DOCTORAL DISSERTATION

A COMPARATIVE STUDY ON CAMPUS EVALUATION STANDARDS FOR GREEN CAMPUS CONSTRUCTION

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A Comparative Study on Campus Evaluation Standards for Green Campus Construction

ABSTRACT

Sustainable campus has become a hot issue of global sustainable development. Firstly, the research of sustainable campus involves the sustainable construction of colleges and universities, namely: the construction of green and ecological building environment, the intelligent management and low-carbon operation, and the integration of sustainable concept into education to realize the sustainable development of education. Secondly, as an experimental site for continuous exploration of sustainable technologies and concepts, campus will eventually play a vanguard role in achieving the global sustainable development goals (SDGs), so as to gradually promote campus sustainable development to the whole society.

Therefore, all countries carry out sustainable campus construction according to their own situation, and have successively issued relevant evaluation standards (system) of sustainable campus. Among them, sustainable campuses in America and China have their own characteristics on a global scale, and there is a big gap between them. Sustainable campus in China takes "energy saving" as the core, while sustainable campus in America take "environment-friendly" as the core. By comparing the sustainable campus evaluation standards and development characteristics of China and America, this study carries out in-depth research on the sustainable campus of the two countries, aiming to summarize the experience of sustainable campus construction in China and America, optimize the sustainable campus construction in China, and provide reference for the development of sustainable campus in the world.

This research is divided into three parts:

The first part mainly compares the development process and related policies of sustainable campus in China and America, summarizes the characteristics of sustainable campus development in two countries, and provides the basis for the latter parts. Under the guidance of campus energy-saving policy, China's green campus mainly focuses on campus's energy-saving. In contrast, the green campus in the United States pays more attention to environmental problems.

The second part studies the evaluation standards of sustainable campus in America, China and Japan. This research makes a comparative study on the latest version of green campus evaluation standard between China and America: *Green Campus Evaluation Standard (GB / T51356-2019)* and *STARS 2.2*. It is carried out from 1) the content of evaluation standards and 2) the characteristics and current application of standards. It's concluded that: 1) The similarities and differences of the evaluation standards of sustainable campus between China and America and their respective characteristics. 2) The hot spots and overall development trend of global sustainable campus. 3)

Specific optimization strategies for Chinese standard. This research expands the scope of the study to the whole campus, discussing the campus building's energy conservation while paying attention to the campus green consciousness, green management and green planning. And based on the relevant data currently used by STARS in the global evaluation, the hot spots and shortcomings of the current global sustainable campus construction are analyzed, so as to put forward some optimization suggestions for standards. As for Japan, this research mainly studies the construction situation and evaluation system of sustainable campus in Japan. Combined with the evaluation and application of practical cases, this research discusses the differences between green campus evaluation standards and green building evaluation standards, in order to put forward suggestions on the optimization of it through the conclusion of the comparison between America and China.

Future construction in China should learn from foreign advanced development experience and achievements. On the one hand, STARS, a global advanced green campus evaluation system, should be introduced to China's green campus construction and on the other hand, the suitability for China's actual needs should also be considered. Therefore, this part mainly studies the suitability of STARS indicators for green campus in China. Taking a representative university of green campus in China as a specific case, starting from the demand side, this paper uses the fuzzy comprehensive evaluation method to evaluate the users' satisfaction of green campus construction. Comparing the result of satisfaction assessment with the result of STARS's sustainable evaluation, the STARS's indexes are divided into four regional grades by two-dimensional suitability evaluation coordinate system. The results show that STARS is generally suitable for green campus evaluation in China, but two of the evaluation categories need to modify the evaluation scores and weights; the other two categories are not suitable and need to be removed or changed.

The third part studies the sustainable campus cases of China, America and Japan, aiming to further analyze the construction measures and achievements of sustainable campus based on their own characteristics, so as to explore the specific sustainable campus construction strategies worthy of promotion.

As for China, the research focuses on the impact of "energy saving" on the sustainable development of green campus. It studies the motivation of "energy saving" to "sustainability" in the construction of green campus in China. In terms of research methods, this study selects Zhejiang University, a typical representative of China's green campus that combined with the comparative group of four American universities, and conducts a quantitative analysis of G-value and S-value represented energy consumption and sustainability, respectively. Zhejiang University's G-value (0.019) in 2016 is one sixth of that of the comparative group in the same period, indicating that the implementation effect of the energy-saving monitoring platform is remarkable. From 2014 to 2017, the G-values are basically stable at 0.02, indicating that its future development potential is insufficient. Zhejiang University's scores in the four categories of S-value are significantly lower than those in the comparative group, showing that there are great differences in the construction achievements of the five universities. According to the score rate of 17 sub-items of S-value, the five universities have different advantages and disadvantages. Therefore, the green campus construction of China's case university is too one-sided and only stays at the level of energy conservation. The diversification of construction and the balanced development of all aspects should be paid more attention in the future. At the same time, the research also focuses on two typical Chinese universities, in order to study the current situation of green campus in China. Firstly, the two campuses are evaluated by introducing STARS, and the quantitative evaluation results of two campus are obtained as the basis for analysis and demonstration. Secondly, through the comparison of the evaluation results of two cases, the construction level of China's green campus is clearly defined, and the specific suggestions are put forward based on the optimization of China's green campus evaluation standards. The results show that the development of green campus in China is still in the preliminary stage, and the overall level of construction is weak. The construction lays particular stress on academics and education, and is seriously inadequate in infrastructure and environment-friendly facilities. Some of top Chinese universities can actively explore green technology and facilities in the light of their own research advantages.

As for America, this research takes Stanford, one of the best green campuses in the world assessed by STARS, as a case study in three steps. Firstly, it introduces the Academics, Energy supply & Demand, Water & Land, Waste, Management, Food & Living, Buildings and Transportation of its campus construction in detail; secondly, it uses STARS to make a comprehensive sustainable evaluation of Stanford; finally, it discusses the development relationship between Stanford and local community. The four characteristics of its green campus development model are summarized, namely, (1) based on its own scientific research; (2) from the aspect of environmental friendliness; (3) to achieve joint participation and (4) forming complementary development with the community. In addition, the construction of green campus has changed from a single triangle framework composed of SDGs, STARS and universities to a compound triangle framework composed of SDGs, universities and communities on the existing basis, greatly expanding the way to realize SDGs. The purpose of this part is to focus on the way to achieve the Sustainable Development Goals (SDGs).

As for Japan, based on the analysis of the sustainable construction of Japan's Kitakyushu Science and Research Park and the green building evaluation of Hibikino campus's main building, this research combs and summarizes the characteristics of sustainable campus construction in Japan. It puts forward the sustainable development mode of "Industry & University & Research" integration. Furthermore, through the comparison with Stanford University, it analyzes the differences in the construction and development of the two universities, aiming to explore the different way compared with the Stanford to realize global SDGs from the perspective of sustainable campus, that is: to build a "science and research park" integrating universities, enterprises and research platform to achieve sustainable development.

Based on the data of sustainable investment from 214 universities in the United States, this research conducts a study on the sustainable investment willingness of colleges and universities. Firstly, according to the sustainable investment concept of ESG, the influencing factors of sustainable investment are classified. Then the important variables are selected by Cp method. Finally, Logit regression model is used to study the influencing factors and the willingness proportion of sustainable investment. The results show that most universities take sustainable industry as their investment object, and promote their own sustainable investment by making a series of policies. The maximum affordability of sustainable investment of universities is 30.3% of the total investment, and about 94% of universities ' actual proportion is lower than this willingness value. And the most important factors affecting the sustainable investment are: (1) size of the school; (2) sustainability instruction training for new employees; (3) the encouragement of employees to participate in community service; (4) whether the school establishes CIR (Committees on Investor Responsibility). It clarifies the determinants and maximum affordability of sustainable investment willingness, so as to provide the direction for promoting sustainable investment, and provide suggestions for the formulation of guiding policies.

Key words

Sustainable campus; Evaluation standard; Development process; Fuzzy comprehensive evaluation method; Comparative study in China, Japan and America; Sustainable investment willingness

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION AND PURPOSE OF RESEARCH

CHAPTER 1 INTRODUCTION AND PURPOSE OF RESEARCH

1.1 Background

Since the United Nations first proposed the concept of green campus in the *Declaration of United Nations Conference on Human Environment* (United Nations, 1972) and "Human Environmental Behavior Plan" in 1972, the construction of sustainable campus has been continuously tried and developed around the world (Tan Hongwei, 2013). Under the core concept of sustainable development, it focuses on three levels: Society, Environment and Economy (see Figure 1.1).

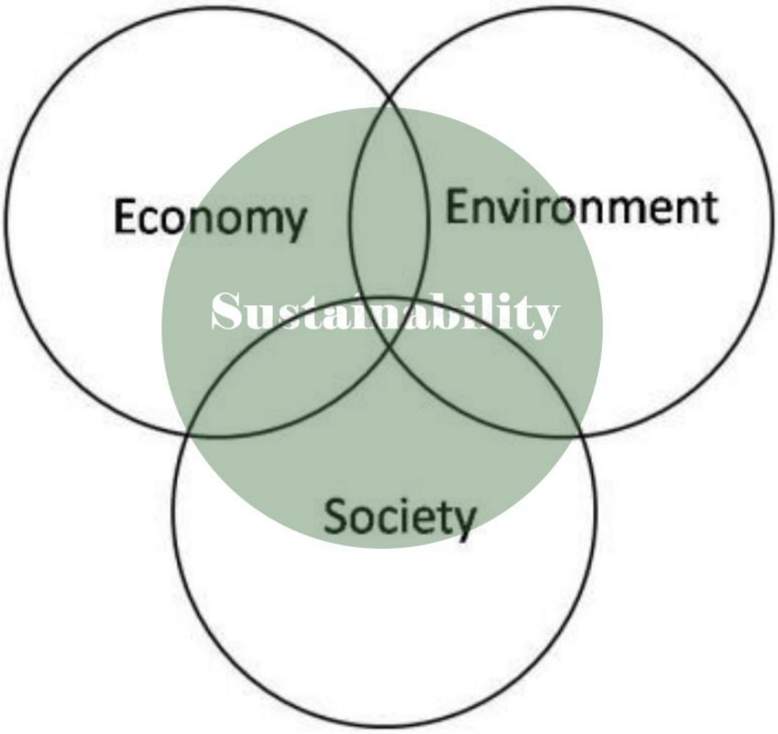

Figure 1.1: The Components of Sustainability

As an important base for scientific and technological development, colleges and universities shoulder the responsibility of providing talents for the society and leading the sustainable development of the whole society. Building a sustainable campus can not only broaden students' vision, improve their awareness of the importance of environmental protection, enhance their sense of responsibility, but also guide their behavior to the direction conducive to sustainable development, so as to implement the sustainable concept into daily life and scientific research (Wang Mingjian, 2010). At the same time, the construction of sustainable campus also urges colleges and universities to integrate the concept of sustainable development into teaching, scientific research, talent training, social services and other aspects (Luan Caixia etal., 2014). The regional green growth will be further promoted. In addition, the construction of sustainable campus is directly related to the global ESD (Education of Sustainable Development). Universities can constantly improve self-management, improve the means of teaching to reduce investment in education and improve efficiency and income (Shen Xinyi etal., 2019). It will lead to think about the reorientation of education, explore the reform of modern education, and then provide better education resources in the world to promote education equity. Therefore, the research on sustainable development of sustainable campus is very necessary.

In the whole process of construction, countries have their own differences in the concept and operation of sustainable campus. Among them, China and the United States have great differences in their development process and current construction achievements. Since China first proposed the concept of "green campus" in 1996, colleges and universities across the country have carried out a series of energy-saving and emission reduction measures around the programmatic document of the Ministry of education on *Building a Conservation Oriented School*, and finally carried out the construction of campus energy-saving monitoring platform throughout the country. This series of measures show that the focus of sustainable campus in China is to save campus energy. The sustainable campus in the United States originated in the late 1980s when American universities were worried about the environment and the sense of responsibility of university to deliver education. The sustainable campus is defined by AGBC (American Green Building Council) as a higher education community that can improve energy efficiency, protect resources and improve environmental quality through sustainable development of education, healthy life and the creation of education environment (Gan Liang etal., 2012). Therefore, in contrast, the focus of sustainable campus in the United States is the protection of the environment.

In order to promote the development of sustainable campus, it is very important to study the evaluation standard of sustainable campus. The concept of sustainable campus has been greatly enriched with the joint efforts of the whole world. More and more countries participate in the construction of sustainable campus, which needs to constantly enrich and improve the evaluation standards, so as to better solve the problems encountered in the construction (Alshuwaikhat, H. et al., 2016). At the same time, through the research and comparison of the evaluation systems of various countries, the evaluation standards of sustainable campus can be learned and improved, so as to promote the development of global sustainable campus.

The research of sustainable campus evaluation standard in America is one of the leading standards in the world. Compared with China and Japan , there are great differences in the process of development and the formulation of evaluation standards. For China, the development of sustainable campus starts late, so it is necessary to learn the more advanced sustainable campus evaluation system in other countries, especially in America, and study their advantages and characteristics. In this way, China and Japan can accumulate valuable experience of sustainable campus construction, make its sustainable campus evaluation system more scientific, more rigorous, more complete, and more in line with the trend of global sustainable campus development, to meet the actual needs of the current stage of development, and focus on the future, integrating with the whole world. And then the development and progress of China's sustainable cause can be promoted (Li, X., Tan, H., Rackes, Adams.， 2015).

1.2 Literature Review

1.2.1 The Concept of Sustainable Campus

Consistently, the concept of sustainable campus has been in the process of constant change and improvement, also, no recognized definition for it. Until 1999, extension and integration of sustainable campus’s characteristics were put forward by ULSF (University Leaders for a Sustainable Future). They are as follows:

●Sustainable development holds a prominent position in the policy of campus.

●The concept of sustainable development has become an academic standard.

●Great change has been taken place in the old academic paradigm, and the dimension of ecosystem is multiplied as students address problems.

●Relation between the knowledge background on sustainability and teaching staff’s employment, reward and promotion system was built.

●Measure the ecological trace.

●Support activities related to sustainable development, such as lectures, Earth Day celebrations, etc.

●Support sustainable organizations to join hands with local enterprises in activities related to sustainable development, and exchange views on global environmental protection and sustainable development issues through lectures and conferences.

The United States Green Building Council (USGBC) defines "sustainable campus" as "a higher education community that is proving energy efficiency, conserving resources, and enhancing environmental quality by education for sustainability and creating healthy living and learning environment". Viewed from the above definitions, the concept of "sustainable campus" in foreign universities abstractly embraces "green" teaching, "green" scientific research, social services, etc.

Generally, "sustainable campus" is defined as “green campus” in China. Since the definition of "green campus (green university)" was proposed in 1994, though no settled consensus, the ongoing research on that has been conducted. Tsinghua University believes that the very heart of construction of "green campus" can be regarded as a process, in which school, guided by the thought of environmental education oriented to sustainable development, constantly improves its self-management, betters its educational methods, reduces its educational investment while enhances its efficiency to realize remarkable achievement. Simultaneously, it is also a process where school constantly addresses its problems of sustainable development.

Wang Min and Hu Jing from Beijing Normal University put forward a perspective that "green campus" based on realization of educational and scientific capability, refers to a university that, takes the thought of environmental protection and sustainable development as the guidance, integrates the management measures beneficial to the environment into the comprehensive daily management of the University, makes full use of all resources inside and outside the University, and improves the environmental literacy of teachers and students in every respects.

Li Jiusheng and others from Nanjing Normal University consider "green campus" as the reference of an university that realizing its fundamental educational function, centers on talent cultivation, grasps the guidance of sustainable development theory, implements effective green education activities and works on a green cultural atmosphere by developing a systematic green action plan. The idea of sustainable development will be integrated into the University's education and management activities to comprehensively raise the environmental awareness and cultivate environmental literacy of teachers and students, as well as a new generation of world citizens with sustainable development awareness.

Zhao Qingnian from Heilongjiang University of Science and Technology believes that the intellectual ecological environment of green campus, on which should be placed emphasis, is the basis of the sustainable development of higher education, namely, construction of a green university. This intellectual ecological environment refers to the required conditions and resources for the high intelligence teachers that engage in teaching, scientific research and senior management positions and students that participating in intellectual and innovate activities, scientific research and development (Wang, Ming etal., 2010).

There are different definitions of green campus proposed by other scholars other than the mentioned definitions above. However, presence of several similarities is proved by the current definition and connotation of sustainable campus at home and abroad. The first is the thought of sustainable development being basis or guidance to the definition, which advocates the development of campus construction, campus management, teaching and scientific research under the instruction of the idea of sustainable development. Different emphasis as experts put on the green campus, they still concentrate on sustainable education, most of which covers sustainable campus construction, sustainable campus operation, sustainable cultural activities and so on. Therefore, the Ministry of education of China summarizes the construction and evaluation of sustainable universities into six aspects, that is green education, green technology, green campus, green civilization, green consumption and green service. Comprehensively, it integrated different suggestion on the construction of sustainable campus from scholars. The last is that the purpose to construct sustainable campus is to continuously extend the concept of sustainable development and the significance of ecological environment protection to the University from all aspects. Being the social epitome of the harmonious development of man and nature, it delivers more professionally qualified talents for the society, so as to further the sustainable development of the whole society.

1.2.2 Main Features of Sustainable Campus

In response to the connotation and essence of sustainable campus, they characterize in decreasing campus energy consumption by efficient energy conservation transformation and energy audits based on the analysis of collecting various energy consumption data in campus, adhering to the principles of sustainable development and ecological construction, outreaching the concept of green ecology rested on Campus planning, architectural design and green ecological education. Distinction on estimation of sustainable campus exists among countries. Generally, they can be encapsulated as 4 aspects.

(1) Sustainable education

The purpose of sustainable education is to penetrate holistic environmental protection and sustainable development consciousness education into the consolidated teaching and practice of natural science, technological science, humanities and social science, making it an important part of the basic knowledge structure and overall quality training requirements of all students (Wang, D., 1999).

"Sustainable education" encompasses three aspects, knowledge, value, practice. The knowledge part is to educate college students what the idea of ecology or sustainable development is, and offer them the "sustainable" courses. It enables students to advance with the time, constantly adapt knowledge reserves through open trade, form a well developed sustainable knowledge structure. Meanwhile, the courses imperceptibly influence their behavior and cultivate their sustainable behavior pattern. Concrete examples is embodied in the elective or compulsory courses related to "sustainable education"; Values comprises sustainable behavior and morality which is manifest at not only in the low-carbon transportation, but also in the personal behavior conservation. It is more like an exemplary role, with the ultimate goal of building a low-carbon society; The last part is practice. The achievement of sustainable education mainly depends on the fruit of practice. For colleges, the most intuitive data is the energy consumption index and energy consumption pattern, which is conservation habits like turning off the lights and saving the water.

(2) Sustainable management

The construction of sustainable management system represents the integration the concept of sustainable management through organizing sorts of school activities and building an advanced management system, hoping that it can fully reveal personalities of teachers and students in teaching activities, and unfold the real connotation of humanistic thought and fair education (Lei, J., 2014). "Sustainable management" encompass in teaching experiment, scientific research, administrative business, infrastructure and logistics, whose objective is to establish a strict, scientific and reasonable management system. Specific implementation measures should be formulated based on the conservation of water, electricity, food, office supplies and funds (Liu, Y., 2013). To fulfill the goal of establishing a sustainable development management system with "people-oriented" as the core, the management department and the managed department should learn to understand and sympathize mutually.

(3) Sustainable construction

"Sustainable campus" should be a community of sustainable development, a demonstration zone to replicate the application of environmentally sound technology and cleaning technology, and a park with meticulously planned ecological landscape, where there is wide range of greening area, and various energy-saving measures are widely utilized (Li, Y., He, Q., 2013). The idea of environmental protection and sustainable development penetrates in the campus culture. An enabling learning and working environment is offered to teachers and students and school administrative and logistics personnel. Additionally, sustainable community is embodied in the construction scale and land use pattern of campus. However, many colleges, the recently built campus in particular often exchange high greening rate and low plot ratio with the luxury land-use pattern, which goes against the connotation of sustainable campus.

(4) Sustainable energy using

Measures to consume energy sustainably embrace establishing a sound energy consumption monitoring platform, integrating with the relevant national energy saving and emission reduction standards, devising the statistical monitoring and implementation plan of energy saving in line with university, improving the energy measurement, and regularly publicizing the energy consumption situation of the university. On the front, energy-saving campus construction leaders in China, such as the University of Hong Kong, the Chinese University of Hong Kong, Tsinghua University, Tongji University and Zhejiang University, have already established real-time energy consumption monitoring platforms to monitor campus energy consumption synchronously, analyzed energy consumption data regularly, and put forward rectification suggestions for abnormal energy consumption, only to reduce the overall energy consumption of campus.

The universities and colleges have carried out various sustainable activities and measures in the construction of sustainable campus, and have been exploring all aspects of sustainable with their own characteristics, like:

A Top Performer under Food & Dining: Activity on harvesting tomatoes is holden by LaFarm student employee at Lafayette College.

A Top Performer in Buildings: The Science and Engineering Building at University of California, features solar panels that help power the building and provide shade during the hottest months, as well as a rooftop lab for researchers to gather data.

A Top Performer in Campus Engagement: The farmer's market at Cornell provides fresh, healthy food to the campus - and is completely run by students.

A Top Performer in Curriculum: Students apply sustainability science in the field at Unity College.

A Top Performer in Acdemics: Cal Poly students conduct research at the Gold Tree Solar Farm.

A Top Performer in Grounds: Central New Mexico Community College's landscaping includes low-impact design and xeriscaping.

A Top Performer under Public Engagement: Indiana University-Purdue University Indianapolis (IUPUI) students volunteer during the IUPUI Day of Caring.

A Top Performer under Transportation: Locksmith Shop Electric Vehicle at Stevens Institute of Technology.

A Top Performer under Waste: Volunteers at the "We All Live Here" campus clean-up day at Aquinas College.

1.2.3 Evaluation Standards

At present, *LEED for School* in America and *BREEAM Education* in Britain are the objects of comparison with Chinese standard. Jingjing Yang et al. (2016) analyzed and compared *LEED for School 2007* and *BREEAM Education 2008* and *China's Green Campus Evaluation Standard (CSUS/GBC04-2013)*. The similarities and differences between the evaluation range and the proportion of each index score in the three standards are studied, and the advantages and disadvantages of evaluation methods are analyzed. Finally, five suggestions for improvement of China's 2013 evaluation standard are put forward (Yang, J., Shen, L., Zhou, J., Zhang, P.， 2016). Hui Xi (2018) also analyzed and compared the green campus evaluation of colleges and universities in the *BREEAM Education* and *LEED for School*, proposing that the construction of sustainable campus in China should be improved in quantitative evaluation index, reasonable weight setting and increased flexibility. (Xi, H.， 2018). Jiaying Cheng (2019) compared the contents of green campus evaluation standards in major countries in the world, including *LEED for School*、*WELL*、*CHPS* in the America, *BREEAM Education* in Britain, *CASBEE* in Japan, *Green Star Education* in Australia and *Green Building Evaluation Standard (GB / t50378-2014)* in China. He makes a horizontal comparison and analysis of the research status of each evaluation standard, which is of great significance to the development of green campus evaluation standards in China (Cheng, J., 2019). However, the above researches basically confuse the concepts of "campus" and "campus buildings". And the standards adopted are basically for campus buildings, without strict horizontal comparison on the evaluation standards of sustainable campus.

It is not accurate and comprehensive to use *LEED for School* to study the American sustainable campus. *STARS* should be used instead. Paul Rowland (2010) studied the application of *STARS* in North American colleges and universities, the promotion ability of STARS evaluation system for sustainable campus, and whether *STARS* will replace the existing evaluation systems, confirming the development role of *STARS* in North America （Paul Rowland, 2010）. Based on the coding and analysis of 454 innovations in *STARS* statistical report, Washington-Ottombre (2018) evaluated the status of *STARS*'s self innovation by using big data, and discussed the general rules and modes of campus sustainable concept in development, as well as the internal and external factors promoting innovation (Washington-Ottombre, Camille., Bigalke, Siiri., 2018). All of the above are the researches on the promotion of *STARS* in the sustainable campus development in America and give a high appraisal. However, there is still a lack of research on *STARS* and other countries' sustainable campus standards. The world's representative evaluation standards are systematically sorted out, which has important value for the construction and evaluation of global sustainable campus.

Research on the suitability improvement of the standard of green campus in China based on STARS published in 2016, compared with other studies of this kind, adopts the American Standard *STARS 2.0* for sustainable campus for the first time, instead of *LEED for School*, which is widely used before, and focuses on the whole campus rather than campus buildings (Zhu, B., Zhou, Y. and Ge, J., 2016). This study compares *STARS 2.0* with *Green Campus Evaluation Standard" (CSUS/GBC04-2013)* (CGBC, Tongji University, CABR, 2013) in China at that time. With the continuous updating of the standards, *STARS* has been improved on the basis of the original version 2.0 to version 2.2; China's standard has been greatly modified and updated on the basis of the previous association standards, adjusted the overall evaluation framework, issuing China's national standard *Green Campus Evaluation Standard (GB/T51356-2019)*. Therefore, it is necessary to comprehensively sort out and summarize the updated standards. On the basis of the comparative study of the contents and evaluation methods of the previous standards, the analysis of the application of the standards in the actual evaluation is added, which is helpful to a more comprehensive understanding of the advantages and disadvantages of *STARS* in the global application (AASHE, 2021).

1.2.4 Development Characteristics of Sustainable Campus

At present, the research on the development characteristics of sustainable campus in the United States is that: in 2005 Wang Donghua summed up the characteristics of the early development of sustainable campus in the United States through the case of George Washington University, which provided a theoretical basis for the movement of sustainable campus at that time (Wang Donghua, 2005). In 2007, AASHE (The Association for the Advancement of Sustainability in Higher Education) made clear the construction content of the sustainable campus in the United States with STARS (The Sustainability Tracking, Assessment & Rating System) (AASHE, 2007). It is the movement from a single environmental protection to construction of the sustainable campus including the sustainable development academic research, campus engagement, campus operation, planning and administration. In 2011, Gan Liang and his team studied the development process of sustainable campus in the United States, and summarized the development characteristics of the sustainable campus in the United States, so as to fully demonstrate the development process of sustainable campus in America (Gan Liang, 2011). In 2017, Yoon Jung Choi and his team emphasized the importance and functionality of sustainable measures in sustainable campus construction by investigating all aspects of sustainable campus of Portland State University (Yoon Jung Choi et al., 2016).

The research on the development characteristics of sustainable campus in China is mainly as follows: in 2013, Tan Hongwei and his research team from Tongji University made a comprehensive summary of the construction and development of sustainable campus in China. And he proposed to improve the sustainable development of campus in China in the future based on the update of the evaluation standard of sustainable campus (Tan Hongwei et al., 2013). In 2014, Caixia Luan and others comprehensively sorted out the current situation of sustainable campus construction in China's colleges and universities, and put forward suggestions to further strengthen the construction and development of conservation oriented campus from the technical and management levels (Luan Caixiaet al., 2013). In 2017, Lu Mingyan and her research team from Zhejiang University summarized the development of sustainable campus in China to "energy-saving campus" as the core and the development needs of China's sustainable campus construction from saving campus to diversified sustainable campus by studying the construction process of China's sustainable campus and analyzing the construction results of specific cases (Lu Mingyan et al., 2017). In 2019, South China University of Technology conducted research on the sustainable campus construction strategies of China Capital Market Institution and Chinese University of Hong Kong (Shenzhen), in order to analyze the advantages and disadvantages of the main energy-saving strategies of China's sustainable campus construction at this stage (Liu Xiao and Bao Ying, 2019).

However, according to the process and characteristics of China's sustainable campus development, there is a lack of combined research on campus "energy-saving" and "sustainable construction". (1) There is a lack of targeted research on the advantages and disadvantages of sustainable campus development led by "energy saving" in China, especially by comparing the development characteristics of different countries (such as the United States). (2) The impact of campus’s energy-saving construction on the sustainability of the whole campus and the needs of future development are not discussed enough, so that specific optimization suggestions cannot be put forward to promote the construction of sustainable campus. At present, China's sustainable campus construction is in the transition period from "energy-saving campus" to "sustainable campus". The practical problems of China's sustainable campus mainly lie in the lack of systematic summary of construction achievements, the lack of objective evaluation in the development stage, the lack of scientific prediction of development potential, and the lack of comprehensive carding of sustainability. Therefore, it is impossible to formulate specific development strategies and development directions in the future.

1.3 Research Questions

This study focuses on the following three issues

(1) Characteristics carding: What are the characteristics of sustainable campus development in China, Japan and America?

(2) Standard optimization: What are the advantages and disadvantages of the evaluation standards of sustainable campus in China, Japan and America? How to optimize the evaluation standard of sustainable campus in China and Japan?

(3) Development Strategies: What is the current development stage and main construction achievements of sustainable campus in China, Japan and America? What are the better construction measures? How will sustainable campus develop in the future?

1.4 Research Objectives

The research objects of this study are sustainable campus in China, Japan and America

(1) Evaluation standards (system) of sustainable campus

This research studies the evaluation standards of sustainable campus in China, Japan and America, combing the characteristics of the three standards and comparing the differences between them. At the same time, the suitability of the application of the standard is studied to make it meet the needs of users in the development of national conditions, so that the optimization strategy is put forward for the evaluation standard of sustainable campus in China and Japan.

(2) The construction situation and development strategy of sustainable campus

The research uses the evaluation standards to evaluate the sustainable campus construction achievements of China, Japan and America at present to summarize the advantages and disadvantages of the construction. And the case study method is adopted, according to the characteristics of the construction in three countries, thus the optimization measures and future development direction of sustainable campus construction are analyzed.

1.5 Scope of Research

The scope of this research is sustainable campus construction and development in China, Japan and America. The specific scopes are as follows:

●The concept of "sustainability" in "sustainable campus" continues the content of sustainable development of the United Nations, including "Society", "Environment" and "Economy". It emphasizes the relationship between "demand" and "development", not just "Green" and "Ecology".

●The scope of "campus" is one or more campuses of higher education institutions, including campus material facilities, natural environment, human resources, education and planning & management, which is a comprehensive "campus" concept.

●The evaluation standards involved in this research are mainly the current evaluation criteria of sustainable campus in China, Japan and America: *Green Campus Evaluation Standard (GB/T51356-2019)*, CASBEE - School and *STARS* (The Sustainability Tracking, Assessment & Rating System).

1.6 Research Outlines

CHAPTER 1:

This chapter aims to explain the background of the study together with problem statement of research. The literature reviews of this dissertation are illustrated, a lack of consideration from other studies is drawn in details including sustainable campus evaluation standards and sustainable campus development in China and America. Moreover, the objective and the scope of study are also explained in this chapter.

CHAPTER 2:

This chapter mainly reviews the history of global sustainable campus development, including the development of sustainable campus connotation and global evaluation standards. Secondly, it focuses on the development process of sustainable campus in China and America and the evolution of relevant policy documents, in order to summarize the characteristics of sustainable campus development in China and America.

CHAPTER 3:

Aims to explain the case study and study process of research with the framework of integrated evaluation of case universities. This chapter also describe the step of analysis approach in term of qualitative and quantitative research. The research framework is provided for understanding the whole process.

CHAPTER 4:

This chapter focuses on the current evaluation standards of sustainable campus in China and America. The evaluation methods, contents and application of the evaluation standards are compared in detail, and the differences and advantages of the standards are summarized. In addition, this chapter also discusses the suitability of American standard (STARS) for Chinese campus evaluation. This research adopts the Fuzzy Comprehensive Evaluation Method to study the suitability of the standard from the perspective of campus users, in order to further optimize Chinese evaluation standards according to China's national conditions.

CHAPTER 5:

This chapter mainly studies the construction situation and evaluation system of sustainable campus in Japan. Combined with the evaluation and application of practical cases, this research focuses on the analysis of green campus evaluation standards and green building evaluation standards in Japan and China, in order to put forward suggestions on the optimization and development of sustainable campus evaluation system in Japan through the conclusion of the comparison between America and China.

CHAPTER 6:

This chapter is a case study of sustainable campus in China, America and Japan.

As for China, on the one hand, this research makes a comparative study on energy consumption and sustainability of Zhejiang University in China, in order to explore the current construction effect and future development potential of sustainable campus construction with "energy saving" as the core. On the other hand, it evaluates and compares Zhejiang University and Zhejiang University of Technology Zhijiang College to analyze the stage and deficiency of sustainable campus construction in China.

As for America, taking Stanford University as an example, this research analyzes the specific measures and sustainability evaluation of its sustainable campus construction, and further summarizes the implementation path of its future development, and finally discusses the relationship between sustainable campus development and the realization of SDGs.

As for Japan, based on the analysis of the sustainable construction of Japan's Kitakyushu Science and Research Park and the green building evaluation of Hibikino campus‘s main building, this chapter combs and summarizes the characteristics of sustainable campus construction in Japan. Furthermore, through the comparison with Stanford University, it analyzes the differences in the construction and development of the two universities, aiming to explore the ways to realize global SDGs from the perspective of sustainable campus.

CHAPTER 7:

Based on the data of sustainable investment from 214 universities and colleges, this chapter conducts a study on the sustainable investment willingness of colleges and universities. According to the sustainable investment concept of ESG, the influencing factors of sustainable investment are classified. Then Logit regression model is used to study the influencing factors and the willingness proportion of sustainable investment. It clarifies the determinants and maximum affordability of sustainable investment willingness of colleges and universities, so as to provide the direction for promoting sustainable investment in the future, and provide suggestions for the formulation and implementation of guiding policies related to sustainable investment of colleges and universities in the future.

CHAPTER 8:

The conclusion of dissertation is drawn in this chapter. Also, benefits and implications to implement an improvement program for sustainable campus in China, Japan and America are summarized in this section. This chapter would contribute further study for sustainable campus in the world.

1.7 The Innovations

●For the Evaluation Standards:

(1) This study compares the green campus evaluation standard of China with STARS, and no longer compares LEED for School. The study uses the latest version of the standards of the two countries to make a systematic comparison in three dimensions, and expands the scope to the whole campus, rather than just campus buildings. While the campus buildings' energy saving and greening are discussed, the campus green consciousness, green management and green planning are also worthy of attention.

(2) On the basis of systematic comparison of standards, this study makes an objective analysis of the current global evaluation by STARS, in order to put forward optimization suggestions for China's and Japan's green campus evaluation system, which is more practical and in line with the global development.

(3) This study mainly discusses the suitability of the application of the evaluation system. Different from the research of analyzing the advantages and disadvantages of each national standard or other evaluation system (i.e., the content and evaluation mode of the system itself), this study focuses on the application of the evaluation system (i.e., the relationship and suitability between the evaluation system and the evaluation object). Therefore, the suitability is very important and directly related to the effect of system application, but at the same time it is often overlooked.

(4) The fuzzy comprehensive evaluation method is adopted in the research, which is applied to the satisfaction evaluation of the case university. This method reflects the core concept of human-oriented sustainable development and conforms to the research theme. Meanwhile, the research method is extended on the basis of fuzzy comprehensive evaluation. The evaluation results of satisfaction are compared with those of STARS, and the two-dimensional suitability evaluation coordinate system is established. The original one-dimensional satisfaction evaluation values are changed into two-dimensional Satisfaction-Sustainability evaluation values, which make the results more scientific and intuitive. This method can also be further applied to other similar studies, and has a certain value of popularization and application.

(5) It provides some research ideas for the update and improvement of green campus evaluation standards, and puts forward the importance of the research on the suitability of standards. That is: on the basis of fully considering the national conditions and the suitability of the application, the targeted suggestions for the future development of green campus are put forward through the representative case evaluation.

●For the Construction of Sustainable Campus:

(1) In view of the characteristics of green campus development in China, this study analyzes the advantages and disadvantages of China's green campus construction mode dominated by "energy-saving" through comparing the development mode in the United States. The research is to

evaluate the current green campus situation based on the representative cases, which can directly put forward specific suggestions for the implementation of green campus construction in the future.

(2) "Energy-saving" and "Sustainability" are combined. And G-value and S-value representing energy consumption and sustainability respectively are adopted, which provides a new idea for the research of green campus. In this study, the quantitative analysis of green campus through indicators, not only consider the energy consumption of green campus, but also consider the sustainability of the whole campus, so that the sustainability evaluation is objective and comprehensive, and the research results are more scientific.

(3) One of the purposes of this research is not to discuss the goal itself, but to focus on the way to achieve the goal. It is different from the previous discussion on the SDGs, or only for the sustainable construction results of a few campuses. According to the historical track of its development, this paper combines the two (SDGs and green campus) to discuss by using campus construction as an effective way to achieve the SDGs. Through the introduction and learning of specific cases in America and Japan, this study summarizes the specific process of its development and construction, and directly discusses how to achieve the goal of sustainable development.

●**For the Sustainable Investment :**

(1). Aiming at the sustainable investment of colleges and universities, this study makes a quantitative analysis on the influencing factors and investment willingness of sustainable investment. Different from the previous research focus on the amount of sustainable investment and the sustainable management of investment, this study focuses on the willingness of sustainable investment in colleges and universities, and clearly puts forward the main factors influencing whether to make sustainable investment and the maximum affordability of the proportion of sustainable investment, which provides a scientific basis for the construction of sustainable investment in the future.

(2). In the quantitative analysis of sustainable investment factors, this paper combines the Logit model widely used in sociology with ESG sustainable investment concept in economics. The ESG concept provides a basic framework for the exploration and classification of influencing factors in this study. Then the logical selection model is used to screen out the important factors. It is a comprehensive application of economic concept and sociological methods. At the same time, according to the basic principle of WTP (willingness to pay), it is a new attempt to transform the original specific value into the proportion of the total amount.

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CHAPTER 2

OVERVIEW SUSTAINABLE CAMPUS PROCESS AND DEVELOPMENT

CHAPTER 2 OVERVIEW SUSTAINABLE CAMPUS PROCESS AND DEVELOPMENT

2.1 Global Sustainable Campus Development

2.1.1 Connotation of Green Campus and Sustainable Development

With the continuous deterioration of the global natural environment, as countries continue to develop, the concept of sustainable development has reached a consensus in the world, and become a common construction goal related to the future destiny of mankind. Among them, "sustainable", which is composed of three core elements of "environment", "economy" and "society", has been continuously improved in its connotation and its objectives have been continuously clarified and refined (AASHE, 2017). When the concept of "environmental protection" was put forward, the concept of "environmental education" was elevated to the same important position. Subsequently, the former one has gradually developed into a discussion of sustainable development related to the common destiny of mankind, while the latter has developed into the construction practice of green campus with global universities as the pioneer. Therefore, the connotation of "Green campus" is in the same line with the concept of "Sustainability", which also includes three dimensions of "environment", "economy" and "society". "Sustainable development" and "Green campus" develop simultaneously and promote each other (see Figure 2.1). Among them, the exploration of sustainable development has never stopped, because the Universities, as the base of advanced concept promotion and new technology experiment, play an important role in the process of achieving the global sustainable development goal.

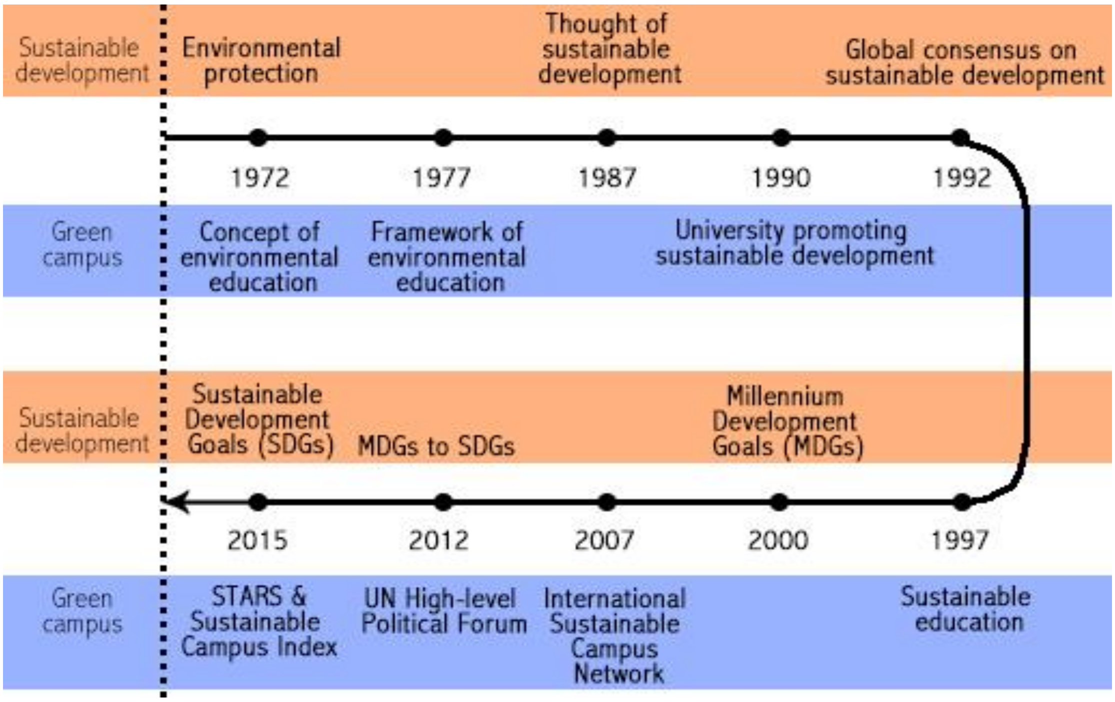

Figure 2.1: Sustainable Development and Green Campus Development Process Map

As early as 1972, at the conference on human environment held in Stockholm, *The Declaration of The Conference on Human Environment* with environmental protection as the core was put forward, in which the concept of "environmental education" was also put forward (Conference on the Human Environment 1972). In *The Tbilisi Declaration* of 1977, for the first time, the goal of environmental education was established as five aspects: consciousness, knowledge, attitude, skills and engagement, which laid a basic framework and system for the development of global environmental education (Cuihua Zhang, 2006). In 1987, the United Nations published *Our Common Future* and formally put forward the idea of "sustainable development" (World Commission On Environment And Development, 1987). In 1990, *The Talloires Declaration* was announced and is currently internationally recognized as the most significant document to promote sustainable development in universities. Ten key principles were put forward at the meeting. Presidents of 22 universities and several environmental experts of the United Nations signed a consensus. After the meeting, more than 250 colleges and universities from more than 40 countries joined in succession (Bifeng Zhu, 2016). In June 1992, at the Earth Summit in Rio de Janeiro, Brazil, more than 178 countries adopted Agenda 21, a comprehensive plan of action to build a global partnership for sustainable development to improve human lives and protect the environment (United Nations, 2019). The concept of "sustainable development" has been recognized all over the world. In 1997, United Nations Education Scientific and Cultural Organization (UNESCO) officially put forward the concept of "sustainable education", emphasizing the importance of education in environmental protection. The emergence of "sustainable education" provides a strong theoretical basis for the development of "green campus". In the same year, George Washington University (USA) was the first to put forward the pilot plan of green university (Yanlun Han, 2011).

