy consumption. Finally, in the demolition stage, renewable materials can continue to be reused due to the use of these materials during construction. That means less material input and reduced construction waste production during redevelopment.

C. Livable

The purpose of the building is to provide living space for human beings to live, work, and live. Compared with the traditional architecture, green buildings are designed to create a more suitable living environment for human beings, including artificial and natural environments. The green building reflects the harmonious relationship between human beings and nature in the organic combination of artificial environment and natural environment, making the building sustainable, and closely linking the building and the ecology (Song, 2013). This is a kind of “livable” in a broad sense, not only the building in which human beings live, but also the natural environment in which human beings live. For example, the caves in Shanxi have extremely simple construction principles and low cost, but they effectively combine the local environment, making the building warm and cool in winter, healthy and comfortable, fully reflecting energy conservation and environmental protection, and meeting the requirements of using functions. Shanxi can be considered a model of green architecture (Danfeng, 2013).

2.3 Global Development of Green Building

In the 1960s, Italian-American architect Paola Soleri merged the words ecology and architecture into “Arology” to propose a new concept of the famous “ecological architecture”. In the 1970s, the outbreak of the oil crisis made people soberly aware that the history of high-speed civilized development at the expense of the ecological environment was unsustainable. The construction industry that consumes the most natural resources must change its development model and must take the road of sustainable development. Various building energy-saving technologies such as solar energy, geothermal energy, wind energy, and energy-saving include structures that have emerged as the times require them. Energy-saving buildings have become the forerunners of building development (Baizhan, 2011).

In 1992, the Rio de Janeiro's "United Nations Conference on Environment and Development" held a consensus on the important idea of "sustainable development" in the world. GB has gradually formed a system and has been practiced and promoted in many countries, becoming the direction of world architecture development (Baizhan, 2011).

In 2001, the International Sustainable Energy Solutions Award received funding for energy efficiency and renewable resources. The bonus attracted competition from more than 1,000 projects in 75 countries in the year, eventually granting 100,000 Euros to Linz City in Austria.

In July 2001, the International Environmental Technology Center of the United Nations Environment Programme and the International Committee for Architectural Research and Innovation signed a cooperation framework. Both of them will cooperate on a wide range of ways to improve the predictive power of environmental information. This is in line with the needs of developing countries. There is a close relationship between the development and implementation of sustainable buildings (Baizhan, 2011).

Until now, green building has made great progress. However, there are still some challenges,such as lack of consciousness and lack of promotion. Most researchers and professionals have not examined relationships between evaluation criteria of different systems and residents' perception/opinions. For example, Cole (1998), Crawly and Aho (1999), and Ding (2008) examined only similarities or differences among various building environmental assessment systems (Joo, 2013). Given this, there should be more researches that can connect professionals and residents. By promoting communication between the two groups, professionals can assess residents' point of view, which can result in improving the quality of residential environment (Joo, 2013). Besides, there are still some factors that have an impact on development of green building, such as market demand, environmental regulations and owner requirements. Among them, the owner's requirements accounted for 40% of the global proportion, while market demand and environmental regulations accounted for 30% and 35% respectively (ECEP, 2017). This is where the opinions of residents are crucial. Unfortunately, the opinions of residents are often neglected in the literature and not much data is available. Hence this research aims to fill that gap by showing what can be learned about improving GB by studying the perceptions of residents.

2.4 International Green Building Rating Tools

From 1969, the concept of "ecological architecture" was first proposed, and nowadays, the green building has been widely promoted. During this period, the green building rating system has also moved from the burgeoning stage to the mature stage. At present, in the international arena, the development of green building evaluation system has been relatively mature, such as LEED in the United States, BREEAM in the United Kingdom, and GBCC in South Korea.

LEED

United States Green Building Council launched LEED in 1994. LEED is the most widely used green building rating system in the world with 1.85 million square feet of construction space certifying every day and accepted in more than 150 countries worldwide and also considered to be the most perfect, influential evaluation system among all the green building assessment systems worldwide (Zhikun, 2018). As the construction industry continues to change, the LEED system continues to innovate. From 2000 to 2009, LEED V1 was upgraded to the LEED V3 version. Since 2011, the discussion and research on the release of the new version of LEED V4 has been conducted, and it was formally adopted in November 2013 (Ge, 2017).

LEED adopts the scorecard mode. First, according to the evaluation system used by the participating buildings, scores are determined according to the indicators to determine the degree to which the participating buildings reach each sub-point, and then the scores of each index are accumulated. The total score obtained is P= P1+p2+p3+p4+p5+p6+p7+p8 (Note: i=1, 2, 3, 4, 5, 6, 7, 8 represent integrated design, site selection and transportation, sustainable venues, Water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, and innovation and regional priority indicators. The certification level is determined with reference to the rating scale. There are four certification levels for LEED V4, namely: certification level is 40 to 49 points, silver The rating is from 50 to 59 points, the gold rating is from 60 to 80 points, and 80 points or more is in platinum (Ge, 2017).

BREEAM

BREEAM is the first building assessment method in the world, since its inception in 1990 (Zhikun, 2018). The core goal of the BREEAM system is to reduce energy consumption and carbon emissions while ensuring the safety and comfort of buildings. Therefore, the evaluation of buildings is concerned with the health and comfort level that buildings bring to users, the performance of the energy consumption of the building, the choice of alternative transportation, the rational use of natural resources, and the impact of buildings on the environment. When BREEAM manages these measures, it relies on policies and regulations promulgated by the government to regulate such areas as transportation, energy, water resources, material resources, regional ecology, and pollution (Simon, 2008).

The BREEAM system uses a full life cycle assessment method to examine the extent to which participating buildings meet the indicators represented by each performance and give corresponding scores. The full number of each indicator and the weight of the total score are different. The scores of this indicator are compared. The resulting ratio is multiplied by the weight coefficient corresponding to each indicator. Finally, the numbers obtained by each indicator are accumulated, and the rating of the indicator is determined according to the score. A certificate of the assessment result is awarded to an individual building based on a single rating scheme of pass, good, very good, excellent, or outstanding (BRE Trust, 2012). The rating is shown in the table 1.

Table 1 BREEAM rating

Rating	Pass	Good	Very good	Excellent	Outstanding
Grade	>30	>45	>55	>70	>85

GBCC

In 2001, Korea's first green building certification system was established by the Ministry of Land, Infrastructure and Transport (MLIT) and the Ministry of Environment of Korea. In 2002, South Korea's "Green Evaluation Criteria for Residential Buildings" was formally released. The Korean government subsequently launched green building evaluation standards for schools, public buildings, residential complexes, and high-rise buildings. In the year of 2011, the Ministry of Land, Maritime Affairs and the Ministry of Environment jointly issued the latest "Green Building Certification Criteria in Korea 2011", namely GBCC 2011. The standard was introduced by the Korean government through past evaluation criteria research and updates, and the assessment coverage was comprehensive. In recent years, the Korean construction market has been committed to promoting the development of green buildings, and the evaluation system has been continuously updated. The Ministry of Land, Infrastructure and Transport promulgated the "Green Standard for Energy and Environmental Design" after further improvement in December 2014 (Jiruo, 2015).

As the scores of diverse major building indicators are different, firstly, one has to determine the building type to which the building belongs, and select the corresponding scoring standard. Then, one should consider the sub-items under each indicator to determine the scores obtained by satisfying the degree, and add the sub-item points to obtain the index score. Multiply the score by the reciprocal of the total score of the indicator to obtain the corresponding ratio and multiply the ratio by the weighted values of the indicators are added together to obtain the total score. The evaluation criteria also set the general items and control items. For the control items to make the minimum threshold requirements, the participating building must meet the minimum requirements of the indicators in the control items, and then the next step of the evaluation can be performed, and the scores determined according to the last Green building level (Ge, 2017).

2.5 Development of Green Building in China

GB started later in China and its concept was introduced in the late 1980s. In 1986, the "Civil Building Energy Efficiency Design Standards (Heating Part of Residential Buildings)" was released, and the goal was to have buildings consume 30% less energy than currently. In 1994, the standard was amended to raise the building energy saving rate target to 50%. The "Civil Building Energy Conservation Regulations" was issued in 1999 and was revised in 2005 (Wenjie, 2013).