After entering the 21st century, global sustainable development has accelerated its pace and put forward more practical goals. The Millennium Summit adopted in 2000 at UN Headquarters, led to the elaboration of eight Millennium Development Goals (MDGs) to reduce extreme poverty by 2015 (United Nations, 2019). The Association for the Advancement of Sustainability in Higher Education (AASHE) was officially launched in December 2005, serving as the first professional higher education association for the campus sustainability community in North America (AASHE, 2019a). In 2007, the International Sustainable Campus Network was established in Switzerland, aiming to establish a global recommendation agency and communication platform for sustainable campus construction. More than 30 famous universities in the United States, Europe and Japan have joined the organization (Hongwei Tan, 2013). At the United Nations Conference on Sustainable Development (Rio+20) in Rio de Janeiro, Brazil, in June 2012, Member States adopted the "*The Future We Want*" to launch a process to develop a set of Sustainable Development Goals (SDGs) to build upon the MDGs (United Nations, 2019). At the same time, the Green University Alliance of China, together with the Green Campus Alliance of Australia, the United States and Europe, jointly organized the "sub forum on sustainable development of higher education", which opened a new chapter in the sustainable development of universities. In 2015, the United Nations adopted a plan to help create a prosperous future for the planet and guide its work through 2030 (United Nations, 2015). The agenda establishes 17 SDGs, which countries will aim to advance progress toward. *STARS 2.2* (The Sustainability Tracking, Assessment & Rating System) was also launched in 2019 and is now widely used all over the world. The Sustainable Campus Index publication was introduced to recognize top-performing colleges and universities in 17 distinct aspects of sustainability, as measured by *STARS* (AASHE, 2019a).

2.1.2 Development of Global Sustainable Campus Evaluation Standards

As an important part of achieving the global sustainable development goals, the sustainable development of colleges and universities has positive significance for the whole society. The construction and promotion of sustainable campus cannot do without the support of sustainable campus evaluation standards. Evaluation standards help to promote the development of sustainable campus, help the theory of sustainable campus from concept to practice, and help more universities clear their own development direction (Ozdemir, Y., Kaya, S., and Turhan, E. 2020). But at the same time, the establishment of sustainable campus evaluation standards in different countries should be in line with their own national conditions, which is conducive to solving the problems in the process of sustainable campus development in various countries, so as to form a unique sustainable campus construction scheme （Zhu, B., Dewancker, B., 2021） . Through the formulation of standards, the specific connotation of sustainable campus can also be defined from the policy level, which can provide support for the sustainable development of the whole society.

Since the concept of "green campus" was put forward by the United Nations in 1972 （Conference on the Human Environment， 1972） , many countries in the world have begun to devote themselves to the exploration and practice of sustainable campus, and formulated relevant evaluation standards, among which the standards of the America, Britain, China, Japan and Australia have their own characteristics. Although they are all sustainable campus evaluation standards, there are some differences in index setting and evaluation methods (see Table 2.1).

Table 2.1: Evaluation Standards of Sustainable Campus in Major Countries

Country	Standard	Establishment organization	Publication year	Categories
America	STARS 2.2 （The Sustainability Tracking, Assessment & Rating System） （AASHE, 2019）	The Association for the Advancement of Sustainability in Higher Education	2019	Academics
				Engagement
				Operations
				Planning & Administration
				Innovation & Leadership
Britain	EcoCampus ISO14001:2015	Loreus Ltd	2015	Planning phase
				Implementing phase
				Operating phase

	(Loreus Ltd UK, 2015)			Checking and correcting phase
China	Green Campus Evaluation Standard (GB/T51356-2019) (CGBC, Tongji University, CABR, 2019)	Ministry of Housing and Urban-Rural Development in China	2019	Planning & Ecology
				Energy & Resources
				Environment & Health
				Operation & Management
				Education & Promotion
				Characteristics & Innovation
Japan	Regulations on green schools and "green school experimental model enterprise" (formulated by each ministry or province, taking the Ministry of education as an example) (Liu, J., 2003)	Ministry of Education and Ministry of Trade and Industry	1997	New energy utilization type
				Green recommended type
				Sewage utilization type
				Other energy saving & resource saving type
Australia	Green Star Education 2010 (Green Building Council Australia, 2010)	Green Building Council Australia	2003	Management
				Indoor environmental quality
				Energy
				Transportation
				Water
				Material
				Land use & ecology
				Discharge
				Innovation

2.2 Sustainable Campus Development in China and America

2.2.1 Development Process

Since the concept of "green campus" was first put forward at the Human Environment Conference held in Stockholm in 1972, it has developed rapidly in the United States (Conference on the Human Environment, 1972) .From the University of Michigan's "Global River Environmental Education" program to the University of Washington's "Green University pilot program", the concept of "green campus" has been upgraded to "green campus", "ecological campus" and "sustainable campus" (Wang, Y., Xi, X., 2013) , so that the concept of "green campus" has been clearly defined, recognized and gradually promoted (see Table 2.2). The development of American green campus can be said to rise from the theoretical level to the practical level. In its nearly 30 years of development, the concept of green campus in the United States has been constantly improved, emphasizing the sustainability of the whole campus, and has become one of the important models for global reference(RS Shahrullah, 2014).

The construction of sustainable campus in China is obviously later than that in America. Compared with the gradually enriched idea of sustainable campus in America, the Chinese idea in this field has experienced two stages, that is, from "energy-saving campus" to "green campus" （Zhu, B., Wang, Z., Sun, C. et al., 2021）. Tongji University in China is the first to carry out green construction of campus, but more attention is paid to energy conservation and greening of campus buildings （Tongji university， 2012）. Despite of a later start before time, the development of the concept of green campus in China has been at a faster rate since the beginning of the 21st century. Chinese universities are actively exploring the development of green campus, especially in the aspects of the participants and sustainable campus buildings, rather than just limited to the "energy saving" campus. At the same time, Chinese universities are trying to cooperate with global universities to participate in the global sustainable campus development, and have achieved certain results （Lu, M., Chen, S., 2017）.

Throughout the process of sustainable campus development in China and America, America is committed to deepening the concept of green, forming a comprehensive connotation of sustainable campus, while China is from the "energy-saving" campus transformation, so the sustainable campus development of the two countries is generally very different, and has their own priorities. As far as the current development stage of China is concerned, it is in the transition period from "conservation oriented campus" to "sustainable campus", and it is still in the initial stage of sustainable campus （Zhu, B., Wang, Z., Sun, C. et al., 2021）. Therefore, China needs to fully learn from the experience of other countries in the construction of sustainable campus, and explore its own way of construction according to local conditions.

Table 2.2: Development Process of Sustainable Campus in China and America

China			**America**	
Event	**Significance**		**Event**	**Significance**
		1970s	In 1972, the United Nations adopted the declaration of T*he Human Environment Conference* and T*he Human Environmental Action Plan* in Stockholm	The concept of "green campus" is put forward for the first time
			In 1977, UNESCO issued the *Tbilisi Declaration* and the proposal on how to carry out environmental education	Providing the early development basis for the construction of American green campus

		1980s	In 1989, the University of Michigan formulated the *Global River Environment Education* Program	Opening a chapter of green campus in America
In 1996, T*he national Environmental Publicity and Education Action Plan (1996-2010)* was issued. The concept of "green campus" was put forward for the first time	Marking the initial formation of the concept of green campus in China	the 1990s	In 1990, many university presidents all over the world jointly initiated and signed *The Talloires Declaration*	The connotation of green campus is enriched for the first time
			In 1994, George Washington University launched the precursor plan of building a sustainable campus, and built the first green university in America	It is the first attempt of sustainable campus and promotes the concept of "green campus" to "sustainable campus"
In 1998, Tsinghua University put forward the idea of creating a "Green University" and then put forward the "Green University plan"	The concept of green university is mentioned for the first time		In 1996, the first green campus seminar was held at Bauer State University in Indiana	Promoting the further improvement of the green campus system
Tsinghua University held International Symposium on University green education	Promoting the construction of "Green University" in China		Hundreds of US university presidents signed climate declaration	The connotation of green campus is enriched for the second time
2000, Universities all over the country reached a consensus on the concept of running a school, the quality of teachers, setting up sustainable courses and innovative thinking mode of teaching	Basic principles of green campus in China	2000s	ULSF (University Leaders Association of Sustainable in Future) issued the academic journal *International Journal of Sustainability in Higher Education*	Promoting the sustainable campus in America to be widely known and internationalized
In 2001, Tsinghua University was officially named "Green University"	The first green university in China			
In 2007, Tongji University was the first energy-saving campus demonstration project in China's building	The first model of energy saving campus in China			

energy saving special plan				
In 2008, Tongji University, together with five other universities, compiled the *Guidelines for the Construction and Management of Energy Efficient Campus in Colleges and Universities*	Defining the task of energy-saving campus construction			
In 2010, the National University energy saving alliance and China Green University Alliance were established	Promoting the development of China's green universities	2010s	In 2010, the American Green Building Council established the green school center and launched the U.S. Green Campus Movement	Demonstration of green campus model in the world
In 2013, Zhejiang University won the Global Sustainable Development Campus Student Innovation and Practice Award at the International Sustainable Campus Alliance Conference	Creating a collaborative development mode of students' participation in the school administrative department			
In 2016, China Green Campus Association Alliance was established	Promoting the cooperation of associations and connecting with government departments and social enterprises		In 2012, the UN summit on sustainable development was held in Rio. The Green Campus Alliance of America and the Green Campus Alliance of other countries jointly issued the global declaration of sustainable development of higher education	Opening a new chapter of sustainable development of university
In 2019, the International Conference on student environment and sustainable development issued *the Universal Youth Tongji Declaration*	The connotation is enriched again, and is striding forward to "sustainable campus"			

2.2.2 Comparison of Development Characteristics

According to the development process of green campus in China and the United States, this study analyzes their development process from three perspectives of concept formation, practice process and international development. And their respective development characteristics are shown in Table 2.3:

Table 2.3: Comparison of the Characteristics of Green Campus Development between China and the United States

Stage	America	China	Characteristics
Concept formation	Spontaneous action of universities → Approved and supported by the government → Government plan	Government documents → Universities recognize the importance of green campus → Universities' actions	1. In terms of universities' action, the U.S. makes students the main body, while university is the main body in China. 2. American universities pay attention to environmental issues in the early stage, while Chinese universities pay attention to energy issues.
Practice process	Establishment of the first green campus → Exchange of experience through seminars → Establishment of University Alliance → Establishment of an evaluation system (STARS) to guide the construction	Establishment of the first green campus → Exchange seminar → Release of various documents → Establishment of University Alliance → Establishment of evaluation standards	1. Most of the green campus initiatives in the U.S. are self-organized and initiated by universities, while those in China are promoted by documents issued by the government. 2. Both countries build a green campus first and then spread it to other domestic campuses. 3. Both countries set up University Alliance to promote the construction of green campus.
International development	The promotion of international registration of STARS → release of SCL by AASHE	Exchange with University Alliances of other countries → Zhejiang University won Innovation Practice Award	1. Through STARS, the U.S. establishes an exchange platform and develops in an all-round way. China has stepped into the international track through exchanges with universities in other countries, taking "several universities" as the breakthrough point of development. 2. The U.S. has a complete evaluation system to evaluate the degree of campus construction, while China is still in the exploration stage.

2.3 Development of Policies Related to Sustainable Campus

Since American government began to participate in the sustainable campus in 1990, the development of green campus and green building has always maintained a parallel relationship. In 2007, *STARS 0.4* was released, marking the birth of the evaluation system of sustainable campus in American. After continuous practice and development, *STARS* has been continuously improved and developed to version 2.2. The evaluation content is mainly divided into four categories: Academics, Engagement, Operations and Planning & Administration (AASHE, 2019). The construction evaluation of green campus is also carried out from these four aspects, and its scientific and comprehensive evaluation system has attracted the wide participation of many universities around the world.

The concept of green campus was first put forward in China in 1996. *The National Environmental Publicity and Education Action Plan* issued by the Chinese government combines the concept of sustainable development with school construction for the first time （SECPRC, 1996）. In 2008, the Ministry of Housing and Urban rural development and the Ministry of Education jointly issued *The Opinions on Promoting the Construction of Energy-saving Campus and Further Strengthening the Work of Energy and Water Conservation in Colleges and Universities*, marking the beginning of China's energy-saving campus （MHURDPR, MEPRC, 2008）. *The Green Campus Evaluation Standard (CSUS/GBC04-2013)* was issued by the government in 2013. Relevant provisions are made from the aspects of campus land planning, energy saving, resource saving, pollution control, management & operation and promotion & education, marking that China's green campus has entered the formal construction stage （CGBC, Tongji University, CABR, 2013）. Since then, with the continuous implementation of green campus construction in China, the version of 2013 has been unable to meet the needs of evaluation of green campus at that time. Therefore, in 2016, on the basis of *Green Building Evaluation Standard (GB/T50378-2014)* （CGBC, Tongji University, CABR, 2014）, an updated version named *Green Campus Evaluation Standard* was proposed. Many modifications and innovations are made in the evaluation content. The focus of the evaluation is not only on the campus buildings, but also on the operation and education & promotion in sustainability. *The Green Campus Evaluation Standard (GB/T51356-2019)* was formally put forward in 2019, becoming the most complete green campus evaluation system in China (see Table 2.4).

In contrast, China's green campus evaluation system is later than that in America. Developing step by step from the government's policy documents, China's evaluation standard has a stronger policy orientation （Tan, H., Chen, S., Shi, Q. et al, 2014）. While the American evaluation standard is proposed by AASHE and constantly updated and improved, widely collecting the construction experience and research results of colleges and universities, and has strong spontaneity and openness. Besides, *STARS* aims to provide a platform for global universities to share the achievements of sustainable construction, so as to promote open evaluation and exchange among universities （AASHE, 2021a）.

Table 2.4: Development Process of Sustainable Campus Policies in China and America

China				America		
Publisher	**Document**	**Significance**		**Publisher**	**Document**	**Significance**
The 16th Executive Meeting of the State Council	1994, *China's Agenda 21*	Concept sprouting	1990s	US Environmental Protection Agency	1990, *"Tufts Clean" Plan*	Getting the approval and support of the U.S. government
Environmental	1996, *Action*	Putting				

Protection Administration, Education Commission and Propaganda Department of the CPC Central Committee	*Outline of National Environmental Publicity and Education(1996-2010)*	forward the concept of "green campus" for the first time				
Ministry of Education	2006, *Notice of the Ministry of Education on the Construction of Conservation Oriented Schools*	Providing specific implementation plan for green campus	2000s	Higher Education Association Sustainable Development Alliance	2006, *The Evaluation System of Campus Sustainable Development*	From "idea" to "regulation"
Ministry of Housing and Urban Rural Development and Ministry of Education	2008, *Management and Technical Guidelines for the Construction of Conservation Oriented Campus in Colleges and Universities (Trial)*	From concept to concrete theoretical basis		AASHE	2007, *STARS 0.4*, and Started the pilot project of *STARS*	The birth of sustainable campus evaluation system
UN Summit on Sustainable Development	2012, *Global Declaration on "Sustainable Development of Higher Education"*	Opening a new chapter of sustainable development of global universities	2010s	UN Summit on Sustainable Development	2012, *Global Declaration on "Sustainable Development of Higher Education"*	Opening a new chapter of sustainable development of global universities
Ministry of Housing and Urban Rural Development	2013, *Evaluation Standard of Green Campus (CSUS/GBC04-2013)*	China's first systematic association green campus evaluation standard		AASHE	2013, *STARS 2.0*	The road to international demonstration
Ministry of Housing and Urban Rural Development	2019, *Evaluation Standard of Green Campus (GB/T51356-2019)*	The first national standard of China		AASHE	2020, *Sustainable Campus Index (SCI)*	Providing reference and demonstration

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CHAPTER 3

RESEARCH METHODOLOGY

CHAPTER 3 RESEARCH METHODOLOGY

3.1 Research Framework

The framework of this study is shown in Figure 3.1, which is mainly divided into three parts: Construction background, Evaluation & Standard and Case study & Development.

Part 1: Construction background

This part mainly studies the construction and development background of sustainable campus in China and America. In order to clarify the context of sustainable campus construction in the two countries and summarize the characteristics of their development, this study analyzes the development process and relevant policies of sustainable campus in the two countries by using the method of comparison.

Part 2: Evaluation & Standards

This part focuses on the evaluation standards of sustainable campus in China, Japan and America. Firstly, STARS (USA) and National Standard (China) are compared in terms of evaluation method, evaluation content and evaluation application, so as to analyze the characteristics and advantages of the two standards. Secondly, in order to identify the advantages of STARS which are suitable for application in China, the Fuzzy Comprehensive Evaluation Method is used to study the suitability of STARS to evaluate Chinese campus. Thirdly, this part also analyzes the current situation of sustainable campus construction in Japan and related evaluation standards, namely: CASBEE and green campus evaluation standards. Therefore, specific optimization suggestions can be put forward for China's evaluation standards and Japanese evaluation system.

Part 3: Case study & Development

Based on the research results of part 1 and 2, this part mainly studies the specific cases of sustainable campus in China, Japan and America, in order to further understand the characteristics and future development trend of sustainable campus construction. For the study of sustainable campus in China, this research selects two representative universities in China (Zhejiang University and Zhejiang University of Technology Zhejiang college) for comparison, in order to analyze the development stage, sustainability level and future development potential of sustainable campus with "energy saving" as the core. For the study of sustainable campus in the United States, it mainly focuses on the development for SDGs' achievement. This research selects the representative American university (Stanford University) for analysis, to summarize its sustainable campus construction measures to achieve SDGs, and put forward the concept of the coordinated development of sustainable campus and community in the future. For the study of sustainable campus in Japan, the sustainable campus of Kitakyushu Science and Research Park and the green building assessment of Hibikino campus's main building are analyzed in detail, and compared with Stanford, discussing the realization path of global SDGs. As for the sustainable investment willingness, 214 representative sustainable American universities are selected. And the main factors influencing the investment willingness and the maximum affordability of sustainable investment are studied. In order to provide scientific basis for relevant policy-making, quantitative research and analysis for the sustainable investment of universities are carried out.

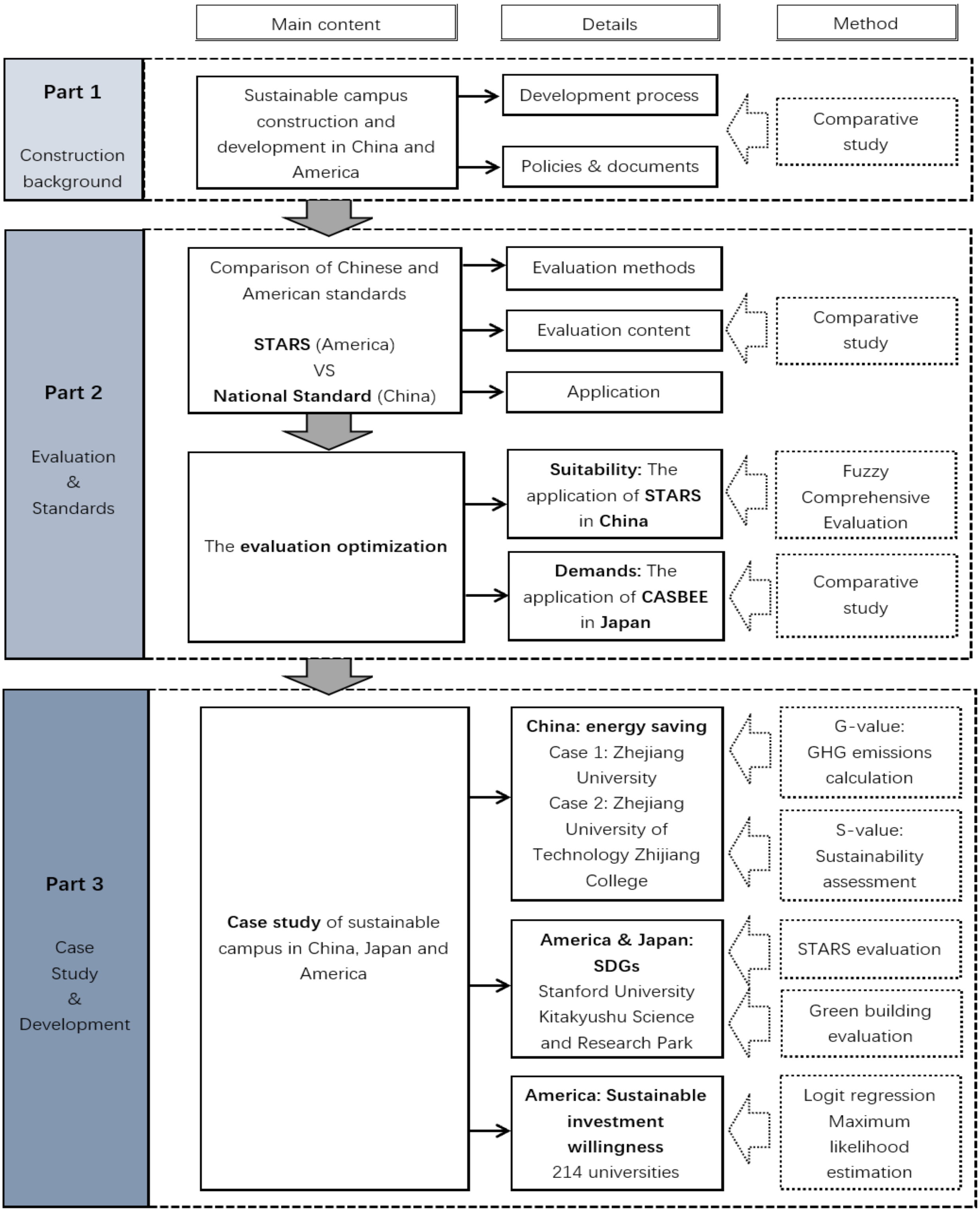

Figure 3.1: Research Framework

3.2 Research Samples

3.2.1 Evaluation Standards

The research standards used in this thesis are the current evaluation standards of sustainable campus in China, Japan and America. Because there is no national uniform sustainable campus evaluation standard in Japan, this study adopts its green building evaluation standard CASBEE as the main research object. As the trial objects of the standard are different from those of Chinese and American standards, CASBEE is not compared in this chapter. And its introduction will be carried out in Chapter 5. The Chinese standard is *Green Campus Evaluation Standard (GB/T51356-2019)* (hereinafter referred to as the *Standard*). The American standard is *STARS 2.2* (The Sustainability Tracking, Assessment & Rating System).

(1) Chinese standard

China's *Green Campus Evaluation Standard (GB/T51356-2019)* is issued by the Ministry of Housing and Urban-Rural Development. Based on the version of *Green Campus Evaluation Standard (CSUS/GBC04-2013)*, the construction of green campus is strictly standardized according to various economic policies put forward at national conferences after 2013. And the new standard is based on the actual situation of green campus construction and innovation in Colleges and universities at that time（CGBC, Tongji University, CABR，2019）. The *Standard* is applicable to the evaluation of the construction and operation of new and existing campuses, including auxiliary buildings, teaching buildings, administrative offices, service buildings, as well as the comprehensive evaluation of the organizational system construction, campus planning, energy efficiency management, green education, green humanities and other aspects of green campus construction. It can be used as an evaluation tool for institutions to apply for green campus demonstration units, as well as the planning evaluation of new campuses and the operation evaluation of existing campuses（CGBECC, 2012）.

(2) American standard

STARS (The Sustainability Tracking, Assessment & Rating System) is an American evaluation system for sustainable campus, which is edited by AASHE and independent of *LEED for School*. It provides a clear and complete system, which can be used as a benchmark for setting goals and evaluation of higher education institutions today and in the future, and focuses on all aspects of the system, including research & curriculum, campus engagement, planning & institutional capacity, strategic planning, so as to promote cross sectoral dialogue on campus sustainable development and stimulate communication and learning between institutions（AASHE, 2021b）. At present, more than 700 colleges and universities in 21 countries participate in campus sustainable development data sharing through *STARS* with great influence in the world（AASHE, 2021c）.

The specific contents of evaluation Standards in China and America are shown in Table 3.1:

Table 3.1: The Comparison of Evaluation Standards between China and America

Standard	STARS 2.2	Green Campus Evaluation Standard (GB/T51356-2019)
Sources of system framework	Starting from the sustainable education proposed by AASHE	Green Campus Evaluation Standard (CSUS/GBC04-2013)
Content	Academics Engagement Operations Planning & Administration * Innovation & Leadership	Planning & Ecology Energy & Resources Environment & Health Operation & Management Education & Promotion *Characteristics & Innovation
Object	Institutions of higher learning	Primary and secondary schools, vocational schools and institutions of higher learning
Method	The evaluation content is divided into several categories, and each clause is scored according to the conditions to be met, and the rating are determined according to the scoring results	All the control items should be satisfied, the scoring items should be scored according to the conditions to be met, and the bonus items are extra scores. The evaluation rating is determined according to the total score.
Effective period	Three years	Permanent
Classification	There is no qualitative evaluation clause and the evaluation items are selected independently	Control items, scoring items and bonus items
Phase	Development phase of campus construction (sustainability tracking)	Four phases of planning, design, construction and operation
Rating	Bronze, silver, gold and platinum	One-star, two-star, three-star

3.2.2 Brief introduction of Sample Universities

(1) Zhejiang University (China)

Zhejiang University is a comprehensive and research-oriented university with distinctive features and great influence at home and abroad. With the educational thought of keeping pace with the times, its education and teaching model has been reformed to always walk in the forefront of all Chinese colleges and universities. The rich campus culture, advanced teaching facilities and extensive international exchanges create excellent conditions for the growth of students. It has five campuses. Its disciplines cover philosophy, economics, law, education, literature, history, art, science, engineering, agriculture, medicine, management and other twelve categories. The university has 7 divisions and 37 colleges (departments). Until the end of December 2017, there are 3419 teachers, 46,666 full-time students and 4,221 international students (including non-academic students) (ZJU, 2018).

As one of the initiators and members of China Green Campus Alliance in green campus, it has achieved good results in green campus construction, especially in the control and supervision of building energy consumption. A campus energy consumption monitoring platform is established to conduct a comprehensive three-dimensional real-time monitoring and management of campus energy, water supply system, steam system, central air conditioning system, street lamp, renewable energy system and other systems.

As the first vice president unit of "China University Energy Conservation Alliance" (Zhejiang University, 2011), Zhejiang University is one of the core members of "China Green University Alliance", which is a typical example of China's green campus. It has taken a series of measures for the construction of green campus from many aspects, and has achieved certain results, especially in the campus energy-saving.

After the evaluation of STARS 2.1 evaluation system by my research group, Zhejiang University scores 43.88, 33.61, 17.29 and 20.17, respectively in four categories of Academics, Engagement, Operations and Planning & Administration, and the final grade score is 56.63, reaching the silver-rating.

The following is detailed lists of evaluation indicators for each category:

For the Academics (AC), the total score is 43.88, the score rate is 75.66%, and most of the scores are obtained. In the general, the construction achievements of this part are good. AC is divided into two parts: Curriculum and Research, which represent the teaching and scientific research ability of the university respectively, evaluating the sustainable education achievements for students and the sustainable research and innovation ability of the institution itself. The Curriculum score is 30.17, and the score rate is 75.43%. The score of the Research is 13.71, with a score rate of 76.17%. The development of the two parts is balanced and basically at the same level. Academic Courses, Learning Outcomes, Undergraduate Program, Graduate Program, Immersive Experience and Campus as a Living Laboratory are the better parts in Curriculum. However, Sustainability Literacy Assessment and Incentives for Developing Courses are relatively lacking. The Research and scholarship and Open Access to Research are the better ones in Research. And Support for Research needs to be improved.

Table 3.2: Academics (AC) Category Assessment Indicators' Score of Zhejiang University

Category (score)	Sub-item (score)	Serial number	Assessment indicator (score)	Indicator's score	Sub-item score	Total score
Academics AC （58）	Curriculum (40)	AC1	Academic Courses （14）	12.17	30.17	43.88
		AC2	Learning Outcomes （*8）	6		
		AC3	Undergraduate Program （*3）	3		
		AC4	Graduate Program （*3）	3		
		AC5	Immersive Experience （*2）	2		
		AC6	Sustainability Literacy Assessment（4）	0		
		AC7	Incentives for Developing Courses （2）	0		
		AC8	Campus as a Living Laboratory（*4）	4		
	Research (18)	AC9	Research and Scholarship（*12）	9.71	13.71	
		AC10	Support for Research （*4）	2		
		AC11	Open Access to Research（*2）	2		

For the Engagement（EN）, the total score is 33.61, the score rate is 81.97%, and most of the scores are obtained. In the general, the construction achievements of this part are good. EN is divided into two parts: Campus Engagement and Public Engagement, which represents the sustainable activities of the university in the campus and the surrounding communities, evaluating the university's support and policy encouragement for sustainable activities. The Campus Engagement score is 14.85, and the score rate is 70.71%. The score of the Public Engagement is 18.76, with a score rate of 93.80%. The development of the two parts is balanced and the score is high. Student Orientation, Student Life, Outreach Materials and Publications, Employee Educators Program, Employee Orientation and Staff Professional Development are the better parts in Campus Engagement. However, Student Educators Program、Outreach Campaign and Assessing Sustainability Culture are relatively lacking. Community Partnerships, Inter-Campus Collaboration, Continuing Education, Community Service, Participation in Public and Trademark Licensing for Public Engagement are all in high level.

Table 3.3: Engagement (EN) Category Assessment Indicators' Score of Zhejiang University

Category (score)	Sub-item (score)	Serial number	Assessment indicator (score)	Indicator's score	Sub-item score	Total score
Engagement EN（41）	Campus Engagement (21)	EN1	Student Educators Program（*4）	0.85	14.85	33.61
		EN2	Student Orientation（*2）	2		
		EN3	Student Life（2）	2		
		EN4	Outreach Materials and Publications（2）	2		
		EN5	Outreach Campaign（4）	2		
		EN6	Assessing Sustainability Culture（1）	0		
		EN7	Employee Educators Program（3）	3		
		EN8	Employee Orientation（1）	1		
		EN9	Staff Professional Development（2）	2		
	Public Engagement (20)	EN10	Community Partnerships（3）	3	18.76	
		EN11	Inter-Campus Collaboration（3）	2		
		EN12	Continuing Education（*5）	5		
		EN13	Community Service（*5）	4.76		
		EN14	Participation in Public Policy（2）	2		
		EN15	Trademark Licensing（*2）	2		

For Operations (OP), the total score is 17.29, the score rate is 24.01%, and most of the scores are not obtained. The overall construction of this part is relatively deficient. The OP is divided into Air & Climate, Buildings, Energy, Food & Dining, Grounds, Purchasing, Transportation, Waste and Water, which represents the quality of the physical environment of the university's buildings and the application of infrastructure, evaluating the measures for the use of the physical environment and the sustainability of life services. Air & Climate scores 0; Buildings scores 0; Energy scores 0, Food & Dining scores 5, with a score rate of 62.5%; Ground scores 2, with a score rate of 66.67%; Purchasing scores 1.5, with a score rate of 25%; Transportation scores 4.17, with a score rate of 59.57%; Waste scores 2.2, with a score rate of 22%; Water scores 2.42, with a score rate of 40.33%. The development of each part is generally weak, and there are some differences, among which the good results of the construction are Food & Dining, Grounds and Transportation. Food and Beverage Purchasing is the best part in Food & Dining. The better part of the Grounds is Biodiversity. The better development of Transportation is Student Commute Modal Split and Employee Commute Modal Split. The rest needs to be further improved.

Table 3.4: Operations (OP) Category Assessment Indicators' Score of Zhejiang University

Category (score)	Sub-item (score)	Serial number	Assessment indicator (score)	Indicator's score	Sub-item score	Total score
Operations OP（72）	Air & Climate (11)	OP1	Greenhouse Gas Emissions（10）	0	0	17.29
		OP2	Outdoor Air Quality（1）	0		
	Buildings (8)	OP3	Building Operations and Maintenance（*5）	0	0	
		OP4	Building Design and Construction（*3）	0		
	Energy (10)	OP5	Building Energy Consumption（6）	0	0	
		OP6	Clean and Renewable Energy（4）	0		
	Food & Dining (8)	OP7	Food and Beverage Purchasing（*6）	4	5	
		OP8	Sustainable Dining（*2）	1		
	Grounds (3-4)	OP9	Landscape Management（*2）	0	2	
		OP10	Biodiversity（*1-2）	2		
	Purchasing (6)	OP11	Sustainable Procurement（3）	1.5	1.5	
		OP12	Electronics Purchasing（1）	0		
		OP13	Cleaning and Janitorial Purchasing（1）	0		
		OP14	Office Paper Purchasing（1）	0		
	Transportation (7)	OP15	Campus Fleet（*1）	0.01	4.17	
		OP16	Student Commute Modal Split（*2）	1.90		
		OP17	Employee Commute Modal Split（2）	1.26		
		OP18	Support for Sustainable Transportation（2）	1		
	Waste (10)	OP19	Waste Minimization and Diversion（8）	1.70	2.20	
		OP20	Construction and Demolition Waste Diversion（*1）	0		
		OP21	Hazardous Waste Management（1）	0.5		
	Water (6-8)	OP22	Water Use（4-6）	1.42	2.42	
		OP23	Rainwater Management（2）	1		

For the Planning & Administration (PA), the total score is 20.17, the score rate is 63.03%, and more than half of the score is gotten. In the general, the construction achievements of this part are good. PA is divided into four parts: Coordination & Planning, Diversity &Affordability, Investment & Finance and Wellbeing & Work, which represent the sustainable strategic planning and operation ability of the university, evaluating its sustainability of the overall construction management and long-term development planning. The Coordination & Planning score is 8, with a score rate of 100%. The Diversity & Affordability score is 6, with a score rate of 60%. The Investment & Finance score is 3.67, with a score rate of 52.42%. And the score of the Wellbeing & Work is 2.5, with a score rate of 35.71%. The development of each part is quite different. Among them, Coordination & Planning achieves the best results and got all the scores. Diversity and Equity Coordination, Assessing Diversity and Equity, Support for Underrepresented Groups are the better parts in Diversity & Affordability. Committee on Investor Responsibility is the best part in Investment & Finance. And Wellness Program is the best part in Wellbeing & Work. However, the rest needs to be further improved.

Table 3.5: Planning & Administration (PA) Category Assessment Indicators' Score of Zhejiang University

Category (score)	Sub-item (score)	Serial number	Assessment indicator (score)	Indicator's score	Sub-item score	Total score
Planning & Administration PA （32）	Coordination & Planning (8)	PA1	Sustainability Coordination （1）	1	8	20.17
		PA2	Sustainability Planning （4）	4		
		PA3	Participatory Governance （3）	3		
	Diversity & Affordability (10)	PA4	Diversity and Equity Coordination （2）	2	6	
		PA5	Assessing Diversity and Equity （1）	1		
		PA6	Support for Underrepresented Groups （3）	2		
		PA7	Affordability and Access （4）	1		
	Investment & Finance (7)	PA8	Committee on Investor Responsibility （*2）	2	3.67	
		PA9	Sustainable Investment （*4）	1.67		
		PA10	Investment Disclosure （*1）	0		
	Wellbeing & Work (7)	PA11	Employee Compensation	1.5	2.5	

			(3)			
		PA12	Assessing Employee Satisfaction (1)	0		
		PA13	Wellness Program (1)	1		
		PA14	Workplace Health and Safety (2)	0		

(2) Zhejiang University of Technology Zhijiang College (China)

Zhejiang University of Technology Zhijiang College is an independent college in China with only one campus. The college covers an area of 546,666 square meters, among which the usable water area is about 146,666 square meters, with a total construction area of 220,000 square meters. It has 36 undergraduate majors, covering seven disciplines of engineering, science, liberal arts, law, management, economics and art. Until the end of December 2017, there are nearly 7,500 full-time undergraduate students. The college has 10 secondary colleges and 1 teaching department (ZJ-ZJTU, 2018).

As a newly relocated independent college, campus infrastructure has been rebuilt in recent years, which largely avoids the disadvantages of limited infrastructure conditions and large cost of green renovation in the old buildings. Its whole campus construction process advocates green teaching and actively carries out environmental education. Its green campus construction and development level is among the general level of Chinese universities.

After the evaluation of STARS 2.1 evaluation system by my research group, Zhejiang University of Technology Zhijiang College scores 43.68, 18.09, 11.5 and 15.5 respectively in four categories of Academics, Engagement, Operations and Planning & Administration, and the final grade score is 43.73, reaching the bronze-rating.

The following is detailed lists of evaluation indicators for each category:

For the Academics (AC), the total score is 43.68, the score rate is 75.31%, and most of the scores are obtained. In the general, the construction achievements of this part are good. AC is divided into two parts: Curriculum and Research, which represent the teaching and scientific research ability of the university respectively, evaluating the sustainable education achievements for students and the sustainable research and innovation ability of the institution itself. The Curriculum score is 27.68, and the score rate is 69.20%. The score of the Research is 16, with a score rate of 88.88%. The scores of the two parts are high, which has a certain foundation. Academic Courses, Learning Outcomes, Undergraduate Program, Immersive Experience and Campus as a Living Laboratory are the better parts in Curriculum. However, Graduate Program, Sustainability Literacy Assessment and Incentives for Developing Courses are relatively lacking. The Research and scholarship, Open Access to Research and Support for Research are all in high level.

Table 3.6: Academics (AC) Category Assessment Indicators' Score of Zhejiang University of Technology Zhijiang College

Category (score)	Sub-item (score)	Serial number	Assessment indicator (score)	Indicator's score	Sub-item score	Total score
Academics AC（58）	Curriculum (40)	AC1	Academic Courses（14）	12.07	27.68	43.68
		AC2	Learning Outcomes（*8）	6.61		
		AC3	Undergraduate Program（*3）	3		
		AC4	Graduate Program（*3）	0		
		AC5	Immersive Experience（*2）	2		
		AC6	Sustainability Literacy Assessment（4）	0		
		AC7	Incentives for Developing Courses（2）	0		
		AC8	Campus as a Living Laboratory（*4）	4		
	Research (18)	AC9	Research and Scholarship（*12）	11	16	
		AC10	Support for Research（*4）	3		
		AC11	Open Access to Research（*2）	2		

For the Engagement（EN）, the total score is 18.09, the score rate is 44.12%, and less than half of the score is gotten. The overall construction of this part is relatively deficient. EN is divided into two parts: Campus Engagement and Public Engagement, which represents the sustainable activities of the university in the campus and the surrounding communities, evaluating the university's support and policy encouragement for sustainable activities. The Campus Engagement score is 10.39, and the score rate is49.47%. The score of the Public Engagement is 7.7, with a score rate of 38.50%. The scores of both parts are low. Student Orientation, Outreach Materials and Publications, Employee Educators Program, Employee Orientation and Staff Professional Development are the better parts in Campus Engagement. However, Student Educators Program、Student Life, Outreach Campaign and Assessing Sustainability Culture are relatively lacking. Community Service, Participation in Public Policy and Trademark Licensing are the better parts in Public Engagement. However, Community Partnerships, Inter-Campus Collaboration, Continuing Education all need further improvement.

Table 3.7: Engagement (EN) Category Assessment Indicators' Score of Zhejiang University of Technology Zhijiang College

Category (score)	Sub-item (score)	Serial number	Assessment indicator (score)	Indicator's score	Sub-item score	Total score
Engagement EN（41）	Campus Engagement (21)	EN1	Student Educators Program（*4）	0.14	10.39	18.09
		EN2	Student Orientation（*2）	2		
		EN3	Student Life（2）	1		
		EN4	Outreach Materials and Publications（2）	1.25		
		EN5	Outreach Campaign（4）	0		
		EN6	Assessing Sustainability Culture（1）	0		
		EN7	Employee Educators Program（3）	3		
		EN8	Employee Orientation（1）	1		
		EN9	Staff Professional Development（2）	2		
	Public Engagement (20)	EN10	Community Partnerships（3）	1	7.7	
		EN11	Inter-Campus Collaboration（3）	0		
		EN12	Continuing Education（*5）	0		
		EN13	Community Service（*5）	2.7		
		EN14	Participation in Public Policy（2）	2		
		EN15	Trademark Licensing（*2）	2		

For Operations (OP), the total score is 11.5, the score rate is 15.97%, and most of the scores are not obtained. The overall construction of this part is very deficient. The OP is divided into Air & Climate, Buildings, Energy, Food & Dining, Grounds, Purchasing, Transportation, Waste and Water, which represents the quality of the physical environment of the university's buildings and the application of infrastructure, evaluating the measures for the use of the physical environment and the sustainability of life services. Air & Climate scores 0. Buildings scores 0.5, with a score rate of 6.25%. Energy scores 0. Food & Dining scores 5, with a score rate of 62.5%. Ground scores 0. Purchasing scores 1, with a score rate of 16.67%. Transportation scores 4.5, with a score rate of 64.29%. Waste scores 0.5, with a score rate of 5.00%. Water scores 0. The development of each part is generally weak, and there are some differences, among which the good results of the construction are Food & Dining and Transportation. Food and Beverage Purchasing is the best part in Food & Dining. The better development of Transportation is Student Commute Modal Split and Employee Commute Modal Split. The rest needs to be further improved.