With the deepening of building energy conservation work, the concept of GB was also introduced and applied. In 2005, the Ministry of Construction and the Ministry of Science and Technology jointly issued the “Technical Guidelines for Green Buildings” and proposed to develop GB according to local conditions. The implementation of "Green Building Evaluation Standard" started on June 1st 2006 and "100 green building demonstration projects and 100 low-energy building demonstration projects" (referred to as "double hundred project") was launched in 2007. Since then, it has also issued the “Administrative Measures for Green Building Evaluation Marking” and the “Technical Details for Green Building Evaluation”, and officially launched the green building evaluation work in China (Wenjie, 2013).

In April 2012, the Ministry of Finance and the Ministry of Housing and Urban-Rural Development jointly issued the "Implementation Opinions on Accelerating the Development of China's Green Buildings", clearly setting up an incentive mechanism for high-star GB financial policies, and adopting different standards for GB with two or more stars to give financial incentives to the central government. Under this guidance, local governments have also introduced incentive policies to further increase incentives. For example, In August 2012, Shanghai issued the “Special Support Measures for Building Energy Efficiency Projects in Shanghai”, which included the green building demonstration project in the scope of use of building energy conservation support funds, and clearly stated that the support standard was 60 yuan per square meter (360 doc, 2016).

On January 1, 2013, the No. 1 Document of the General Office of the State Council forwarded the "Green Building Action Plan" jointly formulated by the National Development and Reform Commission and the Ministry of Housing and Urban-Rural Development, highlighting the Chinese government's firm determination and support for vigorously developing GB. The Programme further clarified that by the end of the "Twelfth Five-Year Plan", the goal of building GB of 1 billion square meters and 20% of newly-built buildings in urban areas to meet the GB standards will require the government to invest in construction and affordable housing since 2014 (Wenjie, 2013). Large-scale public buildings shall fully implement the GB standards, and propose a series of incentive policies such as fiscal fund awards, preferential tax policies, land use preferential policies, and improving and perfecting financial services for GB. After three months, the Ministry of Housing and Urban-Rural Development also released the "12th Five-Year Plan for the Development of Green Buildings and Green Ecological Urban Areas", which combines the development of GB with the construction of green ecological urban areas and further strengthens the promotion of GB.

By the end of 2016, China had a total of 7,235 construction projects with green building evaluation marks, with a construction area of more than 800 million square meters. Among them, 3,164 construction projects with green building evaluation marks were obtained in 2016, with a construction area of more than 300 million square meters. However, the current green building operation identification project is still relatively small, accounting for only about 5% of the total construction projects (ECEP, 2017). Market demand is the most widely recognized driver of China's future green building projects. However, in addition to the pull demand of the market itself, the owner's request is also a key driver of the Chinese market. Among them, this item accounts for 34%, and the global average of this item is as high as 40% (ECEP, 2017). Therefore, residents' cognition of green buildings is a subject worthy of study.

2.6 Chinese Evaluation Standard of Green Building(ESGB)

At present,GB development in China is still at an initial stage. However, there are many approaches adopted by the government and other policy-making authorities to promote GB in China. Since 2001, China has issued legislation and regulations about green building as shown in Fig.2.

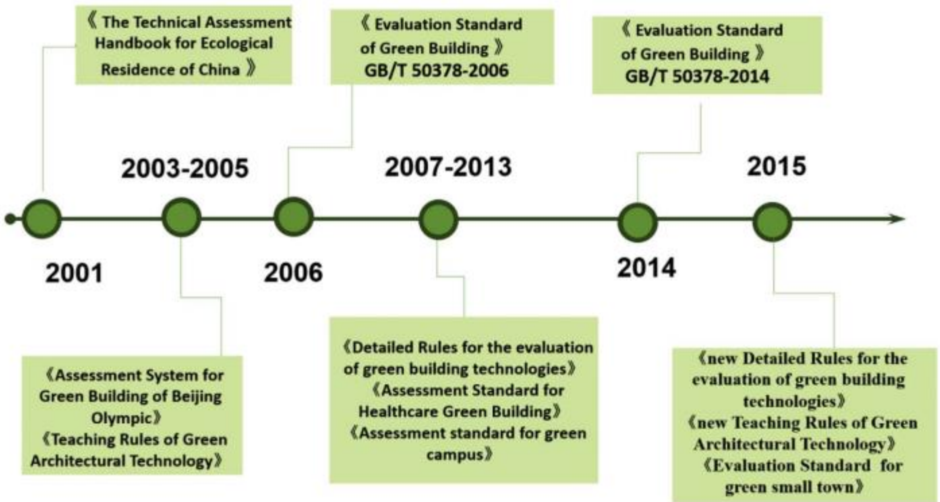

Fig.2. Green building evaluation standard development process of China (Zhikun Ding, 2010)

The "Green Building Evaluation Standard" (GB/T50378-2014) was revised on the basis of the original national standard "Green Building Evaluation Standard "(GB/T 50378-2006), and implemented from January 1, 2015. The original "Green Building Evaluation Standard" (GB/T50378-2006) was abolished at the same time. The "Green Building Evaluation Standard" is used to evaluate residential buildings and office buildings, shopping malls, hotels and other public buildings. The evaluation criteria system of the Standard includes the following six indicators:1) Saving land and outdoor environment;2) Energy Saving and Energy Utilization;3) Water Saving and Water Resources Utilization;4) Use of materials and materials resources;5) indoor environment quality;6) Operational management (residential buildings), full life-cycle comprehensive performance (public buildings) (Ge, 2017). There are 17 national and trade standards, and more than 50 local standards. All Chinese standard for green building are summarized in table 2 and 3.

The evaluation method of green building in China is to quantitatively analyze the satisfaction degree of participating buildings. Weighted scores are used to determine the scores. The scores are determined according to the degree of detail of each index. Each score is then used to cumulatively determine the index scores, including improvement and innovation as additional items. The maximum score is 10 points, and the final score is obtained by combining the accumulated score of each index with the additional corresponding value. Secondly, the score of each type of indicator must not be lower than 40 points, and the final rating should be based on the total score. Green buildings are classified into one-star, two-star, and three-star categories depending on the score (50-60), (60-80), and (greater than 80) (Ge,2017).

Table 2 National and Trade Standards for Green Building in China (Ling, 2014)

Title and number (if possible)	Scope	Category	Enforcement date	Note
Evaluation Standard for Green Building (GB/T50378-2006)	National	Engineering	1st June, 2006	Design or operation stage evaluation of all buildings
Evaluation Standard for Green Construction of Building (GB/T50640-2010)	National	Engineering	1st October, 2011	Specific stage evaluation
Evaluation Standard for Green Refurbishment of Existing Building	National	Engineering	Under development	Specific stage evaluation
Evaluation Standard for Green Industrial Building (GB/T50878-2013)	National	Engineering	1st March, 2014	Specific building evaluation
Evaluation Standard for Green Industrial Building of Tobacco Industry (YC/T396-2011)	Trade	Product	15th July, 2011	Specific building evaluation
Evaluation Standard for Green Office Building (GB/T50908-2013)	National	Engineering	1st May, 2014	Specific building evaluation
Evaluation Standard for Green Store Building	National	Engineering	Under approval	Specific building evaluation
Evaluation Standard for Green Hospital Building	National	Engineering	Under approval	Specific building evaluation
Evaluation Standard for Green Hotel Building	National	Engineering	Under development	Specific building evaluation
Green Hotels (GB/T21084-2007)	National	Product	1st March, 2008	Partial correlation

Evaluation Standard for Green Exhibition Building	National	Engineering	Under development	Specific building evaluation
Evaluation Standard for Green Railway Station	Trade	Engineering	Under development	Specific building evaluation
Evaluation Standard for Green Campus	National	Engineering	Under development	Specific building evaluation
Evaluation Standard for Green Eco-District	National	Engineering	Under development	Specific building evaluation
Code for Green Design of Civil Building (JGJ/T229-2010)	Trade	Engineering	1st October, 2011	For building design
Code for Green Construction of Building	National	Engineering	Under development	For building construction
Code for Operation and Maintenance of Green Building	National	Engineering	Under development	For building O&M

Table 3 Province level standards for green building (Ling, 2014)