Table 3.8: Operations (OP) Category Assessment Indicators' Score of Zhejiang University of Technology Zhijiang College

Category (score)	Sub-item (score)	Serial number	Assessment indicator (score)	Indicator's score	Sub-item score	Total score
Operations OP（72）	Air & Climate (11)	OP1	Greenhouse Gas Emissions（10）	0	0	11.5
		OP2	Outdoor Air Quality（1）	0		
	Buildings (8)	OP3	Building Operations and Maintenance（*5）	0.5	0.5	
		OP4	Building Design and Construction（*3）	0		
	Energy (10)	OP5	Building Energy Consumption（6）	0	0	
		OP6	Clean and Renewable Energy（4）	0		
	Food & Dining (8)	OP7	Food and Beverage Purchasing（*6）	4	5	
		OP8	Sustainable Dining（*2）	1		
	Grounds (3-4)	OP9	Landscape Management（*2）	0	0	
		OP10	Biodiversity（*1-2）	0		
	Purchasing (6)	OP11	Sustainable Procurement（3）	1	1	
		OP12	Electronics Purchasing（1）	0		
		OP13	Cleaning and Janitorial Purchasing（1）	0		
		OP14	Office Paper Purchasing（1）	0		
	Transportation (7)	OP15	Campus Fleet（*1）	0	4.5	
		OP16	Student Commute Modal Split（*2）	2		
		OP17	Employee Commute Modal Split（2）	1.5		
		OP18	Support for Sustainable Transportation（2）	1		
	Waste (10)	OP19	Waste Minimization and Diversion（8）	0	0.5	

		OP20	Construction and Demolition Waste Diversion（*1）	0		
		OP21	Hazardous Waste Management（1）	0.5		
	Water (6-8)	OP22	Water Use（4-6）	0	0	
		OP23	Rainwater Management（2）	0		

For the Planning & Administration (PA), the total score is 15.5, the score rate is 48.44%, and less than half of the score is gotten. The overall construction of this part is relatively deficient. PA is divided into four parts: Coordination & Planning, Diversity &Affordability, Investment & Finance and Wellbeing & Work, which represent the sustainable strategic planning and operation ability of the university, evaluating its sustainability of the overall construction management and long-term development planning. The Coordination & Planning score is 6.5, with a score rate of 81.25%. The Diversity & Affordability score is 5.5, with a score rate of 55.00%. The Investment & Finance score is 0. And the score of the Wellbeing & Work is 3.5, with a score rate of 50.00%. There are great differences in the development of some parts, among which the Investment & Finance part has the worst construction results and does not get a score. Sustainability Planning and Participatory Governance are the better parts in Coordination & Planning. Diversity and Equity Coordination and Assessing Diversity and Equity are the better parts in Diversity & Affordability. Assessing Employee Satisfaction and Wellness Program are the best part in Wellbeing & Work. However, the rest needs to be further improved.

Table 3.9: Planning & Administration (PA) Category Assessment Indicators' Score of Zhejiang University of Technology Zhijiang College

Category (score)	Sub-item (score)	Serial number	Assessment indicator (score)	Indicator's score	Sub-item score	Total score
Planning & Administration PA（32）	Coordination & Planning (8)	PA1	Sustainability Coordination（1）	0	6.5	15.5
		PA2	Sustainability Planning（4）	3.5		
		PA3	Participatory Governance（3）	3		
	Diversity & Affordability (10)	PA4	Diversity and Equity Coordination（2）	2	5.5	
		PA5	Assessing Diversity and Equity（1）	1		
		PA6	Support for Underrepresented Groups（3）	1.5		
		PA7	Affordability and Access（4）	1		

	Investment & Finance (7)	PA8	Committee on Investor Responsibility（*2）	0	0	
		PA9	Sustainable Investment（*4）	0		
		PA10	Investment Disclosure（*1）	0		
	Wellbeing & Work (7)	PA11	Employee Compensation（3）	1.5	3.5	
		PA12	Assessing Employee Satisfaction（1）	1		
		PA13	Wellness Program（1）	1		
		PA14	Workplace Health and Safety（2）	0		

(3) Stanford University (America)

Stanford University is located in the gulf area of California. Its IECC climate division is 3-warm, mild and rainy in winter, high temperature and little rain in summer. Stanford is one of the world's leading research universities, with 11367 students and 15620 employees (staff + faculty) as of December 2018 (Stanford Sustainable, 2019a). Stanford has 8180 acres (1 acre = 4046.86 ㎡), 60% of which are undeveloped, and the remaining 40% include Stanford 's main campus, which contains about 15 million square feet of building space, 1.5 million laboratory building area and about 60000 square feet (1 feet = 0.3048m) of high- energy consumption building space (AASHE,2019a). Stanford is a sustainable Laboratory for research, teaching, student's campus activities and communities. At present, Stanford has unique landmark buildings such as central energy facility (CEF), William and Croydigar resource recovery center (CR2C), etc., which provides a place for researchers, tourists and students from all over the world to observe and study (Stanford Sustainable, 2019a).

Marc Tessier-Lavigne, President of Stanford, calls for "The great power and intellectual property of Stanford are used for the benefit of mankind". To this end, Stanford announced two sustainable construction goals in the spring of 2018, namely, to achieve 80% carbon free emissions by 2025 and zero waste by 2030. At the same time, Stanford has incorporated "sustainability" into its future vision strategy (Stanford Sustainable, 2019a).

Stanford has made outstanding achievements through a series of "sustainable" measures, and has also been recognized by the locals. In 2019, AASHE tracked "sustainable development" at Stanford University, using STARS for assessment. Stanford is still rated platinum after its 2017 assessment, becoming one of the only two higher education institutions in the world to achieve this milestone (Stanford Sustainable, 2019a). It is a practitioner and pioneer of global green campus, representing the highest level of construction. Therefore, this study chooses Stanford as a special case for research and analysis, which is of great significance for promoting the construction of green campus in the world.

After the evaluation of STARS 2.1 evaluation system from STARS platform, Stanford University scores 55.2, 39.35, 50.46 and 25.52, respectively in four categories of Academics, Engagement, Operations and Planning & Administration, and the final grade score is 84, reaching the platinum-rating.

The following is detailed lists of evaluation indicators for each category:

For the Academics (AC), the total score is 55.2, the score rate is 95.17%, almost getting full marks. In the general, the construction achievements of this part are excellent. AC is divided into two parts: Curriculum and Research, which represent the teaching and scientific research ability of the university respectively, evaluating the sustainable education achievements for students and the sustainable research and innovation ability of the institution itself. The Curriculum score is 38.2, and the score rate is 95.50%. The score of the Research is 17, with a score rate of 94.44%. The development of the two parts is balanced and basically at the high level. The construction of the Curriculum is good. The Research and scholarship and Support for Research are the better ones in Research. However, Open Access to Research needs to be improved.

Table 3.10: Academics (AC) Category Assessment Indicators' Score of Stanford University

Category (score)	Sub-item (score)	Serial number	Assessment indicator (score)	Indicator's score	Sub-item score	Total score
Academics AC （58）	Curriculum (40)	AC1	Academic Courses （14）	12.2	38.2	55.2
		AC2	Learning Outcomes （*8）	8		
		AC3	Undergraduate Program （*3）	3		
		AC4	Graduate Program （*3）	3		
		AC5	Immersive Experience （*2）	2		
		AC6	Sustainability Literacy Assessment （4）	4		
		AC7	Incentives for Developing Courses （2）	2		
		AC8	Campus as a Living Laboratory （*4）	4		
	Research (18)	AC9	Research and Scholarship （*12）	12	17	
		AC10	Support for Research （*4）	4		
		AC11	Open Access to Research （*2）	1		

For the Engagement（EN）, the total score is 39.35, the score rate is 95.97%, almost getting full marks. On the whole, this part has achieved excellent results. EN is divided into two parts: Campus Engagement and Public Engagement, which represents the sustainable activities of the university in the campus and the surrounding communities, evaluating the university's support and policy encouragement for sustainable activities. The Campus Engagement score is 20.5, and the score rate is 97.62%%. The score of the Public Engagement is 18.85, with a score rate of 94.25%. The development of the two parts is balanced and the score is high. Compared with other parts, there is still development room for Staff Professional Development in Campus Engagement and Community Service in Public Engagement.

Table 3.11: Engagement (EN) Category Assessment Indicators' Score of Stanford University

Category (score)	Sub-item (score)	Serial number	Assessment indicator (score)	Indicator's score	Sub-item score	Total score
Engagement EN（41）	Campus Engagement (21)	EN1	Student Educators Program（*4）	4	20.5	39.35
		EN2	Student Orientation（*2）	2		
		EN3	Student Life（2）	2		
		EN4	Outreach Materials and Publications（2）	2		
		EN5	Outreach Campaign（4）	4		
		EN6	Assessing Sustainability Culture（1）	1		
		EN7	Employee Educators Program（3）	3		
		EN8	Employee Orientation（1）	1		
		EN9	Staff Professional Development（2）	1.5		
	Public Engagement (20)	EN10	Community Partnerships（3）	3	18.85	
		EN11	Inter-Campus Collaboration（3）	3		
		EN12	Continuing Education（*5）	5		
		EN13	Community Service（*5）	3.85		
		EN14	Participation in Public Policy（2）	2		
		EN15	Trademark Licensing（*2）	2		

For Operations (OP), the total score is 50.46, the score rate is 70.08%, and most of the scores are obtained. The overall construction of this part is relatively good. The OP is divided into Air &

Climate, Buildings, Energy, Food & Dining, Grounds, Purchasing, Transportation, Waste and Water, which represents the quality of the physical environment of the university's buildings and the application of infrastructure, evaluating the measures for the use of the physical environment and the sustainability of life services. Air & Climate scores 9.02, with a score rate of 82.00%. Buildings scores 3.3, with a score rate of 46.63%. Energy scores 7.37, with a score rate of 73.70%. Food & Dining scores 3.67, with a score rate of 45.88%. Ground scores 3, with a score rate of 75.00%. Purchasing scores 4.71, with a score rate of 78.5%. Transportation scores 5.21, with a score rate of 74.43%. Waste scores 5.75, with a score rate of 57.50%. Water scores 8, getting full marks. Most of the development is relatively good, but there are some differences in some parts. Among them, Air & Climate, Energy, Grounds, Purchasing, Transportation and Water have achieved good results. The construction of Buildings, Food & Dining and Waste are poor , needed to be further improved.

Table 3.12: Operations (OP) Category Assessment Indicators' Score of Stanford University

<table>
<tr><th>Category (score)</th><th>Sub-item (score)</th><th>Serial number</th><th>Assessment indicator (score)</th><th>Indicator's score</th><th>Sub-item score</th><th>Total score</th></tr>
<tr><td rowspan="14">Operations OP（72）</td><td rowspan="2">Air & Climate (11)</td><td>OP1</td><td>Greenhouse Gas Emissions（10）</td><td>8.02</td><td rowspan="2">9.02</td><td rowspan="14">50.46</td></tr>
<tr><td>OP2</td><td>Outdoor Air Quality（1）</td><td>1</td></tr>
<tr><td rowspan="2">Buildings (8)</td><td>OP3</td><td>Building Operations and Maintenance（*5）</td><td>2.23</td><td rowspan="2">3.73</td></tr>
<tr><td>OP4</td><td>Building Design and Construction（*3）</td><td>1.5</td></tr>
<tr><td rowspan="2">Energy (10)</td><td>OP5</td><td>Building Energy Consumption（6）</td><td>5.14</td><td rowspan="2">7.37</td></tr>
<tr><td>OP6</td><td>Clean and Renewable Energy（4）</td><td>2.23</td></tr>
<tr><td rowspan="2">Food & Dining (8)</td><td>OP7</td><td>Food and Beverage Purchasing（*6）</td><td>1.67</td><td rowspan="2">3.67</td></tr>
<tr><td>OP8</td><td>Sustainable Dining（*2）</td><td>2</td></tr>
<tr><td rowspan="2">Grounds (3-4)</td><td>OP9</td><td>Landscape Management（*2）</td><td>1</td><td rowspan="2">3</td></tr>
<tr><td>OP10</td><td>Biodiversity（*1-2）</td><td>2</td></tr>
<tr><td rowspan="4">Purchasing (6)</td><td>OP11</td><td>Sustainable Procurement（3）</td><td>3</td><td rowspan="4">4.71</td></tr>
<tr><td>OP12</td><td>Electronics Purchasing（1）</td><td>0.97</td></tr>
<tr><td>OP13</td><td>Cleaning and Janitorial Purchasing（1）</td><td>0.51</td></tr>
<tr><td>OP14</td><td>Office Paper Purchasing（1）</td><td>0.23</td></tr>
</table>

	Transportation (7)	OP15	Campus Fleet（*1）	0.44	5.21	
		OP16	Student Commute Modal Split（*2）	1.76		
		OP17	Employee Commute Modal Split（2）	1.01		
		OP18	Support for Sustainable Transportation（2）	2		
	Waste (10)	OP19	Waste Minimization and Diversion（8）	4.02	5.75	
		OP20	Construction and Demolition Waste Diversion（*1）	0.73		
		OP21	Hazardous Waste Management（1）	1		
	Water (6-8)	OP22	Water Use（4-6）	6	8	
		OP23	Rainwater Management（2）	2		

For the Planning & Administration (PA), the total score is 25.52, the score rate is 79.75%, and most of the scores are gotten. In the general, the construction achievements of this part are good. PA is divided into four parts: Coordination & Planning, Diversity &Affordability, Investment & Finance and Wellbeing & Work, which represent the sustainable strategic planning and operation ability of the university, evaluating its sustainability of the overall construction management and long-term development planning. The Coordination & Planning score is7.25, with a score rate of 90.63%. The Diversity & Affordability score is 9.87, with a score rate of 98.70%. The Investment & Finance score is 2.33, with a score rate of 33.28%. And the score of the Wellbeing & Work is 6.07, with a score rate of 86.71%. The development of four parts is quite different. Except for the investment & finance part, the construction achievements of other parts are excellent. Especially, the Committee on Investor Responsibility, Sustainable Investment and Investment Disclosure of Investment & finance need to be further improved.

Table 3.13: Planning & Administration (PA) Category Assessment Indicators' Score of Stanford University

Category (score)	**Sub-item (score)**	**Serial number**	**Assessment indicator (score)**	**Indicator's score**	**Sub-item score**	**Total score**
Planning & Administration PA（32）	Coordination & Planning (8)	PA1	Sustainability Coordination（1）	1	7.25	25.52
		PA2	Sustainability Planning（4）	4		
		PA3	Participatory Governance（3）	2.25		
	Diversity & Affordability (10)	PA4	Diversity and Equity Coordination（2）	2	9.87	
		PA5	Assessing	1		

			Diversity and Equity（1）			
		PA6	Support for Underrepresented Groups（3）	3		
		PA7	Affordability and Access（4）	3.87		
	Investment & Finance (7)	PA8	Committee on Investor Responsibility（*2）	1	2.33	
		PA9	Sustainable Investment（*4）	1.33		
		PA10	Investment Disclosure（*1）	0		
	Wellbeing & Work (7)	PA11	Employee Compensation（3）	3	6.07	
		PA12	Assessing Employee Satisfaction（1）	1		
		PA13	Wellness Program（1）	1		
		PA14	Workplace Health and Safety（2）	1.07		

(4) Kitakyushu Science and Research Park (Japan)

Kitakyushu Science and Research Park is located in the northernmost city of Kyushu, Japan, and is under the government of Fukuoka. Due to serious environmental pollution in the 1960s, Kitakyushu was called the "Smoke City of Seven Colors". In order to solve the serious environmental pollution problem, enterprises, citizens, and research institutions, Kitakyushu have become the first Japanese city to be awarded the “Global 500” by the United Nations Environment Program in 1990 through the joint efforts of the Japanese government. In June 2010, the city established the Kitakyushu Asia Low-Carbon Center to promote the building of a low-carbon society. And in June 2011, Kitakyushu was selected as the “Green City Plan” of the Organization for Economic Cooperation and Development (OECD), which will move forward the building of an ecological model city to a wider range of environmental and social fields.

Kitakyushu has built a "Science and Research Park" in April 2001 while restoring the environment. The Science and Research Park includes 4 universities, 12 research institutions, and 48 companies (The University of Kitakyushu, 2020). The joint research cooperation between research and development enterprises and universities has become an ecological research park that integrates industry, education and research (Industry & Education & Research). The built park not only meets the demand of function and space, but emphasizes the realization of energy intensive and reduction in pollution. Moreover, the park aims to realize the harmonious coexistence of man, nature and architecture.

3.3 Main Research Methods

3.3.1 Comparative Study

One of the main research methods used in this study is comparative study, which involves three types: the comparison of evaluation standards, the comparison of case universities, and the comparison among the actual construction situation, evaluation values and calculated values of case universities.

(1) Comparison of evaluation standards

This study will make a comparative study of the evaluation standards of sustainable campus between China and America from the organization & participation of evaluation standards, evaluation methods and evaluation category & content, in order to make a scientific comparison of the current evaluation standards of the two countries.

(2) Comparison of case universities

This study involves the comparison of the sustainable construction of case universities. It is divided into vertical comparison, that is, the comparison of construction data of case universities over the years; and horizontal comparison, that is, the comparison of construction data between different universities. The purpose is to deeply analyze the gap between the specific cases of sustainable campus construction in China, Japan and America and the degree of sustainable campus construction in China.

(3) The comparison among the actual construction situation, evaluation values and calculation values of case Universities

This study will focus on a case university and in-depth analysis of the results of sustainable construction. There are three groups of data combinations for comparison: ① The actual construction situation is compared with the evaluation values of the relevant sustainable evaluation standard to analyze the advantages and disadvantages of its development. ② The evaluation values of sustainability is compared with the evaluation values of user’s satisfaction in order to analyze the suitability of relevant evaluation standard. ③ The evaluation values of sustainability is compared with the greenhouse gas emission values, in order to analyze the relationship between energy conservation and sustainability.

3.3.2 Fuzzy Comprehensive Evaluation Method

Fuzzy comprehensive evaluation method is a comprehensive evaluation method based on fuzzy mathematics. Using the membership degree theory of fuzzy mathematics, the qualitative evaluation is transformed into quantitative evaluation, that is, using fuzzy mathematics to make an overall evaluation of things or objects constrained by many factors (Fangfang Gu and Zhuoming Tao, 2013).

Firstly, the evaluation factor set U and the evaluation set V, which can influence the object of study, are established. The aggregated evaluation information is expressed quantitatively according to the degree of membership, and then the fuzzy vector and the fuzzy relation matrix R relative to the evaluation set are obtained. Then B = W * R (W is the weight vector). Finally, the comprehensive evaluation score E = B * H (B is a set of fuzzy comprehensive evaluation; H is a measurement scale) is calculated by removing the ambiguity value (Jijian Xie and Chengpin Liu, 2006).

3.3.3 Calculation of Greenhouse Gas (GHG) Emissions

The statistics of GHG emissions used in this study mainly include two ranges of emissions:

Scope 1 GHG emissions are direct emissions occurring from sources that are owned or controlled by the institution. They include: (i) Combustion of fuels to produce electricity, steam, heat, or power using equipment in a fixed location such as boilers, burners, heaters, furnaces, incinerators. (ii) Combustion fuels by institution-owned cars, tractors, buses, and other transportation devices (WRI and wbcsd, 2011).

Scope 2 GHG emissions are indirect GHG emissions that are a consequence of activities that take place within the organizational boundaries of the institution, but that occur at sources owned or controlled by another entity (WRI and wbcsd, 2011).

EUI-adjusted (energy use intensity per unit area adjustment) is a number that adjusts the actual building area of the calculation object to explain the significant difference in energy use intensity between different types of building spaces (ENERGY STAR, 2018).

In this study, the G-value is set as GHG emission / EUI adjusted.

The GHG emissions are the total GHG emission of adjusted net Scope 1 and 2. In the process of GHG emissions, universities will produce carbon offsets and emissions reduction caused by REC (Renewable Energy Certificates are also known as green tags, renewable energy credits, renewable electricity certificates, and tradable renewable certificates.) /GO (A Guarantee of Origin is a certificate issued by European energy authorities to certify that electricity was produced from renewable energy sources.) purchase. Therefore, certain additions and subtractions are needed in the calculation of emissions (AASHE, 2014).

GHG emissions of adjusted net Scope 1 and 2= {[A+B]–(C+D+E-F)}

A = GHG emissions of Scope 1 ($MtCO_2e$)

B = GHG emissions of Scope 2 ($MtCO_2e$)

C = Institution-catalyzed carbon offsets generated ($MtCO_2e$)

D = Carbon storage from on-site composting ($MtCO_2e$)

E = Third-party verified carbon offsets purchased ($MtCO_2e$)

F = Carbon sold or transferred ($MtCO_2e$)

The floor area used in this study is EUI-adjusted Floor Area. For school buildings, the amount of energy consumption is not the same. It varies greatly because of different functions. For example, laboratories, healthcare spaces are more energy-intensive than general offices and classrooms.

Therefore, when calculating the energy-consuming floor area of campus, we should distinguish them and consider its energy-consuming weight.

EUI-adjusted = {A + [2 × (B + C)] + D} (AASHE, 2019)

A = Gross floor area of building space (m^2)

B = Floor area of laboratory space (m^2)

C = Floor area of healthcare space (m^2)

D = Floor area of other energy intensive space (m^2)

"Other energy intensive space" is a place with high energy consumption except for laboratory and healthcare space. Its average energy use intensity (EUI) is more than twice that of the general office space (AASHE, 2019).

3.3.4 Sustainability Assessment

STARS is a green campus evaluation system from North America. It was developed by AASHE in North America, and constantly updated and improved. Global universities can share their own green campus data on STARS's platform, and share the global green campus construction experience.

According to the overall evaluation framework of STARS, Sustainability assessment is divided into four categories and 17 sub-items, each of which corresponds to a number of evaluation indicators; a total of 70 indicators, each of which has a corresponding score; in addition, 4 innovation scores are included (see Table 3.3) (AASHE, 2014). According to their own situation, each university evaluates and scores the completion degree of each construction, and the final score is S-value. According to the S-value, the final evaluation results are rated as Platinum, Gold, Silver and Bronze from high to low.

Table 3.14: Main Evaluation Contents and Scores of STARS (AASHE, 2014)

Categories	Sub-items	Assessment content	Full Credit
Academics	Curriculum	Formal sustainability education programs and courses in schools	40
	Research	Research on sustainability	18
Engagement	Campus engagement	Formal courses beyond sustainable learning experience, faculty involvement, training sustainability development projects	20
	Public engagement	Helping promote sustainable development projects, community partnerships and services through public participation	22
Operations	Air&Climate	Emission measurement of greenhouse gases and air pollutants and measures taken to reduce emissions	11
	Buildings	Improving the performance of sustainable buildings	8
	Dining services	Supporting sustainable food systems	7

	Energy	By saving and efficiency, reduce energy consumption, turning to cleaner and renewable energy sources, such as solar, wind, geothermal and hydroelectric power	10
	Grounds	Sustainability plan	3-4
	Purchasing	Use the purchasing power to help build a sustainable economy	6
	Transportation	Sustainable development of transportation system	7
	Waste	Reduction of waste, reuse, recycling and composting	10
	Water	Preserve water sources, strive to protect water quality, treat water resources as a resource rather than a waste product	5-9
Planning & Administration	Coordination, Planning & Governance	Sustainability resources and coordination input Systematic Management, planning for Sustainability, attracting Students and staff Management	8
	Diversity & Affordability	Campus diversity and affordability	10
	Health, Wellbeing & Work	Integrating sustainable development into human resources plans and policies	7
	Investment	Investment decision-making for sustainable development	7
Innovation		Innovation	4

3.3.5 Logit Regression Model

The Logit model is widely used in the study of Willingness To Pay (Gomez-Valenzuela V, Alpizar F, 2020). Logit model is one of the discrete choice models. In 1974, McFadden proved that the utility uncertainty of the model in the form of Logit must obey the extreme value distribution, which verified the rationality of Logit model for solving the choice problem (Xiaolin Wang, Xiujie Zhao, 2020). After that, other discrete choice models have been derived and developed, such as Probit analysis (a nonlinear model) and Logistic regression analysis, forming a complete discrete choice model system (Xiaolin Wang, Xiujie Zhao, 2020). The formulas of Probit and Logistic are very similar. Probit assumes that the random variables obey the normal distribution, while Logistic function assumes that the random variables obey the logical probability distribution (Cortes JC, Navarro-Quiles A, 2019). In this study, the distribution of factors affecting the school's sustainable investment willingness does not conform to the normal distribution of random variables, but conforms to the logical distribution. Therefore, Logistic model is adopted in this study to analyze the data.

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CHAPTER 4

COMPARISON AND SUITABILITY OF EVALUATION STANDARDS OF SUSTAINABLE CAMPUS BETWEEN CHINA AND AMERICA

CHAPTER 4 COMPARISON AND SUITABILITY OF EVALUATION STANDARDS OF SUSTAINABLE CAMPUS BETWEEN CHINA AND AMERICA

4.1 Evaluation Method of Standards

4.1.1 Organization and Participation

STARS is published by AASHE. AASHE is an alliance spontaneously organized by colleges and universities. Its purpose is to promote the concept of sustainable development of universities, and emphasize the construction of sustainable concept. This organization mode is conducive to mobilize the enthusiasm of participants and improve the degree of participation （AASHE，2021a） . *STARS* is continuously developed and improved through the feedback of participants. The self-assessment report of *STARS* adopts the individual accountability system, requiring students to participate in the evaluation committee and institutions fully share the scores and data. *STARS* is compiled by AASHE through collecting feedback from participants of 2006 symposium, 2007 Rocky Mountain sustainable development summit, 2007 smart and sustainable campus conference and 2007 campus greening conference (AASHE， 2021d） .

According to the requirements of the Green Building and Energy Saving Committee of China Urban Science Research Association, *Standard* is compiled after extensive investigation and research, by referring to the relevant standards at home and abroad, and on the basis of extensive consultation （CGBC, Tongji University, CABR， 2019） .The *Standard* is compiled and issued by the government. This kind of government leading development mode has strong operability and implementation from top to bottom. However, due to the lack of positive feedback regulation mechanism, the flexibility is lower than *STARS*. Many departments in Chinese universities are relatively independent, and data is not shared among them. Although some universities have set up special management departments for campus sustainable, it is difficult to mobilize the participation of other departments. Therefore, in the construction of sustainable campus in the future, the consensus of sustainable development in the whole campus has become an important issue in sustainable administration to mobilize the enthusiasm of students, teachers, employees and departments (Putri, N., Amrina, E., and Nurnaeni, S., 2020).

4.1.2 Scoring method

The *Standard* sets up a scoring method combining control items, scoring items and bonus items （CGBC, Tongji University, CABR， 2019） . Among them, the control items must be met by all the participating institutions. It sets the minimum requirements for sustainable campus and pursues the balanced development of each campus. As a routine measure to evaluate the sustainable development of institutions, scoring items account for a large proportion of the total scores (see Figure 4.1). Bonus items can stimulate the creativity and initiative of campus and promote the personalized and characteristic development of sustainable campus. Such an evaluation method can ensure the lowest level of sustainable campus construction and help institutions control the overall direction of campus development. At the same time, based on the actual situation of the campus, combined with long-term development planning, the sustainable measures suitable for the development can be chosen. The score can not only directly reflect the sustainability in campus, but also play an incentive role for the participants.

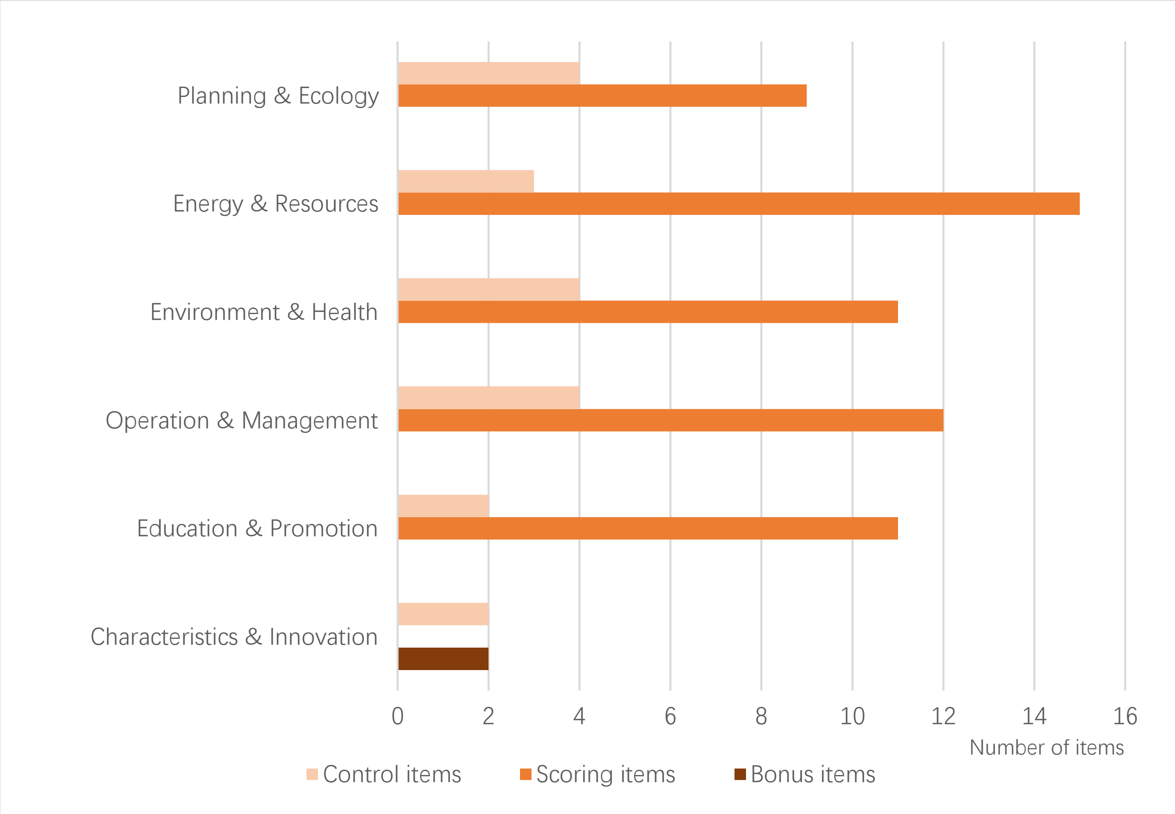

Figure 4.1: The Proportion of Six Categories of Evaluation Items in the *Standard*

The evaluation content of *STARS 2.2* is divided into five categories, which are further divided into 17 sustainability impact areas, and each area is scored according to the requirements. According to the final score, the evaluation rating with the lowest score requirement, is determined （AASHE, 2019） . Adopting the scoring method of controlling total score can give full play to the subjective initiative of participants. The participants only need to choose the evaluation items they want to participate in, which highlights the development of their characteristics. The process of evaluation is also the process of understanding the concept of sustainable development. Before determining the application for evaluation, the participants need to study the guidelines and relevant cases to ensure a systematic and comprehensive understanding of sustainable development.

4.2 Evaluation Content of Standards

4.2.1 The Scope of Evaluation

The evaluation scope of *STARS 2.2* includes five categories: Academics, Engagement, Operations, Planning & Administration and Innovation & leadership. The former four are conventional evaluation categories, and the last Innovation & Leadership category is additional category. The former four general assessment categories are divided into 17 sustainability impact areas: Curriculum, Research, Campus engagement, Public engagement, Air & Climate, Buildings, Energy, Food & Dining, Grounds, Purchasing, Transportation, Waste, Water, Coordination & Planning, Diversity & Affordability, Investment & Finance and Wellbeing & Work （AASHE, 2019） . The evaluation contents of the *Standard* are: Planning & Ecology, Energy & Resources, Environment & Health, Operation & Management, Education & Promotion and Characteristics & Innovation. The former five are the conventional evaluation categories, and the last one is the feature additional category （CGBC, Tongji University, CABR， 2019） . Based on the 17 sustainability areas of *STARS*, this chapter classifies the scoring items in the *Standard*. The results show that the evaluation contents of the *Standard* are less than that of *STARS* in four areas: Food & Dining, Purchasing, Diversity & Affordability, Investment & Finance (see Figure 4.2).

In terms of Investment & Finance, most American universities are supported by alumni and enterprises, so they pay attention to the sustainability of their capital operation （Muller, Helen S., 2004） . While, most Chinese universities belong to the national or local government, and are supported by the national finance. Therefore, the investment of the university itself has not been included in the consideration of sustainable construction. However, with the rise of private universities and the financial adjustment of public universities （Wu, J., Zhi, T.， 2020） , the area of Investment & Finance should be included in the whole sustainable campus. The area of Diversity & Affordability, on the one hand, advocates fair competition on campus and individual diversity; on the other hand, reflects the concern for minorities and vulnerable groups. For America, racial discrimination need to be eliminated, so as to promote the integration of different cultures. For China, all ethnic minorities need to be united, and remote and backward areas are supported （Duan, J., 2009） . Therefore, it is necessary to bring Diversity & Affordability into the scope of green campus evaluation in China. The area of Purchasing represents the input of material products in colleges and universities. The construction of sustainable campus should start from the source, emphasizing the green and sustainable life cycle of the whole campus. However, the characteristics of each university are different, so there is no need to impose too many restrictions, just set a guarantee in the control items. In terms of Food & Dining, *STARS* mainly puts forward two aspects of evaluation: one is the choice of catering food and suppliers; the other is to provide a variety of catering services such as vegetarian food. The former is necessary to evaluate and ensure the safety in purchasing, and provide healthy food supply. The latter involves personal eating habits, and is greatly influenced by religion, region, national culture and other factors, which cannot be enforced. At the same time, the canteens of universities in China are basically operated by contractors and implemented a competitive mechanism, so they basically provide a wealth of product choices （Xu, Y., 2009）.

4.2.2 Score Proportion

In the 17 sustainability areas of *STARS*, the score proportions of most areas are about 5%. Among them, the score proportions of four areas are particularly high, with 19.5% in Curriculum, 10.2% in Campus engagement, 9.8% in Public engagement and 8.6% in Research. The lowest score proportion is Grounds with 2.0%. While, in the *Standard*, except for the lack of the four areas mentioned above, the score proportions of most areas are between 2% and 8%. The largest proportions are in five areas: Buildings (17.2%), Coordination & Planning (17.2%), Water (8.8%), Grounds (8.6%) and Energy (8.4%). The lowest score proportion is Research with 2% (see Figure 4.2) (AASHE，2019).

It can be seen that a). *STARS* is relatively balanced in various areas, and Academics and Engagement are the key points of construction. b) The *Standard* has great differences in various areas, focusing on the development of Buildings and Planning. c) *STARS* and *Standard* for the focus of the evaluation is quite different, showing a completely different proportion of the score. China pays more attention to buildings, planning, energy and other material aspects of campus, which has a lot to do with the evolution of China's green campus from energy-saving campus, emphasizing infrastructure construction in the early stage (Faghihi, V., Hessami, A., and Ford, D., 2015). America pays more attention to curriculum, engagement and research, which shows that America focuses on the cultivation of sustainable and participation of teachers and students (Too, L., Bajracharya, B., 2015). From a long-term point of view, the cultivation of sustainable talents in the United States is of great significance to promoting the development of green campus and the sustainable development of society, and China's understanding of sustainable campus should also be transformed from infrastructure construction to spiritual civilization construction. Therefore, it is suggested to adjust the proportion of each evaluation area in the *Standard* and balance the score proportion among each area appropriately. At the present stage, the Curriculum and Research areas with a lower proportion in the *Standard* should be improved, and proportion of Buildings’ value should be appropriately reduced, so as to advocate sustainable campus to cultivate green talents, improve green management, promote green education and promote the sustainable development of the whole society （Wang, Z., Zhang, Q., 2019）.

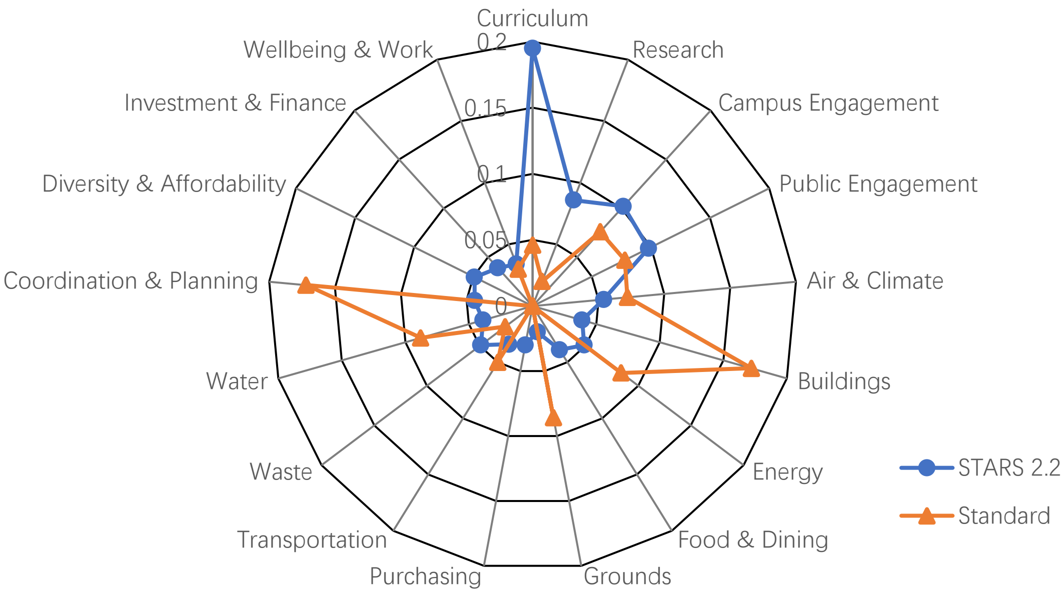

Figure 4.2: The Distribution of Evaluation Content and Score Proportion between *STARS 2.2* and *Standard*

4.3 The Application of STARS

4.3.1 The Average Scores in 17 Sustainability Impact Areas

The data are collected and released by AASHE from 356 institutions in the world participating in the *STARS* assessment. The types of universities involved associate colleges, baccalaureate institutions, master's institutions and doctorial institutions. It is based on reports evaluated by *STARS* version 2.0, 2.1, and 2.2, and submitted in the three years from March 7, 2017 to March 6, 2020 （AASHE，2021c）.

The overall average score of 356 institutions is 57.19 (2018), 58.00 (2019) and 58.18 (2020), which shows that the overall development trend is stable and remains at about 58.00 （AASHE，2021c）. But the overall score is not high, in the medium level. According to the criterion set by *STARS*, there is still great room for sustainable campus development in the future. According to different types of institutions, the highest score is doctoral institutions, the same score is found in baccalaureate institutions and master's institutions, and the lowest score is associate colleges, It can be seen that the sustainable development level of campus is related to the degree type of the university, which further indicates that there is a certain relationship between the sustainable development level of campus and the scientific research level of the institution (see Figure 4.3).

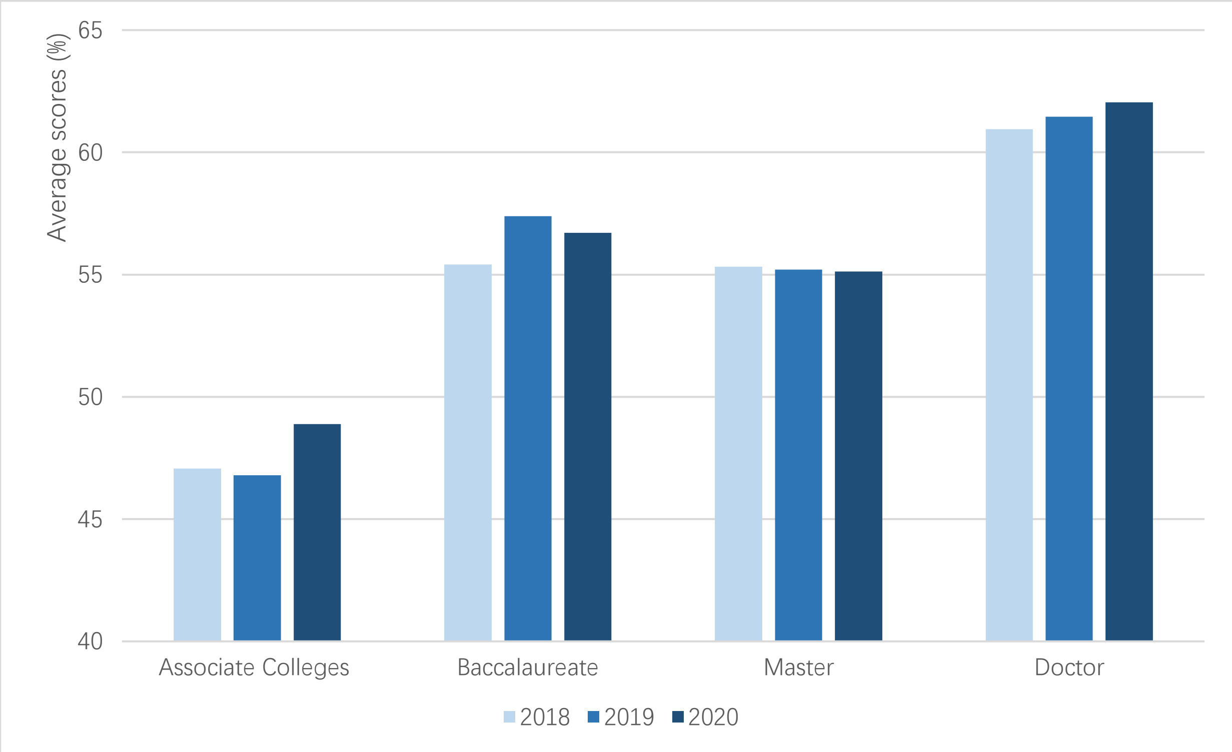

Figure 4.3: Average Scores of Different Types of Universities by *STARS* (2018-2020)

Based on the statistics of the average scores of 17 sustainability impact areas (2020) in *STARS*, since the total scores of each area are different, the scores of each area are compared with the score rate. It is found that the scores of 17areas are quite different (see Figure 4.4), indicating that the sustainable development of various areas is not balanced. Among the four categories, Academic and Engagement scores are higher than the overall average score. The scores of half items in Planning & Administration are higher than the overall average score, and the other half items are lower. The scores of Operation category are lower than the overall average score. It can be seen that the short board of global sustainable campus lies in the Operation part, which represents the development and application of environmental friendly technology measures and the operation of campus infrastructure. As a whole, it presents the development trend of strong education and management, weak technology & operation.

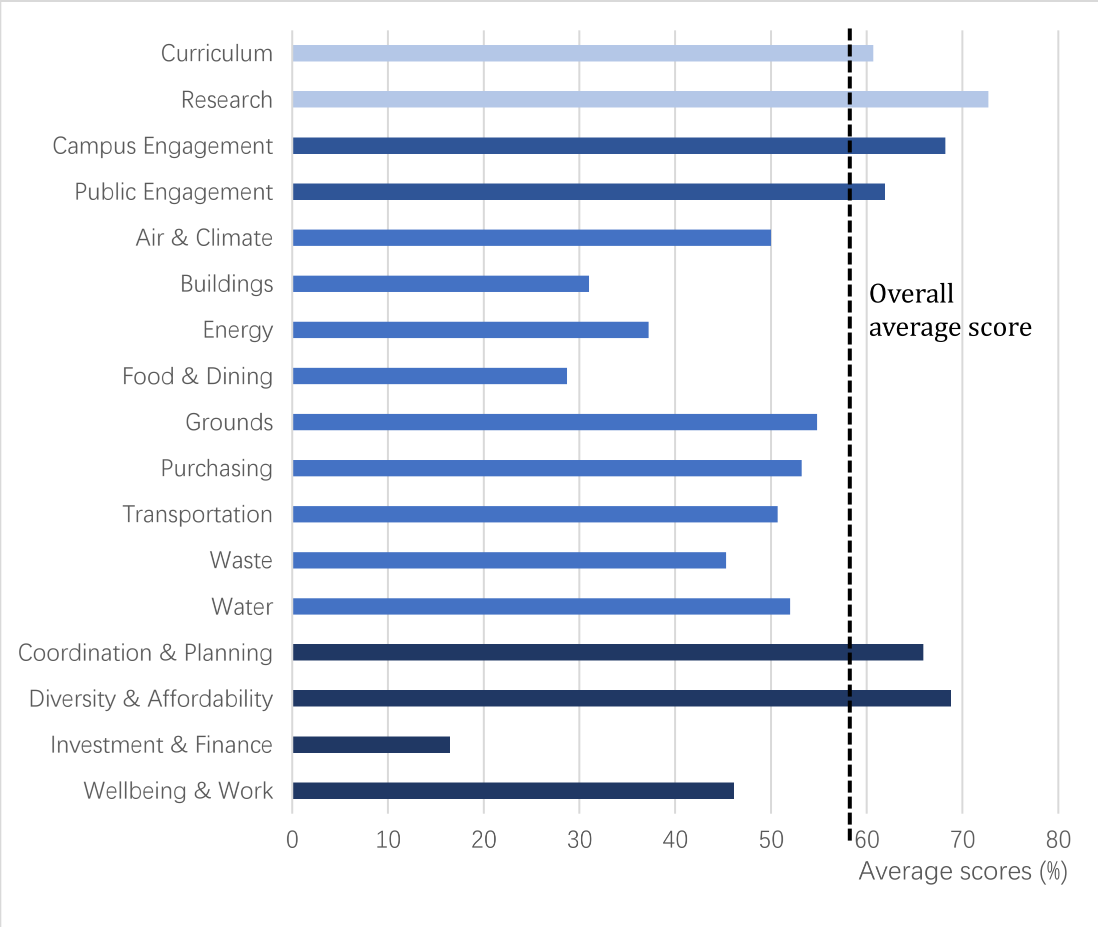

Figure 4.4: Average Scores of *STARS* in 17 Sustainability Impact Areas

Among the 17 sustainability impact areas, Research (72.7), Campus engagement (68.2), Coordination & Planning (65.9) and Diversity & Affordability (68.8) have scored higher, which have become the focus of global sustainable campus and achieved good results. Except for Diversity & Affordability, the other three areas have corresponding contents in the *Standard*. In the future, Diversity & Affordability should be added to the *Standard* to keep pace with the trend of global sustainable campus development.

Among the 17 sustainability impact areas, Buildings (31), Energy (37.2), Food & Dining (28.7) and Investment & Finance (16.5) score the lowest. These four areas have become the weak points of global sustainable campus development, and are the focus of improving sustainability in the future. What's more, Investment & Finance is the lowest among the 17 areas. And most of the participating universities have little or very low scores in this area, which is not conducive to feedback their own construction through detailed evaluation. However, there is no corresponding evaluation clause in the *Standard*. In the future, it is suggested that the relevant evaluation clauses in this field should be added to the *Standard*. With refining and appropriately reducing the requirements according to the relevant evaluation contents of *STARS*, China formulate its own evaluation clauses, so as to explore new development ideas and participate in global sustainable

Investment & Finance. Food & dining with the second lowest score, also has no corresponding evaluation content in the *Standard*. As the eating habits of individuals in China are greatly influenced by religion, region, national culture and other factors, the *Standard* can only add relevant clauses on food safety and health, so as to focus more on the sustainability of Food & Dining in Chinese universities. Building energy consumption accounts for the vast majority of campus energy consumption, so Buildings and Energy are closely related （Bryan, Bradley., 2014）. The evaluation content of the *Standard* for this area is very detailed, while the evaluation of buildings in *STARS* is too general and not detailed enough. Therefore, the *Standard* can better provide specific measures and goals for the sustainable development of this area. It is been the focus of China's sustainable campus construction. Because China's sustainable campus is developed from energy-saving campus, and has a certain construction history and good achievements, China's construction experiences can be used for reference by the world, jointly promoting the global sustainability.

4.3.2 High-impact Institutional Highlights

Based on the 40 high-impact institutional highlights released by AASHE in 2020, we classify these 40 projects into 17 sustainability impact areas. High-impact institutional highlights are the most representative sustainable innovation projects selected by AASHE from the sustainability assessment reports of colleges and universities received from March 2, 2019 to March 6, 2020 （AASHE，2021c）. These projects represent the continuous attempts and challenges of global sustainable campus in 17 areas, so as to provide specific action plans for sustainable campus development in the future.

Through statistics, it is found that among the 17 areas, the top three areas involved by 40 projects are Public engagement with 11 projects, Energy with 10 projects and Campus engagement with 8 projects (see Figure 4.5). Among them, Public engagement and Campus engagement have the same high ranking of the percentage scores in *STARS*, which indicates that campus and society have a high degree of participation in sustainable campus construction. At the same time, multi participation and cooperation can further enrich the connotation of sustainable campus and promote the popularization of green concept in the world. The area of Energy shows that colleges and universities attach importance to energy conservation in the construction of green campus, which is consistent with China's *Standard* on energy conservation and environmental protection. It shows the urgency of the world's energy problem in sustainable development and is one of the common challenges facing the world (Mi Yan, Agamuthu P, Joko Waluyo, 2020). Among these 17 areas, two areas involved the least are Purchasing with on project and Transportation with only one project, which is consistent with the ranking of STARS’ score proportion, reflecting that these areas are not the focus of the current global sustainable campus.

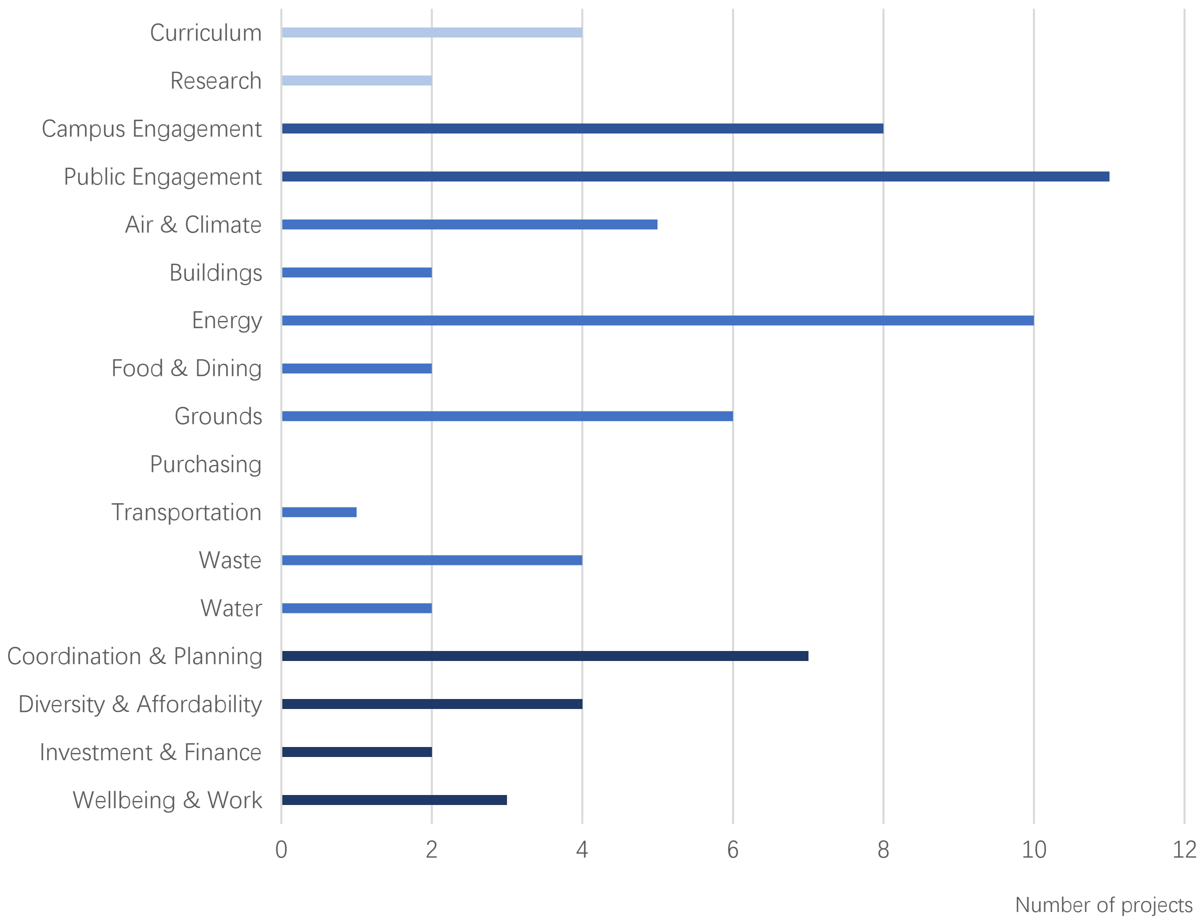

Figure 4.5: The Number of High Impact Institutional Highlights in 17 Sustainability Impact Areas

4.4 The Conclusions of Comparison

This chapter makes a comparative study on the latest edition of the evaluation standards of sustainable campus in China and America, namely *Green Campus Evaluation Standard (GB / T51356-2019)* and STARS 2.2. It develops from three dimensions: the development process of sustainable campus in China and America, the evaluation method & content and the application of *STARS* in the world. It can be concluded as follows:

(1) There are great differences in the development process of sustainable campus between China and America. The United States has always been committed to deepening the concept of “green” and forming a comprehensive connotation of sustainable campus. While China has transformed from "energy saving" campus, focusing on energy saving and green building construction. The development of sustainable campus related policy documents is consistent with the development of campus. The sustainable campus evaluation standard in America is independent

of the green building evaluation standard with developing in parallel. China's sustainable campus evaluation standard based on the green building evaluation standard, is developed from the campus energy conservation policy.

(2) There are great differences between the evaluation standards of China and America in organization & participation mode, evaluation method and content. *STARS* adopts a "bottom-up" organizational model and has a high degree of participation. The *Standard* is implemented by the way of "top-down" administrative order, and the participation of the whole school is not as good as *STARS*. As for the standard evaluation method, *STARS* adopts the open self-evaluation mode, which ensures the freedom and characteristics of the participating universities. The *Standard* adopts the scoring method of combining control items and scoring items, which ensures the minimum level of sustainable campus and encourages the adoption of more appropriate construction measures. In terms of the content of evaluation, the *Standard* does not cover as many fields as *STARS*, such as Food & Dining, Purchasing, Diversity & Affordability, Investment & Finance. There is a huge difference between the two standards in terms of scores, *STARS* has a large proportion in terms of Academic and Engagement. While the *Standard* sets most of the scores in terms of Buildings and Planning.

(3) The overall average score of 356 universities Participating in the *STARS* assessment in 2020 is 58.18. And the global sustainable campus is still in the medium development level. Among the 17 sustainability impact areas, Research, Campus Engagement, Coordination & Planning and Diversity & Affordability score the highest. The lowest scores are Buildings, Energy, Food & Dining and Investment & Finance. They will become the focus of sustainable campus in the future. From 2019 to 2020, the areas most involved by the global innovative and high impact projects are Public engagement, Energy and Campus engagement. These projects have made innovation and contribution to the sustainable development of global sustainable campus in these areas.

Through the systematic comparison of the two standards, it is of far-reaching significance to the development of sustainable campus and evaluation standards. The advantages and disadvantages of the current global sustainable campus construction are clarified, and the basis for the next stage of development policy is provided. At the same time, countries continue to optimize their own evaluation standards, which will help them to formulate construction guidelines that not only meet their own actual needs, but also conform to the trend of global sustainable campus development （Zhu, B., Zhu, C. and Dewancker, B., 2020）.

In terms of Chinese standard, the main optimization suggestions are as follows:

(1) China's sustainable campus construction is in the initial stage of development from "energy-saving campus" to "sustainable campus". The standard should pay more attention to the overall connotation of sustainable campus and better connect with the world on the basis of keeping campus energy saving and green building as the core content.

(2) In the evaluation method, the combination of control items and scoring items can be

continued to use. The proportion of scoring items can be appropriately increased, so as to encourage more innovation and practice.

(3) In terms of evaluation content, the evaluation clauses in the areas of Food & Dining, Purchasing, Diversity & Affordability and Investment & Finance should be added. Among them, the Investment & Finance field can be refined on the basis of *STARS* to formulate its own evaluation. In the area of Food & Dining, clauses to ensure food safety and health are mainly added.

(4) In order to ensure the common development of all areas, it is necessary to balance the proportion of the scores in each area of sustainability, especially in the areas of Curriculum, Research and Engagement.

(5) China should change the way of issuing the evaluation standard based on administrative orders, actively publicize the concept of sustainability, mobilize all teachers, students and staff to participate in the sustainable construction of the campus, forming a construction mechanism of public participation and feedback optimization.

4.5 Setting of Evaluation Method

4.5.1 User Satisfaction Assessment

This study uses the advantage of fuzzy comprehensive evaluation method to quantify users' satisfaction and evaluate the overall satisfaction of green campus under the influence of many factors.

Satisfaction assessment uses questionnaire form to collect data. Questionnaire design is evaluated from two aspects: importance and satisfaction. In terms of importance, respondents need to rank the four indicators at the index level first, and then rank the factors in each index separately. In terms of satisfaction, the respondents evaluate the construction satisfaction of 17 evaluation factors in turn. Satisfaction was assessed by Likert scale of 5 levels, which was represented by 1-5: unsatisfied, less dissatisfaction, neutral, less satisfaction and satisfied. By calculating the weight of each factor and satisfaction score, we can understand the satisfaction degree of each factor and the overall satisfaction degree in the evaluation system.

For the evaluation system of sustainable campus construction based on users' demand, this study has three levels: target level, index level and factor level. The target level is the overall satisfaction of users; the second level is academics, engagement, operations and planning & management; and the third level is a number of evaluation factors corresponding to each index level (see Table 4.1).

Table 4.1: Satisfaction Assessment of Green Campus Construction

Index	Factors	Evaluation Content
Academics (A)	Curriculum (A1)	Formal sustainability education programs and courses in schools
	Research (A2)	Research on sustainability
Engagement (E)	Campus engagement (E1)	Formal courses beyond sustainable learning experience, faculty involvement, training sustainability development projects
	Public engagement (E2)	Helping promote sustainable development projects, community partnerships and services through public participation
Operations (O)	Air & Climate (O1)	Emission measurement of greenhouse gases and air pollutants and measures taken to reduce emissions
	Buildings (O2)	Improving the performance of sustainable buildings
	Dining services (O3)	Supporting sustainable food systems
	Energy (O4)	By saving and efficiency, reduce energy consumption, turning to cleaner and renewable energy sources, such as solar, wind, geothermal and hydroelectric power
	Grounds (O5)	Sustainability plan
	Purchasing (O6)	Use the purchasing power to help build a sustainable economy
	Transportation (O7)	Sustainable development of transportation system
	Waste (O8)	Reduction of waste, reuse, recycling and composting
	Water (O9)	Preserve water sources, strive to protect water quality, treat water resources as a resource rather than a waste product
Planning & Administration (P)	Coordination, Planning & Governance (P1)	Sustainability resources and coordination input Systematic Management, planning for Sustainability, attracting Students and staff Management
	Diversity & Affordability (P2)	Campus diversity and affordability
	Health, Wellbeing & Work (P3)	Integrating sustainable development into human resources plans and policies
	Investment (P4)	Investment decision-making for sustainable development

4.5.2 Establishment of Two-dimensional Suitability Evaluation Coordinate System

The sustainability evaluation results of STARS are compared with the satisfaction evaluation results of users. According to the scores, a two-dimensional suitability evaluation coordinate system is established (see Figure 4.6).

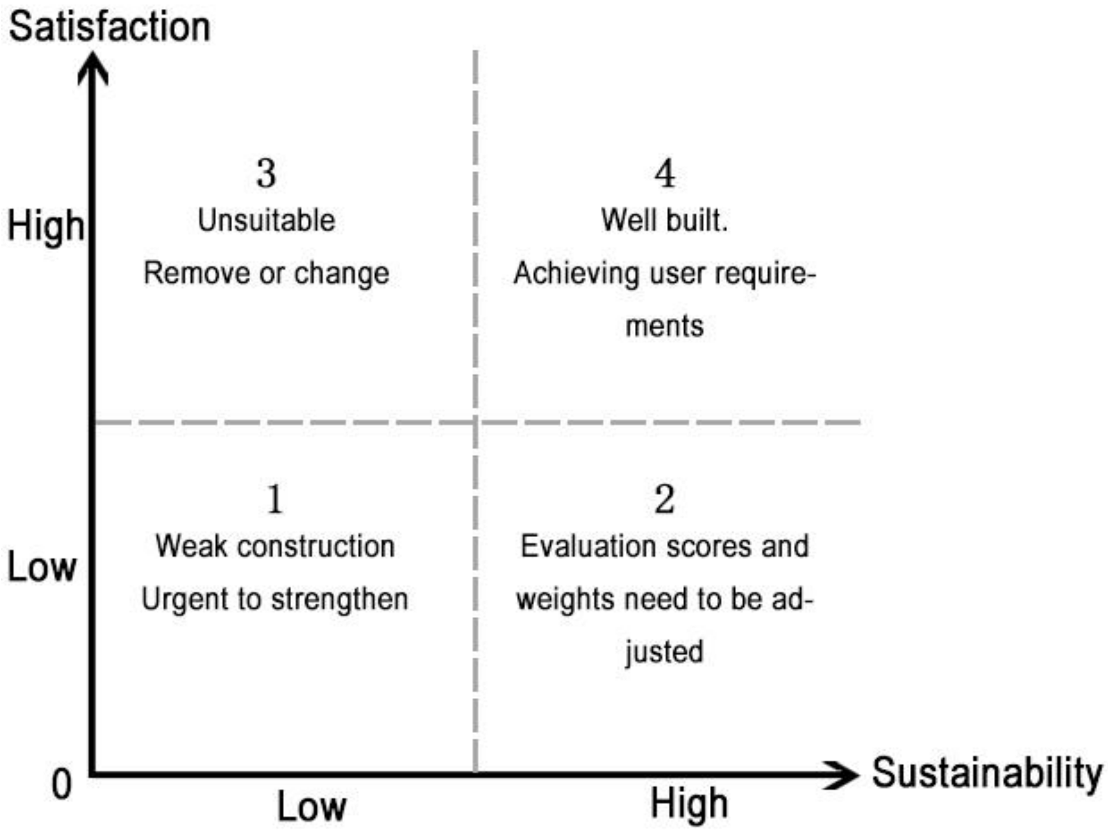

Figure 4.6: Two-dimensional Suitability Evaluation Coordinate System Diagram

The two coordinate dimensions of the evaluation coordinate system are user satisfaction and campus construction sustainability. Each coordinate dimension is divided into high and low zones according to its overall evaluation value (overall sustainability value, overall satisfaction value). The coordinate system is divided into four scoring areas according to the score of two dimensions., i.e. Area 1, with low satisfaction and sustainability, which indicates that the evaluation item is weak in construction, high in demand, and urgently in need of further development and promotion; Area 2, with low satisfaction and high sustainability indicates that the score and weight of the evaluation on China's conditions are unreasonable and need to be adjusted.; Area 3, with high satisfaction and low sustainability, shows that the evaluation content is not suitable for the current green campus construction in China, and can be directly removed or changed; Area 4, with high satisfaction and sustainability, shows that the pre-construction of the item is better and can basically meet the needs of campus users' demand.

4.5.3 Selection of Evaluation Case

The main purpose of this chapter is to discuss the suitability of STARS through the study of case university, rather than to study the commonalities of green campuses in China through multiple case studies. Therefore, this study selects one university that is one of founding member of China Green University Alliance as a specific case to study. First of all, this university is a comprehensive and research-oriented university, which is in line with the characteristics of multi-disciplinary integration and multi-campus composition in Chinese universities at present. Secondly, as one of the first national energy-saving campus demonstration institution in green campus construction, the construction time is long and the construction results are rich, which fits in with the development process of China's green campus, and better represents the achievements of China's green campus construction. So the case university represents a group of the best green campuses in China. As for the research on the optimization of green campus standards by finding out the commonalities of green campuses in China, it is not enough to just rely on one case university. It needs to make a comparative summary of multiple cases, which is also one of the future development directions of this research. The research methods and conclusions proposed in this chapter provide new ideas for future researches.

4.6 Analysis of Suitability Evaluation Results

4.6.1 Sustainable Evaluation Results

Based on STARS evaluation system, 225 survey data points were sorted out and analyzed, 18 departments of the school were interviewed on the spot and interviewed by telephone, and combined with questionnaire survey and data annual report collection. The sustainability evaluation score was 114.95, and the silver award grade was obtained (see table 4.2).

Table 4.2: STARS Sustainability Evaluation Results

<table>
<tr><th>Categories</th><th>Sub-items</th><th>Score</th><th>Category score</th><th>Total score</th><th>Rating</th></tr>
<tr><td rowspan="2">Academics</td><td>Curriculum</td><td>30.17（40）</td><td rowspan="2">43.88（58）</td><td rowspan="9">114.95（203）</td><td rowspan="9">Silver</td></tr>
<tr><td>Research</td><td>13.71（18）</td></tr>
<tr><td rowspan="2">Engagement</td><td>Campus engagement</td><td>14.85（20）</td><td rowspan="2">33.61（42）</td></tr>
<tr><td>Public engagement</td><td>18.76（22）</td></tr>
<tr><td rowspan="5">Operations</td><td>Air & Climate</td><td>0（11）</td><td rowspan="5">17.29（71）</td></tr>
<tr><td>Buildings</td><td>0（8）</td></tr>
<tr><td>Dining services</td><td>5（7）</td></tr>
<tr><td>Energy</td><td>0（10）</td></tr>
<tr><td>Grounds</td><td>2（4）</td></tr>
</table>

	Purchasing	1.5（6）			
	Transportation	4.17（7）			
	Waste	2.2（10）			
	Water	2.42（8）			
Planning & Administration	Coordination, Planning & Governance	8（8）	20.17（32）		
	Diversity & Affordability	6（10）			
	Health, Wellbeing & Work	2.5（7）			
	Investment	3.67（7）			

Note: The full score of this item is in parentheses.

The evaluation results show that the overall level of campus sustainability construction is silver rating, with overall score rate of 0.566, which is below the global medium level. Among them (see Figure 4.7), the level of sustainability in Curriculum, Research, Engagement, Dining services and Coordination, Planning & Governance is relatively high, which is related to the construction of green campus in China from the perspective of software. According to the advantages of teaching and scientific research, the sustainable construction of campus is emphasized from the perspective of policy and service. In terms of Grounds, Transportation, Diversity & Affordability and Investment, they are equal to the overall level of construction. These aspects can be greatly developed in the future due to the accumulation of certain construction achievements. In Air & Climate, Buildings, Energy, Purchasing, Waste, Water and Health, Wellbeing & Work, sustainability is very low, some even zero. On the one hand, the results of sustainable construction are obviously insufficient in these aspects. On the other hand, it may be because the evaluation criteria are not suitable for the current situation of China's construction in terms of the content and proportion of scoring points.

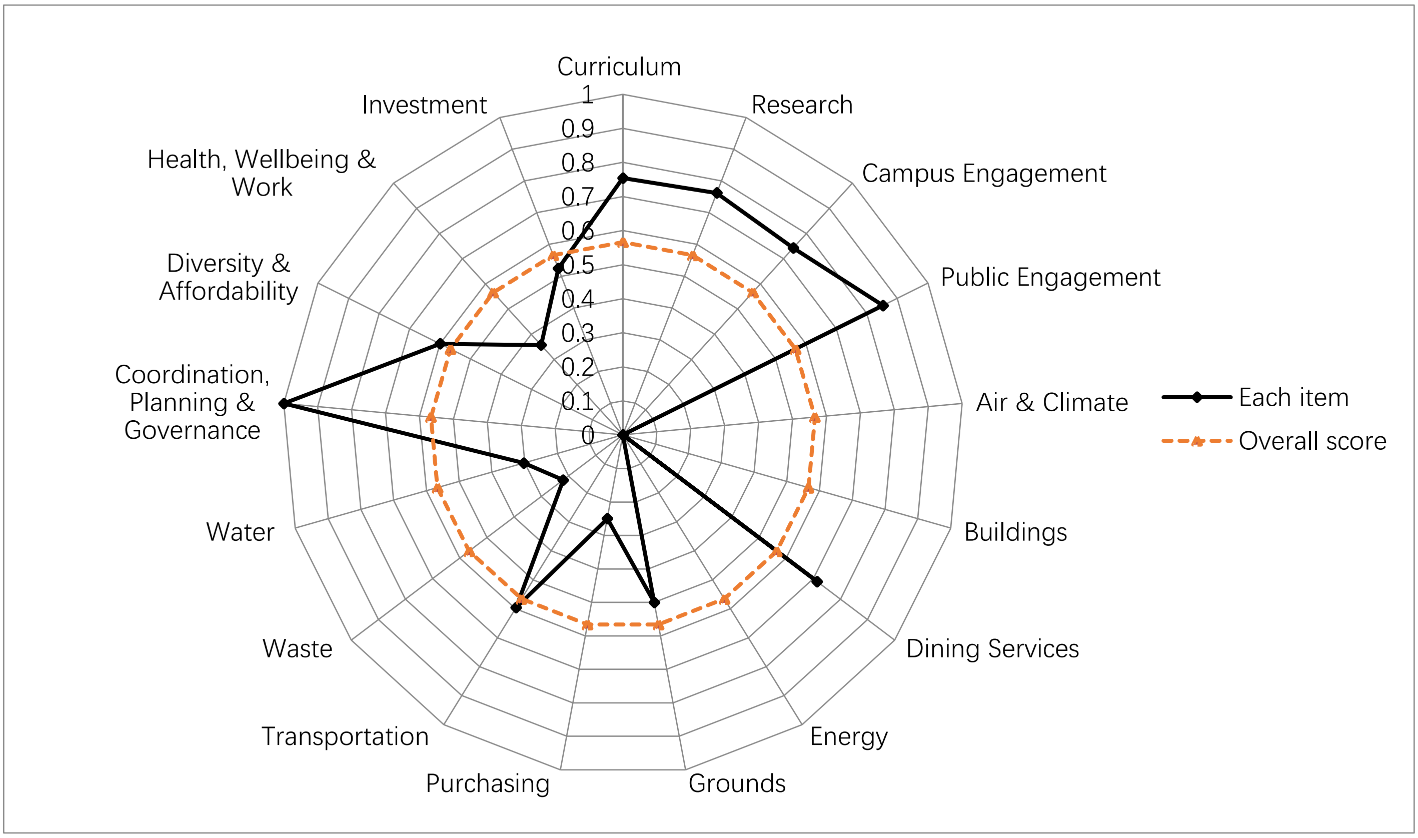

Figure 4.7: Score Ratio of Sustainability Evaluation Items

4.6.2 Satisfaction Assessment Results

Considering the particularity of campus users, each group has its own aspects and focus of attention in the sustainable construction of campus, so the subjects of this study are set as students, teachers and employees, and the final number of respondents is determined according to the proportion of the three groups in the current school. At the same time, the selection of respondents takes into account different professional background, different grades, different posts and different campuses. From April to May in 2019, the questionnaire was carried out in five campuses of the case university. We chose the main teaching buildings, canteens and administrative office buildings as the main survey sites. A total of 500 questionnaires were distributed, including 412 students, 30 teachers and 55 employees (3 of them were invalid) according to the ratio of students, teachers and employees 13.6:1:1.8. The data will be used to test the reliability of SPSS questionnaire. The reliability coefficient of this survey is 0.756 (a > 0.7), which shows that the reliability of the questionnaire is good.

(1) Weight of satisfaction assessment indicators

In this study, users are allowed to score the importance of evaluation factors independently in order to truly and objectively respond to the needs of sustainable campus construction. At the index level, the four indicators are sorted according to their importance, while at the factor level, the most important indicator is selected in category A, one in category E, four in category O and two in category P. According to the ratio of score to total score, the weight (W) of each index and factor is obtained (see table 4.3).

Table 4.3: The Weights of Indicators & Factors

Index	Weight（W）	Factors	Weight（W）
Academics (A)	0.192	Curriculum (A1)	0.475
		Research (A2)	0.535
Engagement (E)	0.227	Campus engagement (E1)	0.352
		Public engagement (E2)	0.648
Operations (O)	0.454	Air & Climate (O1)	0.068
		Buildings (O2)	0.123
		Dining services (O3)	0.022
		Energy (O4)	0.24
		Grounds (O5)	0.081
		Purchasing (O6)	0.052
		Transportation (O7)	0.105
		Waste (O8)	0.185
		Water (O9)	0.124
Planning & Administration (P)	0.127	Coordination, Planning & Governance (P1)	0.184
		Diversity & Affordability (P2)	0.282
		Health, Wellbeing & Work (P3)	0.412
		Investment (P4)	0.122

(2) Fuzzy Evaluation of Satisfaction Degree

Evaluation set V and evaluation index set U are Established. V= (V_1, V_2, V_3, V_4, V_5)= (dissatisfied, less dissatisfaction, neutral, less satisfaction, satisfied); U= (U_i) (i = A, E, O, P), factor level indicator is U_j (j = A x, Ex, Ox, Px) (x is a number).

According to the summary of the user satisfaction questionnaire (see Figure 4.8), the ratio of the number of U_j subordinate to the evaluation set V to the total number of people, that is, R_i (i=A, E, O, P). Therefore, the satisfaction assessment matrix of four kinds of index is calculated by using the fuzzy comprehensive evaluation model.

$$R_A = \begin{Bmatrix} 0.058 & 0.183 & 0.243 & 0.384 & 0.132 \\ 0.012 & 0.145 & 0.323 & 0.386 & 0.134 \end{Bmatrix}$$

$$R_E = \begin{Bmatrix} 0.022 & 0.058 & 0.152 & 0.453 & 0.315 \\ 0.183 & 0.285 & 0.323 & 0.149 & 0.060 \end{Bmatrix}$$

$$R_O = \begin{Bmatrix} 0.271 & 0.524 & 0.139 & 0.066 & 0.000 \\ 0.104 & 0.263 & 0.381 & 0.196 & 0.056 \\ 0.000 & 0.051 & 0.152 & 0.381 & 0.416 \\ 0.056 & 0.247 & 0.557 & 0.140 & 0.000 \\ 0.076 & 0.156 & 0.451 & 0.223 & 0.094 \\ 0.103 & 0.156 & 0.360 & 0.337 & 0.044 \\ 0.053 & 0.120 & 0.291 & 0.384 & 0.152 \\ 0.153 & 0.103 & 0.357 & 0.235 & 0.152 \\ 0.077 & 0.086 & 0.206 & 0.413 & 0.218 \end{Bmatrix}$$

$$R_P = \begin{pmatrix} 0.162 & 0.115 & 0.366 & 0.316 & 0.041 \\ 0.004 & 0.125 & 0.325 & 0.363 & 0.183 \\ 0.085 & 0.203 & 0.324 & 0.225 & 0.163 \\ 0.157 & 0.186 & 0.276 & 0.235 & 0.146 \end{pmatrix}$$

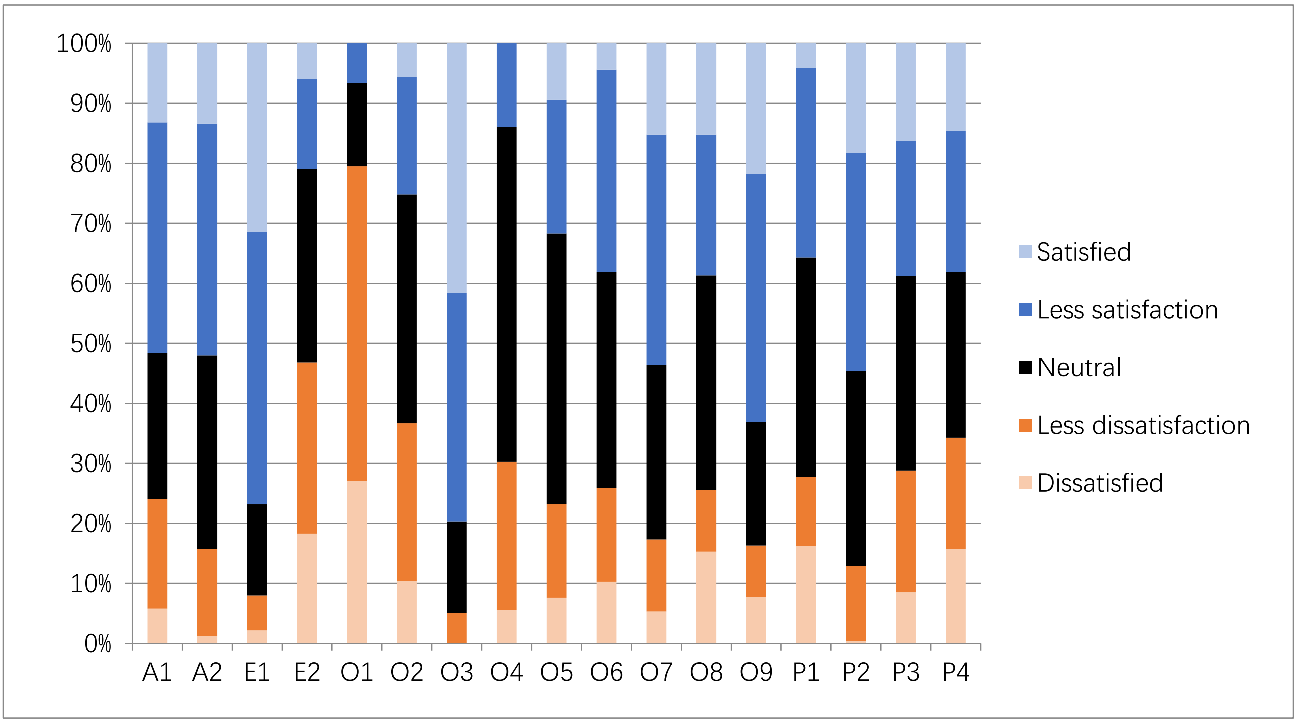

Figure 4.8: The Green Campus Satisfaction Assessment Results of Each Factor

According to the weight value W of each factor, the fuzzy comprehensive evaluation set of the second level index is calculated as follows:

$B_A = W_j \times R_A =$ (0.040 0.165 0.288 0.389 0.134)

$B_E = W_j \times R_E =$ (0.126 0.205 0.263 0.256 0.150)

$B_O = W_j \times R_O =$ (0.100 0.191 0.371 0.241 0.097)

$B_P = W_j \times R_P =$ (0.085 0.163 0.326 0.282 0.144)

The satisfaction assessment values of the four categories of index are as follows:

$E_A = b_{A1}+2b_{A2}+3b_{A3}+4b_{A4}+5b_{A5} = 3.455$

$E_E = b_{E1}+2b_{E2}+3b_{E3}+4b_{E4}+5b_{E5} = 3.098$

$E_O = b_{O1}+2b_{O2}+3b_{O3}+4b_{O4}+5b_{O5} = 3.045$

$E_P = b_{P1}+2b_{P2}+3b_{P3}+4b_{P4}+5b_{P5} = 3.237$

Through the fuzzy comprehensive evaluation method, the comprehensive evaluation set of sustainable campus satisfaction is obtained:

$A = W_i \times B_i =$ (0.091 0.186 0.325 0.278 0.122)

The final evaluation set is defuzzed to get a comprehensive evaluation of sustainable campus satisfaction:

$$E = A_1+2\times A_2+3\times A_3+4\times A_4+5\times A_5 = 3.160$$

Based on the overall satisfaction of the users of STARS for sustainable campus construction, the satisfaction of the index-level of four categories of indicators is compared with the satisfaction of the factors assigned by the Lichter scale of 5 level (see Figure 4.9). The evaluation results are as follows:

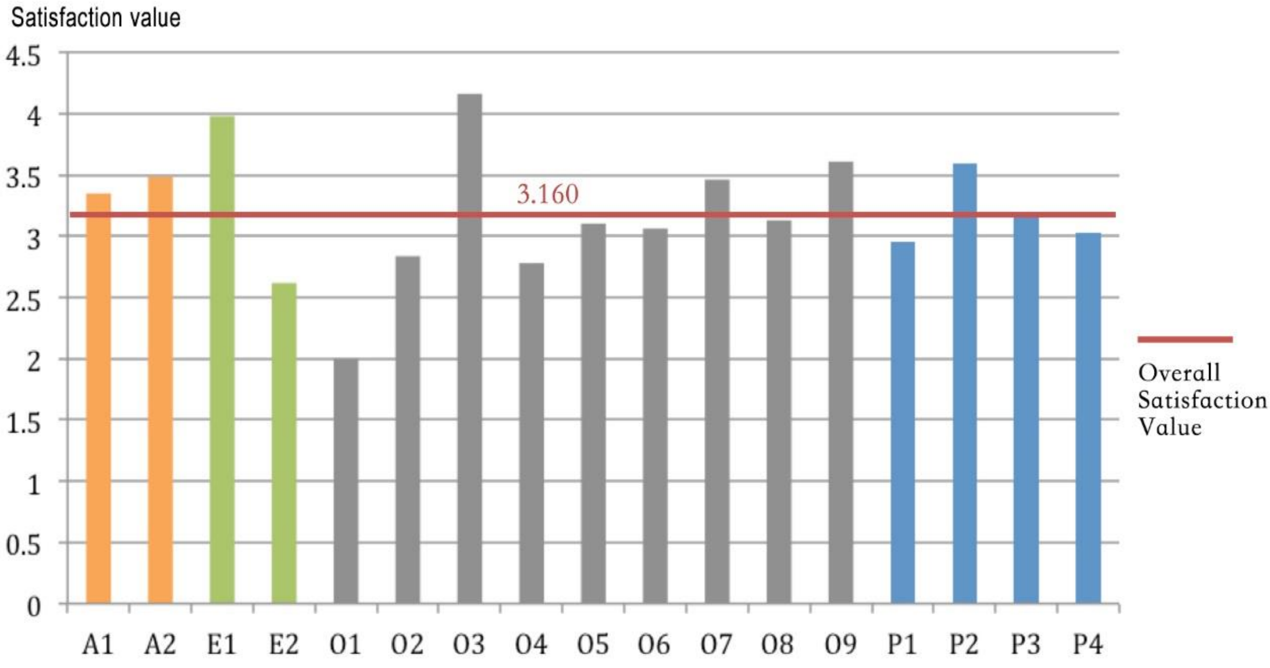

Figure 4.9: The Satisfaction Value of Each Assessment Factor

The overall satisfaction of sustainable campus construction is 3.160, which is between "neutral" and "less satisfaction". Students, teachers and employees think that the overall satisfaction of sustainable campus construction is general. Among them, the highest degree of satisfaction is Dining services (O3), which indicates that the school has a good sustainable dining service system and can maximize the diversification of dining needs, which is also a major feature of green campus construction in China. The Air & Climate (O1) factor has the lowest satisfaction. It can be seen that this part is higher from the user's demand. The reason lies in the contradiction between the air pollution of the whole environment, such as PM2.5, and the immaturity of the existing air monitoring optimization technology.

Among them, Curriculum, Research, Campus engagement, Dining services, Transportation, Water and Diversity & Affordability are of high satisfaction. From the user's point of view, the sustainable construction results meet their needs. Grounds, Waste and Health, Wellbeing & Work satisfaction are equal to the overall satisfaction. Public engagement, Air & Climate, Buildings, Energy and coordination, and Coordination, Planning & Governance satisfaction are obviously low. These aspects are closely related to users' daily campus life, involving the participation of policy planning and infrastructure construction.

4.7 The Analysis on the Suitability of STARS

Seventeen evaluation factors are distributed in four regions in the two-dimensional coordinate system of suitability according to sustainability evaluation value and satisfaction assessment value (see Figure 4.10). Most of the factors are concentrated in area 1 and area 4. It can be seen that the degree of sustainable construction is consistent with the satisfaction of campus users. That is, the higher the score of sustainable evaluation, the better the construction situation, the higher the satisfaction of users.

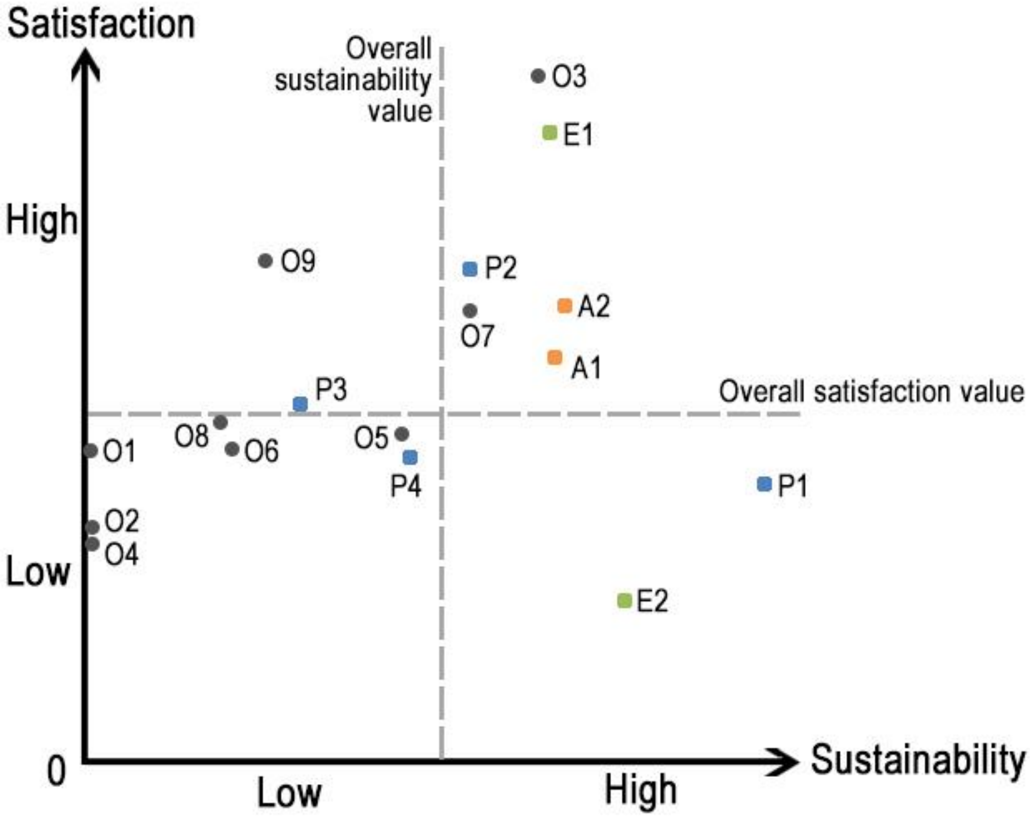

Figure 4.10: Distribution of Each Factor in Two-dimensional Suitability Evaluation Coordinate System

At present, the main indicators that fall into the area 1 are Operation index, which mainly involve the construction of infrastructure and hardware facilities of green campus and the application of environmentally friendly technology. It is pointed out that these aspects are the shortcomings of the current green campus construction in China, and far from meeting the international general requirements. At the same time, from the user's point of view, users have a strong demand for it, and the current construction situation is far from meeting their needs.