Provincial-level Region	Title and number (if possible)	Enforcement date	Note
Anhui	Evaluation Standard for green Building in Anhui	Under development	For evaluation
Beijing	Management Specification of Green Construction in Beijing (DB11/513-2008)	1st May,2008	For construction
	Evaluation Standard for Green Building in Beijing (DB11/938-2012)	1st December, 2011	For evaluation
	Design Standard of Green Building in Beijing (DB11/938-2012)	1st July, 2013	For design
Chongqing	Green Building Standard (DBJ/T50-066-2007)	1st October, 2007	For design, construction and O&M
	Technical Specification for Eco-Residential Building Construction (DBJ/T50-039-2007)	1st February, 2008	For evaluation
	Evaluation Standard for Green Building in Chongqing (DBJ/T50-66-2009)	1st February, 2010	For evaluation
	Design Code of Green Building in Chongqing (DBJ50/T-135-2012)	1st March, 2012	For design
	Code of Green Construction Management in Chongqing (DBJ50/T-166-2013)	1st June, 2013	For construction
Fujian	Evaluation Standard for Green Building in Fujian (DBJ/T13-118-2010)	1st March, 2010	For evaluation
	Technical Specification of Green Construction in Fujian (DBJ/T13-180-2013)	31st December, 2013	For construction
Gansu	Evaluation Standard for Green Building in Gansu (DB62/T25-3064-2013)	1st August, 2013	For evaluation

Guangdong	Evaluation Standard for Green Building in Guangdong (DBJ/T15-83-2011)	15th July, 2011	For evaluation
	Evaluation Standard for Green Construction in Guangdong (DBJ/T15-97-2013)	1st December, 2013	For evaluation
Guangxi	Green Building Evaluation in Guangxi (DB45/T567-2009)	23rd February, 2009	For evaluation
	Code for Design of Green Building in Guangxi (DBJ/T45-001-2011)	1st September, 2011	For design
Guizhou	Evaluation Standard of Green Construction of Small Towns in Guizhou (Trail) (DBJ52/T060-2012)	1st September, 2012	For evaluation
	Evaluation Standard for Green Building in Guizhou (Trail) (DBJ52/T065-2013)	1st December, 2013	For evaluation
Hainan	Evaluation Standard for Green Building in Hainan (Trail) (DBJ46-024-2012)	1st August, 2012	For evaluation
Hebei	Evaluation Standard for Green Building in Hebei (DB13(J)/T113-2010)	1st March, 2011	For evaluation
Hebei	Technical Standard for Green Building (DB13(J)/T132-2012)	1st May, 2012	For design, construction and O&M
	Management Specification of Green Construction in Hebei (DB13(J)/T154-2013)	1st April, 2014	For construction
Heilongjiang	Evaluation Standard for Green Building in Heilongjiang	Under development	For evaluation
Henan	Management Specification of Green Construction in Henan (DBJ41/T107-2010)	1st May, 2011	For construction
	Evaluation Standard for Green Building in Henan (DBJ41/T109-2011)	1st January, 2012	For evaluation
	Evaluation Standard for Green Indemnificatory Houses in Henan (DBJ41/T116-2012)	1st January, 2013	For evaluation
Hong Kong	Evaluation Standard for Green Building in Hong Kong	December, 2010	For evaluation
Hubei	Evaluation Standard for Green Building in Hubei	June, 2010	For evaluation
Hunan	Evaluation Standard for Green Building in Hunan (DBJ43/T004-2010)	1st January, 2011	For evaluation
Jiangsu	Evaluation Standard for Green Building in Jiangsu (DGJ32/TJ76-2009)	1st April, 2009	For evaluation
Jiangxi	Evaluation Standard for Green Building in Jiangxi (DB36/J001-2010/T)	1st May, 2010	For evaluation
Jilin	Evaluation Standard for Green Building in Jilin (DB22/T1591-2012)	16th October,2012	For evaluation
Liaoning	Evaluation Standard for Green Building in Liaoning (DB21/T2017-2012)	1st October, 2012	For evaluation
Neimenggu	Evaluation Standard for Green Building in Neimenggu	Under development	For evaluation
Ningxia	Evaluation Standard for Green Building in Ningxia	1st April, 2014	For evaluation

	(DB64/T954-2014)		
Qinghai	Evaluation Standard for Green Building in Qinghai (DB63/T1110-2012)	15th August, 2012	For evaluation
Shandong	Evaluation Standard for Green Building in Shandong (DBJ/T14-082-2012)	1st March, 2012	For evaluation
Shanghai	Evaluation Standard for Green Building in Shanghai (DG/TJ08-2090-2012)	1st March, 2012	For evaluation
	Management Specification of Green Construction in Shanghai (DG/TJ08-2129-2013)	1st October, 2013	For construction
	Green Design Standard for Residential Building (DGJ08-2139-2014)	1st July, 2014	For design
	Green Design Standard for Public Building	Under approval	For design
Shanxi	Standard for Green Design of Public Buildings in Shanxi (DBJ61/T80-2014)	30th April, 2014	For design
	Standard for Green Design of Residential Buildings in Shanxi (DBJ61/T81-2014)	30th April, 2014	For design
Shanxi	Evaluation Standard for Eco-Residential Building in Shanxi (DBJ61/T83-2014)	1st June, 2014	For evaluation
Sichuan	Evaluation Standard for Green Building in Sichuan (DBJ51/T009-2012)	1st November, 2012	For evaluation
	Design Standard of Green Schools in Sichuan (DBJ51/T020-2013)	1st March, 2014	For school design
Tianjin	Evaluation Standard for Green Building for Sino-Singapore Tianjin Eco-City (DB29-192-2009)	11st September, 2009	For evaluation
	Green Building Design Standard for Sino-Singapore Tianjin Eco-City (DB29-194-2009)	27th January, 2010	For design
	Technical Specification for Green Construction for Sino-Singapore Tianjin Eco-City (DB/T29-198-2010)	1st August, 2010	For construction
	Green Building Construction Management Technical Specification in Tianjin (DB29-201-2010)	15th September, 2010	For construction
	Evaluation Standard for Green Building in Tianjin (DB/T29-204-2010)	1st January, 2011	For evaluation
Yunnan	Evaluation Standard for Green Building in Yunnan (DBJ53/T-49-2013)	1st August, 2013	For evaluation
Zhejiang	Evaluation Standard for Green Building in Zhejiang (DB33/T1039-2007)	1st January, 2008	For evaluation
	Green Design Standard of Civil Buildings in Zhejiang (DB33/1092-2013)	1st January, 2014	For design

Evaluation standards in Table 2 covers almost all lifecycle stages of all types of building. In terms of lifecycle stage, the standard GB/T50378 applies to both design and operation stage, GB/T50640 applies to construction stage and *Evaluation Standard for Green Refurbishment* *of Existing Building* will apply to refurbishment or retrofit stage. In terms of building type, there are standards for factories,offices, retails, hospitals, hotels, expohalls, railway stations, and school campus, respectively (Ling, 2014). In Table 3, there are differences in green building standards in various provinces and cities in China, and the standards in the economically developed eastern coastal areas are more complete. At present, there are a plethora of duplication of green building standards. Some provinces and cities do not fully standardize them to the local conditions, and there is a debate on how to develop and improve standards. For example, in Anhui, local green building standards are still under development. Therefore, it is a good opportunity to listen to residents' perceptions about green buildings and adopt their opinions.

2.7 Explanations of the ESGB Criteria

The ESGB is not a worldwide standard, so in this section, it will be further described. In general, the ESGB is similar to other building environment assessment systems, which primarily addresses five aspects of green building: land-use efficiency, energy efficiency, water efficiency, material efficiency and indoor environment quality (Joo, 2013). The sections below will zoom in each one of the criterion.

2.7.1 Land-use Efficiency

Regarding the conservation of land resources, the requirements for the construction of cultural relics and other protected areas must be implemented when selecting sites for urban and rural planning construction land. In addition, for the selected location, human life cannot be threatened by natural disasters, pollution, or other factors that affect physical health. The specific sectors concerning land development are shown in table 5 (Ge, 2017).

Table 4 China’s GB evaluation criteria section and outdoor environment specific measures (Ge,2017)

Categories	Measures (scores)
Land use	➢ Saving intensive use of land (19) ➢ Reasonable green land for site (9) ➢ Reasonable development and utilization of underground space (6)
Outdoor environment	➢ Designs that will avoid light pollution will be applied to buildings and lighting (4) ➢ The environmental noise in the site meets the relevant provisions of the "Acoustic Environmental Quality Standard" GB 3096 (4) ➢ Meet the natural ventilation and comfortable wind environment for the building (6) ➢ Take measures to reduce heat island intensity (4)
Transportation	➢ Convenient public transportation (9)

and service	➢ Accessible pedestrian access (3) ➢ Reasonable setting up parking lot (6) ➢ Providing convenient public services (6)
Site Design and Site Ecology	➢ Integrate the topography of the terrain, design and layout of the site, protect the original ecological water body, wetland and vegetation, and use ecological compensation measures such as surface soil (3) ➢ Fully and reasonably arrange green rainwater infrastructure in the site, and design rainwater special programs for sites larger than 20h ㎡ ➢ Rationally plan surface runoff and rainwater runoff on the roof and implement total discharge control of site rainwater (6) ➢ Site annual runoff control rate of 55% (3), up to 70% (6) ➢ Choosing a reasonable greening plan and greening plant matching science (6)

As it can be seen from the above table, the Green Building Evaluation Standard puts the safety of site selection as first, and improves land use efficiency by developing underground space and transforming abandoned sites. However, the standard lacks guiding indicators on the impact of the building on the surrounding environment. Therefore, the measures taken are relatively simple, and usually rely on the greening measures adopted within the building to maintain the stability of the ecological environment as much as possible.

2.7.2 Energy Efficiency

On the basis of the provisions, energy efficiency means that the building's internal equipment can meet the minimum energy efficiency, the equipment is controlled and optimized so as to achieve energy-saving effect. In table 5 are various indicators and measures to explain the criteria.

Table 5 China's green building evaluation criteria (Ge, 2017)

Categories	Measures (scores)
Construction and containment structures	➢ Combine the natural conditions of the site, the shape of the building, the direction of the building, the distance of the building, and the ratio of window to wall to optimize the design (6) ➢ Reasonable design of architectural, glass-curtained windows allows users to enjoy natural ventilation (6) ➢ Building maintenance structure design meets corresponding energy conservation standards (10)
Heating, ventilation and air conditioning	➢ The building core energy consumption for heating and air conditioning systems used to obtain a comfortable temperature and ventilation environment must comply with energy-saving design standards and national standard energy efficiency limit values (6) ➢ The energy consumption of the hot water circulating pump and the air conditioning system fan used in central heating meets the relevant provisions of the "Energy-saving Design Standards for Public Buildings"

	GB 50189, in which the energy consumption of circulating water pumps of air-conditioning hot and cold water systems is higher than that of "heating, ventilation and air for civil buildings. Regulatory Design Specification" GB 50736 is 20% lower (6) ➢ Optimum selection of heating, ventilation and air-conditioning systems, taking appropriate measures to reduce the energy consumption during the transient transitional period (6) ➢ Rationalize measures to reduce energy consumption from non-essential space (9)
Lighting and Electrical	➢ Energy-saving measures such as zoning, timing, and induction are used to control lighting systems in hallways, stairwells, foyers, lobbies, underground parking lots and other places (5) ➢ The target value of the current national standard "Architectural Lighting Design Standard" GB 50034 is used to meet the requirements of the building lighting power density (8) ➢ Optimize the ratio of the selected elevator and escalator scheme, in which the elevator adopts the group control section and the escalator adopts automatic start-stop measures while meeting the national energy-saving requirements (3) ➢ Reasonable choice of energy-saving electrical equipment (5)
Comprehensive energy utilization	➢ Rationally design exhaust energy recovery system to ensure reliable operation (3) ➢ Preferred cold storage and thermal storage system (3) ➢ Use waste heat to meet the needs of the building's steam, heating, or domestic hot water (4) ➢ According to the local climate and natural resources conditions, choose a reasonable renewable energy (10)

From table 5, in the aspect of building energy conservation, the Green Building Evaluation Standard reduces building energy consumption by rationally selecting building equipment and household appliances, and considering external resources at the beginning of design. Improve the proportion of renewable energy use and optimally reorganize the energy composition of buildings to achieve energy conservation. The standard does not focus on the cost of using energy, but focuses on the amount of resources used, but the unit of energy consumption is not deterministic. In the evaluation, there is no uniformity in the types and usage of renewable energy, making the evaluation results lack scientific and accurate.

2.7.3 Water Efficiency

ESGB optimizes water conservation by establishing a rational water use plan, setting up an efficient drainage system, and using water-saving equipment. The specific measures are shown in the table 6.

Table 6 China's green building evaluation criteria for specific measures of water saving

(Ge,2017)

Categories	Measures (scores)
Water saving system	➢ The average daily water consumption of the building complies with the requirements of GB 50555, the national standard “Water saving standard for water saving design of civil buildings” (10) ➢ Take effective measures to avoid network leakage (7) ➢ There is no over-pressure outflow in the water supply system (8) ➢ Set up water metering device (6) ➢ Shared bathroom to take water saving measures (4)
Water-saving appliances and equipment	➢ Use efficient water-saving sanitary appliances and equipment (10) ➢ Landscape greening irrigation selection water saving irrigation method (10) ➢ Water-saving cooling technology for air-conditioning equipment or systems (10) ➢ Water saving techniques or measures for sanitary ware, green irrigation, cooling towers and other aspects (5)

The Green Building Evaluation Standard optimizes water conservation by developing reasonable water use plans, setting up efficient drainage systems, and adopting water-saving equipment. Specifically embodied in the following three aspects: First, greening garden irrigation water advocates the use of drip irrigation, rainwater harvesting, water facilities and other technologies to improve garden water use efficiency, reduce the consumption of potable water for greening landscape; second, through water metering water management to effectively control water use; third, save water, and reduce water consumption through measures such as improved sanitary ware.

2.7.4 Material Efficiency

Saving material should be the strategy for the whole life cycle of materials from the raw material stage to the waste recycling stage. By adopting the six measures of low consumption, low energy consumption, low emission, no pollution, multi-functionality, and recycling, it can reduce the consumption of energy and reduce the load on the environment. Some standards concerning material usage are explained in table 7.

Table 7 Material resources utilization specific measures (Ge, 2017)

Categories	Measures (scores)
Design	➢ Choose to use architectural shapes (9) ➢ Optimize and upgrade the design from the base foundation, structural system and structural components (5) ➢ Integrated design of civil engineering and decoration engineering

	(10) ➢ Reuse of partitions used in a convertible indoor space in public buildings (5) ➢ Industrial production of prefabricated components (5) ➢ Kitchen and bathroom use integrated design (6)
Material selection	➢ Using locally produced building materials (10) ➢ Cast-in-place concrete with ready-mixed concrete (10) ➢ Building mortar using ready-mixed mortar (5) ➢ Reasonable use of high-strength building materials (10) ➢ Reasonably adopt high durability building materials (5) ➢ Use reusable, recyclable materials whenever possible (10) ➢ Using waste as raw material to produce building materials (5) ➢ Reasonably adopting renovation building materials with good durability and easy maintenance (5)

As it can be seen from the table 7, the green building evaluation standard measures the building material performance in the two major processes of design and construction. In terms of architectural design optimization, prefabrication and reuse, the indicators are set around the selection of materials, the production and reuse of building materials, and the optimal design of materials. After the interpretation of the indicators, in order to avoid the waste of materials and quality problems caused by on-site cast-in-place, the construction materials are encouraged to be prefabricated. For buildings using new building materials, it is necessary to consider whether the materials are within the service life of the building.

2.7.5 Indoor Environment Quality

Indoor environmental quality is an important category, since it directly affects residents' quality of life. As a result, this category allocates many points (Joo, 2013). The standard evaluates indoor environmental quality in terms of sound, light, and heat and air quality. It contains 13 items for rating and 7 items for control. From the point of view of the distribution of scores, the highest proportion is to improve the indoor natural lighting effect, improve the natural ventilation effect and choose effective measures such as the scores obtained by the three types of technology, in order to make the indoor air environment to meet the evaluation criteria, in the design stage, from the sound insulation , sunshine and ventilation are controlled in three aspects, shown in table 8 (Ge, 2017).

Table 8 Measures of indoor environmental quality (Ge, 2017)

Categories	Measures (scores)
Indoor acoustic environment	➢ Main function room noise level (6) ➢ Superior sound insulation in the main function room (9) ➢ Take measures to reduce noise interference (4) ➢ The important rooms for acoustic requirements in public buildings, such as multi-function halls, reception halls, large conference rooms, etc., shall be designed to meet the

	corresponding functional requirements (3)
Indoor light environment and vision	➢ The main functional room of the building has a good view (3) ➢ The main function room lighting factor meets the current national "architectural lighting design standards" GB 50033 (8) ➢ Improve natural lighting in the building (14)
Indoor hot and humid environment	➢ Select adjustable sunshades to reduce the heat emitted by summer solar radiation (12) ➢ The end of the heating and air conditioning system can be adjusted independently (8)
Indoor air quality	➢ Improve the natural ventilation effect by rationally arranging the building space, planning layout and structural design (13) ➢ Air distribution is reasonable (7) ➢ Indoor air quality inspection system for main function rooms with high density of people and large variations over time(8) ➢ Carbon monoxide concentration detection assembly linked with exhaust equipment in an underground garage (5)

As it can be seen from table 8, the standard is slightly rough in assessing both good outdoor vision and indoor environmental quality. The building has a good outdoor view, which not only relieves visual fatigue, but also improves work efficiency. Therefore, the improvement of the indoor environment can be controlled by a good view. The indoor environmental indicators of this standard focus on orientation, illumination, ventilation, noise reduction, and pay less attention to indoor air quality. Only the indoor elements such as formaldehyde, benzene, and ammonia are required to avoid negative human health effects.