Water (O9) and Health, Wellbeing & Work (P3), which fall in the area 2, are both highly satisfied which means they have been accepted from the demand side, but their scores are low in terms of sustainability evaluation. This may be because China has relevant laws and regulations to enforce the basic working conditions and occupational health of employees, and relevant policies to require the management of water resources in universities. Therefore, the current construction situation is generally good to meet the needs of users. However, the evaluation of STARS takes North America as the starting point. Due to the differences between countries, the content does not conform to the relevant policy system of China, so it should not be included in the evaluation system of green campus in China. It is also possible that there is a divergence between the user's demand goal and the STARS evaluation goal. The STARS goal setting is not suitable for the situation in China, so the evaluation content and its construction goal need to be changed.

The indicators that fall in the area 3 are Public engagement (E2) and Coordination, Planning & Governance (P1), which have high sustainable evaluation value, especially for P1, but low satisfaction assessment score. Therefore, it is inappropriate for STARS to set the evaluation scores and weights for these two items. Especially for the evaluation of Coordination, Planning & Governance, there is a great difference between the satisfaction value and the sustainability evaluation value. These two evaluations should be re-examined. Firstly, according to China's national conditions, the emphasis of the evaluation should be adjusted from the user's point of view. Secondly, the weight of the scoring points should be set to measure specific scoring points, so as to reflect China's construction situation more truly.

4.8 Conclusions for Suitability Evaluation

4.8.1 The Results of STARS's suitability

There are 17 evaluation categories in STARS, which are generally suitable for evaluating green campus construction in China. The degree of sustainable construction in each evaluation category is basically the same as the satisfaction degree of teachers, students and employees. At present, the advantages of green campus construction in China lie in academic sustainability and "software" construction of campus services and activities. However, the application of environmentally friendly technologies and "hardware" facilities such as campus buildings, indoor air quality, energy, grounds, waste, are obviously insufficient, which can not meet the requirements of the standards, and can not meet the daily needs of teachers, students and employees. This will become the focus of work which urgently need to be promote in the next step of China's green campus construction.

There are four main categories of inappropriateness in STARS: Public engagement, Coordination, Planning & Governance, Water and Health, Wellbeing & Work. The former two need to adjust the specific scoring points and their proportion; the latter two should change or remove the specific evaluation content and focus.

In the field of Public engagement, teachers and students help promote the sustainable development of local communities through public participation, and establish partnerships or services with them. The main points of evaluation are Community partnerships, Inter-campus collaboration, Continuing education, Community service, Community stakeholder engagement, Participation in public policy and Trademark licensing (AASHE, 2014). As far as users' satisfaction is concerned more about the experience and participation of activities, we can increase the proportion of Community partnerships, Continuing education, Community service and Public policy participation on the basis of existing scoring points. Coordination, Planning & Governance mainly measures the sustainability of resource input and the coordination of investment and institutionalized management. The specific evaluation points are Sustainability coordination, Sustainability planning and Governance (AASHE, 2014). The specific manifestations are policies, plans and related institutions. From the user's point of view, most teachers, students and employees do not understand and have not engaged. This requires that the evaluation points should be adjusted, more attention should be paid to the participation of users, and the forms of implementation are mostly activities and public discussions.

The specific evaluation points of Water category are Water use, Rainwater management and Wastewater management (AASHE, 2014). Among them, water use mainly focuses on drinking water consumption and construction-vegetation area, which is completely different from the current focus on water in China. As drinking water is widely used in China from municipal pipelines, boiling water by users their own, which makes the indicator insignificant. Rainwater management mainly focuses on LID (Low Impact Development) policy standards. Since China has not implemented LID policy, rainwater and wastewater are discharged into municipal pipeline network in accordance with national standards. The implementation of reclaimed water utilization for rainwater is encouraged, so that the Water category evaluation point of STARS needs to be completely changed. The Health, Wellbeing & Work's specific points are Employee compensation, Assessing employee satisfaction, Wellness program and Workplace health and safety (AASHE, 2014). Since the evaluation points of STARS are mostly the same as those required by China's labor law, universities have basically met the relevant requirements while complying with the law. It is easy for universities to ignore statistics on completion when they think they have met the requirements. Lack of statistics leads to low scores in STARS. Therefore, in the evaluation of this category, the overlapping part with the law can be removed, and only the part evaluated by users can be retained. Meanwhile, more attention can be paid to the statistics and collection of relevant feedback data.

4.8.2 The Implications of Green Campus Evaluation Criteria in China

Campus is a community involving a certain geographical scope and spatial scale, complex buildings and facilities, diverse teaching, scientific research and life function needs, various types of teaching staff and students (Hongwei Tan et al., 2014). The evaluation system, categories and methods of green buildings cannot be fully applied to the evaluation of green campus in directly. Therefore, a diversified, qualitative and quantitative evaluation system need to be built on the basis of drawing lessons from other countries' green campus standards. At the same time, China's green campus national standard also needs to check the omissions and make up the deficiencies, closely combined with China's characteristics, so as to build a rich green campus system, and establish their own exclusive sustainable plan.

At present, the national standard of green campus evaluation in China is still in the stage of discussion and research. This study suggests that STARS can be used as a blueprint for China's national standard, using the internationally commonly used total score calculation method (B.F. Zhu et al., 2016). The research results of this study on the suitability of STARS can be used as a reference to determine the evaluation scope of national standards. Meanwhile, the evaluation points and weights of individual indicators can be adjusted to make it more in line with China's national conditions and current needs.

In addition, green campus evaluation standard is not only a technical standard, but also a development planning. It is also advocates for sustainable life. Standard setting should be integrated into the core concept of people-oriented, with a long-term concept of sustainable development. From the point of view of users' demand side, while monitoring campus energy consumption, we should pay more attention to the indoor environment quality of buildings and the degree of environmental friendliness (Luan Caixia et al., 2014). The guidance of teachers and students on energy use behavior mode are strengthened, while the sustainable life learning and working methods are advocated. Improving the sustainable development of campus hardware facilities as the carrier, the real overall upgrading can be achieved by thinking from many aspects, such as energy saving, low carbon environmental protection, efficient resource allocation, green industrial planning, economic sharing and life.

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CHAPTER 5

COMPARISON OF SUSTAINABLE CAMPUS CONSTRUCTION AND EVALUATION SYSTEM BRTWEEN JAPAN AND CHINA

CHAPTER 5 COMPARISON OF SUSTAINABLE CAMPUS CONSTRUCTION AND EVALUATION SYSTEM BETWEEN JAPAN AND CHINA

5.1 Sustainable Campus Development in Japan

Since 1990s, global environmental problems, such as climate warming, ozone layer destruction, acid rain spread, land desertification, tropical forest reduction, air pollution, water pollution, marine pollution, transboundary movement of hazardous wastes, etc., have become more and more serious (Zhang, H, 2020), and environmental problems have become a common issue that the world needs to deal with. Therefore, in October 1990, December 1994, and November 1999, the Japanese government (cabinet) respectively formulated environmental protection-related plans and related laws and regulations, such as the Action Plan for the Prevention of Global Warming, the Basic Environmental Plan, and the Basic Environmental Law, in order to strengthen Japan's environmental protection efforts and ensure the smooth progress of Japan's environmental protection work (Liu, J, 2003).

Against the background of deteriorating global environment, the Ministry of Education, Culture, Sports, and Culture of Japan began to work on sustainable campus in 1993, and entrusted the Japanese Architectural Society to set up a "Green School Committee" to carry out a series of investigations on campus related matters concerning green sustainable development. In 1994, the Ministry of Education, Culture, Sports, and Culture launched the "Collaborators' Meeting on the Investigation and Research of Green Campus", and in 1996, compiled the report "Green School", which summarized the basic ideas and schemes for promoting and perfecting green schools, and defined the green goals of sustainable campus from the aspects of facilities, education and operation. In 1997, the "Green Campus Research Collaborators Meeting" also compiled the "Investigation Report on Technical Methods of Green Schools", an advanced example data set of characteristic green schools (Liu, J, 2003). This report clearly points out that in order to adapt to the changes in the 21st century and coexist harmoniously with the environment, from a new perspective of environmental protection, it is necessary for schools to take corresponding countermeasures to deal with the deteriorating environmental problems.

In December, 1998, "Kyoto Conference on Preventing Global Warming" was held in Kyoto, Japan, During the conference, the goal of "taking the actual value of carbon dioxide emissions in 1990 as the standard, the total carbon emissions in the five years from 2008 to 2013 will be reduced by 5% or more than that in the standard year" was reached, and the Kyoto Protocol was issued (Zhou, J, 2016). After that, the development plan of sustainable campus in Japan has been paid more and more attention.

In 2001, under the leadership of the Ministry of Land, Infrastructure, Transport and Tourism, Japan established JSBC (Japan Sustainable Building Consortium), which aims to construct the concept of sustainable building and develop a comprehensive evaluation tool for building environmental performance (Liu, X, 2020). JSBC established the framework of CASBEE, and launched the earliest evaluation tool "CASBEE- Office Edition" in 2002, With the expansion of the number of CASBEE tools, the evaluation system of campus buildings has been continuously improved. On April 1, 2009, CASBEE changed its name from "Building Comprehensive Environmental Performance Evaluation System" to "Building Comprehensive Performance Evaluation System" (Gao, Y, 2019).

Up to now, Japan's sustainable campus plan has been developed, and all universities have explored a sustainable campus development model suitable for their own development under the framework of CASBEE, which generally presents a model of building sustainable development as the core and free development in other campus sustainable fields. Taking Kitakyushu City University in Japan as an example, its sustainable campus construction plan mainly focuses on the following nine points: (1) effective utilization of natural wind, (2) effective utilization of natural light, (3) roof greening and vertical greening, (4) effective utilization of geothermal energy for precooling and preheating, (5) reuse of waterway system, (6) construction of biological community and natural waterway, (7) solar energy system, (8) fuel cell, and (9) electric heating supply of cogeneration.

Observing the development process of sustainable campus in Japan, we can find that its development characteristics can be summarized as follows: (1) The Japanese government attaches great importance to the development of sustainable campus, and has been committed to guiding the domestic academic circles to study and investigate the related work of sustainable campus, and forms its own distinctive sustainable campus construction mode through the combination of theoretical research and sustainable campus practice. (2) The sustainable development model of Japanese campus is different from that of the United States, which first deepens its own sustainable campus concept and then forms a comprehensive sustainable campus development. The sustainable campus development in Japan pays more attention to solving the problems encountered in the implementation of sustainable development. Therefore, the development of sustainable campus in Japan is not perfect at present, and the concept of sustainable campus has not been put forward completely. (3) From the content and development of the current evaluation standard CASBEE in Japan, the sustainable campus in Japan pays more attention to the environmental friendliness of buildings and is committed to solving environmental problems. The development of sustainable campus in Japan mainly focuses on the research and development of sustainable buildings, that is, the sustainable development of buildings in the construction of campus and the relationship between buildings and environment.

5.2 The Comparison between Japanese and Chinese Evaluation Standards

5.2.1 Evaluation Standards of Sustainable Campus and Green Building in Japan （CASBEE）

The sustainable campus development in Japan focuses on reducing the energy consumption of buildings, solving the contradiction between buildings and environment, and creating an environment-friendly campus. Therefore, Japan has not proposed a green campus evaluation standard that can cover all aspects of sustainable campus. The CASBEE evaluation system, which is widely used in Japanese campuses, mainly focuses on the green buildings on campus. As China's sustainable campus is developed from the concept of energy-saving campus, China attaches relatively high importance to architecture in the concept of sustainable campus, so it is more suitable to compare Chinese standards with Japanese standards. CASBEE is widely used in Japanese campus mainly because the campus is based on campus architecture. Green and sustainable campus buildings and green friendship with the environment can improve the present situation of environmental degradation, Sustainable campus construction in Japan pays more attention to building energy conservation and environmental protection. Therefore, its essence is to evaluate the development of sustainable architecture in Japan. In view of the current situation of the evaluation standard of sustainable campus in Japan, this study selects Chinese green building evaluation standard, namely "Evaluation Standard for Green Building" (GB/T 50378-2019), to compare with CASBEE. As "Green Building Evaluation Standard" and CASBEE belong to the same dimension, that is, the evaluation standard of sustainable building, it is more appropriate and authoritative to study these two standards in this chapter.

The Comprehensive Environmental Performance Evaluation System for Buildings in Japan (CASBEE) was developed and researched with the support of the Ministry of Land, Infrastructure, Transport and Tourism of Japan. The research started in 2001 and was mainly developed by JSBC, with members from industries (enterprises), governments (governments) and academia (academia). The earliest evaluation tool "CASBEE- Office Edition" has been completed since 2002, "CASBEE-New Edition" in July 2003, "CASBEE- Existed Edition" in July 2004, "CASBEE- Reconstruction Edition" in July 2005, "CASBEE- Block Construction Edition" launched in July 2006 and September 2007 (Hua, J, 2012).

CASBEE creates a closed imaginary space, in which the influence of architecture and environment in the same space is considered, and whether architecture can "coexist with environment" is evaluated by this method. In Japan, the concept of green building has not been clearly defined, only the concept of "environmental symbiotic building", which is similar in essence

(Zhong, D, 2012). Environmental symbiosis is to fully protect the earth's resources and adjust the relationship among energy, resources and wastes, so as to develop harmoniously. People-oriented, giving full consideration to residents' physical health and psychological feelings, can make people happy physically and mentally in buildings, improve their quality of life and work efficiency, and then promote the organic integration of buildings, residents and regional environment, and realize the harmonious coexistence of the three.

Up to now, CASBEE's published evaluation scope includes Buildings, Market Promotion, Real Estate, Urban Development, Homes, Cities-pilot version for worldwide use, cities and Property Appraisal. According to the ratio of the quality of the building environment to the environmental load, the score is obtained to determine the grade of the evaluated object, which can be divided into S, A, B+, B-, C in turn (CASBEE, 2020a).

5.2.2 Comparison of Two Standards

Because the evaluation of sustainable campus in Japan is all around campus architecture, the evaluation standard of sustainable campus in China covers a wide range, so it can't be compared with CASBEE horizontally. Therefore, this chapter chooses CASBEE for Buildings and GB/T 50378-2019 as the evaluation standard for green buildings for comparative study (Table 5.1). Through the full comparison of the two standards, the deficiencies in CASBEE are found, and some referential optimization suggestions are put forward, so as to improve the evaluation system of sustainable campus in Japan.

Table 5.1: Comparison of Green Building Evaluation Standards between China and Japan

Standard	CASBEE for Buildings (CASBEE, 2020b)	《Evaluation Standard for Green Building》GB/T 50378-2019 (CABR, 2019)
Compiling organization of system framework	The Japan Sustainable Building Consortium（JSBC）	Ministry of Environmental Protection of the People's Republic of China
Content	Building Environmental Quality & Performance（Q） Reduction of Building Environmental Loadings（LR）	Safe and Durable Healthy and Comfortable Life Convenience Saving Resources The Habitable Environment * Improvement & innovation
Object	Including office, medical, school, shopping malls, restaurants, clubs, hotels and residences	Residential buildings, public buildings
Method	Environmental efficiency was evaluated by BEE(Q/L). Buildings are divided into different grades according to the size of BEE value and the requirements of Q value.	Set control item, score item and add points item. All the control items should be satisfied. The scoring items should be scored according to the satisfaction, and the additional items

		should be scored as extra points. According to the total score to determine the evaluation grade.
Rating	Rank C (poor), Rank B-, Rank B+, Rank A, and Rank S (excellent)	Basic level, One-star, Two-star, Three-star

(1) Evaluation objects

CASBEE has a wide range of evaluation objects, including new buildings, existing buildings, temporary short-term use buildings, renovation and renewal buildings, etc, Among them, offices, medical care, schools, shopping malls, restaurants, clubs, hotels and residences are the evaluation objects (CASBEE, 2020c).

China's "Green Building Evaluation Standards" is the latest version issued by the Ministry of Housing and Urban-Rural Development in 19 years, Based on the old version, it summarizes the practical experience and research achievements of China's green buildings in recent years, and draws lessons from international advanced experience. The evaluation objects of Green Building Evaluation Standard are divided into two categories, one is residential buildings and the other is public buildings, This standard is mainly applied to the evaluation of single buildings (CABR, 2019).

Compared with "Green Building Evaluation Standard", CASBEE is more specific in the division of evaluation objects, so when evaluating campus buildings, CASBEE's evaluation is more targeted and adapted to local conditions. Different evaluation clauses are applied to different buildings, so as to make more accurate evaluation. Therefore, "Green Building Evaluation Standards" should refine the evaluation system, and set targeted indicators or evaluation methods for different types of buildings with different functions, so that the evaluation results have more reference value.

(2) Scoring method

The evaluation method of CASBEE is embodied by "environmental efficiency BEE". The specific evaluation method is to use the ratio of building environmental quality (Q) to building environmental load (LR) to evaluate the relationship between building and environment (BEE=Q/L). Each evaluation item is divided into 1, 2, 3, 4 and 5 grades with a full score of 5, The average level is 3 centered, the highest is 5, and the lowest is 1, Then, each item is summed up according to its weight coefficient, and finally the score is obtained. With regard to l, LR (Load Reduction) is used to evaluate the effect of efforts to reduce environmental load l, and LR is converted into l when calculating BEE value (CASBEE, 2020a).

Here, q is related to l. For example, by reducing the energy used for heating and cooling to reduce the environmental load, the L value will be reduced, but this may be related to enduring the heat and cold, and at the same time reduce the environmental quality Q.

Therefore, in order to evaluate comprehensively, CASBEE defines the ratio of Q to L as the evaluation index as environmental (performance) efficiency: Bee = Q/L. The BEE value can better reflect the comprehensive evaluation of the building environment, and only when the score of q increases and the score of l decreases will the BEE value increase. Finally, according to the different requirements and standards of BEE value and Q value, the buildings are divided into five different grades, which can be divided into excellent (S), excellent (A), good (B+), poor (B-) and poor (C) according to their advantages and disadvantages (Table 5.2) (CASBEE, 2020c).

Each index of Green Building Evaluation Standard consists of three parts, namely, control item, score item and bonus item. The evaluation results of control items are not expressed by score values, but only evaluated by yes or no. The evaluation results of the scoring items are expressed by scoring values, which represent the merits and demerits of the building performance. In addition, in order to evaluate green buildings more accurately and encourage the application of sustainable technologies, extra bonus items are added in the evaluation index system, and the evaluation results of bonus items are also calculated by scores. On the basis of meeting the requirements of corresponding items, different grades are divided according to the scores and additional scores of scoring items. From low to high, they are divided into four grades, namely, basic grade, one star grade, two star grade and three star grade (Table 5.2) (CABR, 2019).

Table 5.2: Comparison of Scoring Methods of Green Building Evaluation Standards between China and Japan

CASBEE for Buildings		**《Evaluation Standard for Green Building》 GB/T 50378-2019**	
Rating	Score Requirements	Rating	Score Requirements
S	BEE≥3.0 & Q≤5.0	Three-star	The total score≥85
A	BEE=1.5-3.0 BEE≥3.0 & Q≤5.0	Two-star	The total score=70-85
B+	BEE=1.0-1.5	One-star	The total score=60-70
B-	BEE=0.5-1.0	Basic level	Satisfy all control item
C	BEE≤0.5	No level	Not met all control item

From the comparison of the above two standards, it can be seen that the evaluation methods of the two systems are based on scores, which determine the building quality and its impact on the environment. CASBEE obtains the final result by associating the building quality performance Q with the environmental load L, which ensures the connection between the building and the environment, and ensures that the two can develop synergistically in the process of developing green buildings and creating green environment, so as to achieve the sustainable development of the campus through their common sustainable development. Compared with STARS, which scores all fields according to whether the conditions are met or not, and the scores in all fields do not affect each other, CASBEE's evaluation method can avoid pursuing only the development of its own advantageous fields and ignoring the unbalanced development brought by its own shortcomings, which has a positive effect on the balanced development of sustainable campus itself. But at the same time, when there are many evaluation items in this method, there may be some problems such as inaccurate data and inconvenient horizontal comparison of multiple items. China's Green Building Evaluation Standard adopts weighted evaluation method, and different evaluation contents are set with different weights. In contrast, "Green Building Evaluation Standard" sets the minimum requirements for sustainable buildings because of the control items, which ensures the minimum level of green building construction and can control the overall direction of green building development. At the same time, based on the actual situation of the building, combined with the building function, we can choose the sustainable technical measures suitable for its use.

(3) Evaluation content and scores

CASBEE's system framework is different from "Green Building Evaluation Standard", CASBEE makes comprehensive evaluation from two aspects of architecture and environment, which not only meets the needs of architecture's own performance, but also reduces the load of architecture on the environment, It conducts long-term experimental evaluation on the use of architecture, focusing on the mutual influence between architecture and surrounding environment to reduce the damage to the environment. The "Green Building Evaluation Standard" mainly focuses on evaluating the performance of green buildings.

The evaluation contents of CASBEE are divided into two categories: the first category is the quality of building environment (Q), which consists of three parts: the first is indoor environment (Q1): sound environment, thermal environment, light environment and indoor air quality. Second, quality of service (Q2): functionality, durability and safety and reliability, adaptability of functional environment and variable renewability. The third is outdoor environment (Q3): ensure and create biological environment, consider street combination arrangement and landscape form, and consider regional characteristics and environmental comfort. The second category is to reduce the building's environmental load (LR), which is divided into three parts: the first is energy load (LR1): reducing the building's cold and heat load, making effective use of renewable energy, and making equipment and systems more efficient. Second, resources and materials load (LR2): water resources protection and use of materials with low environmental load. The third is the surrounding environment (LR3): air pollution, noise, vibration and stench, wind damage, light pollution, heat island effect and regional infrastructure load (CASBEE, 2020d).

There are five categories of evaluation items in Green Building Evaluation Standard: safety and durability, health and comfort, convenient living, resource saving and environment livability, and one additional item is improvement and innovation. According to the content, the five categories of scoring items correspond to CASBEE, in which the safety, durability, health, comfort, livable environment and convenience of life in Green Building Evaluation Standard correspond to the outdoor environment quality, indoor environment quality, surrounding environment load and service quality in CASBEE. It should be mentioned that the resource saving in Green Building Evaluation Standard corresponds to two categories in CASBEE, namely, energy load and resource and material load. In addition, "Green Building Evaluation Standard" has a kind of improvement and innovation, which is a bonus item, aiming at encouraging universities to carry out self-innovation and explore their own characteristic development direction (Table 5.3) (CABR, 2019).

Table 5.3: The Content Correspondence of Green Building Evaluation Standards between China and Japan

CASBEE for Buildings	《Evaluation Standard for Green Building》GB/T50378-2019
Outdoor Environment on Site	Safe and Durable
Energy	Saving Resources
Resources and Materials	
Indoor Environment	Healthy and Comfortable
Off-site Environment	The Habitable Environment
Quality of Service	Life Convenience
/	* Improvement & innovation

Overall, the scores of the six categories in CASBEE are evenly distributed. In the building environmental quality (Q) score, indoor environmental quality accounts for 40%, service quality accounts for 30%, and outdoor environmental quality accounts for 30%. Among the three items, indoor environment scores accounted for the highest proportion. In the building environmental quality (LR) score, the energy load accounts for 40%, the surrounding environment load and resources and materials load account for 30%, and the energy load occupies the most important position (Han, F, 2020).

In the scoring items of Green Building Evaluation Standard, resource saving accounts for 35%, environment livability, health, comfort, safety and durability are all 17.5%, and living convenience accounts for 12.5%. It can be seen that, except for resource saving, the scores are basically the same and considered equally important. Among them, living convenience accounts for the lowest, and resource saving accounts for the highest, which is twice as much as other items. It can be seen from this that CASBEE mainly takes the adaptation of the internal and external environment of the building as the main evaluation object, which fully embodies the concept of "environmental symbiotic building". "Green Building Evaluation Standard" mainly focuses on controlling the waste of resources and attaches importance to energy conservation, while other aspects, especially the convenience of life, need to be improved.

The overall scores of CASBEE and Green Building Evaluation Standard are similar. However, the requirements for indoor environmental quality and service quality in CASBEE are higher than those in Green Building Evaluation Standard, and the weight of safety, durability and environmental livability in Green Building Evaluation Standard is higher than that in CASBEE. In addition, the weight ratio of resource saving in the two standards is obviously higher than other evaluation items, which shows that both China and Japan pay more attention to energy problems, and whether the energy problems can be effectively solved will determine whether the sustainable campus can develop in an all-round way (see Figure 5.1).

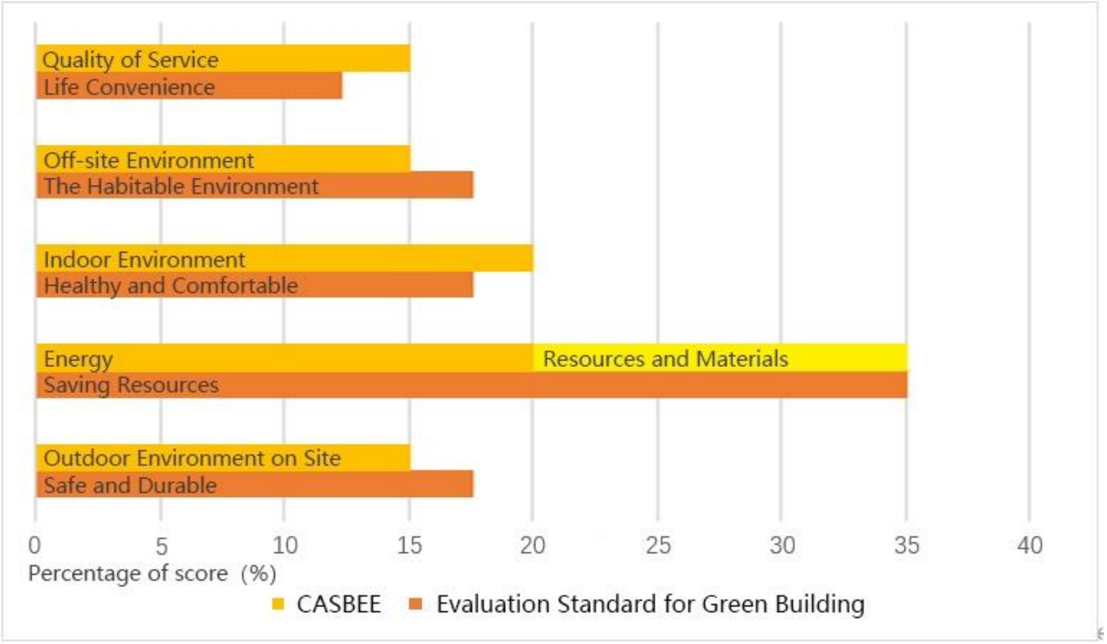

Figure 5.1: Score Proportion of Evaluation Content of Green Building Standards between China and Japan

5.3 Case Analysis of CASBEE

5.3.1 Case Overview

Collaboration complex (kyosei-Kan) in Hiyoshi campus is an open learning building for students, teachers and local communities, aiming at designing according to the design concept of "global learning center" and encouraging cooperation and communication. The open space consists of Hiyoshi forest and sports ground. The Collaboration Complex is a newly built place which integrates sports, culture, health, commercial promotion and practical activities, and provides a physical architectural space for students and all people to meet, communicate and study. It is located in Yokohama City, with a total area of 38,207m2, and has been evaluated by CASBEE as Grade S (see Table 5.4). The building is characterized by environmental friendliness, and has taken a series of measures to reduce energy consumption and operating costs. It embodies the idea of "excellent environment, proper safety and healthy campus" of Hiyoshi University (JSBD, 2020).

Table 5.4: The Basic Information of Keio University Hiyoshi Campus Collaboration Complex

CASBEE rank	S
CASBEE tool used	CASBEE-Yokohama（2006 edition）
Location	Yokohama City, Kanagawa Prefecture
Completion date	July, 2008
Site area	358,226m2
Total floor area	38,207m2
Structure	Steel frame reinforced concrete below ground, seismically isolated steel structure above ground
Floors	2 basement levels/7 floors above ground plus penthouse

As the evaluation of sustainable campus in Japan relies on the campus green buildings under CASBEE evaluation system, this study selects typical green campus buildings in Japan to study, in order to further analyze the specific strategies and advantages of sustainable campus construction in Japan. In this chapter, the collaboration complex (kyosei-Kan) of Hiyoshi campus, which was published by CASBEE in official website and evaluated as S-class by CASBEE, is selected as a representative case to analyze and study the green building technology adopted in the sustainable campus construction and the evaluation and application of CASBEE.

5.3.2 Application and Evaluation of Green Technology

Keio University Hiyoshi Campus Collaboration Complex adopts a large number of technologies and design means to achieve sustainability (see Table 5.5). In which Q-1 Indoor Environment reaches minimum 2.0% daylight in training/accommodation rooms, And ventilation volumes in individual training/accommodation rooms designed at 40% above building standards act (60-120cmh per room), which ensure sufficient indoor comfort and save some related energy. In the Q-2 Quality of Service section, the building adopts the middle layer seismic isolation structure, and seismic isolation is carried out below the first floor to improve the building life and meet the building safety and integrity standards of educational research facilities. In Q-3 Outdoor Environment on Site, it provides sunken garden with open plaza for large collections and water scape incorporated into sunken garden, which greatly improves the quality of outdoor environment and becomes a transportation hub linking indoor and outdoor (JSBD, 2020).

Cogeneration system, Ice thermal storage system and external ventilation cooling system are adopted in LR-1 Energy, the comprehensive application of these three systems effectively controls the use of energy in buildings. LR-2 Resources and Materials adopt Blast-furnace cement piles and Recycled materials, which reduces the overall energy cost and resource consumption of the building. Energy-saving equipment and facilities are installed in LR-3 Off-site Environment. Use of ventilation in cooling system to minimize heat source load provides great help for energy saving of the building. Waste storage facility below ground level to contain odors is set outside the building, which improves the external environment quality of the building and greatly reduces the impact on the surrounding environment (JSBD, 2020).

Table 5.5: Green Technology Assessment of Keio University Hiyoshi Campus Collaboration Complex by CASBEE

Q-1 Indoor Environment	Soundproofing features of Fujiwara Hiroshi Hall including six-sided floating floor structure
	Top lights
	Minimum 2.0% daylight in training/accommodation rooms
	JIS/JAS rated F☆☆☆☆ materials used throughout
	Ventilation volumes in individual training/accommodation rooms designed at 40% above Building Standards Act (60 - 120 CMH per room)
	Smoking prohibited inside building except in designated smoking booths on training/accommodation floor
Q-2 Quality of Service	Heart Building Law compliant
	Excellent earthquake protection
	Seismic isolation structure
	Tiled precast concrete boards for exteriors
	Main internal finishes designed to last at least 20 years before replacement
	Water-saving fixtures and fittings
	Multiple heat sources in heating/cooling system (gas and electricity)
	Ceiling height = 4.15 m in school section, 3.6 m in training/accommodation section
	Minimum floor load = 4,900 N/m2 in school section
	Spare capacity in vertical power and data cable ducts
Q-3 Outdoor Environment on Site	Sunken garden with open plaza for large gatherings, on the grounds and to the subway station entrance.
	Facilities for engaging with the local community on first and second levels of building
	Waterscape incorporated into Sunken Garden
	Pedestrian routes along southern road edge of site area
	Japanese keyaki trees along Tsunashima Kaido
LR-1 Energy	Cogeneration system
	Ice thermal storage system
	BEMS
	Natural light from top lights
	External ventilation cooling system
LR-2 Resources and Materials	Main toilets with automatic flush, water-saving toilets and recorded flushing sounds.
	Electrosteel framing members such as beams and studs
	Blast-furnace cement piles
	Recycled materials
	Nitrogen-based inert gas fire extinguishers
LR-3 Off-site Environment	Energy-saving equipment and facilities
	Use of ventilation in cooling system to minimize heat source load
	Peak shifting via ice thermal storage
	Kitchen exhaust ported through to rooftop

	Waste storage facility below ground level to contain odors

According to CASBEE evaluation, the BEE value of keio university hiyoshi campus collaboration complex is 3.3, which is rated as s grade. In the evaluation of CASBEE, the indexes of the building are relatively balanced, and the best performance is Energy and Off-site Environment (see Figure 5.2), which shows that the building pays more attention to the exploration and application of building energy efficiency. The lowest score is Outdoor Environment on Site, so the building needs further improvement in creating environment-friendly campus.

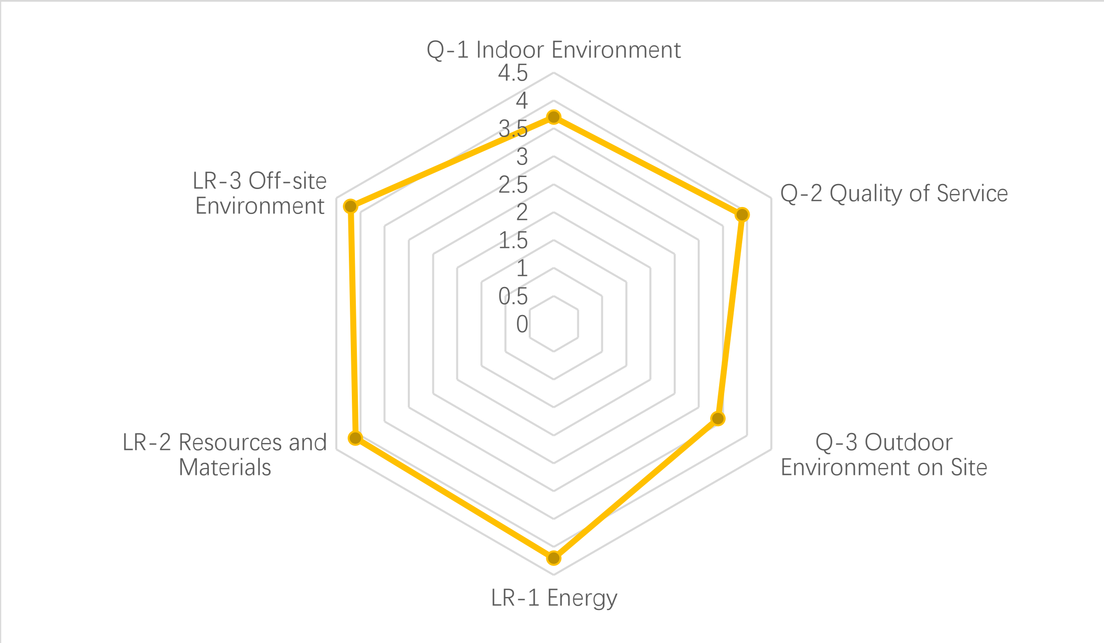

Figure 5.2: Scores of Six Categories of Keio University Hiyoshi Campus Collaboration Complex

5.4 Optimization and Development Strategies of Sustainable Campus Evaluation System in Japan

5.4.1 The Establishment of Evaluation System

Because the construction of sustainable campus in Japan mainly focuses on the degree of environmental friendliness, CASBEE, as the evaluation standard of campus green buildings, is more focused on evaluating the buildings in the campus, which is embodied in the integration of buildings and environment and the energy saving and consumption reduction of buildings themselves. In contrast, China's "Green Campus Evaluation Criteria" and American STARS have a wider scope when evaluating sustainable campus, including evaluation items in almost all aspects of campus, such as architecture, planning, energy, life, education and investment (AASHE, 2020). Therefore, compared with CASBEE, the evaluation standards of China and the United States can comprehensively and reasonably evaluate the sustainable campus construction. CASBEE's evaluation points are too single, which does not cover the current mainstream sustainable campus culture in the world, which leads to its imperfect development in other aspects while blindly pursuing the quality of green buildings in sustainable campuses. This also shows that the current CASBEE is not completely applicable to the evaluation of sustainable campus.

As to CASBEE itself, the evaluation system includes eight versions: Buildings, Market Promotion, Real Estate, Urban Development, Homes, Cities-pilot version for worldwide use, cities and Property Appraisal(CASBEE, 2020e). The evaluation of sustainable campus is included in Buildings, but with the continuous development of sustainable campus culture, it is far from enough to evaluate sustainable campus only through the evaluation subject of campus architecture. Therefore, the evaluation system of sustainable campus in Japan needs to be further comprehensive, and the evaluation standard of green campus can be set independently in addition to the evaluation standard of green buildings in the way of China and the United States, so as to form a wide-dimensional, multi-level and systematic evaluation standard of sustainable development.

5.4.2 Management and Participation

The development of sustainable campus and its evaluation criteria in Japan can be divided into two stages, In the early 1990s, the evaluation criteria of sustainable campus in Japan developed from top to bottom under the guidance of the government, The government guided the academic circles to study sustainable campus, and then the universities practiced and explored the theoretical achievements. However, after the 10' s of the 21st century, Japanese universities began to explore and practice the construction of sustainable campus independently, and developed sustainable campus from bottom to top. In the future, the Japanese government should integrate the practical experience of universities, set up a unified national management organization, issue unified evaluation standards and related policies for sustainable campuses, strengthen the overall management of universities by the government, and guide the sustainable development of Japanese campuses from top to bottom. At the same time, special management departments are set up in colleges and universities to carry out self-planning and management, formulate relevant regulations for the university, encourage students, teachers and employees to join in the decision-making and planning of campus construction, and promote the construction of sustainable campus from bottom to top. Through the combination of top-down and bottom-up, the development and improvement of the evaluation standard of sustainable campus in Japan are constantly advancing.

5.4.3 Method and Scoring

CASBEE determines the grade of the evaluated object by BEE value. This evaluation system associates Q with L value, which can ensure the friendship between the evaluated building and its surrounding environment, and ensure the balanced development of green building and environmental development, However, this method is not conducive to the creation of campus characteristics. Therefore, in the future, control items and bonus items can be added on the basis of the original scoring method. This can ensure the quality of sustainable development and the basic construction level of Japanese universities. It can also encourage the innovation of sustainable development mode in Japanese universities, so that universities can integrate their own characteristics while developing with high quality, and enrich the sustainable campus culture in Japan.

5.4.4 Content and Focus

The evaluation category of CASBEE mainly includes six categories: outdoor environmental quality, energy load, resource and material load, indoor environmental quality, surrounding environmental load and service quality. These six points are divided into 23 influencing factors for the sustainable development of campus buildings (CASBEE, 2020d). These 23 influencing factors are all evaluation items about campus buildings and the surrounding environment of buildings, From the perspective of evaluating green buildings, these 23 influencing factors can evaluate the quality of green buildings completely. However, as the evaluation standard of sustainable campus, these 23 factors are far from enough to evaluate the whole campus. Besides buildings, the influencing factors of students' daily life, logistics service, curriculum education, school-enterprise participation and financial investment should be added to improve the evaluation content construction of sustainable campus construction. At present, the scores of six evaluation contents in CASBEE account for a large proportion, among which the energy load, resources and materials load account for a large proportion, which is similar to the situation in early China, Sustainable campus emphasizes the overall sustainable development of campus and pays too much attention to energy conservation, which will lead to the unbalanced development of sustainable campus.

5.5 Conclusions

5.5.1 Diversity & Unity

At present, the problems that need to be solved in Japan's sustainable campus are as follows: (1) The evaluation standard is imperfect, and the evaluation object is only the campus building and its surrounding environment. (2) Each campus or region in Japan is exploring the development path of sustainable campus by itself, lacking unified management and complete evaluation system. (3) The evaluation of sustainable campus in Japan has developed slowly in recent ten years. In view of the current situation of sustainable campus development in Japan and its evaluation criteria, there are some shortcomings such as fragmentation, disunity and incompleteness in the development of sustainable campus in Japan. Local or universities adopt their own standards, which can guide local campuses according to local conditions, but at the same time, new problems arise, that is, local universities can't make horizontal comparisons, and then they can't know their own defects and deficiencies, which limits their own development. Therefore, it is particularly important for Japan to establish a unified evaluation standard of sustainable campus, which covers the international mainstream sustainable campus culture.

5.5.2 Internationalization & Localization

At present, Japan does not have a unified evaluation standard for sustainable campus, and has not participated in the global trend of sustainable campus development. This makes it difficult for Japan's sustainable campus evaluation standards to be widely recognized and applied in the international field, and it is also difficult for Japan's sustainable campus development to be in line with international standards, thus promoting the development of Japan's sustainable campus. The Japanese government should continue its own development characteristics, reform the sustainable evaluation standard according to its own advantages, and introduce a unified sustainable campus evaluation standard. On the basis of taking into account the differences in climate, customs, culture and economy, the evaluation criteria of sustainable campus with local characteristics are compiled. At the same time, Japan, as a developed country and one of the world's major economies, needs to integrate international mainstream culture into the culture of sustainable campus, promote the development and improvement of the global sustainable campus evaluation system, solve the global sustainable development problems, and finally contribute to the realization of the global sustainable development goal.

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CHAPTER 6

SUSTAINABLE CAMPUS CONSTRUCTION IN CHINA, AMERICA AND JAPAN BASED ON THEIR OWN CHARACTERISTICS

CHAPTER 6 SUSTAINABLE CAMPUS CONSTRUCTION IN CHINA, AMERICA AND JAPAN BASED ON THEIR OWN CHARACTERISTICS

6.1 Sustainable Campus of China's Case University Based on Energy Conservation Monitoring

6.1.1 Overview of the Cases

In this chapter, two groups are made for study. In the first group, five universities are selected as research cases: Zhejiang University in China, Colorado State University, Stanford University, University of California, Irvine, and University of New Hampshire in the United States. As for the second research group, Zhejiang University and Zhejiang University of Technology Zhijiang campus in China are compared.

6.1.1.1 China's Case University

As the first vice president unit of "China University Energy Conservation Alliance" (Zhejiang University, 2011), Zhejiang University is one of the core members of "China Green University Alliance", which is a typical example of China's green campus. It has taken a series of measures for the construction of green campus from many aspects, and has achieved certain results, especially in the campus energy-saving (see Table 6.1).