2.7.6 Summary

Overall, research on building environmental assessment systems has undergone a great development for the past decades in the field of architecture. However, most studies focus on only a few worldly renowned building environmental assessment systems such as LEED and BREEAM (Joo, 2013). However, due to the different actual conditions in each country, a more in-depth study of evaluation standards is needed. Among them, China's green building evaluation system is the focus of this study. Most importantly, most existing systems, including ESGB, lack user feedback between the capabilities they design and the capabilities they perform. Therefore, this study focused on user feedback to improve China's green building evaluation system.

Chapter 3 Research Design

In this chapter, theoretical framework and method will be described. Based on residents survey, the research tries to study to what extent the green building scores match with residents' perceptions about how 'green' the building are. To analyze my research data, different statistical tools will be used including quantitative method and qualitative method. The results of this analysis will provide information for future research.

3.1 Research Framework

The aim of the research is to verify the perceptions of residents against the scores of green building criteria. The research object in this research is the relationship between the scores of green building criteria and post occupancy evaluation by residents. By analyzing it, the study will aim to identify gaps, as well as gains, in the current practice of GB and will provide some recommendations to improve the system of GB certification. With the purpose to give recommendations, questionnaire survey (text is in appendix 1) is considered to be taken in the design. Hence, the research aims to gather information from residents.

The following diagram depicts a conceptual model of the structure of this study.

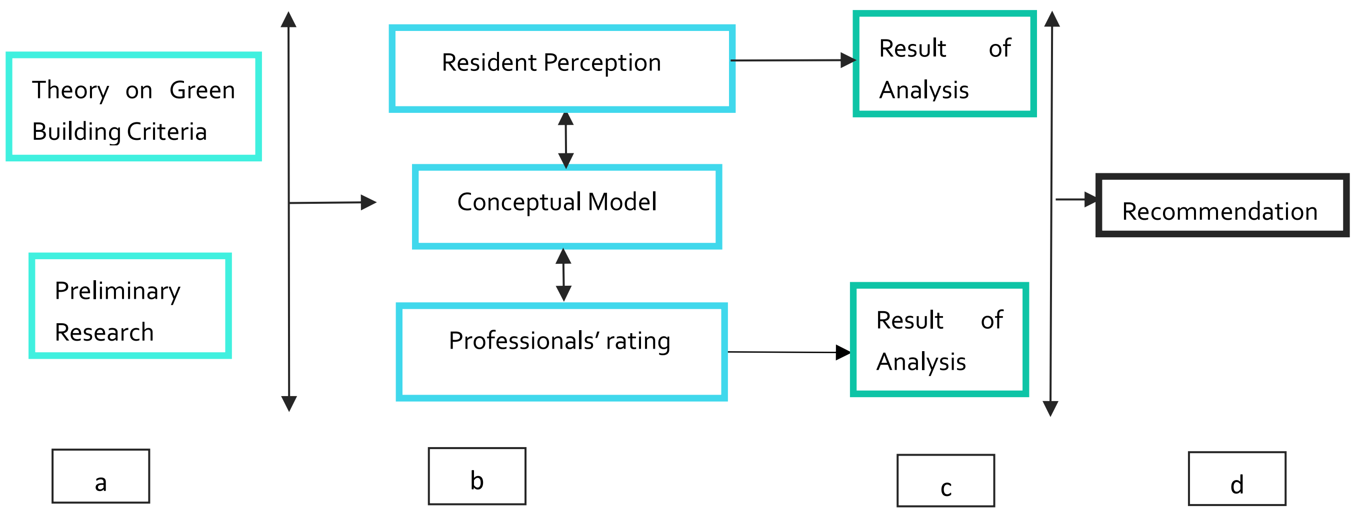

Fig.2. Conceptual model

3.2 Research Questions

The main research question:

(a) To what extent, the rating of green buildings through the ESGB is consistent with residents' perceptions on the "green" degree of buildings?

Sub-research question:

1. What are the current green building assessment standards in China? What are the main

aspects of evaluating green buildings?

2. How do residents rate green buildings according to ESGB?

3. How to improve the ESGB in the case of considering residents' perception?

3.3 Research Strategy

The research uses single case study as a research strategy. It means the researcher chose for depth in view of the research objective. Additionally, other sources of information were also analyzed, i.e. media, scientific publications, interviews to school staff members, also residents.

3.3.1 Research Unit

The research unit for the case study is Shenzhen Yantian High School. Yantian High School is located in Shenzhen province, which is certificated as green building (Green Building Map, 2018). The total construction area of Shenzhen Yantian High School is 72,461.19 ㎡. The main construction contents of the project include: teaching building, arts and office buildings, reading rooms, gymnasiums, dormitories and other housing construction projects and outdoor sports facilities, roads, pipe networks, green areas, fences, surrounding slopes, pre-school squares, civil air defense projects, solar hot water systems and other ancillary works. The project is designed according to the two-star standard of green building, including rainwater reclamation project, mid-water treatment project and wind-solar hybrid power generation system. It also adopts energy-efficient lighting fixtures, energy-saving lamps with high shading coefficient, and other energy-saving materials and measures (SZxuexiao, 2014).

Fig.3. Yantian High School, Source: baike.com, 2018

3.3.2 Selection of Research Unit

Choosing the target green building is a critical first step. I went to the green building map to check the distribution of green buildings in China. Beijing, Jiangsu, Guangdong and Taiwan

(Darker areas in figure 4) are the provinces with the most number of green buildings (Fig.4). Considering the time cost and geographical location, Shenzhen was chosen for practical reasons, the location is closer to the researcher address (in Guangdong Province). When choosing a specific green building, Shenzhen Yantian High School became the case to be analyzed in this research. First of all, high school students have a strong ability to understand relative new concepts than primary school students and have a higher acceptance of a new concept. Therefore, it was less difficult to explain the concept of green building to them. In addition, compared with college students, high school students have a fixed time and activity range, and it is easier to obtain a larger data sample.

After choosing the school, contact with the school principal was established and he was introduced him to the study purpose. The principal allowed to conduct the survey, and also the attendance to student weekly meetings. As a result, 500 people participated in the survey. As a survey administrator, I explained my research and distributed questionnaires to students.

Fig.4. China Green Building Map (Green Building Map, 2018)

3.3.3 Research Boundary

Research boundary is used to determine the limitation of study and its consistency. The limitation is the limited study site. There are 3510 green building projects that have been certified in China (Green Building Map, 2018). There are also many types of green buildings,such as residential buildings, commercial buildings and teaching buildings. The surveyed building is only a kind of teaching building. Therefore, the outcomes of the study may not be generalized to other locations inside and outside of the nation. It just provides a new idea for improving green building assessment standards from the user's perspective but requires further research.

3.4 Research Material and Accessing Method

Research material and accessing method is the way of organizing and defining where are data and information that a researcher needs to have access in order to answer the research questions. Which sources should be analyzed, and how to obtain them are all considered during the planning and designing phases of any research project (Verschuren and Doorewaard, 2010).

There are about 2500 students in Shenzhen Yantian High School. The sample can be chosen through Solvin formula with margin of error 4%:

$n = N / (1+N.e^2)$.

Whereas:

n = no. of samples

N = total population

e = error margin / margin of error

According to the Solvin formula, the number of sample is 500 students.

In this research, data sources were interviewees, documents and direct observations. The information about the school can be found on the internet. So I went to the official website of the school and inquired about the green building of the school. After that, I contacted the principal of the school and obtained the permission to apply the survey. Then I handled the surveys to 500 participants and gave them a brief introduction of my research objectives. The data was gathered after they finished the surveys.

The data and information required and its accessing method in this research are identified through the set of sub-research question, as shown in Table 9.

Table 9: Types of data and information needed, Data sources, and Accessing method

Research Question	Types of Information Needed	Data Source	Accessing Method
1. What are the current green building assessment standards in China?	-GB assessment standard	Secondary Data -Document	Content analysis Documents
2.How do residents rate the green buildings?	-residents' standards	Primary Data -residents Secondary Data -Document	Survey Content analysis Documents

3. How to improve the ESGB in the case of considering residents' perception?	-the results of survey	Secondary Data -Documents -Questionnaire	Content analysis Documents survey

3.5 Data Analysis

Data analysis means data processing through logical and analytical framework as presented in the following section.

3.5.1 Data Analysis Methods

The research used both qualitative and quantitative methods. The information and data are analysed by using qualitative and quantitative methods to obtain information related to the research objectives. The detailed methods are presented in the table 10.

Table 10: Data and information to be collected and respective method of analysis

Data and information to be collected	Method of analysis
-GB assessment standards	Qualitative method: Analysis of how professionals evaluate green building
-residents' standards	Qualitative method: Analysis of how residents evaluate green building
-the results of survey	Quantitative method: Analysis of the proportion of residents

3.5.2 Analytical Framework

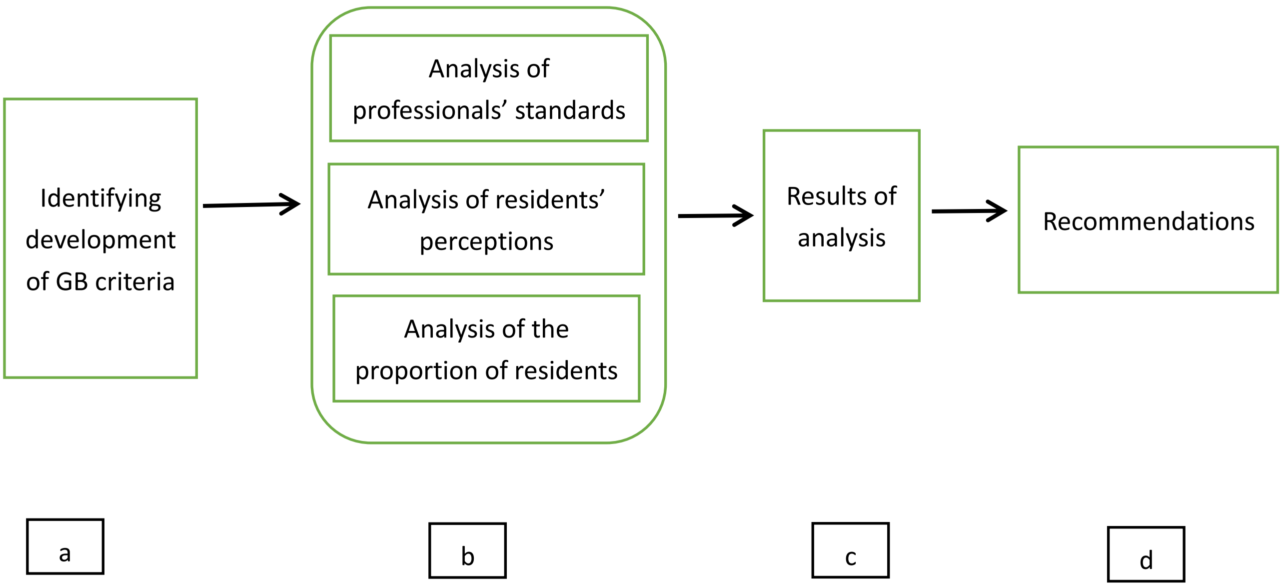

Fig.3. Analytical framework

Data analysis was conducted by the following procedure:

A. Firstly, the research makes a review of development of GB criteria from documents, literature and website to get some information. Also, the professionals standards about green building evaluation should be focused. From this step, the sub-question number 1 is answered.

B. Secondly, analysis of how residents evaluate green building. Residents evaluate green buildings from six aspects, including awareness, land-use efficiency, energy efficiency, water efficiency, material efficiency and indoor environment quality. This is done by doing survey in Shenzhen Yantian High School. Under this analysis step, research sub-question number 2 is answered.

C. Finally, based on the answer of sub-question in the previous steps, recommendations are given to improve the ESGB in China.

3.6 Ethics

This research aims to find to what extent the green building scores match with residents' perceptions about how 'green' the buildings are, then some recommendations are provided to improve the green building criteria in China. The residents who have experience living in both green building and non-green buildings are surveyed. Before the survey, some information about the research's topic was introduced. Their private information is not be disclosed without their permission. After the research report is finished, I will contact and inform them about the results of this research.

Chapter 4 Findings

This chapter focuses on the analysis of data from survey to answer subquestion 1 and 2. The detailed information of questionnaire is shown in appendix 1. It is to establish an understanding of the data. The results are divided into six main parts, which include awareness, land-use efficiency, energy efficiency, water efficiency, material efficiency and indoor environment quality. All people perception variables were measured on a 5-point scale, running from excellent at rating 5 to poor at rating 1. But some variables were captured by dichotomous measures (e.g., know or don't know and yes or no).

4.1 Awareness

Due to the rapid development of the economy, people are increasingly demanding buildings. The promotion of green buildings is also of great significance to the development of green buildings. Therefore, people's understanding of green buildings has also been formulated in the survey, which can be seen in Table 11. Even further, the answers of the 500 respondents at the school are shown in the same table in both, total numbers and percentage per question and per point-scale. This was done for the 2 questions comprising the awareness category to answer subquestion 1.

Table 11 Descriptive Statistics for People's Awareness

Question	Yes	No	Total
1.Are you familiar with Green Building concept?	210(42%)	290(58%)	500(100%)
2.Do you know whether your school is certified by ESGB?	181(36.2%)	319(63.8%)	500(100%)

Question 1 shows students' awareness of green building. Only 42% of students were familiar with the concept of green building. More than half of the students in Shenzhen Yantian High School had not heard of the concept of green building. In addition, the concept of green building is only popular in the construction industry, and the degree of publicity is insufficient (Fangfang, 2014). Question 2 illustrates the students' awareness of their school's certification status. 36.2% of students knew that their school was certified by ESGB and 63.8% of students didn't know their school's certification status. It can be seen that the ESGB certification did not seem to attract much students' attention. Some students said that they only paid attention to the school's enrollment rate, did not notice what was written on the school's bulletin board and did not get information from their teachers. Besides, the school did not vigorously promote the news that it was certified.

4.2 Land-use Efficiency

As presented in section 2.7.1, land-use efficiency represents one of the ESGB criteria assessing diverse geographical aspects of any construction that evaluates the interaction between the user's well-being and the physical conditions of the construction area. Some of those aspects were used to formulate questions that I include in my survey and can be seen in the first column of table 12. Even further, the answers of the 500 respondents at the school are shown in the same table in both, total numbers and percentage per question and per point-scale. This was done for the 6 questions comprising the land use efficiency category to answer subquestion 2.

Table 12 Descriptive Statistics for Land-use Efficiency

Question	Poor	Fair	Moderate	Good	Excellent	Total
3.How do you rate the outdoor environment in your school? (for example: greening, noise level)	96(19.2%)	110(22%)	108(21.6%)	84(16.8%)	102(20.4%)	500(100%)
4.How do you rate the building structure of your school?	98(19.6%)	118(23.6%)	98(19.6%)	85(17%)	101(20.2%)	500(100%)
5.How do you rate the connection between the walkways in your school?	108(21.6%)	86(17.2%)	96(19.2%)	104(20.8%)	106(21.2%)	500(100%)
6.How do you rate the public utilities in your school? (for example: basketball court, playground)	30(6%)	103(20.6%)	111(22.2%)	96(19.2%)	160(32%)	500(100%)
7.How do you rate the public transportation near your school? (for example: traffic type, time to the public transportation stations)	180(36%)	98(19.6%)	80(16%)	65(13%)	77(15.4%)	500(100%)
8.How do you rate the location of parking lot in your school?	94(18.8%)	96(19.2%)	103(20.6%)	104(20.8%)	103(20.6%)	500(100%)

From table 12, it can be seen that land-use efficiency is mainly evaluated from the aspects of outdoor environment, building structure, public facilities and transportation. Question 3 describes outdoor environment of the school, such as greening and noise level. According to the data, 19.2% of students were not satisfied with their school environment. This latter because their classroom was very close to the street and hence they could not concentrate on their study. Question 4 and 5 are linked to the building structure. It can be seen that almost one-fifth of student thought the structure of their school was poor. Some students said they were divided into different teaching buildings according to different grades and because the teaching buildings were separated, it was difficult for them to communicate with people of different grades. However, some students said they did not have time to spend on things other than learning. Question 6 is concerning public facilities of the school. It can be seen that the students were enjoying advanced public facilities of the school because the poor rate only accounted for 6%. The school has an independent teaching building for all grades, a well-equipped experimental building, a library with a collection of over 100,000 books, ample sports venues, a standard track and field stadium with a 400-meter-eight-track runway, an indoor basketball court, and eight indoor standard badminton courts. These are great to meet the needs of students' daily study and life. Question 7 and 8 show the transportation's perception of the students. They were not satisfied with the transportation near the school, especially school time. Many parents drove to pick up students, causing traffic jams at the school gate. Therefore, they had to spend more time to go home than usual. At the same time, there are very few parking spaces available to parents that cars are blocked at the school gate, resulting in inefficiency. This is why poor rate occupies 18.8%.