Table 6.1: Main Achievements of Green Campus Construction of Zhejiang University

(Zhu Bifeng, 2016)

Projects	Specific measures	Achievements
Energy utilization management	Building a campus building energy conservation supervision platform (energy consumption statistics, real-time energy consumption monitoring, energy efficiency evaluation, monitoring and early warning).	Reducing the unreasonable leakage phenomenon; establishing the energy consumption indicators of different types of buildings.
Save electricity saving	Reconstruction of hydropower infrastructure and installation of far-infrared intelligent control switch in public places.	The electricity saving rate in public places is about 20%.
Renewable energy utilization	Adopting solar energy, energy tower heat pump and other efficient energy equipment.	Clean and renewable energy consumption is about 60000kwh (0.05% of total energy consumption).
Water resource utilization and management	Reconstruction of water supply network, reasonable allocation of metering equipment, and reconstruction of high water consumption equipment in toilets.	54.4% water consumption is saved.
Heating and energy saving	Layout optimization and energy saving transformation of heating network.	The energy-saving rate of canteen is 28.9%; and that of hot water in student apartments is 73%.
Transportation	Free or cheap commute, free school bus.	The proportion of green travel for

	Encourage employees to live near the school through preferential housing prices for apartments near the school.	teachers and students is high, and vehicles conforming to A-H fuel and power types account for 0.6%.
Sustainability training	Holding training activities such as energy conservation management knowledge training	Popularization of behavior energy saving knowledge.

6.1.1.2 Case Universities in Comparison Group

Although this chapter is a case study of Zhejiang University, it is necessary to set up a comparative group under different development modes, so as to objectively and comprehensively discuss the influence of "energy-saving" and "sustainability" on each other. Therefore, this research also selects four American universities -- Colorado State University, Stanford University, University of California, Irvine and University of New Hampshire -- as comparative cases. These four American universities are currently the only platinum rated American universities evaluated by STARS. They are typical examples of green campus construction in the United States.

6.1.2 Setting of Evaluation Method

6.1.2.1 Evaluation Factors

(1) GHG emissions per EUI-adjusted (G-value)

In the process of green campus construction, whether it is the energy consumption and water consumption of building facilities operation, or the advocacy of sustainable education and management, it will ultimately have different degrees of impact on the environment (Huang Kaiqiang. And Xu Shuitai.,2019). Because the essence of various behavior modes is its interaction with the environment (Hao Qi atel.,2019), judging the degree of green campus construction from the degree of environmental impact is not completely equivalent, but it can basically reflect the overall situation of green campus environment-friendly.

Since the green campus construction in China is developed from the energy-saving campus, the focus of the construction has always been on the energy conservation and monitoring of the campus (Wang Lili,2010), and the GHG emissions not only includes the direct energy consumption of the campus, but also includes the indirect energy consumption and the use of new energy. Therefore, the index of GHG emissions per unit area will be used as one of the factor for specific analysis. G-value directly reflects the construction effect of campus's energy saving.

In this research, the G-value is set as GHG emission / EUI adjusted.

(2) Sustainability (S-value)

Another factor is sustainability (S-value). S-value is the evaluation result of comprehensive sustainable development of campus by STARS.

Compared with China's emphasis on energy saving on campus, the green campus development in the United States is more balanced in all aspects and more in line with the connotation of sustainable nature. Therefore, the cases are evaluated by using STARS. S-value reflects the sustainable construction degree of campus comprehensively and objectively.

According to the overall evaluation framework of STARS, the calculation of S-value is divided into four categories: Academic, Engagement, Operation and Planning & Administration.

6.1.2.2 Technical Route of Evaluation

Based on the G-value and S-value, this study analyzes energy consumption and sustainability of Zhejiang University (see Figure 6.1).

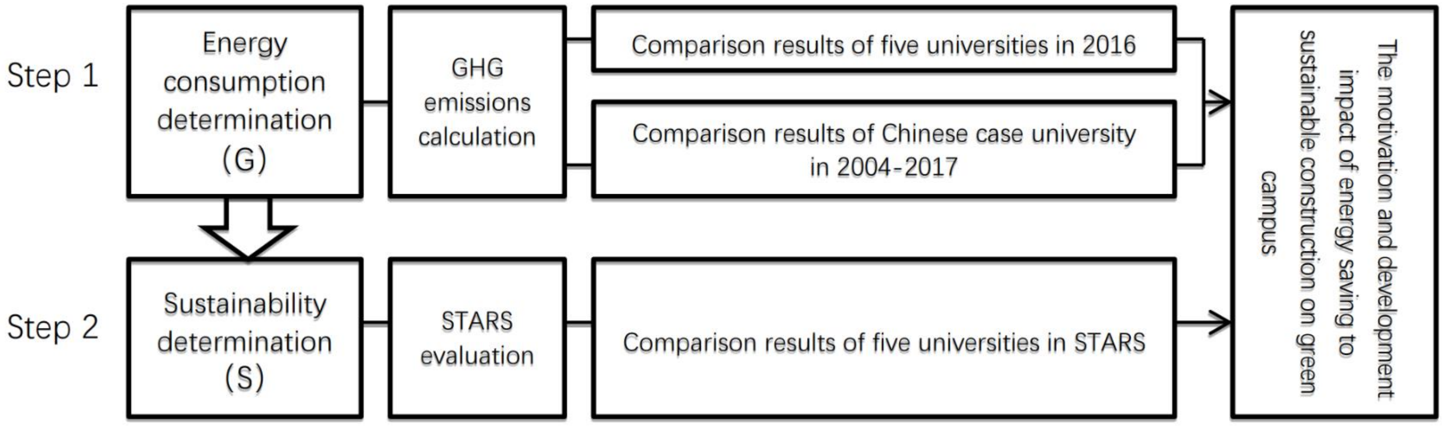

Figure 6.1: The Flow Chart of Research Method

Step 1: G-value determination

At present, the development of China's green campus is mainly focused on the construction of Energy-saving Monitoring Platform, so the energy-saving of campus has become the focus of case university, and various construction measures focus on energy conservation and emission reduction. The analysis of G-value is helpful to understand the advantages and disadvantages of green campus and development mode in Zhejiang University. The G-values are compared in two groups: the first group analyzes the G-values in 2016 of the case university and four universities in comparative group, aiming to discuss the situation of campus energy-saving under different green campus construction emphases. The second group analyzes the G-values of Zhejiang University from 2004 to 2017, so as to understand the construction effect and future energy saving potential of the case under a series of energy-saving measures. All needed energy consumption data of Zhejiang University in G-value judgment is from the statistical results of *Zhejiang University's Yearbook* from 2005 to 2018 annual. The energy consumption data of the four American universities are from the green campus assessment reports published by STARS platform.

Step 2: S-value determination

As energy saving is only one aspect of green campus, it cannot fully represent the achievements of green campus, so S-value is selected to comprehensively analyze the sustainable achievements of Zhejiang University. The S-value of the case is compared with that of the comparative group, in order to analyze the degree of sustainable campus construction in Zhejiang University. Then, it summarizes the motivation and development impact of "energy-saving" on campus "sustainability". The data of Zhejiang University in S-value judgment is from the research team. According to STARS's evaluation method, we interview the management departments of the university, collect relevant data and make statistics. The data of four American universities is from the green campus evaluation reports published by STARS platform.

6.1.3 G-value Analysis of Greenhouse Gas (GHG) Emission Intensity

According to the statistical results of various energy consumption in the yearbook of Zhejiang University, it can be calculated that the G-value of Zhejiang University in 2016 is 0.019163 $MtCO_2$ / m^2, which is significantly lower than the other four American universities. The lowest G-value of comparative universities is University of New Hampshire, which is 0.030679 $MtCO_2$ / m^2 (see Table 6.2). It shows that Zhejiang University of China has done a good job in reducing campus energy consumption, and the implementation of energy-saving monitoring platform has achieved remarkable results.

Table 6.2: G-values of Five Universities in China and the United States in 2016

	Name of the university	GHG emissions ($MtCO_2$)	EUI-adjusted (m^2)	G-value
Case university	Zhejiang University	76649.99	3999812.00	0.019163
Comparative universities	Colorado State University	168702.90	1390652.97	0.121312
	Stanford University	99643.75	1891514.72	0.052679
	University of New Hampshire	22179.20	722925.28	0.030679
	University of California, Irvine	71463.00	1508772.40	0.047364

China's green campus construction is mainly focuses on the construction of energy-saving campus. Since 2008, Zhejiang University has started to comprehensively promote the construction of the " Building Energy Saving Supervision System of Energy Saving Campus " project, and gradually build the energy-saving campus digital information supervision system. An online energy consumption monitoring and analysis platform covering four campuses is built (Zhejiang University, 2010). It can be seen that the energy-saving effect of the energy-saving supervision platform, which supervises the reasonable use of electricity, makes the GHG emissions of the universities be controlled.

Although four American universities have also intervened in building energy consumption, the main measures are to partially update the original buildings that do not meet the requirements and to build new buildings according to the design and construction rating system established by the GBC (Green Building Council) (Gao Yunting,2019). However, due to the large number of new and renovated campus buildings not in accordance with the rating system, the GHG emissions of four American universities are still higher than that of Zhejiang University.

Since 2003, Zhejiang University began to open a new campus (Zhejiang University, 2004). Therefore, the G-value of Zhejiang University in China from 2004 to 2017 is calculated. It is found that from 2004 to 2011, with the continuous increase of the campus building area, the total energy consumption also increases significantly, and the G-value shows an increasing trend year by year. It is mainly due to the expansion of campus, which leads to the increase of buildings (energy consumption area) and the increase of energy consumption. The energy consumption mainly includes the use of a large number of non-clean energy, extensive energy use patterns and habits, and energy consumption of construction. Regression analysis is adopted for the data, and its development trend can be approximately regarded as linear relationship development (see Figure 6.2). According to the model, the G-value will increase at the rate of about 0.0027 $MtCO_2/m^2$ per year. A large number of GHG emissions increase year by year, which has an impact on the environment.

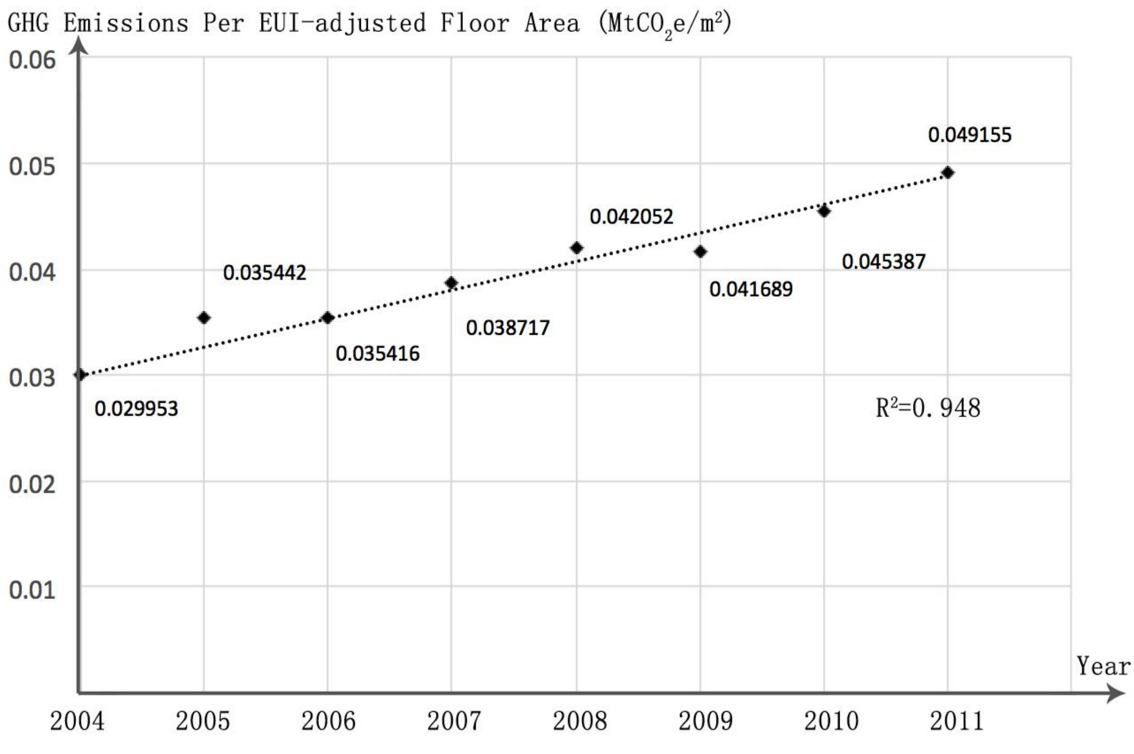

Figure 6.2: Trend of G-values in 2004-2011

While the new campus is still being built, Zhejiang University completed the basic construction of energy conservation supervision platform in 2011, becoming the only "Energy Conservation Information Demonstration Project of Campus Buildings " in Chinese universities. Zhejiang University basically realizes the intelligent management of campus energy consumption, accumulatively completing the energy consumption of more than 1.4 million square meters of buildings, real-time monitoring of water consumption of all buildings, and intelligent control of some energy consumption systems (Zhejiang University, 2013). From 2011, the G-value begins to decline year by year (see Figure 6.3). From the data in the figure 3, the construction of energy conservation monitoring platform from 2011 to 2014 has played a huge role in energy conservation and emission reduction. After 2014, the G-values basically stabilize and are controlled at about 0.02 $MtCO_2/m^2$. Compared with 2016, the G-value increases in 2017, and the value of 2016 is likely to be the lowest at present.

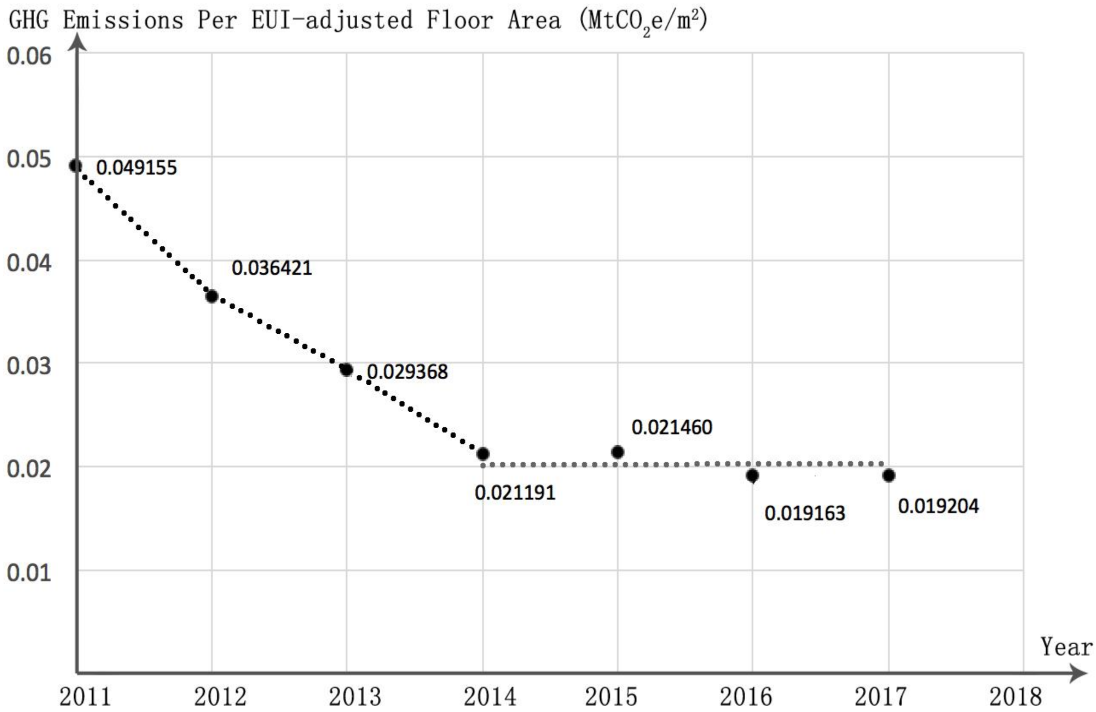

Figure 6.3: Trend of G-values in 2011-2017

6.1.4 S-value Analysis of Sustainability Evaluation

According to the data of STARS's open platform, all four American universities and one Japanese campus have the highest S-value rating of platinum. However, Chinese Zhejiang University, according to the relevant data collected and evaluated by the research team, is only silver-rating. Therefore, the case university still has a big gap with the five comparative universities in the United States and Japan in terms of sustainability.

According to the scores of each sub-item in Figure 6.4, the scoring rates of six universities are relatively high in terms of two categories of Academics and Engagement. However, the scoring rate of Operations and Planning &Administration is relatively low. It shows that the advantages of green campus in six universities lie in sustainable curriculum and research. At the same time, it has actively carried out various sustainable activities relying on the campus, local communities and society. However, there is still a lot of room for improvement in the construction of various facilities on campus, and the research and appliance related to sustainable technologies (Zhou Yana and Wang Xufeng.,2019). Therefore, promoting the construction of green campus as a whole by enhancing the various facilities and related technology research has become the focus of future development.

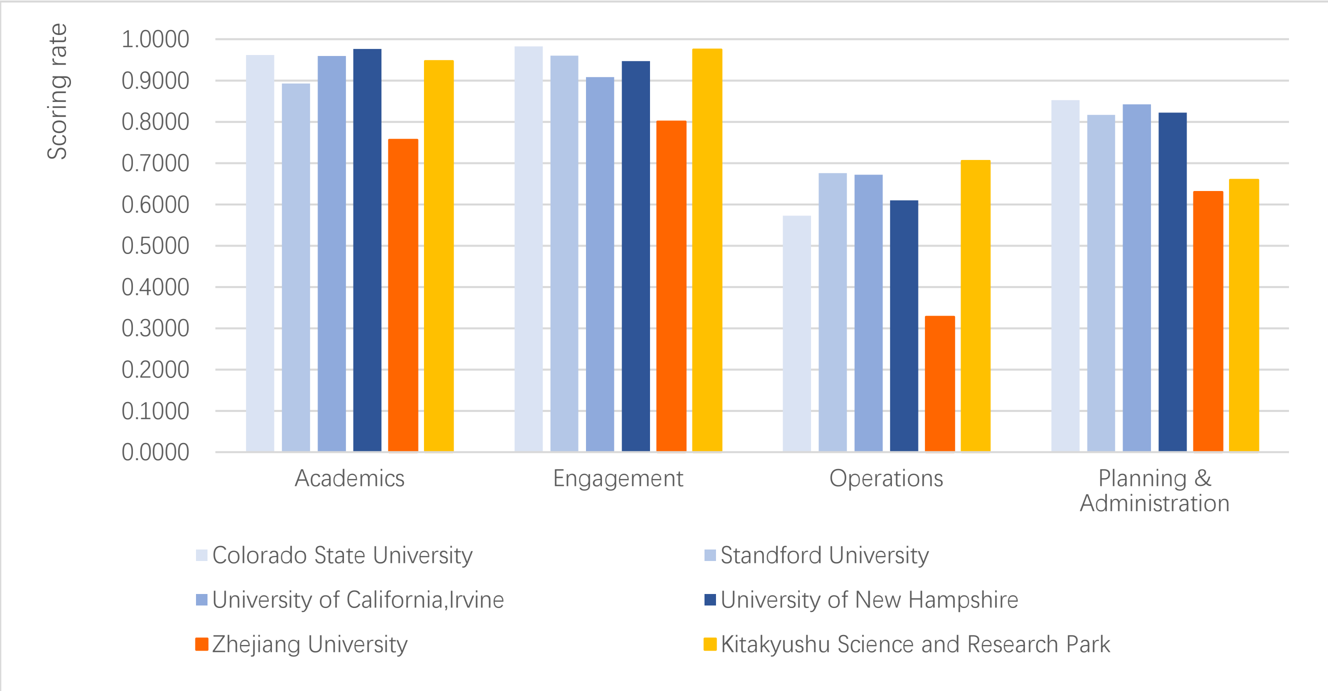

Figure 6.4: Statistics of STARS's Scoring Rates in Four Categories of Six Universities

The scoring rates of 6 universities' S-value in 17 sub-items are shown in Figure 6.5. It is found that the scoring rates of Zhejiang University in most sub-items are significantly lower than that of four American universities and one Japanese campus. Compared with them, the overall sustainability of green campus in case university still has a certain gap, and the development of all aspects is not balanced. Kitakyushu Science and Research Park is basically consistent with American universities in terms of Academics and Engagement. And its Operations are slightly higher than the average level of American universities. In the item of Planning & Administration, Japanese campus is lower than American universities, almost at the same level as Zhejiang University. This shows that the overall level of sustainable campus in Japan is close to that in the United States and has reached a high level of development.

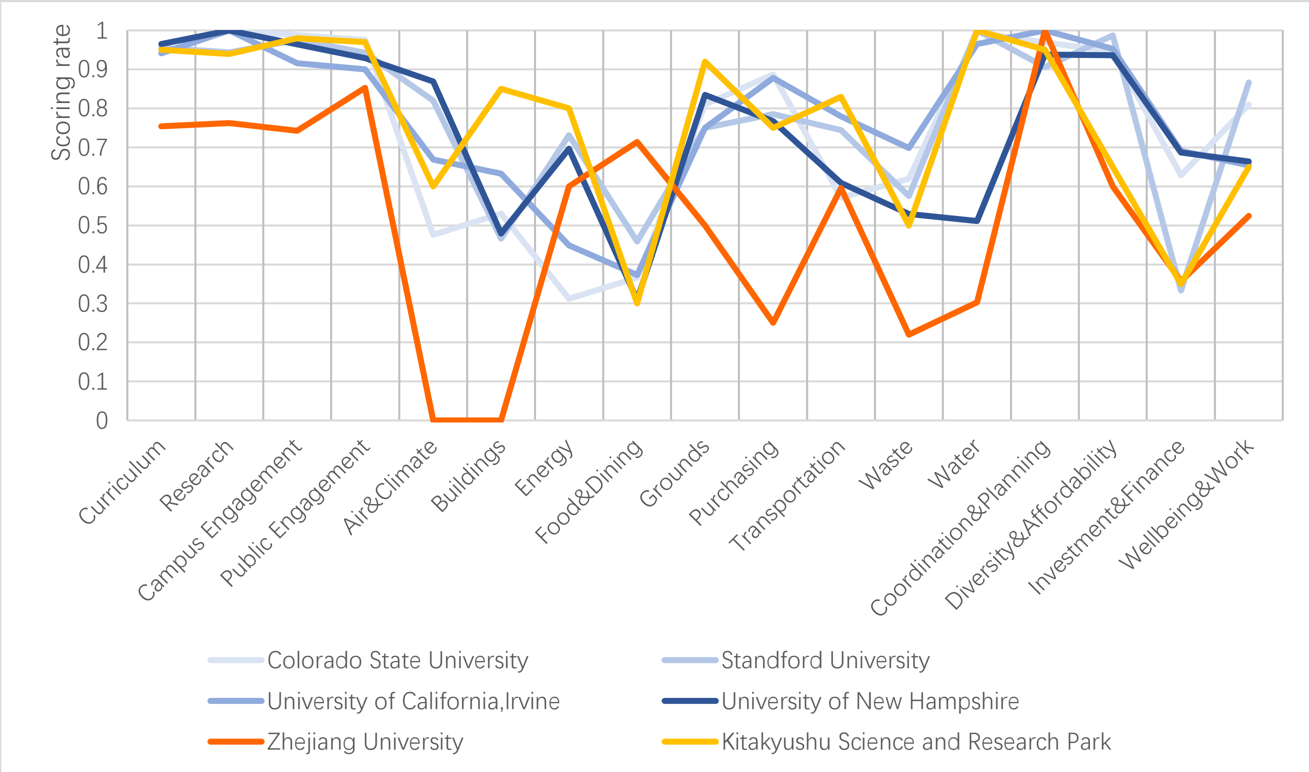

Figure 6.5: Statistics of the Scoring Rates in STARS's 17 Sub-items of Six Universities

Among the four categories, the category of Operations is composed of 9 sub-items, including Air & Climate, Buildings, Food & Dining, Energy, Grounds, Purchasing, Transportation, Waste and Water. Zhejiang University only scores higher on Food & Dining than other four American universities (see Figure 6.6). In the sub-item of Food & Dining, Zhejiang University has a high scoring rate because China has compulsory provisions of relevant national standards and the implementation is relatively simple. Four American universities spend less on third-party certified food, which directly leads to their low score. In the process of green campus construction, it is necessary to formulate relevant mandatory standards and ensure the reasonable purchase of food through policies (Hao Ziguang,2016). The score of Kitakyushu Science and Research Park in Food & Dining is not ideal. The main reason is that there is no choice of food diversity on campus, and there is relatively little room for selection on the basis of ensuring food safety and rich nutrition. Secondly, in terms of diet, it did not take into account the possible ethnic, national and religious differences of diners, and did not provide corresponding meal choices.

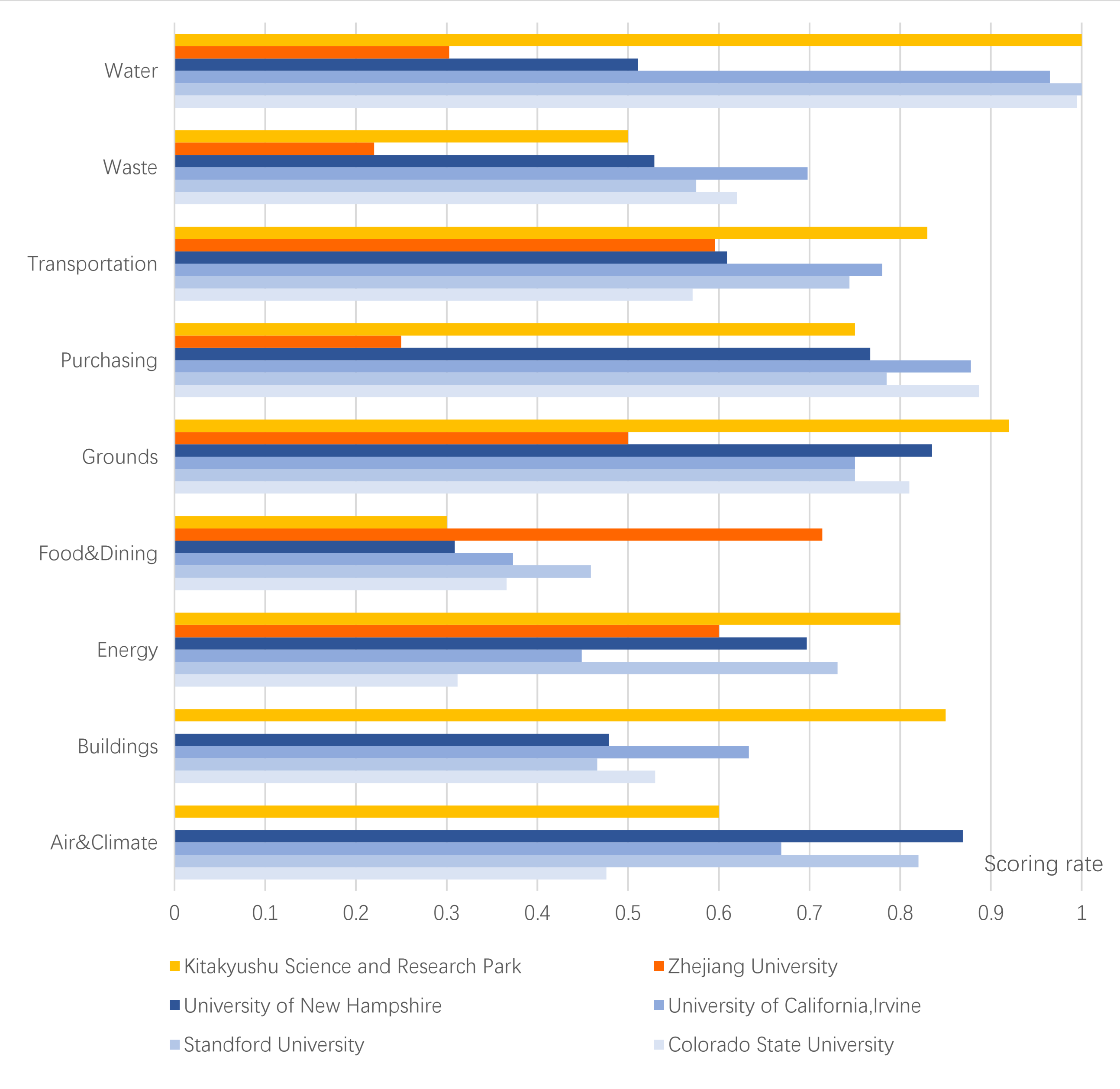

Figure 6.6: Statistical Chart of Scoring Rate of Each Sub-item in Operations of Six Universities

Zhejiang University scores zero on the categories of Air & Climate and Buildings. Air & Climate mainly involves GHG emissions and outdoor air quality. The reason lies in the lack of GHG emission monitoring and inventory statistics in Chinese universities. Four American universities have established an open list of GHG emissions and formulated policies or guidelines to improve outdoor air quality (Han Yanlun,2011). The evaluation of Buildings category mainly involves the green certification of campus buildings and indoor air quality. Zhejiang University campus's buildings cannot meet the needs of future green campus development only by energy-saving monitoring, so the new breakthroughs need to be sought, such as strengthening the green building certification of new buildings and energy-saving transformation of existing buildings. The practice of the four American universities is that they have renovated and newly built buildings according to the design and construction rating system of GBC, and maintained all the building spaces without GBC certification according to the published IAQ (Indoor Air Quality) management policy (AASHE, 2019).

Kitakyushu Science and Research Park is higher than the other five universities in Buildings, Energy, Grounds and Transportation. In Buildings and Grounds, Japan's sustainable campus construction takes the campus building and its surrounding environment as the core of development, so it scores higher. In terms of Energy, Kitakyushu Science and Research Park uses a lot of clean energy and has also established a relatively perfect energy consumption monitoring system, which greatly reduces the pressure on the environment caused by campus energy consumption. As Chinese universities that also pay attention to energy conservation, there is still a certain gap with Japanese universities in energy due to the lack of a perfect and unified energy consumption monitoring system. In terms of Transportation, it has established a perfect public rail transit system on campus to improve the road system and bicycle parking conditions, enhancing the diversity of low-carbon travel modes on campus and students' willingness to low-carbon travel. In addition, the highest scoring rate of Kitakyushu science and Research Park in Operations is Water, which has reached full score. It can be seen that Japan, as a country with scarce fresh water, has reached a high level in the protection and reuse of water resources in the development of sustainable campus.

At present, the sustainable development of case Chinese university is still at the level of energy conservation, mainly by regulating the use of energy and reducing unnecessary waste, rather than actively reducing energy consumption through technological innovation. The green campus in American universities takes the campus building as a breakthrough point, constantly improving and expanding the scope of its construction services, and emphasizing the balanced development of all aspects. Japanese campus focuses on the green development of campus buildings, so as to achieve the sustainable development by building an environment-friendly campus on the basis of adapting the building to the environment.

6.1.5 Comparison of Two Chinese Universities through STARS

6.1.5.1 University Classification

Based on the development process of green campus in China, this study roughly divides Chinese universities into two categories: one is the eight founding universities of China Green Campus Alliance, which have long time, large funding and remarkable achievements in the construction and have won the commendation of the first batch of national demonstration campuses. It can be said that they represent the advanced level. The second category is the general institutions of higher learning that participate in China's green campus construction, with short construction time and a few achievements. They represent the general level of China's green campus construction.

Of course, the classification of this study is not detailed enough to accurately take into account the characteristic differences of various colleges and universities. In the future, the characteristic clustering analysis of colleges and universities can be carried out to increase the number of sample cases. However, it is still of positive significance to understand the green campus in China and to study the innovation of green campus construction methods by extracting two representative cases under the current classification.

Therefore, the selection of cases in this study is mainly considered in the following points:

(1). The development of campus infrastructure, corresponding functional departments and disciplines is complete and comprehensive, which meets the characteristics of the university to facilitate the complete collection of research data.

(2). The object of study is clear, which can be one or multiple campuses. It is easy to determine the physical boundary of the campus, which is conducive to the definition of the scope of assessment.

(3). In the construction of green campus, construction has begun to be promoted. The green campus has been building for some time and achieved results. The construction features are in line with the development of Chinese green campus construction.

(4). The case can represent the construction level of each category.

In this chapter, Zhejiang University is selected as case 1 in the first category of University; Zhejiang University of Technology Zhijiang Campus is selected as case 2 in the second category.

6.1.5.2 Comparison of Evaluation Results

STARS is used to evaluate case 1 and case 2 respectively, to analyze the construction of two cases, so as to further understand the current situation of green campus construction in China. The assessment results are as following (see Table 6.3).

Table 6.3: The Statistical Table of Two Cases' Evaluation Results by STARS

Campus		Categories				Total score (203)	Level
		Academics (58)	Engagement (42)	Operations (71)	Planning & Administration (32)		
Case 1	Score	43.88	33.61	17.29	20.17	114.95	Silver
Case 2	Score	43.68	18.09	11.50	15.50	88.77	Bronze

Note: The full score of this item is in parentheses.

Both cases are seriously deficient in such aspects as Air & Climate, Buildings, Energy, Purchasing, Waste and Water (see Figure 6.7). On the one hand, it specifically reflects China's insufficient development of facilities in green campus construction; on the other hand, it also indicates China's imperfect environmental monitoring and utilization green technologies, such as energy consumption control, building environment quality monitoring, waste recycling and so on.

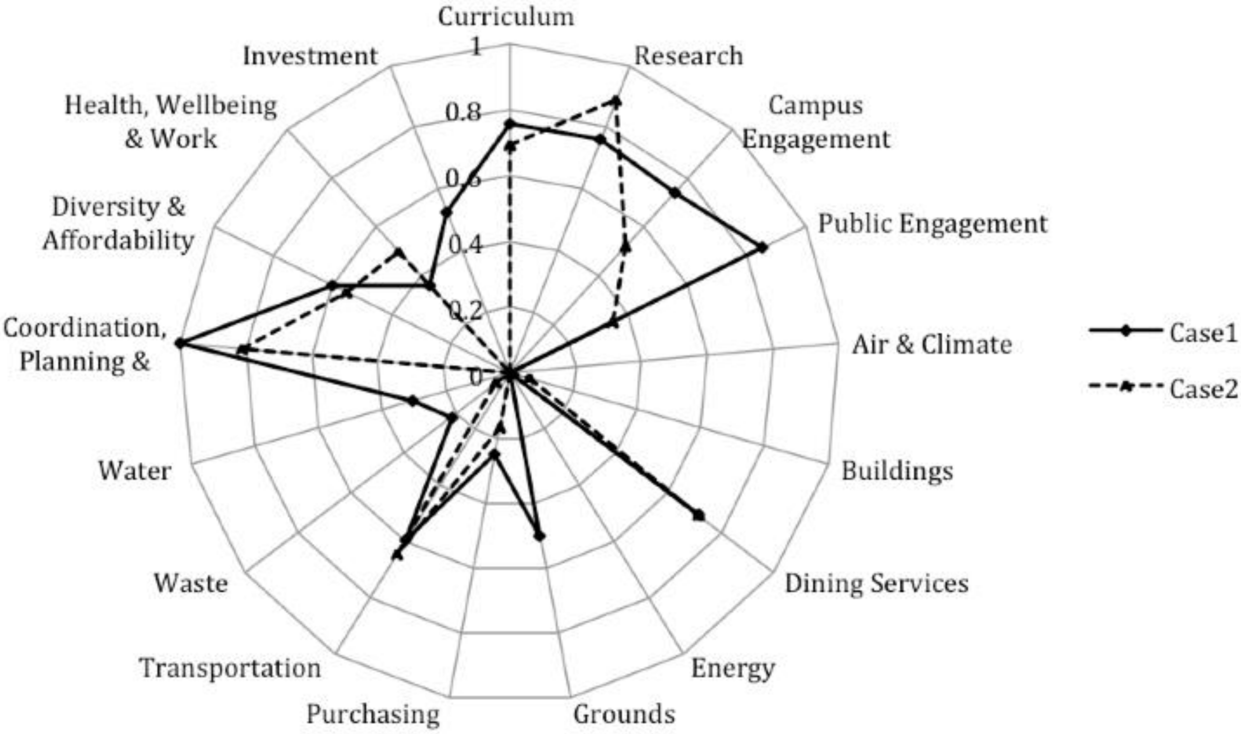

Figure 6.7: The Two Cases' Score Ratio Distribution of Each Assessment Item of by STARS

In terms of Curriculum, Research, Dining Services, Transportation, Coordination, Planning & Governance, both of the two cases have achieved high scores. It can be seen that these aspects have become the strengths of China's green campus construction and the focus of development and construction can be changed in the future.

With the compare of two cases, case 1 is significantly superior to case 2 in Engagement, Grounds, the Health and Wellbeing & Work, Investment. These aspects can be regarded as the key content of the second period of Chinese green campus construction. Drawing on the construction experience and technology of domestic first-class universities, it can be quickly promoted to the whole country to comprehensively improve the overall level of Chinese green campus construction.

At the same time, in the investigation of the two cases, it is found that the faculty and students are not familiar with the construction of green campus, which are mainly reflected in two aspects: first, they don’t understand the connotation of green campus; the second content is that the faculty and students don’t understand the green campus construction activities carried out by the school. The reason is that

the construction of green campus in China is mostly at the policy level, which is completed by some departments of the school, and lacks the joint participation of teachers, students and even the society. In the future, the standards should be applied to every user of the campus to encourage public participation, establish a feedback mechanism and mobilize the enthusiasm of all parties.

6.1.6 Conclusions

6.1.6.1 Energy Saving for Sustainable Campus Development

In order to study the motivation of "energy-saving" to campus sustainable development and provide a scientific basis for future green campus construction, this research selects G-value and S-value which respectively represent energy consumption and sustainability, and makes quantitative analysis on a typical representative case of green campus in China. It sets up a comparative group of American universities, based on the development process of green campus in China and the United States. Results are as follows:

(1). The G-value in 2016 of Zhejiang University in China is 0.019163 $MtCO_2 / m^2$, significantly lower than that of other four American universities. The lowest G-value is University of New Hampshire in the United States, which is 0.030679 $MtCO_2 / m^2$. It shows that the construction of energy-saving monitoring platform implemented by China has remarkable energy-saving effect.

(2). The G-values from 2004 to 2011 of Zhejiang University show an increasing trend year by year. Since 2011, due to the active development of the platform construction of the energy conservation supervision system, its G-value begins to decline significantly. The policy's promotion and implementation of China's energy conservation monitoring system plays a positive role in promoting campus energy conservation. The data from 2014 to 2017 is basically stable at 0.02 $MtCO_2 / m^2$. With the increase of energy demand brought by the development and construction of the school, the follow-up data has a rebound trend. Although the policy still has great energy-saving effect, the future development is not optimistic and the development potential is insufficient.

(3). Although Zhejiang University is a typical representative of green campus in China, its S-value is significantly lower than that of four universities in the United States, and it is only silver rating. At the same time, Zhejiang University's S-values of sustainability's four categories are all lower than that of the four American universities. It can be seen that there is still a big gap between the overall sustainability of Chinese case university and American comparative universities.

(4). According to the S-values of these universities, the development of green campus construction is not balanced between China and the United States. Two of the 17 sub-items of S-value of Zhejiang University are zero, which indicates that there is a big gap between Zhejiang University and American universities in campus buildings and indoor and outdoor air quality, which is the focus of future development. As far as the green campus in China and the United States and even the world is concerned, waste management and utilization, rainwater reuse and new energy utilization will become the core of future construction.

Based on the conclusion of this chapter, some suggestions on the construction of green campus are put forward for Zhejiang University, Chinese universities and the government:

(1). The construction of campus energy saving plays an important role in promoting the sustainable development of campus. The construction of green campus only depends on the implementation of energy-saving supervision system, so the future development prospects are not good. A number of Chinese universities, represented by Zhejiang University, need to formulate new policy guidance based on the current construction achievements, expand the technical application direction of regulatory system and the innovation of specific energy-saving technologies.

(2). With the continuous development of global green campus sustainable connotation and construction requirements, the overall concept of sustainable development in green campus should be established. Especially in the policy-making, the government and relevant departments should be detailed and all aspects of the overall consideration. Based on the national conditions and the characteristics of the university itself, the early development can focus on the development of advantageous projects of each university, so as to form a breakthrough point for the construction of green campus. With the formation and continuous improvement of advantage projects, the advantages will be transformed in time to drive the development of weak and difficult projects.

(3). Energy saving is an important part of the whole green campus, but the sustainability of campus should not only stay in the level of energy saving. The sustainability of campus should be based on both physical facilities construction and sustainable management planning, which provides a clear direction for the future green campus construction policy. For the construction of green campus in the future, campus buildings, water resource utilization, waste disposal and sustainable investment in campus have become the key objects of sustainable development in the future.

6.1.6.2 The Development Level of Sustainable Campus in China

According to the evaluation results, the construction of the green campus of the case universities are still in the preliminary stage, and the overall construction level is weak. Some of China's first-class universities are leading the construction of the whole green campus, whose level has reached the world's middle. The campus construction focuses on academic and education, and is seriously deficient in installation construction such as infrastructure and environmentally friendly utilization, which can be regarded as the direction of future efforts. Based on the current construction status and development accumulation, the construction of China's green campus in the next stage can be comprehensively promoted from the three aspects of participation in universities, staff care and investment. Meanwhile, first-class universities can actively explore environmental monitoring, green building construction, renewable energy utilization, waste recycling and water resource reuse in combination with their own scientific research advantages.

The future construction of the green campus should be guided by evaluation standards. These universities have carried out reasonable and effective energy saving renovation and energy audit on campus to reduce school energy consumption. In addition, the concept of green campus is carried out by adhering to the principle of sustainable development and ecological construction with the starting from campus planning, life service and green ecological education.

6.2 Sustainable Campus of American Case University Based on Global Sustainable Development Goals (SDGs)

6.2.1 The Development Between SDGs and STARS on Campus

6.2.1.1 Sustainable Development Goals (SDGs)

Transforming our world: the 2030 Agenda for Sustainable Development, adopted by all United Nations Member States in 2015, provides a shared blueprint for peace and prosperity for people and the planet, now and into the future. At its heart are the 17 Sustainable Development Goals (SDGs)(see Figure 6.8), which are an urgent call for action by all countries - developed and developing - in a global partnership. They recognize that ending poverty and other deprivations must go hand-in-hand with strategies that improve health and education, reduce inequality, and spur economic growth – all while tackling climate change and working to preserve our oceans and forests (United Nations, 2019).