4.3 Energy Efficiency

As presented in section2.7.2, Energy efficiency represents one of the ESGB standards, assessing measures to reduce energy consumption and renewable energy use during the construction phase of the building, and assessing energy use by users during the building operations phase. Some of those aspects were used to formulate questions that I include in my survey and can be seen in the first column of table 13. Even further, the answers of the 500 respondents at the school are shown in the same table in both, total numbers and percentage per question and per point-scale. This was done for the 3 questions comprising the energy efficiency category to answer subquestion 2.

Table 13 Descriptive Statistics for Energy Efficiency

Question	Yes	No	Poor	Fair	Moderate	Good	Excellent	Total
9.Do you know whether any other renewable energy systems are installed in your school?	143 (28.6%)	357 (71.4%)						500 (100%)
10.If YES, how do you rate the systems' ability to reduce the fee?			20 (14%)	30 (21%)	35 (24.5%)	25 (17.5%)	33 (23%)	143 (100%)
11.If NO, do you think it is necessary to have one in your school?	278 (77.9%)	79 (22.1%)						357 (100%)

This part mainly focuses on the renewable energy. From the results of question 9, there are only 28.6% of students who know about the installed renewable energy systems. Some students said that they knew solar water heating system by chance, otherwise they had no knowledge of this. Solar water heating system is only applied to provided dormitory hot water, so those students who don't live in school don't know about it. As for question 10, the fee here means the students' own payment to the school for using hot water. According to school regulations, students use hot water to charge according to the amount of hot water. Most of students were satisfied with the solar water heating system because it can provide hot water 24 hours a day and the price per liter of hot water is cheaper. Besides, they can take a bath directly in the dormitory instead of bathhouse. Students who answer question 11 think it is necessary to have one in the school. Renewable energy is not only clean, but also relieves energy stress, which reduces the use of fossil energy.

4.4 Water Efficiency

As presented in section 2.7.3, water efficiency represents one of the ESGB standards for assessing the performance of building water-saving systems and water-saving equipment. They were used to formulate questions that I include in my survey and can be seen in the first column of table 14. Even further, the answers of the 500 respondents at the school are shown in the same table in both, total numbers and percentage per question and per point-scale. This was done for the 4 questions comprising the water efficiency category to answer subquestion 2.

Table 14 Descriptive Statistics for Water Efficiency

Question	Yes	No	Poor	Fair	Moderate	Good	Excellent	Total
12.how do you rate the drainage systems' ability to drain surface water when it comes to a storm?			66 (13.2%)	105 (21%)	99 (29.8)	103 (20.6%)	127 (25.4%)	500 (100%)
13.Do you know whether any water saving appliances are installed in your school?	324 (64.8%)	176 (35.2%)						500 (100%)
14.If YES, how do you rate the performance of water saving appliances such as faucets, toilets?			35 (10.8%)	75 (23%)	85 (26.2%)	88 (27.2%)	41 (12.8%)	324 (100%)
15.If NO, do you think it is necessary to have water saving appliances in your school?	150 (86.4%)	26 (13.6%)						176 (100%)

Water efficiency includes drainage systems and water saving appliances performance. Question 12 is concerning drainage systems' performance when it comes to a storm. The data shows only

13.2% of students don’t feel good because they are not satisfied with the drainage systems’ performance. They hope that the drainage systems of school can drain faster. Question 13 to 15 shows that most of students are aware of the facts that water saving appliance are installed in school. Meanwhile, more than half of the students think that these water saving appliances are very easy to use and more water-saving.

4.5 Material Efficiency

As presented in section 2.7.4, material efficiency represents one of the ESGB standards to assess the use of renewable energy in the construction phase. It was used to formulate questions that I include in my survey and can be seen in the first column of table 15. Even further, the answers of the 500 respondents at the school are shown in the same table in both, total numbers and percentage per question and per point-scale. This was done for the 2 questions comprising the material efficiency category to answer subquestion 2.

Table 15 Descriptive Statistics for Material Efficiency

Question	Yes	No	Poor	Fair	Moderate	Good	Excellent	Total
16.Do you know whether any renewable materials are used in your school?	163 (32.8%)	337 (67.4%)						500 (100%)
17.If YES, how do you rate these materials?			13 (8%)	24 (14.7%)	45 (27.6%)	57 (35%)	24 (14.7%)	163

This section emphasizes students’ understanding of the use of renewable materials. The data shows that only 32.8% of the students know renewable materials are applied in the construction of the school. Though the number of students who know the use of renewable materials is small, most of them think renewable materials should be widely used.

4.6 Indoor Environment Quality

As presented 2.7.5, indoor environment quality represents one of the ESGB standards to assess the environmental quality of a building's interior. Some of those aspects were used to formulate questions that I include in my survey and can be seen in the first column of table 16. Even further, the answers of the 500 respondents at the school are shown in the same table in both, total numbers and percentage per question and per point-scale. This was done for the 3 questions comprising the indoor environment quality category to answer subquestion 2.

Table 16 Descriptive Statistics for Indoor Environment Quality

Question	Poor	Fair	Moderate	Good	Excellent	Total
18.How do you rate the cooling system in your school?	67 (13.4%)	101 (20.2%)	189 (37.8%)	76 (15.2%)	67 (13.4%)	500(100%)
19.How do you rate the lighting	25	78	203	65	109	500(100%)

system in your school?	(5%)	(15.6%)	(40.6%)	(13%)	(21.8%)	
20.How do you rate the performance of the ventilation systems such as fans, operable windows?	58 (11.6%)	43 (8.6%)	176 (35.2%)	98 (19.6%)	125 (25%)	500(100%)

Indoor environment quality consists of three aspects, cooling system, lighting system and ventilation system. According to question 18, most of students were satisfied with their cooling system. Cooling systems are installed in every building of this school. Therefore, students are provided comfortable rooms to concentrate their study during hot weather periods. Question 19 shows that only 5% of the students think the lighting system is not good because the lights on the school square are not bright. Because they have to study in the evening, it is very late to go back to the bedroom. However, the lights on the road are not bright, which may cause security problems. As for ventilation system, most students think ventilation system works well. Sometimes, indoor air quality can be improved by nature ventilation, which reduces the use of mechanical ventilation to a certain extent and saves energy.

Chapter 5 Recommendations

This chapter entails recommendations presented to the Chinese government to aid the development of green building in China. These recommendation are addressing improvements in the six main areas discussed in the chapter 4, which are used to answer subquestion 3. Hence this section follows the same structure, i.e. awareness, land-use efficiency, energy efficiency, water efficiency, material efficiency and indoor environment quality.

5.1 Awareness

To raise people's awareness of green buildings, it is necessary not only to stipulate policies, but also to promote the concept in a bottom up approach. First of all, provinces and cities should confirm their goal of developing green buildings according to the actual situation of the province. At the same time, it is necessary to increase investment in green buildings and related subsidy policies, and set up science and technology innovation funds related to green buildings to encourage enterprises and scientific research institutions to strengthen their awareness of independent innovation. Secondly, it is necessary to increase the promotion of green buildings and related concepts, and publicize them through media and newspapers. For example, green buildings can be used as a breakthrough to promote green buildings. Compared with other institutions, schools have more members who are more likely to accept scientific ideas and are more concerned with the characteristics of social issues such as environmental protection. Most of the buildings owned and used are public buildings, and it is more feasible to promote green buildings with schools as a breakthrough (Genfu, 2017). As for other types of green buildings, they can be promoted through the media and newspapers.