Figure 6.8: Contents of 17SDGs

The SDGs cover a broad range of topics, and help countries and industries consider the impacts of their operations in a uniform manner. Depending on these 17 goals, it points out the direction of future development for human beings, and what is worth exploring now is how to achieve these goals. In the past five years, people have paid a lot of efforts and practices from all walks to SDGs. And in the next 10 years, SDGs will be comprehensively promoted and implemented in various fields around the world.

6.2.1.2 The Development Relationship among SDGs, STARS and Universities

SDGs are national and even global development goals, which provide a clear direction and requirements for global sustainable development. But they are only goals, lack of operability, difficult to implement, they need to be refined and implemented to the specific operational level. STARS is the specific goal at the school level under the framework of SDGs, which not only provides a clear development direction for the sustainable construction of campus, but also provides specific implementation suggestions. University is the frontier of innovation and development. It pays attention to the continuous innovation of technology, which is more conducive to the promotion and renewal of sustainable concept. As the physical carrier of the university, the campus has its own complete life system, and students experience various social activities on campus, so the campuses' construction experience has a good practical and reference significance for the larger scale cities or countries. The sustainable construction of campus is not only a part of SDGs, but also makes up for the lack of specific implementation scheme of SDGs to a large extent (see Figure 6.9).

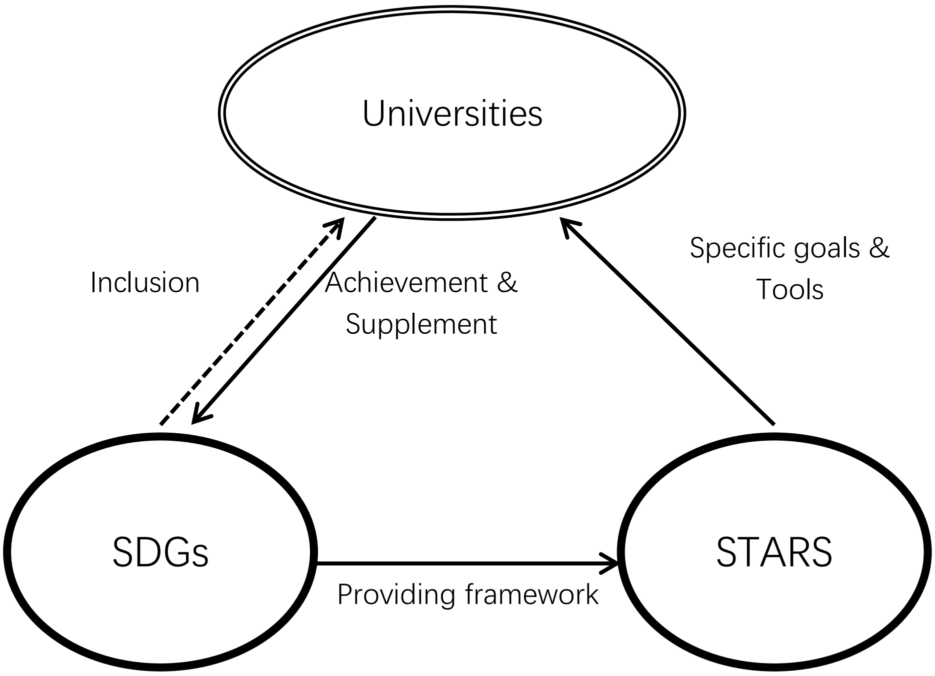

Figure 6.9: The Relationship Among SDGs, STARS and Universities

6.2.2 Stanford's Construction and Achievements

Stanford's construction mainly includes Academics, Energy supply & Demand, Water & Land, Waste, Management, Food & Living, Buildings and Transportation. These aspects of construction correspond to the 17 evaluation sub-items of STARS, and at the same time actively respond to the relevant SDGs (see Table 6.4).

Table 6.4: Correspondence Between Main Aspects of Stanford's Green Campus and SDGs & STARS

SDGs	Stanford's action	STARS
4.QUALITY EDUCATION	Academics	A1. Curriculum A2. Research
7.AFFORDABLE AND CLEAN ENERGY 9.INDUSTRY, INNOVATION AND INFRASTRUCTURE 13.CLIMATE ACTION	Energy supply & Demand	O1. Air & Climate O4. Energy O6. Purchasing
6.CLEAN WATER AND SANITATION 14.LIFE BELOW WATER 15.LIFE ON LAND	Water & Land	O5. Grounds O9. Water
6.CLEAN WATER AND SANITATION 9.INDUSTRY, INNOVATION AND INFRASTRUCTURE 11.SUSTAINABLE CITIES AND COMMUNITIES 12.RESPONIBLE CONSUMPTION AND PRODUCTION	Waste	O8. Waste
6.CLEAN WATER AND SANITATION 9.INDUSTRY, INNOVATION AND INFRASTRUCTURE 11.SUSTAINABLE CITIES AND COMMUNITIES 12.RESPONIBLE CONSUMPTION AND PRODUCTION	Food & Living	E1. Campus engagement E2. Public engagement O3. Dining services P4. Wellbeing & Work
9.INDUSTRY, INNOVATION AND INFRASTRUCTURE 11.SUSTAINABLE CITIES AND COMMUNITIES	Buildings	O2. Buildings
11.SUSTAINABLE CITIES AND COMMUNITIES 13.CLIMATE ACTION 15.LIFE ON LAND	Transportation	O7. Transportation
11.SUSTAINABLE CITIES AND COMMUNITIES 12.RESPONIBLE CONSUMPTION AND PRODUCTION	Management	P1. Coordination & Planning P2. Diversity & Affordability P3. Investment & Finance

(1) Academics

Stanford has 30 sustainability related projects in 2018-19, 420 sustainability researchers, more than 1140 sustainability related courses, and 5200 graduation projects related to sustainability development (Stanford Sustainable, 2019a).

Stanford uses its expertise to influence campus's food & living. R＆DE Stanford Dining has expanded its academic support for sustainability through guest presentations in the course and the launch of two new academic courses (Stanford Sustainable, 2019a). R＆DE Stanford Dining cooperates with two dormitories, Roble and Ng, to integrate sustainable food theme education into dormitories as part of university residential education and community concern. It also offers courses on picking and jam making from garden to Stanford 's food lab, offering a variety of learning and participation courses (Stanford Sustainable, 2019b). And Stanford proposes solutions to climate change, and develops students' deep understanding of the future sustainability of the natural world. From engineering and business to law, natural science and art, all areas cooperate to deal with the impact of climate change from a holistic perspective (Stanford Sustainable, 2019a). Stanford's emphasis on sustainability in its long-term plans ensures that this spirit of collaboration will continue for decades to come.

(2) Energy supply & Demand

In order to ensure the sustainable development of campus and meet the growing energy demand, Stanford has determined and implemented innovative energy saving strategies, especially in the aspect of energy supply management. After the implementation of the SESI (Stanford Energy System Innovations) program in 2015 (Stanford Sustainable, 2015), the school is striving to achieve its goal of reducing greenhouse gas emissions (GHG) in scope 1 and scope 2 by 80% by the 2025 deadline (Stanford Sustainable, 2019a). It's also decades ahead of California's requirement that electricity be 100% carbon neutral by 2045. To achieve this goal, a second solar power station will be put into operation by 2021, raising the university's share of renewable power generation from 69% today to 100% (Stanford Sustainable, 2019a). By 2018, Stanford has reduced the energy intensity in the campus by 26% from the benchmark level in 2000, and the emissions are 72% lower than the peak level. Moreover, it can save more than 4 million dollars a year by systematically renovating the buildings with the highest energy intensity in the campus (Stanford Sustainable, 2019c). In 2018-19, more than 25 energy transformation projects have been completed, and it is estimated that more than 300000 US dollars can be saved every year (Stanford Sustainable, 2019a).

(3) Water & Land

Stanford has experience in efficient water resource management and practice under the guidance of the civil infrastructure organization (WRCI). Since its inception in 2001, the total use of drinking water on campus has been reduced by 44% through the implementation of the water conservation plan in line with the needs of university communities and ecosystems (Stanford Sustainable, 2019a). Although 2018-19 is one of the most rainfall years on record, the implementation of measures to protect water resources during the four-year drought period ending in 2017 still has a long-term impact. Compared with the baseline before the drought in 2013, the water consumption of all major campus water users is significantly reduced (Stanford Sustainable, 2019a). WRCI has completed nearly 20 technical studies on alternative water supply, demand forecasting and water conservation (Stanford Sustainable, 2019a). In the past 18 years, for example, conservation projects, retrofits, capital improvements and behavioural changes have reduced drinking water use by 44 % (Stanford Sustainable, 2019d). In 2018, the consumption of drinking water is 3% lower than that of the previous year, and the consumption of non-drinking water is 1% lower than that of the previous year, with an average reduction of 1.2 million gallons per day (Stanford Sustainable, 2019d).

At the same time, Stanford cooperates with regional water institutions in water resource management to determine the sustainable output of regional water sources through monitoring (AASHE, 2019h). Stanford uses local surface and well water to provide non-potable and irrigation water for the campus. The school's goal is to continuously improve water use efficiency programs, develop new strategies to maximize the use of surface runoff, provide treated domestic water for important uses, and protect water sources. Stanford also improves water efficiency in existing buildings through maintenance and renovation, and educates campus users to save water. Compared with the existing similar buildings, the water consumption of new buildings is reduced by at least 25% (AASHE, 2019h).

(4) Waste

For waste disposal, Stanford is one of the longest universities in the United States to implement waste transfer program, which can be traced back to the 1970s (Stanford Sustainable, 2019e). Stanford's waste reduction program began with a recycling program led by student. And student participation remains an important part of the university's sustainable development program (Stanford Sustainable, 2019e). In order to provide the basis for the overall planning, Stanford launched the "*Zero Waste Plan and Feasibility Study*" in 2017 (Stanford Sustainable, 2018), which conducted a comprehensive analysis of its current waste composition. This study not only confirms that more than 75% of the waste in the landfill can actually be transferred (AASHE, 2019g), but also studies the material types of each waste chain in detail. What’s more, the feasible solutions are put forward. The solutions focus on waste reduction and reuse, which drives a closed-loop system (Stanford Sustainable, 2019a). It highlights responsible sourcing, extensive reuse, ease of recycling, expanded composting and minimal landfill as key components of improving Stanford's diversion and efficiency (Stanford Sustainable, 2019a). The school will strive to transfer zero waste campus to 90% or higher by 2030. Stanford's transfer rate in 2018 is 64% (Stanford Sustainable, 2019e).

(5) Food & Living

In the aspect of, R & DE (Residential & Dining Enterprises), as the largest auxiliary department of Stanford, is the logistic support for the life of 13000 students in Stanford. R & DE's “Sustainable Life (Stanford Sustainable, 2019i) and Sustainable Food (Stanford Sustainable, 2019h)” program helps integrate sustainable behaviors and choices into students' daily habits (Stanford Sustainable, 2019b). R & DE provides sustainable food as much as possible, reduces waste in operations and impacts surrounding communities. Among all its restaurants and cafes, R & DE has expanded its food recycling and donation program to donate surplus food from restaurants, cafes and franchised stores to local organizations (Stanford Sustainable, 2019a). At the same time, R & DE is looking for new ways to reduce food waste, such as through the implementation of 15 waste's weighing machines to help reduce excess food, thereby reducing food excess (Stanford Sustainable, 2019a). In 2018-2019, more than 75 students cooperate with R & DE to carry out research and sustainable development projects in their living and eating spaces (Stanford Sustainable, 2019a).

(6) Buildings

The construction environment of Stanford is very important to support the academic mission. Department of Project Management is responsible for the main construction of the campus and constantly strives to improve the application of sustainable practice in construction and design (Stanford Sustainable, 2019a). Stanford 's new building aims to meet the energy performance goal of the whole building (Stanford Sustainable, 2019f). The design and construction of the building should not only retain the original green space, but also use environmental protection materials to reduce the environmental impact. At present, 93% of the GHG emissions in campus come from the energy generated by building heating, cooling and electricity (Stanford Sustainable, 2019f). The Stanford's design team refers to *The Sustainable Building Guide* to build a green campus that can not only save resources (Stanford Sustainable, 2002), but also accommodate the surrounding environment.

(7) Transportation

Stanford established the "Transportation Demand Management (TDM) Plan" in 2002 (Stanford Sustainable, 2019i), which includes some of the most basic emission reduction strategies in the United States. The TDM project has developed innovative ways for students, teachers and employees to enter the campus in non-single vehicles. In addition to reducing travel during peak hours, TDM aims to reduce university related traffic GHG emissions, traffic congestion and parking demand by adopting sustainable parking facilities, buses, and various alternative modes of transportation. Thanks to the TDM program, Stanford has made great progress in continuously achieving the goal of " No Net New Commute Trips " (AASHE, 2019e). In addition to using bicycles, the campus commuters of Stanford also take the way of carpooling. Its 2089 carpooling members have also contributed to the reduction of traffic volume and enjoy the free senior reserved parking space set up by the university (Stanford Sustainable, 2019g). At the same time, Stanford's free Margaret shuttle has increased from 23 to 41 all electric buses, with 2.86 million passengers taking the free Margaret shuttle every year (Stanford Sustainable, 2019g). In 2018, Stanford commuter club has more than 11000 members (Stanford Sustainable, 2019g), enjoying all kinds of benefits of the school, while actively adopting sustainable transportation. The proportion of Stanford employees and commuters who drive to the main campus alone fell from 67% in 2002 to 42% in 2018, and 58% of campus commuters regularly use sustainable transportation (see Figure 6.10) (Stanford Sustainable, 2019g).

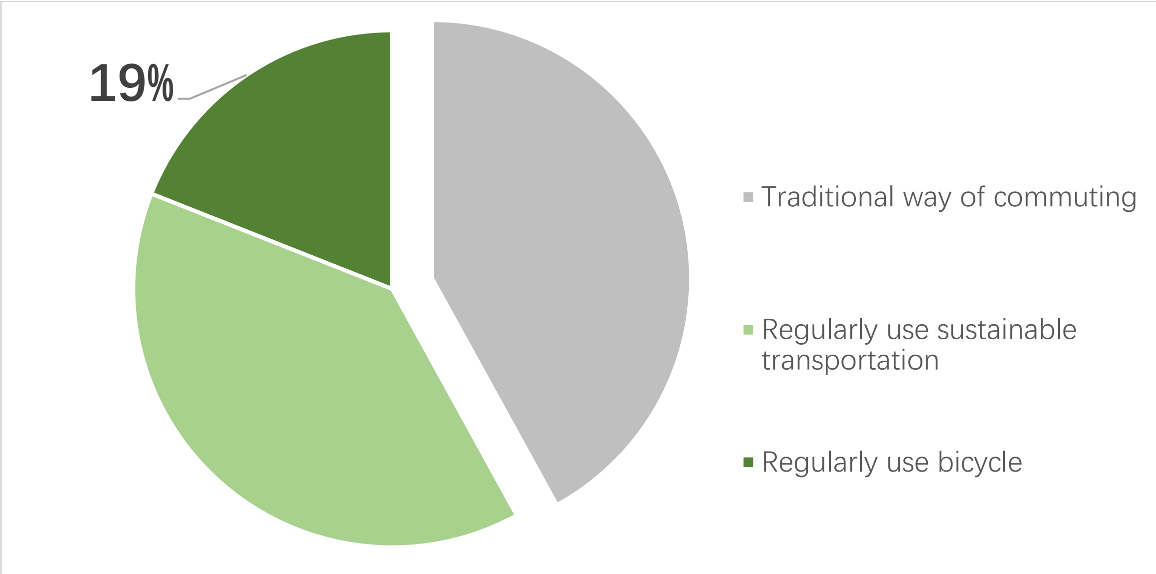

Figure 6.10: Proportion of Sustainable Commuting at Stanford University

(8) Management

Sustainable management is a main line running through all aspects of campus life. The Sustainability and SEM Business Services group (SSBS) constantly evaluates and improves, and strive to shape the future of school sustainable development through long-term planning process (Stanford Sustainable, 2019a). Unified planning and governance enables comprehensive analysis of campus performance and detailed planning for future improvements. SSBS also conducts a strategic assessment of its system group, which manages thousands of public data to monitor and analyze the consumption and trend of maximum efficiency. It plans to provide better transparency for campus performance through 135 building dashboards and 25 system dashboards (AASHE, 2019a).

In addition to the university's own program management, since 2017, “My Cardinal Green” (Stanford Sustainable, 2019j) program has provided more than 4000 members of the campus with a simplified way to engage and practice sustainable behavior (Stanford Sustainable, 2019a). Through the comprehensive protection plan of SSBS, the total savings in 2018-19 are close to 950000 US dollars (Stanford Sustainable, 2019a). Another plan to promote protection is the “Integrated Control and Analysis Plan” (ICAP). The program simplifies various energy monitoring and control platforms into a single enterprise system, helping Stanford become a leader in the field of "smart campus" (Stanford Sustainable, 2019a). The project ensures that Stanford 's operations and AI's academic research projects complement each other, enabling the facilities to bring higher productivity and more efficient operations to households.

6.2.3 Stanford’s sustainability Assessment

Through STARS assessment, Stanford scores 88 points in the four categories of Academic, Engagement, Operation and Planning & Administration, ranking first in the global green campus construction, rated as platinum (Stanford Sustainable,2019a).

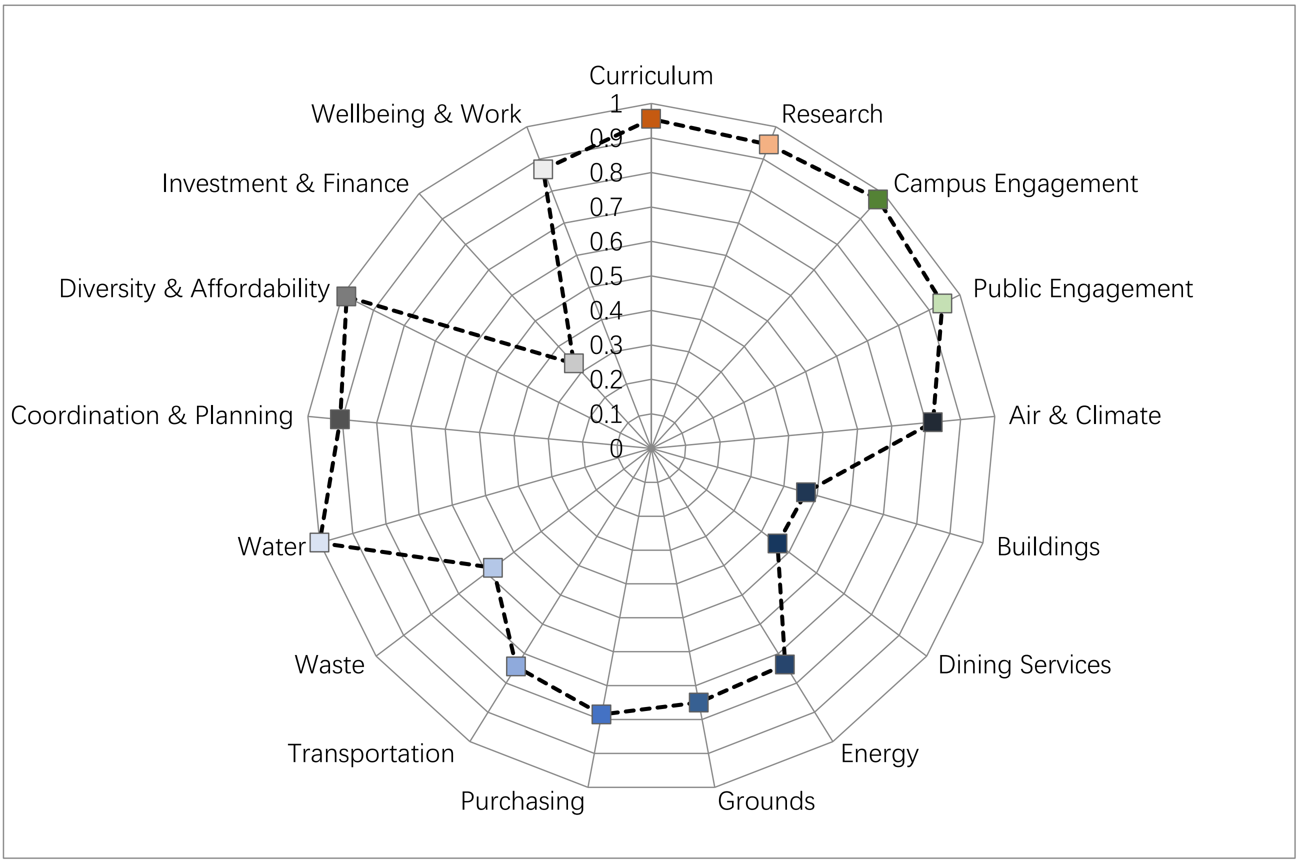

Figure 6.11: Stanford's Score Rate of 17 Categories by STARS

According to the STARS's evaluation results and data published on AASHE website, the scoring rate of 17 sub-items of STARS is calculated as shown in Figure 6.11. Among them, the scoring rate of eight sub-items is higher, which are: Curriculum and Research in the Academic category are all about 95%; Campus engagement (97.6%) and Public engagement (94.3%) in the Engagement category; Water in the Operation category gets full score; Coordination & Planning (90.6%), Wellbeing & Work (86.7%) and nearly the full score of Diversity & Accessibility (98.7%). These sub-items with high scoring rate mainly focus on four aspects of Stanford's green campus, namely, Academics, Water & Land, Food & Living and Management.

However, the Air & Climate, Energy, Purchasing, Transportation, and Grounds of the 17 sub-items have a general scoring rate. Among them, the Air & Climate part is mainly due to the insufficient reduction in GHG emissions, which has become the main point of losing score (AASHE, 2019a). In Energy, clean and renewable energy accounts for a relatively low proportion in Stanford's total energy consumption, which leads to a low score in clean and renewable energy (AASHE, 2019a). In Purchasing, cleaning and primary purchasing and office paper purchasing are not enough. In the later stage, it needs to be improved (AASHE, 2019a). For Transportation, the scoring rate of campus fleet and employee committee modal split is only about 50% (AASHE, 2019a). In the

Grounds part, there is a lack of landscape management (AASHE, 2019a).

Among the 17 sub-items, the score rate of Waste, Dining services, Buildings and Investment & Finance is low, which becomes the short board of Stanford's green campus and the focus of the future construction.

As to the Waste, the score of Waste Minimization and Diversion is only 50% (AASHE, 2019a). Although Stanford reduces its total waste volume by 14.5% in 2018 compared with 1998, it is far from the full score standard (50% reduction) (AASHE, 2019f). Compared with the benchmark, the percentage reduction of total waste generated by one campus user is 44.09%, which still lags behind the full score standard (90%) (AASHE, 2019f). The recycling rate of Stanford for waste is 17.3%, which is lower than the benchmark year of 20.7% (AASHE, 2019f), indicating that there is still new development space for waste recycling. In the future, Stanford can consider expanding garbage stations in public areas, improving the efficiency of storage services, and the joint recycling of paper, plastic, metal and glass, or increasing the recycling rate (Stanford Sustainable, 2019e).

Food and Beverage Purchasing is the lower score part in Dining service. At present, 24% of the total food and beverage expenditure of the school is used for products that meet the qualification of " Third-party Certification " or "Local and Community Certification", which is quite different from 75% of the full score standard (AASHE, 2019d).

The Building Operations and Maintenance and Building Design and Construction in Buildings aspect scored less (AASHE, 2019a). In the past five years, Stanford has been certified as a 0-square-foot building space that meets the green building hierarchy (AASHE, 2019b). Through the certification of green building rating system, the percentage of building space that can be used for the operation and maintenance of existing buildings is 55.36% (AASHE, 2019b). The reason is that Stanford has its own building rating system to evaluate the sustainable development performance of its buildings. But there is a certain gap with LEED-golden required by STARS (AASHE, 2019c).

For Investment & finance, the main deficiency is that the asset value of various categories such as sustainable industry and sustainable development investment fund is 0 (AASHE, 2019j). As a result, the school's decisions cannot be guaranteed to be sustainable, and its related investment cannot guarantee its responsibility for society or environment (AASHE, 2019j). What's more, in the investment management, there is no student representative in the school's Committee of Investor Responsibility (CIR) (AASHE, 2019i), which may lead to the lack of student representative's position and suggestions in the school's investment consideration.

It can be seen that the "software" construction of Stanford's green campus focuses on the implementation of a series of sustainability plans and sustainability education for school students and employees. As to "hardware", the construction of Campus engagement, Water, Diversity & Accessibility and other aspects are firstly promoted, achieving better results. At the same time, through the construction of these advantages to drive the development of other aspects, the overall construction of green campus is gradually realized.

6.2.4 Discussion on the Community Construction from Green Campus

6.2.4.1 Campus and Community Complementary Development

Although Stanford is one of the most outstanding green campuses representative in the US according to STARS, as mentioned above, its own development still has some shortcomings in some areas. But if Stanford wants to further improve these aspects, only relying on the campus itself has certain limitations, because in the process of construction, the development of the campus needs more resources and development space. For example, the further improvement of infrastructure needs a large amount of capital investment, and the establishment of good recyclable capital is the power guarantee for development (Yue Qi, et al, 2019). And as the physical space carrier of construction, more land use space needs to be considered (Chunqi Lu, Meijuan Xu, 2010; Xinqin Li, et al, 2019). In addition, more types of participants need to be considered to engage in it, taking into account the broader public interest and enthusiasm (Xianman Han, 2019). According to the above limits, the communities around the campus undoubtedly provide more possibilities for the sustainable development of the campus (Changwoo Ahn, Stephanie Schmidt, 2019). Therefore, it is very important to give full play to the development concept of win-win cooperation in sustainable communities. By investing in local communities, the school has solved the burden capacity and traffic challenges faced by the campus, while responding more actively to the interests of neighboring residents and jurisdictions.

As an example, Stanford has submitted an offer letter to Santa Clara County detailing a proposed $4.7 billion package of housing, transportation and public school benefits that the university would like to provide as part of a development agreement addressing its new long-term land use permit. The benefits will span the projected 17-year length of the permit, although many are front-loaded prior to the gradual development of new academic facilities (Stanford News, 2019). The university's proposal includes: (1) hundreds of units of new on-and near-campus workforce housing; (2) an expansion of sustainable commute programs and funding for local transportation infrastructure improvements; (3) supporting for Palo Alto public schools. The $4.7 billion community benefits package, including $3.4 billion for housing and $1.1 billion for transportation, will ensure that the General Use Permit meets the needs of the County, community and university (Stanford News, 2019).

The proposed General Use Permit and recently announced community benefits package exceeds many of the requirements Santa Clara County has laid out for Stanford (see Table 7.2)—building housing now, investing more in transportation improvements that encourage sustainable commuting, and providing support to Palo Alto Unified School District (PAUSD). This additional package of community benefits is responsive to community needs and aligned with Stanford's values as a residential university committed to sustainable development and service to the community and its residents (Stanford News-media, 2019).

According to the comparison of Stanford's benefits package and Santa Clara County's original list of requirements, Stanford's offer exceeds Santa Clara County's expectations. In the aspects of academic growth, total workforce housing supply, inclusionary affordable housing, Santa Clara County is satisfied. What's more, for affordable workforce housing, Stanford delivers all 575 below-market-rate housing units more than Santa Clara County's requirement of funding or constructing below-market-rate housing units gradually over time. For affordable housing mitigation Fee, Stanford beats fee ordinance and all provides up front. For reverse-commute/ all-day trips, Stanford enables on-campus workforce housing and public access to campus. For bike/ ped/ transit improvements, Stanford front-loads $30.3M in funding for neighboring communities, while the Santa Clara County's expectation is $1.2M. And for Palo Alto Schools, Stanford provides $138.4M in direct funding to district, while the Santa Clara County's expectation is $4.2M in state-mandated fees (Stanford News-media, 2019).

Stanford's benefits to Santa Clara County, on the one hand, help the construction of community housing, transportation and education, to promote the local sustainable development; on the other hand, the construction and development of the community made up for Stanford's deficiencies in development. The increase of workforce housing, as a social security mechanism, has greatly increased the attraction of the community to the labor force (Jiahui Xie, 2018). At the same time, the increase of the labor force, directly promotes the local production capacity, reducing the transportation cost of food and products (Tingting Pei, et al, 2016). And it is conducive to the sustainable construction of Food & Living category. The construction of community sustainable transportation not only greatly reduces the carbon emission, but also shares the commuting burden of the university to a large extent (Xianbo Zhao, et al, 2020; Min Liu, 2016). The construction of sustainable community provides a broader space for waste disposal (Hongwei Tan, 2019), for example, it is possible to expand garbage stations in public areas and improve the efficiency of storage services (Lei Zhang, Jianmin Liu, 2007). Through the promotion of sustainable concept, the campus has expanded the sustainable participants, which is one of the most important ways to promote from students to residents, providing guarantee for the sustainable construction in the future, and actively responding to the SDGs (Li Yu, 2014). The above series of measures can be regarded as a kind of sustainable investment, which will bring much more value than the actual amount of investment, so as to strengthen the complementary development between universities and communities (Kapil Narula, 2012). Although Stanford's sustainability in investment & finance is relatively low at present, it has great development potential in the near future through co construction with the community.

6.2.4.2 Promoting Joint Participation through Community Supporting Projects

Since founding, Stanford has sought and embraced new ways of fulfilling the university's mission of research, education, and service. And it always carries out the construction of its entire green campus. How to transform the achievements of green campus in the construction, not only benefits itself, but also drives the sustainable construction of surrounding communities, which has always been a concern of Stanford. To this end, Stanford has developed and carried out a series of projects to support the community (see Table 6.5), strengthening the connection between the community and the campus from different latitudes, improving the joint participation of students, teachers, residents and the local government (Xueli Zhu, 2016), and promoting the sustainable development and construction of the community.

Table 6.5: The Main Projects of Supporting Community in Stanford

(Stanford Our Vision, 2019b)

Projects	Main contents
Affordability Task Force (ATF)	The ATF is developing sustainable, broad-based recommendations using data generated from a campus affordability assessment and research by stakeholder groups. Emerging themes are informing priorities around housing, transportation, childcare and benefits that vary across the community.
IDEAL	IDEAL seeks to maintain Stanford's status as a premier institution for research and education by moving the institution culturally into the future. The project team has launched efforts in recruitment, engagement, research and education and has set priorities in each area to embed the values of IDEAL through a shared vision, optimal organizational arrangements, resources, and metrics for accountability.
Town Center & Community Engagement	The Town Center project will consider programs, operations and services that prioritize community-building, authentic social interaction, and intellectual interchange. Community Engagement seeks to build deeper connections across campus to support the mission of the university. It will aim to enhance the sense of belonging and excitement among employees of the university, as well as students.
Professional Development	Programs will develop a comprehensive and contemporary approach to professional development available to staff at various levels, providing a balance of education, experiences and exposure.
Stewardship	This work will ensure that the management of facilities, infrastructure and resources align with and support the needs of a changing workplace. The Executive Cabinet is developing governance models, organizational structures and centralization of resources to support future programmatic and operational needs in light of increased collaboration across campus and multiple worksites.
Engagement Hub	An Engagement Hub will be dedicated to advancing the public good and developing sustained partnerships beyond campus. The hub will support coordination of academic and non-academic community engagement activities through a new Office of Community Engagement in the Office of External Relations with the guidance of an advisory board of faculty, staff and students.

As Stanford said "Stanford is ideally placed to interpret and enhance the transformation of the human experience in a rapidly changing world. We have both the opportunity and the responsibility to do so" (Stanford Our Vision, 2019a). The ultimate goal of green campus is to participate in the realization of SDGs, helping to cope with the rapid development and transformation of the world, externalizing the achievements and experience of campus construction, so as to extend them to the communities and the countries. All sectors of the society jointly meet the challenges of the times of sustainable development (Andre Luis Tejerina Queiroz, 2019).

6.2.5 Conclusions

So far, compared with the benchmark year 2000, the GHG emissions have decreased by 72%, energy intensity by 26%, domestic water use by 45%, and landfill water by 26% (Stanford Sustainable, 2019a). It has achieved remarkable results in construction, won platinum level in STARS evaluation, and became the highest score of global green campus. The commitment is to function on 100% renewable electricity by 2021, reducing campus GHG emissions by 80%. It is also preparing and aligning this year for a zero waste Stanford by 2030, defined as 90% diversion from the landfill or higher (Stanford Sustainable, 2019a).

Stanford's green campus development model can be summarized as four characteristics:

(1) It is based on its own scientific research.

Stanford is a continuously self-improvement and innovation laboratory for sustainable development. Based on its own scientific research and driven by sustainable education, Stanford focuses on campus energy, GHG emissions, water resource utilization and waste disposal. The achievements of campus construction are transformed from multiple perspectives.

(2) It is in depth from the aspect of environmental friendliness.

Focus on 8 aspects of campus, such as Academy, Energy supply & Demand, Water & Land, Waste, Food & Living, Buildings, Transportation and Management, Stanford takes some targeted plans and measures, such as: SESI plan (campus will transition to electric heating and cooling system), Energy and Climate Action plan, Zero Waste Plan and Feasibility Study, rainwater collection and use for campus irrigation, establishment of commuting club and car free club, Sustainable Life and Sustainable Food plan.

(3) The participation of students, teachers, residents and local government is realized.

The construction emphasizes that sustainable development is a joint effort of the whole campus and even the whole region. Through a series of campus participation activities and community supporting activities, the sustainable life concept is promoted. The interests of multiple parties are taken into account in the construction, so that sustainability becomes the common development goal of multiple participants.

(4) It is to realize sustainable investment form complementary development with the community.

Just like Stanford, it will evacuate the traffic and burden problems caused by the development of the campus to the surrounding communities. At the same time, it will bring vitality and benefits to the surrounding communities, and form a benign interaction mode. The sustainable development gradually develops from the campus construction to the sustainable community construction, forms the sustainable community development pattern based on the green campus, and finally achieves the SDGs. With the continuous construction of the green campus, it is insufficient to rely on the development of the campus itself in the future, so it needs to use the resources of the surrounding communities to solve the current obstacles to its own development.

The significance of Stanford's green campus lies not only in its own achievements, but also in its leading role in universities around the world. Other schools can learn from Stanford's construction measures and summarize their experience, so as to develop better and more efficient plans for themselves. This has greatly promoted the development of global green campus. At the same time, through the construction and innovation of campus, 10 SDGs relating to education, energy, climate, water, production and sustainable community have been implemented. In order to achieve the common sustainable development of human beings, it provides a better solution path from the perspective of campus, and has a high promotion value.

The construction of green campus has changed from a single triangle framework composed of SDGs, STARS and universities to a compound triangle framework composed of SDGs, universities and communities on the existing basis, greatly expanding the way to realize SDGs (see Figure 6.12). On this basis, with the continuous development and construction, the framework can continue to grow in the future, compounding more triangular frameworks in terms of scale and categories.

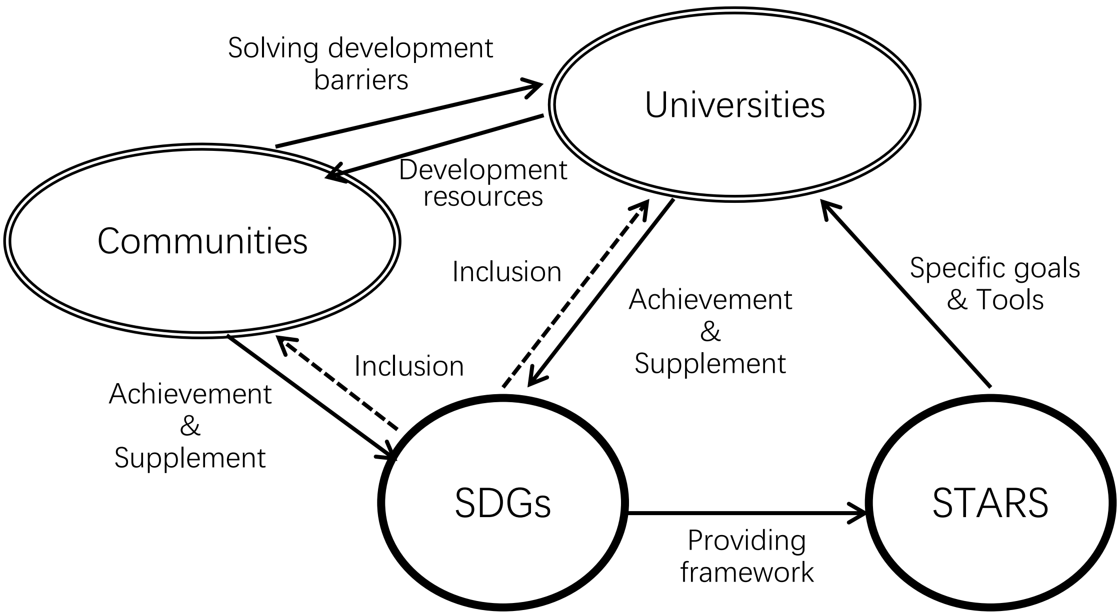

Figure 6.12: From Green Campus to Sustainable Community Development Model Framework

6.3 Sustainable Campus of Japanese Case University Based on Integrated Development of Industry, University and Research

6.3.1 Sustainable Campus Construction in Kitakyushu Science and Research Park, Japan

With a great focus on utilizing natural resources and novel design, Kitakyushu Science and Research Park is based on passive design. The Park has applied solar power generation systems, high-efficiency energy systems (fuel cell power generation and waste heat utilization technology), domestic sewage treatment and rainwater recycling while the local government aims to build a construction that provides convenience for enterprises' research and common facilities for local residents. Moreover, the building of the park has gathered advanced technology education and research institutions that combines science and technology to meet the requirements of the new era. (Feng, H., Qi, X., Gao, W., Fan, L, 2014).

What Kitakyushu has achieved in science research on urban construction can be mainly divided into eight aspects. The following part summarizes the experience of sustainable campus construction by analyzing the measures adopted in Kitakyushu Science and Research Park's concrete construction of sustainability.

(1) Academics

Kitakyushu University joined the United Nations Academic Impact (UN Academic Impact) in July 2019 and joined the SDG University Cooperation Organization. The main members of SDG are United Nations University while the universities put a great emphasis on making constant contributions to the sustainable development of Japan and the world (The University of Kitakyushu, 2020a).

The basic education disciplines of Kitakyushu University cover almost all of the 17 SDGs. And the Basic Education Center in Kitakyushu conducts SDG-conscious education activities including a clear description of the relationship with the SDGs in the syllabus of basic education subjects. Moreover, the first-year courses of the International School of Environmental Engineering "Environmental Technology for the Creation of the Future", "Special Lectures on Environmental Issues" and "Environmental Issues Case Studies" have been added in education through sustainable development goals in cooperation with the company. And this practice can cultivate the ability to consider communities from the perspective of engineers. Since sustainable human resources play a positive role in promoting clean energy and sustainable economic work. Aiming to use the favorable resources of the university to create life results and realize the sustainable development of local communities, the university also offers environmental ESD courses to cultivate "human resources that can contribute to a sustainable society", promote the sustainable development goals in social education (The University of Kitakyushu, 2020b).

Kitakyushu University has been cooperating with Kitakyushu Environment Bureau and University-affiliated Environmental Technology Research Institute to move forward human resource development and conducted joint research on wind energy. The Institute of Environmental Technology has made a variety of studies to achieve sustainable development goals like the compressed cedar materials as a technology to actively use domestic afforestation materials, the development of environmentally friendly foam fire extinguishing agents that have little impact on animals and plants, and the development of hydrogen technology of clean energy for residents' participation (The University of Kitakyushu, 2020b).

(2) Campus Education

Kitakyushu University has been implementing the KITAQ Campus Sustainable Development Goals, which are discovered and designed by students and disseminated as examples to evaluate campus activities that are applicable to the Sustainable Development Goals. Students discover and make the goals in line with the International Sustainable Development Goals on campus initiatives. As part of the community contribution activities of Kitakyushu University, the school community symbiosis education center aims to cultivate the next generation of talents through community practice activities (The University of Kitakyushu, 2020c). With students as the main body, all activities such as children's canteen support projects, crime prevention and disaster prevention projects, and urban beautification charm enhancement projects have been carried out. Hopefully, human resources can be cultivated through social practice and participation and various information technologies can be socialized in the application system using IOT.

(3) Architecture

The building environment of the Kitakyushu Science and Research Park plays a great role in supporting research. And the sustainable goals of the buildings in the Science and Research Park can be divided into the following three aspects: ①Durability: a stronger, more durable, earthquake-resistant and safe structural system. ②In response to the climate and coordinating with nature: The university will strive for natural ventilation and lighting and reasonably solve the problem of sunshade and rain. ③Energy saving, carbon reduction and energy efficiency improvement: rationally formulate building cooling and heating loads, scientifically select air conditioning systems, and improve the thermal insulation performance of building envelopes. Although the functions of the buildings on the campus are different, the selection of appropriate building energy-saving technologies is privileged. Meanwhile, the green design strives to reflect the elegant Japanese architectural aesthetics (Tian, Y., Hu, J., Li, C., Wang, S. 2015). For the layout planning of buildings, the relative positions of different buildings are reasonably allocated to improve the utilization rate and the sharing of service facilities based on the functional features of different buildings. On the other hand, the buildings are organized according to the features of the buildings.

Take the comprehensive building of the Department of International Environmental

Engineering as an example to analyze the construction technology. The comprehensive building where the Department of International Environmental Engineering of Kitakyushu University is located is composed of two east-west slab buildings. The north building is classrooms and teachers' offices, and the south building is the laboratory building. They are connected by five corridors and are the mass of the entire research and research city. The largest building is also a landmark building for the comprehensive use of green technology on the campus. Green building facilities include building equipment management systems, energy-saving lamps, shading facilities, renewable energy systems, non-traditional water source systems, water-saving appliances, water-saving green irrigation measures, waste sorting and treatment, etc. (see Table 6.6).

Table 6.6: Main Green Technologies used in Main Building of Hibikino campus of the University of Kitakyushu

	Appropriate technology	**Energy saving significance**
Ventilation systems	An outdoor courtyard between the north and south blocks, a number of light courts inserted between the teachers' offices and classrooms in the north block, a combination of connecting corridors, air traps, underground ventilation registers, air extraction shafts, solar chimneys and windbreaks have been implanted in both blocks.	A range of measures, such as solar chimneys and underground ventilation systems, improve the comfort of the building and reduce the building's carbon footprint, resulting in greater energy efficiency.
Shading systems	There are two main types of external shading: one is the installation of reflective shading panels on the upper 1/4 of the window, which combines light and shade; the other is the central arrangement of various laboratory pipelines within a uniform metal frame on the façade, forming a recessed window shade of approximately 900mm in depth at the window.	Natural light enhances visual comfort and has a significant impact on building energy consumption. It uses a variety of designs to save energy and create a high quality indoor light environment to achieve energy savings.
Roofing systems	A large membrane structure has been used to create a translucent roof and a large indoor-outdoor transition space; a large number of solar photovoltaic panels have been installed on the concrete roof and various experimental facilities for climate and energy testing; monocrystalline photovoltaic panels with a shading effect have been installed on the eaves of the roof on the south-facing façade of the building.	The transmission of light through the membrane creates a uniform and gentle lighting effect and also shields the building from the heavy rainfall coming from the north. The three roof materials respond to different problems and create a unique

image of the building.