5.2 Land-use Efficiency

Improving land-use efficiency is mainly due to reasonable planning. The technical measures for land saving in the city are mainly: building multi-storey and high-rise buildings to increase the building volume ratio while reducing the building density; using underground space to increase urban capacity and improve the urban environment; urban residential areas, improving the intensive residential land Degree, leaving room for future sustainable development, increasing green area and improving the ecological environment of the settlement (Wei, 2018). In the overall design, it is necessary to design according to the local conditions of the site. At the same time, the building volume, angle, spacing, road orientation and other factors should be reasonably combined to make full use of natural ventilation and sunshine. According to the performance of the building, the surrounding traffic and public facilities are planned reasonably.

5.3 Energy Efficiency

Due to the limitation of technology, only solar energy conversion rate is the highest. Therefore, solar energy is the most used by residents except primary energy (Guangfu, 2017). However, they are unable to estimate the energy consumption during use, and it is impossible to judge whether or not they are energy-saving. The government needs to develop an universal energy evaluation criteria. In addition, the government should invest money to develop technology to improve the utilization of other renewable energy sources.

5.4 Water Efficiency

From the survey, there are many methods used to improve water efficiency, such as water saving appliance installed in toilets. It is a good phenomenon. Besides drainage system, the water system should be established. The water system is a non-potable water that can be used in the living, municipal and environmental, after the proper treatment of the building's domestic drainage. Rainwater recycling can also be recycled to save water and reduce local water and waste-water treatment burdens.

5.5 Material Efficiency

Few renewable materials are used in the construction of the building (Ruida, 2017). And some materials removed from the old site have a low recovery rate. Therefore,renewable materials should be developed in the form of industrial chains. Meanwhile, in order to increase the proportion of renewable materials in green buildings, the share should be specified in the evaluation criteria.

5.6 Indoor Environment Quality

People pay more attention to indoor environment quality, including lighting, ventilation. Lighting, ventilation and oriented are been made concrete criteria in building environmental assessment. But these three aspects are only being set to the minimum required standard. Therefore, residents’ living experience is not good. It is necessary to combine residents’ perception with ESGB criteria to further develop ESGB criteria.

Chapter 6 Conclusions

This research is to find to what extent the green building scores match with residents' perceptions about how 'green' the buildings are. The research is very meaningful since it deepens the field with information on a building environmental assessment system. In this study, survey is adopted to collect information from residents. The research mainly focuses on six aspects of the ESGB, including awareness, land-use efficiency, energy efficiency, water efficiency, material efficiency and indoor environment quality. By analyzing the data gathered from 500 participants, it can be seen that around one third of participants know the target building is certified. The public awareness needs to be improved. As for the other aspects, the residents' evaluations are generally average from poor to excellent.

There are still some limitations in this research. First, the research only studies one site and 500 participants. Maybe residents in other parts of China show different responses and the outcome of the study is different. In addition, there are many aspects in ESGB, which may have a larger impact on resident perception. But they are ignored in this research. Thirdly, the types of respondents are relatively single and only the survey is used in this research. The 5-point scale used in the survey may not be detailed enough to evaluate the resident perception of a range of factors. However, it is one of the easiest methods in support of respondent understanding. It is also one of the most efficient and inexpensive methods for data collection.

Although this research is not complete enough, it provides a new perspective for future green building assessment methods. My study is meaningful as a first time to consider the domestic inclusion of residents' opinions in the green building evaluation standards.

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Appendix 1

SURVEY

You are being asked to participate as a volunteer in a research conducted by Jiange Xu from the Master Energy and Environmental Management (MEEM) programme. The research is designed to gather information about residents perceptions about green building in China.

You will be one of approximately ____ [number] ____ [state who : public servants, expert, etc.] participating in the research by completing this questionnaire.

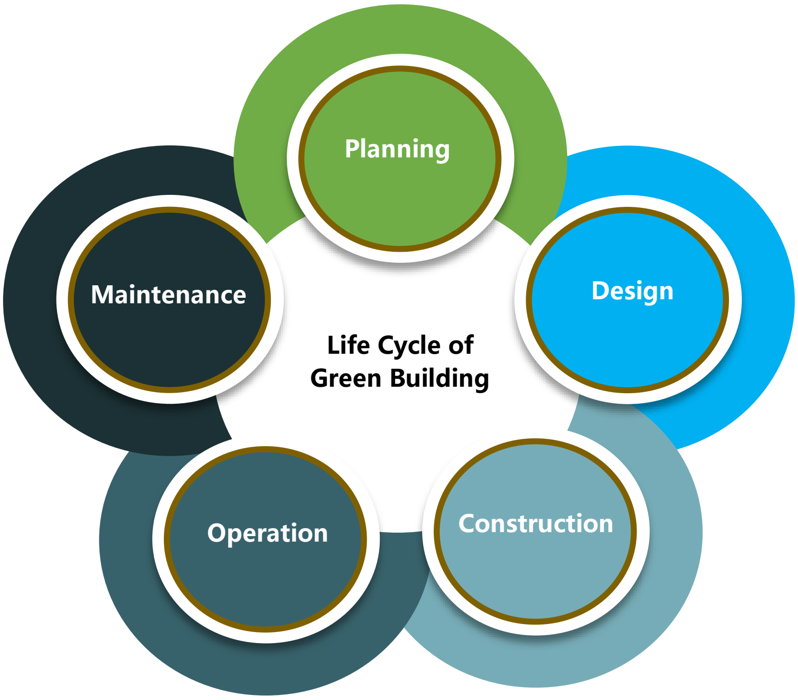
1. Your participation in this research is voluntary.
2. Completing the questionnaire will require about 15 minutes. There are no known risks associated with completing the questionnaire. You may decline to answer some questions.
3. You may choose to participate anonymously, Subsequently, your identity as a participant in this research will remain unknown.
4. The answer to the questionnaire will be used for the purpose of the research only.

Thank you for your participation!

Introduction

Green Building:

Green building (also known as green construction or sustainable building) refers to both a structure and the application of processes that are environmentally responsible and resource-efficient throughout a building's life-cycle: from planning to design, construction, operation and maintenance. The GB process requires close cooperation of the contractor, the architects, the engineers, and the client at all project stages. The GB practice expands and complements the classical building design concerns of economy, utility, durability, and comfort.



First & last name: E-mail Address: Date:

1. Are you familiar with Green Building concept?
   A. YES B. NO
2. Do you know whether your school is certified by ESGB?
   A. YES B. NO
3. How do you rate the outdoor environment in your school? (for example: greening, noise level)
   A. Poor B. Fair C. Moderate D. Good E. Excellent
4. How do you rate the building structure of your school?
   A. Poor B. Fair C. Moderate D. Good E. Excellent
5. How do you rate the connection between the walkways in your school?
   A. Poor B. Fair C. Moderate D. Good E. Excellent
6. How do you rate the public utilities in your school? (for example: basketball court, playground)
   A. Poor B. Fair C. Moderate D. Good E. Excellent
7. How do you rate the public transportation near your school? (for example: traffic type, time to the public transportation stations)
   A. Poor B. Fair C. Moderate D. Good E. Excellent
8. How do you rate the location of parking lot in your school?
   A. Poor B. Fair C. Moderate D. Good E. Excellent
9. Do you know whether any other renewable energy systems are installed in your school?
   A. YES B. NO
10. If YES, how do you rate the drainage systems' ability to reduce the fee?
   A. Poor B. Fair C. Moderate D. Good E. Excellent
11. If NO, do you think it is necessary to have one in your school?

12. how do you rate the system' ability to drain surface water when it comes to a storm?
   A. Poor B. Fair C. Moderate D. Good E. Excellent
13.Do you know whether any water saving appliances are installed in your school?
   A. YES B. NO
14.If YES, how do you rate the performance of water saving appliances such as faucets, toilets?
   A. Poor B. Fair C. Moderate D. Good E. Excellent
15. If NO, do you think it is necessary to have water saving appliances in your school?

16. Do you know whether any renewable materials are used in your school?
   A. YES B. NO
17. If YES, how do you rate these materials?
   A. Poor B. Fair C. Moderate D. Good E. Excellent

18. How do you rate the cooling system in your school?

A. Poor B. Fair C. Moderate D. Good E. Excellent

19. How do you rate the lighting system in your school?

A. Poor B. Fair C. Moderate D. Good E. Excellent

20. How do you rate the performance of the ventilation systems such as fans, operable windows?

A. Poor B. Fair C. Moderate D. Good E. Excellent