(4) Energy & Monitoring

Kitakyushu Science and Research Park protects the ecological environment to the greatest extent while getting power. It mainly uses clean energy, such as solar cells using solar light, fuel cells using chemical reactions and gas generators. At the same time, the heat generated by power generation is not wasted, and it is used to heat and make hot water for buildings in campus. In terms of energy system management, Science and Research Park has managed the energy use and safety in a unified way, and established a 24-hour central monitoring system (see Figure 6.13). It can control the efficiency and safety of energy output, the amount and time of energy use. Kitakyushu Science and Research Park transmits power, heat, water and information to buildings through underground construction pipelines (common ditches). The centralized management of underground pipelines not only makes the monitoring system more timely and accurate, but also makes the pipeline easy to repair and replace. Through the control of data center, only the required energy quantity is transmitted to the necessary buildings at the specified time, so as to avoid energy waste. The energy system greatly reduces the emission of pollutants, and has good energy saving effect, thus reducing the carbon emission of campus.

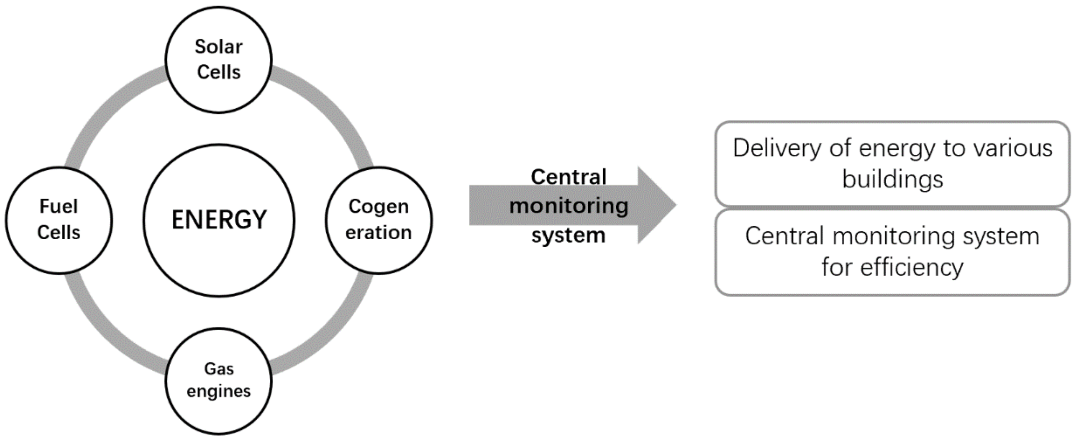

Figure 6.13：The Relationship between Energy and Monitoring System

(5) Water Resources

The campus planning has different countermeasures for living and experimental sewage and rainwater. And a complete and effective water recycling system has been formed. Ordinary domestic sewage and laboratory waste water are collected through the sewage pipe to the waste water treatment room of the environmental center, where the water is processed and then stored for secondary use, such as toilet flushing (The University of Kitakyushu, 2020d). The recycling of rainwater is mainly carried out in two ways. First, the avoiding of buildings on the main surface runoff direction except for the necessary hard soil can make the soil permeable and increase green space as much as possible. The green space is used as an ecological fracture zone between the hard land and the swamp, and most of the runoff is collected in the central pond area. This area is not only a natural waterway for biodegradable rainwater treatment, but also an important ecological splicing area. Secondly, the rainwater from the roof can be collected in a central filtering device and the water is used as circulating water for air conditioning cooling and irrigation water after treatment. The simulation results show that 86.8% of the urban daily water consumption can be treated and reused after use. Moreover, rainwater is filtered in a filtering device and used as circulating water for cooling and water for sprinklers (Tian, Y., Hu, J., Li, C., Wang, S. 2015).

(6) Ecology

Considering the impact on the environment, Kitakyushu Science and Research Park has been taken various methods to effectively provide energy and water for education and research activities. The campus plan retains large areas of relatively concentrated green space in the north and south, and these areas naturally become barriers between residential areas, sports areas and learning areas. There are roads between the concentrated green spaces that are not blocked by roads, and natural means are used to separate functional areas to protect biodiversity. Almost all campus buildings have chosen the form of flat roofs for roof greening to enhance the carbon sink function of the campus. Moreover, building a sustainable campus focuses on restoring the surrounding natural ecosystem and water circulation system. The school of International Environmental Engineering of Kitakyushu University focuses on reducing environmental impact and actively utilizes natural energy such as light, wind, and heat to achieve zero waste of water and energy.

(7) Transportation

Kitakyushu Science and Research Park has taken very many measures such as providing convenient bus connection services to facilitate teachers and students to actively use public rail transportation to encourage bicycle trips on campus and improve walking conditions to attract and encourage teachers and students to choose walking as much as possible. Kitakyushu is about 2.5 kilometers away from the nearest Kagoshima Main Line Railway Station. There are three bus stops at the most populous node on campus, and there is at least one departure point at each hour. The bus stops make getting to the entrance of the railway station very convenient. For the slow-moving system, the sidewalk is seamlessly woven into the square, and bicycle parking stations are provided at the most convenient location, and bicycle parking sheds are set up to improve parking conditions. Almost all buildings are connected by sidewalks, and those without sidewalks are designed with directions planted with cherry blossoms and abundant plants that combine water systems and ramps. For the parking, grass-planting bricks has been used to cover the parking to improve the water permeability of the parking surface. Moreover, the close relationship and symbiotic relationship between the "school and the city" opens the campus to the city without walls. The campus avenue is an important part of the urban road system, and surrounding residents can freely use campus transit traffic.

(8) Regional Development

The development of Kitakyushu Gakuin City has been moving towards the way of "comprehensive urban development" while combining the surrounding nature and urban environment. Meanwhile, the Kitakyushu has integrated educational and research institutions to provide a good living environment. Kitakyushu Science and Research Park has four features: ① Collecting the research departments of universities, research institutes, and companies in the same campus. ②The standardization of university education and research should be advanced. ③ Mutual communication and cooperation among researchers, faculty, and students need to be enhanced. ④ Integrated operation of the campus and the common use of facilities (The University of Kitakyushu, 2020a). The relevant measures implemented by Kitakyushu can be summarized as follows: First, through systematic system and policy support, establish a basic framework for environmental hazard management and ecological economic development. Second, Kitakyushu will actively promote industrial greening and reduce waste discharge. Furthermore, the industrialization of the environment and the hematopoietic function of the environmental industry can be promoted, which will promote a low-carbon lifestyle, reduce consumers' sense of alienation, reduce household waste, and increase recycling rates.

6.3.2 Correspondence Analysis between Campus Construction and SDGs

Kitakyushu Science and Research Park has achieved outstanding results through a series of "sustainability" measures, encouraging more schools to build sustainable campuses, and has also been recognized by all sectors of society. By systematically sorting out the construction measures and achievements of Kitakyushu Science and Research Park, the construction actions of its sustainable campus are compared with the 17 sub-targets of SDGs (The United Nations, 2020), and the number of corresponding target coverage in each aspect is obtained (see Figure 6.14). In order to clarify the shortcomings and advantages of the study of urban construction, summarize the features of its sustainable campus construction, and provide a basis for exploring the sustainable development model of Japan.

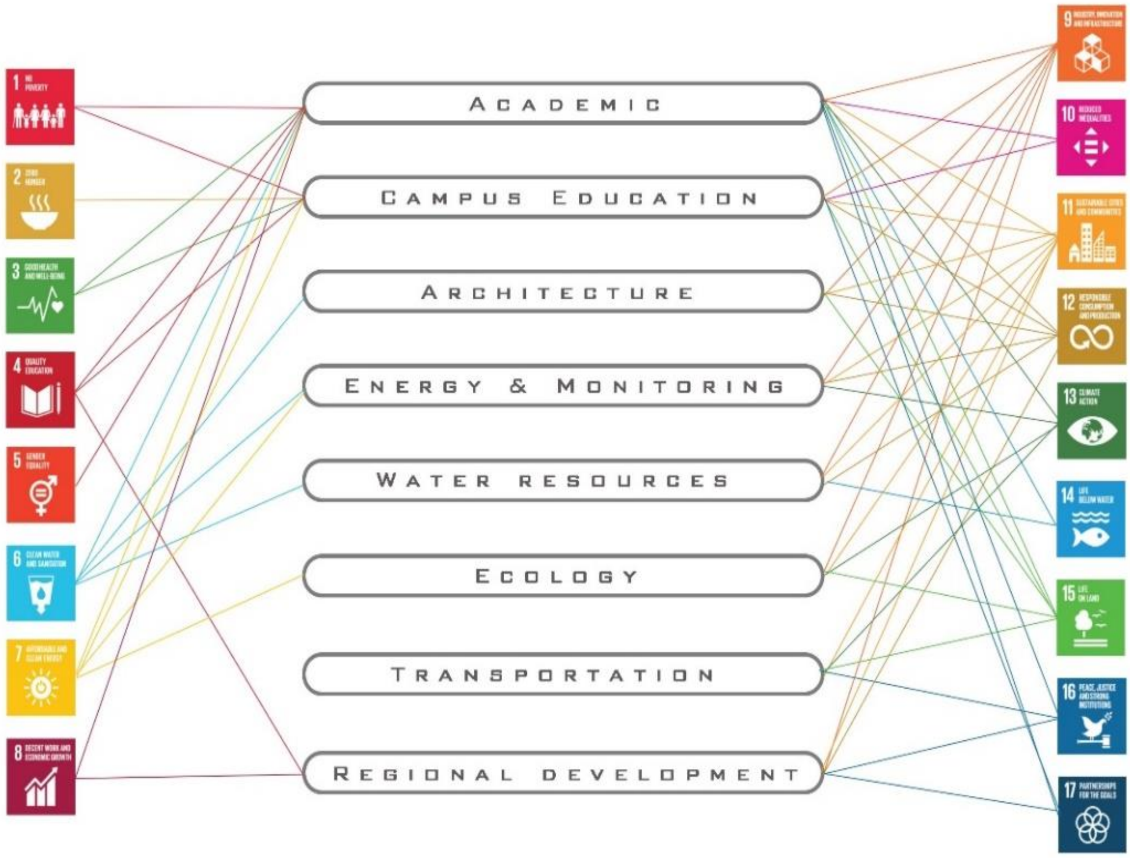

Figure 6.14: The Relationship between SDGs and Kitakyushu's action

6.3.2.1 SDGs Corresponding to Operation Kitakyushu's actions

Kitakyushu Science and Research Park's sustainable campus construction actions can be mainly divided into eight aspects. The number of targets covered by the corresponding SDGs was counted and the results were classified through data analysis. The future development direction is divided into three categories: optimum development, keeping up with development, and enhancing development. The eight aspects of sustainable campus construction activities are more or less related to the sustainable development goals, but the universally covered sustainable development goals are 5-6 items, which are in the Enhancing development stage, and there is still much room for improvement in the future. However, the three aspects of Academic, Campus Education and Regional developments cover more sustainable development goals (see Table 6.7).

Table 6.7: SDGs Corresponding to Kitakyushu's actions

Kitakyushu's action	Number of SDGs target coverage	Development strategy
Academic	17	Optimum Development
Campus Education	11	Optimum Development

Architecture	5	Enhancing development
Energy & Monitoring	6	Keeping up with development
Water resources	5	Enhancing development
Ecology	5	Enhancing development
Transportation	4	Enhancing development
Regional developments	7	Keeping up with development

The Academic part covers all items of SDGs. It is mainly reflected in the basic education of universities. The Basic Education Center carries out education activities with the awareness of sustainable development goals, carries out renewable energy research centered on wind energy, actively uses new technologies, manufactures environmentally friendly products, develops professional models of clean energy, etc., and Cooperate with the company to educate on sustainable development goals. The Campus Education part has also done a good job, covering most of the sustainable development goals, and carrying out campus activities with the goal of sustainable development. Students combine theory with practice, and expand the scope of education to attract surrounding citizens to participate in such activities. By attaching importance to Academic and Campus Education, focusing on advocating conservation awareness, strengthening theoretical education, and combining sustainable technology, it provides a clear development direction for the sustainable construction of the campus.

Although Kitakyushu Science and Research Park has taken certain measures in the Architecture, Water Resources, Ecology, and Transportation sections, improvement from other aspects is needed. When building the campus, Kitakyushu Academy respects the ecological environment of the original site. However, due to the campus is large and the overall control is not strong enough, the construction, water resources, campus ecological environment and transportation parts need to be further strengthened. In the future, the use of green building technology for the entire campus, the recycling of water resources, the expansion of public transportation, the use of more clean energy, the implementation of a sustainable energy management system, and the development of sustainable cities and communities can be considered, which are believed to be an important part of the future construction of the campus.

6.3.2.2 Construction Actions Involved in 17 SDGs

This research summarizes the sustainable campus construction actions of Kitakyushu Science and Research Park in Japan, Stanford University in America and Zhejiang University in China into eight aspects, and makes statistics on the number of construction fields involved in each SDG, in order to obtain the SDGs involved in the three universities' actions. Their sustainable construction fields can be summarized as follows:

① **Kitakyushu Science and Research Park**: Academic, Campus Education, Architecture, Energy & Monitoring, Water resources, Ecology, Transportation, Regional developments.

② **Stanford University**: Energy supply & Demand, Water, Waste, Food & Living, Buildings, Transportation, Management.

③ **Zhejiang University**: Energy Use Management, Electricity Saving, Renewable Energy Use, Water, Energy Efficiency in Heating, Waste, Transportation, Sustainability Training.

Through the data statistics, the research makes a comprehensive evaluation of the three campuses, so as to get the quantitative results of each SDG, and clarify the shortcomings and advantages of their construction. The number of SDGs covered by the campus actions of Kitakyushu Science and Research Park is the largest, followed by Zhejiang University and Stanford University is the smallest (see Figure 6.15). The largest number of SDGs covered by Kitakyushu Science and Research Park and Stanford University are Sustainable Cities and Communities, which shows that they attach great importance to this and have carried out a lot of corresponding sustainable campus construction activities. Zhejiang University pays more attention to the goal of Affordable and Sanitation. There are two sustainable development goals: Zero Hunger and No Poverty. The coverage of the three campuses is not high, which does not mean that their construction is weak, but these two goals have been basically solved in the construction of the campus.

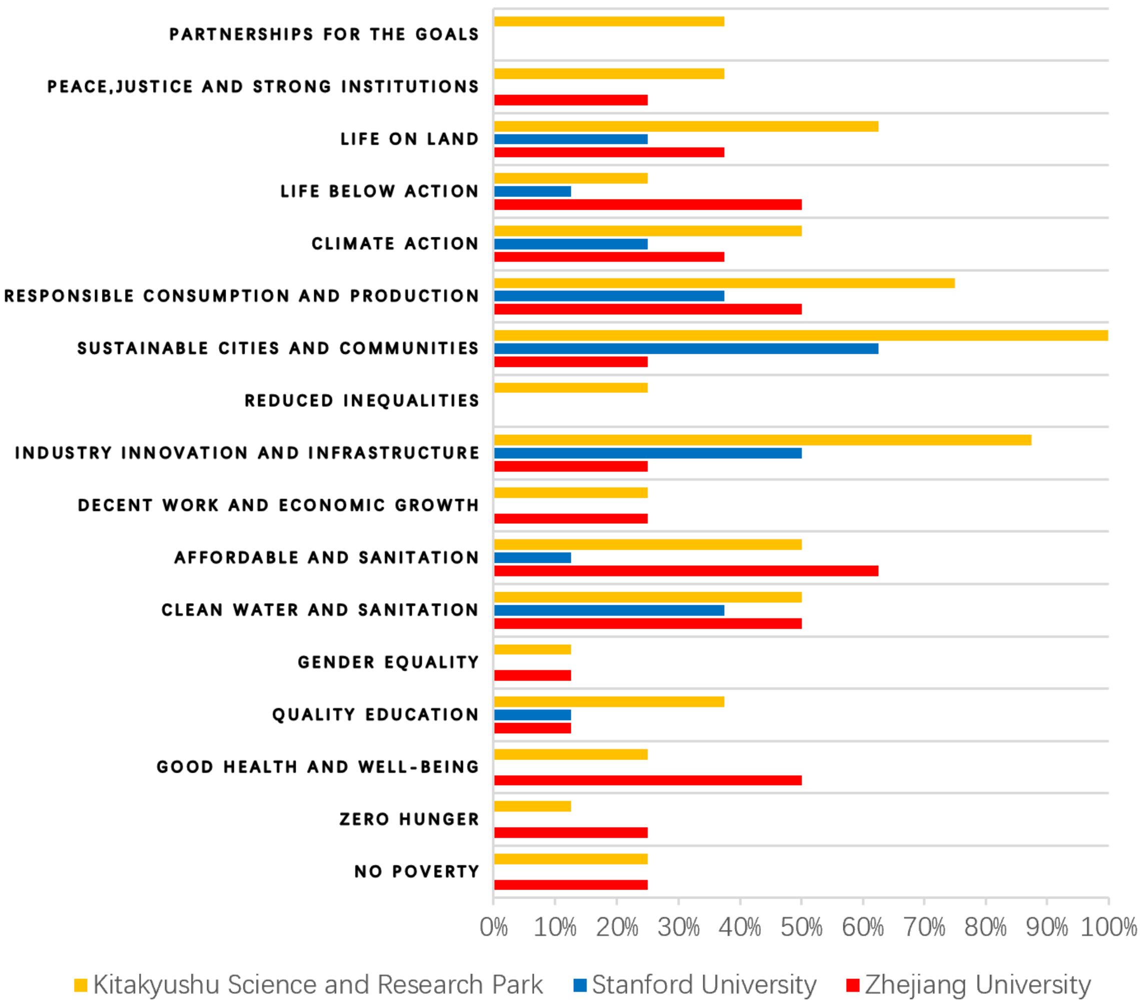

Figure 6.15: Proportion of Three Universities' actions Involved in 17 SDGs

Although the three campuses have some measures in Architecture, Water Resources, Ecology, Transportation, they still need to be improved. During the campus construction, Kitakyushu Science and Research Park respects the ecological environment of the original site, but the campus is large, the overall control is not strong enough, thus there are weak points. In the future, the use of green building technology, expansion of public transportation and the use of clean energy need to be considered. Stanford University, as one of the most outstanding sustainable campus representatives in the world, still has some shortcomings in its own development in some areas. It needs to transit from the original campus perspective to a higher community perspective to think about the ways to achieve the SDGs. The advantages of Zhejiang University's green campus construction in China lie in Academic and Activity Engagement. At present, the use of new energy is relatively weak, so the application and transformation of new technology should to be emphasized. Each university has its own characteristics and advantages, thus each should be combined with the actual situation to make up for the missing, develop strengths to make up for weaknesses, and explore a suitable path for the sustainable development of their own campus.

6.3.3 Comparison of SDGs Implementation Paths between the Kitakyushu Science and Research Park and Stanford

Due to limited local resources and raw materials, Japan has attached great importance to the construction of a recycling-oriented society. And Kitakyushu has took a lead in creating Japan's first eco-city and has now become Japan's largest eco-industrial park, namely Kitakyushu Science and Research Park. From a global perspective, the typical example of sustainable campus construction in the United States is Stanford University. And Sanford has become a practitioner and pioneer of global green campus construction in terms of research, teaching, campus student activities, and community promotion. Since the United States and Japan are essentially different in the construction and development of sustainable campuses, they represent two different directions to achieve the global sustainable development goals from a campus perspective. By comparing the sustainability of these two campuses Sexual construction can give some inspiration to future actions.

6.3.3.1 Features of Implementation Paths

This chapter summarizes the features of how Kitakyushu Science and Research Park and Stanford University achieve a sustainable campus from four points.

(1) Core

Kitakyushu Science and Research Park takes education as its core part and puts an emphasis on the student and aims to cultivate talents with a sustainable development outlook. Kitakyushu Science and Research Park focuses on teachers' teaching and strengthens theoretical education; supplemented by practice, which enables students to combine practice and theory. The campus has been establishing cooperative relationships with relevant enterprises, grasp and control existing educational resources, so that students can improve their own abilities in practice, truly realize their own sustainable development, expand the scope of education, and attract surrounding citizens to participate. Stanford University takes its own scientific research as the core. Stanford is a sustainable campus that is constantly improving and innovating. It has a number of sustainability-related projects, focusing on campus energy, greenhouse gas emissions, water use and waste treatment. With its own scientific research as the core and sustainable education as the driving force, it is committed to transforming the construction results of the campus from multiple angles.

(2) Goal

Based on the global sustainable development, corresponding measures have been made. Kitakyushu Science and Research Park starts from the resource conservation and aims to construct a sustainable campus from eight aspects: academic, campus education, architecture, energy & monitoring, water resources, ecology, transportation, and regional developments. The basic ideas for the construction of Kitakyushu Science and Research Park are: Pay attention to the natural environment, introduce solar power systems, high-efficiency energy systems and fuel cells, waste heat power generation and heating systems, domestic sewage treatment and rainwater recycling, etc.; build common facilities that are convenient for companies to conduct joint research and are convenient for local residents to use. Stanford takes environmental friendliness as an entry point, focusing on 8 areas of Academics, Energy supply & demand, Water, Waste, Food & Living, Buildings, Transportation, and management on the campus, and adopts a series of targeted measures and plans, such as the SESI plan. (The campus will transition to an electric heating and cooling system), energy and climate action plan, zero waste plan, collecting rainwater and using it for campus irrigation, setting up commuter CLUB and car-free clubs, sustainable living and sustainable food plans. A study of development mode in green campus to realize the sustainable development goals (Zhu, B., Zhu, C., Dewancker, Bart, 2020).

(3) Protection

Kitakyushu Institute of Science and Technology takes its own scientific research as the guarantee to further conduct educational activities with the goal of sustainable development, and the sustainable development goals are included in basic education; offers environmental ESD courses, promotes the development of social education, and uses the resources of the university to serve the local community; introduction Advanced research results and technologies promote sustainable energy on campus. Stanford University guarantees the realization of a sustainable campus with the participation of students, teachers, residents and the local government. The construction emphasizes that sustainable development is the joint effort of the entire campus and even the entire region. Through a series of campus participation activities and community support activities, the perception of sustainable living and the code of conduct are promoted. It is built to take into account the interests of multiple parties and make sustainability a common development goal for multiple participants.

(4) Feature

The pathway of Kitakyushu Education and Research City to develop a sustainable campus is characterized by the integration of Industry & Education & Research. Kitakyushu has made full use of the geographical advantages of neighboring Asian countries and the actual results of technical cooperation with Asian countries in the field of environment. The industrial technology that represents the national level is combined with the cutting-edge research and development functions of universities, etc., to create new industries and achieve high technology. The goal is to build the Science and Research Park into Japan's largest industrial technology integration site and Asia's core research base. This creates a good environment for cultivating talents and ensures that cutting-edge high-tech can be applied to enterprises in the first time, put into production and create profits.

The characteristic of Stanford University is to form complementary development with the community and realize sustainable investment. Stanford evacuated the current traffic and burden problems caused by the development of the campus to the surrounding communities, and at the same time brought development vitality and benefits to the surrounding communities, forming a benign interactive model. Sustainable development gradually develops from campus construction to the construction of serving sustainable communities, forming a sustainable community development model based on sustainable campuses, and ultimately achieving sustainable development goals.

6.3.3.2 Comparison of Advantages and Disadvantages of Implementation Paths

Kitakyushu Science and Research Park and Stanford University have similar goals and guarantees (see Figure 6.16). The essence of their direction to achieve sustainable development goals is mainly centered on research, campus education and sustainable development goals, but with different focuses. Since Stanford University has its own scientific research advantages, Stanford takes the implementation part as its core. Kitakyushu Science and Research Park attaches more attention to the education of students, and promotes students and the society to form a public awareness of sustainable development through education. In this regard, the two schools should combine their own features to promote and achieve sustainable development goals from multiple perspectives.

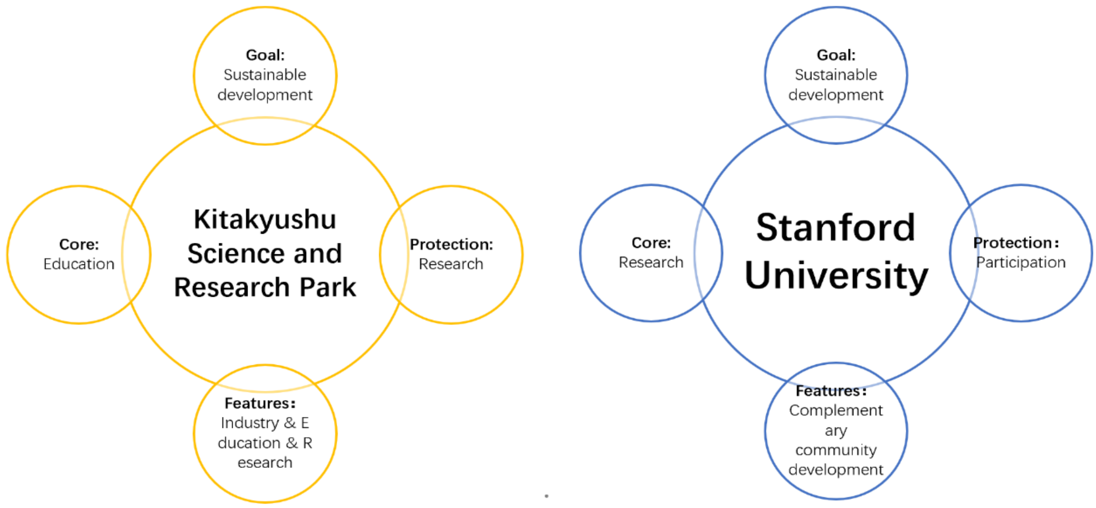

Figure 6.16: Comparison of Paths to Realizing SDGs

From the characteristic direction of realizing a sustainable campus, the sustainable development campus that created by Kitakyushu Science and Research Park is a creative positioning and perception for future industrial progress and urban development. Kitakyushu Science and Research Park broke the traditional "one school, one park" model and organically integrated education, scientific research, industry and urbanization. In terms of funds, a series of tax reductions and subsidies are used to support production, education and research, and the construction of parks will stimulate economic development and employment in surrounding areas. In park management, rents are collected from enterprises to subsidize educational housing costs, and core competitiveness is injected into enterprises through education and scientific research. This framework design has gone beyond simple building energy saving and emission reduction, and more focused on the efficient use of urban resources. The design of the Kitakyushu is not only for sustainable development, but also to enhance the green competitiveness of future cities. This method of thinking about sustainable campus construction at the strategic level of urban development is very worthy of reference. In contrast, the disadvantage of Kitakyushu's urban model is that it has strong regional features and is not universal. There are few places where education, commerce, and industry can be concentrated in one area, which has a higher level for other campuses. Implementation conditions.

From Stanford's development, the future growth potential of the campus alone is not enough as it continues to build a sustainable campus. Therefore, using the resources of the surrounding community to overcome the current obstacles to its own development has become an ideal solution to realize sustainable development. The reason is that the construction process requires more resources and development space, such as financial support, more land use space, and more participants. In this case, the communities around the campus undoubtedly provide more opportunities for the sustainable development of the campus. Therefore, in a sustainable community, it is important to fully embody the perception of cooperative development, which is beneficial to everyone. By investing in the local community, the university has solved the accessibility and transportation challenges faced by the campus, while responding more to the interests of surrounding residents and jurisdictions (Zhu, B., Zhu, C., Dewancker, Bart, 2020).Compared with the universities and research cities in Kitakyushu, the disadvantage of Stanford University is that it has not yet formed a systematic development, making it difficult to rely on community promotion alone for sustainable popularization.

6.3.4 Conclusions

One of the main goals of sustainable campus construction is to make the realization of the global sustainable development goals accessible to the world, help cope with the rapid changes of the world, externalize the construction achievements and experience to the whole society and the country, and jointly make response to the era of sustainable development challenge.

Kitakyushu Science and Research Park has responded to SDGs through eight aspects: Academic, Campus Education, Architecture, Energy & Monitoring, Water resources, Ecology, Transportation, and regional developments, and achieved great results. Through the construction and innovation of the campus, the sustainable campus construction action of Kitakyushu Science and Research Park fully covers the 17 goals of sustainable development, and provides a better solution direction from the perspective of the campus to realize the common development of mankind. High promotion value. The establishment of a research city is a characteristic direction for Japan to achieve a sustainable campus. Kitakyushu organically combines education, scientific research, industry, and urbanization. Meanwhile, Kitakyushu minimizes energy consumption through rational use of natural resources and distributed new energy. Realize the efficient use of energy. The construction of Kitakyushu involves quality education, sustainable economy, innovative infrastructure, sustainable communities and cities, sustainable consumption and production, social life, and national policies. It is a development direction that is very worthy of learning and reference.

By comparing the sustainable development implementation direction of Kitakyushu Science and Research Park and Stanford University campus, it can be summarized as follows:

Kitakyushu Gakuin City：

(1) Kitakyushu Science and Research Park takes education as the core and student-oriented to cultivate talents with a sustainable development outlook.

(2) Aiming at sustainable development, the university has attached an importance to the natural environment, kept researching and developing new energy-saving technologies, establishing a cluster of common facilities, and making the campus public from resource conservation.

(3) With its own scientific research as the guarantee, the campus has been carried out educational activities to promote sustainable development. And the goal of sustainable development has been included in basic education and advanced technology research.

(4) Production, education and research have been integrated in the university. Combining

advanced industrial technology with university research, the campus has made full use of location advantages and practical results obtained, created new industries, and achieved a high degree of technical integration.

Stanford University:

(1) Taking scientific research as the core and sustainable education as the driving force, the university has been committed to transforming campus construction results from multiple perspectives.

(2) Taking sustainable development as the goal, a series of targeted measures and plans should be made in an environmentally friendly manner.

(3) The joint participation of students, teachers, residents and the local government is the guarantee for the realization of a sustainable campus.

(4) A complementary development model should be formed along the community to realize sustainable investment. And the resources of the surrounding communities should be utilized to overcome the current obstacles of the further development of the campus. Sustainable development goals have to be made to serve the construction of sustainable communities (Zhu, B., Zhu, C., Dewancker, Bart, 2020).

The two development directions of Kitakyushu University and Stanford University can be seen as a representation of the features of different sustainable development backgrounds. And both Kitakyushu University and Stanford University have been actively practiced to achieve global sustainable development goals and provide valuable experience for the sustainable campus construction of other universities around the world. For campus construction in other countries around the world, each university must rely on their own resources to form a set of features while different universities in different regions have different directions suitable for their development. Moreover, universities should adhere to the perception of sustainable development, take a suitable development direction, and enrich the construction to achieve global sustainable development goals.

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CHAPTER 7

INFLUENCING FACTORS AND AFFORDABILITY OF SUSTAINABLE INVESTMENT WILLINGNESS OF UNIVERSITIES AND COLLEGES

CHAPTER 7 INFLUENCING FACTORS AND AFFORDABILITY OF SUSTAINABLE INVESTMENT WILLINGNESS OF UNIVERSITIES AND COLLEGES

7.1 Concept and Background

7.1.1 ESG investment Concept

In 1987, the World Commission on Environment and Development proposed the concept of sustainable development (Janker J, 2020). The main form of sustainable investment in the capital market is "Social Responsibility Investment"(SRI), which is the investment behavior based on the comprehensive evaluation of the performance of the investment object in environmental protection, social responsibility and corporate governance (ESG) (Caterina Di Tommaso, John Thornton, 2020). In the 1960s, the rudiment of social responsibility investment emerged with a new concept and investment strategy. During this period, SRI refers to value oriented or exclusive investment that first considers social responsibility, ethics and environmental behavior (Wu Xuzhong, 2012). This provides the foundation for the birth of ESG investment concept. Since the 1990s, the SRI has changed from ethics to environment, society and corporate governance, which have been incorporated into the investment decision-making process. And the investment income has been clearly pursued (Yiming Yan, JingHao Su, 2020). Until 2000, kofiannan, then Secretary General of the United Nations, advocated the establishment of the United Nations Global Compact organization, called on global enterprises to abide by ten internationally recognized values and principles, and in 2004, a landmark report "Who Cares Wins" summarized the ten principles as three dimensions: Environmental, Social and Governance, which formally propose the concept of ESG. In this way, it can transfer the internal value of the sustainable development of enterprises such as reputation, brand value, strategic planning and industrial safety to the management and investors, so as to fill the limitations of market evaluation standards.

ESG is an investment concept widely used by experts, governments, institutions and investors. "Public movement - green consumption - green production - green finance" is the law of the development of ESG's concept. From 1970 to 2014, nearly 2000 companies in various industries around the world adopted ESG for sustainable investment management and risk assessment (DanXia, 2013), which is a widely used concept of sustainable investment. Up to now, ESG concept system has gradually formed a unique style in the development. It not only considers the environmental, social, governance and other non-financial factors besides the traditional investment profit maximization, but also provides a comprehensive and unified framework from the perspective of practical operation to evaluate the effectiveness of enterprises in implementing the green development concept, and to clarify the matters that should be paid attention to in production and investment and development. Integrating sustainability into its business strategies and practices and improving its sustainability reporting can not only help to improve transparency, reputation and legitimacy, enhance brand value, increase employee and customer loyalty, but also reduce costs, obtain better business practices, improve company performance and valuation, so as to create a competitive advantage.

7.1.2 The Development of Sustainable Investment in Universities

Sustainable investment in economics means: an investment behavior based on the concept of sustainable development. The "sustainable investment" discussed in this chapter refers to: as an important part of the whole concept of green campus, it is the university's investment in sustainable industries and related sustainable economic activities.

The investment for colleges and universities can be traced back to the early college education fund. The first American college education foundation was founded by Yale University in 1890. In 1893, the first public college education foundation was established by the University of Kansas to receive and manage donations from alumni (Liu Wen, Yan Hanyue, 2019). The establishment of the university foundation settles the basis for the later investment of the university. With the popularization and scale expansion of higher education, higher education institutions generally face the problem of shortage of educational funds. Therefore, many colleges and universities will carry out reasonable and effective investment operation with funds that need not to be paid for the time being, so as to obtain relatively stable investment income (Tan Xiaohui, Ye Zhou, 2014). American higher education foundations invest under the guidance of the Unified Institution Fund Management Law, so as to obtain greater benefits in avoiding risks (Xing Xiangqin, Ding Miaomiao, 2011). With the rise of the concept of green campus, the sustainable construction of campus has become an important consideration for the future development of colleges and universities, and it needs continuous exploration and active practice. In 2010, by the Sustainability Tracking, Assessment & Rating System (STARS) (STARS. History, 2019), organized by the Association for the Advancement of Sustainability in Higher Education (AASHE), sustainable investment was incorporated into the whole green campus construction, and was taken as an important part of promoting sustainable management and development of campus (Leal Filho Walter, Eustachio JHPP, 2020).

Sustainable investment in colleges and universities not only promotes the construction of sustainable industries, but also promotes the concept and technology of green and low-carbon sustainable development from the campus to the society, which is conducive to the sustainable development and green growth of the whole region (Cole Elaine J, Fieselman Laura, 2013), and will directly affect the sustainable development of higher education (Aleixo Ana Marta, Leal Susana, 2018).They will provide better education resources, promote education equity, improve education system and achieve quality education (Jiang Xue, 2019; Zhu et al.,2020). Therefore, it is necessary for colleges and universities to carry out the construction of sustainable investment.

7.1.3 The Deficiency and Demand of Sustainable Investment in Campus

Although many universities are aware of the importance of sustainable investment, how to promote sustainable investment is still confusing. At present, the construction of sustainable investment mostly stays in the appeal and plan on the policy level, its essence is often just blindly emphasizing the need to strengthen the investment in sustainable industries and activities in colleges and universities, which does not have practical significance (Zhu et al.,2021). This not only has a bad effect on promoting sustainable investment, but also leads to a huge gap between the blind policy requirements and the school's own investment intention, which brings an excessive burden to the whole investment activities of the school. In order to effectively promote the sustainable investment development of colleges and universities, we should first study their willingness to make sustainable investment, so as to clarify the main influencing factors and the affordability of colleges and universities for sustainable investment.

At present, researches on sustainable investment factors mainly include: By using the capital asset pricing model, health & happiness and industry & innovation & infrastructure are considered as the most important factors for investors to promote the realization of SDGs (José Luis Miralles-Quirós, María Mar, Miralles-Quirós,2020). Environmental and social aspects of sustainable investment enterprises are studied by using the DJSI（The Dow Jones Sustainability Indexes） European index to express the indicators of Sustainable Leadership, concluding that Sustainable Leadership plays a positive role in improving the benefits of sustainable investment (Miralles-Quiros MD, Miralles-Quiros JL,2017). DEA（Date Envelopment Analysis） model is used to evaluate the environmental performance of each asset invested by the fund, and it is concluded that the increase of the proportion of sustainable investment contributes to the growth of fund efficiency (Allevi E, Basso A,2019). It can be seen that the factors influencing the sustainable investment of institutions vary greatly, but the research on the investment intention of colleges and universities is very lack, and the influencing factors of sustainable investment of colleges and universities have not been clearly put forward. In addition, there are more researches on the direction and field of sustainable investment (M Danilova, Yu Podoprigora,2019; Botezatu M, Andrei J,2012), but no relevant research on the maximum affordability of sustainable investment in colleges and universities, which is of great significance for the sustainable development of colleges and universities. Therefore, the proportion of sustainable investment in the whole investment needs further quantitative research.

This chapter mainly studies the influencing factors and affordability of sustainable investment willingness of colleges and universities. The value lies in promoting the healthy development of sustainable investment in colleges and universities. This research studies the influencing factors of sustainable investment in order to explore the leading factors affecting sustainable investment in colleges and universities. It provides the construction direction and action target for how to promote the sustainable investment. The purpose of studying the sustainable investment affordability is to explore the largest proportion of sustainable investment in all investments in colleges and universities, and it provides a basis for colleges and universities to formulate sustainable investment plans and policy guidance, so as to form good fund operation to guarantee sustainable development (Weerasinghe AS, Ramachandra T, 2020).

7.2 The Methodology of Investment Willingness

7.2.1 Objects to be Valued

Universities use their investment power to promote sustainability. There are a variety of approaches an university can take toward sustainable investment, including making positive investments that promote sustainability and engaging with companies in which they already hold investments. The term “sustainable investment” in this study is inclusive of socially responsible, environmentally responsible, ethical, impact, and mission-related investment (AASHE, 2019).

In this chapter, the main quantitative analysis is as follows: (1) The influencing factors of sustainable investment. (2) The willingness proportion of sustainable investment in the total investment.

The research object of this study is American universities. The reason for the selection of American universities as target for the study are as follows :(1) In the development of green campuses in the United States, their sustainable investment development is relatively complete, with abundant achievements. Investment is an important part of green campus and plays an important role in the development of the whole campus (Amaral AR, Rodrigues E, 2020). (2) The sustainable investment data of American universities are relatively comprehensive. The publicly available data from the STARS’s platform gives a more general picture of the United States, with more scientific results. (3) Although the results of the study on the WTP for sustainable investment with the American universities cannot represent other countries in the world, they are of positive significance in the world and have reference value for the future development of other countries.

7.2.2 Research Steps

For the research objects, this study mainly uses the Logit regression model and the maximum likelihood estimation (Edwards M, Castruccio S, 2020). The research is divided into two parts (see Figure 7.1).

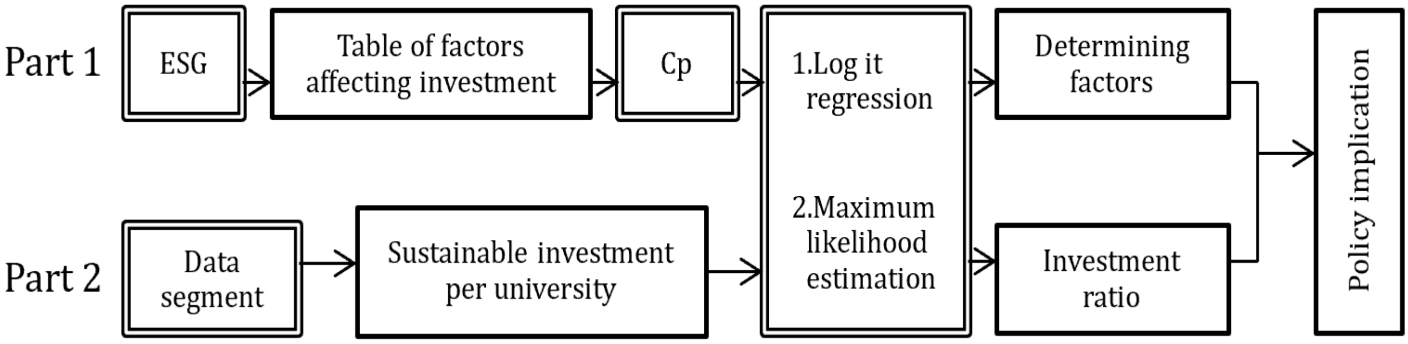

Figure 7.1: Research Method Flow Chart

In part 1, ESG's investment concept is used to classify the influencing factors and make the classification table of the influencing factors.

Then the main influencing factors are screened out by Cp method in advance, so that the non-independent influencing factors are excluded. Cp method is Mallows' Cp, which is proposed by Lingwood Mallows to evaluate the excellence of a linear regression model based on the assumption of ordinary least square method (Fadaee M, Mahdavi-Meymand A, 2020). Based on the original regression model, the Cp value of a possible sub regression model is defined as:

$$Cp = \frac{SSE_{redused}}{MSE_{Full}} - n + 2p = \frac{SSE_p}{MSE_K} - n + 2p = (n-p)\left[\frac{SSE_p}{MSE_K} - 1\right] + p$$

"n" is the sample size; "MSE" is the mean square error; "SSE" is the sum of square error; "p"is the number of regression independent variables screened out.

When Cp ⩽ p, screening can be stopped and this combination of independent variables is the best one, that is, the model can be simplified by using a combination with a small number of independent variables, and the mean square error of the model can be kept unchanged or reduced (Kazemi A., Mohamed A., 2013.). Model selection statistics decrease with the increase of the number of independent variables in the model, which can lead to the problem of over fitting, that is, too many independent variables lead to the decline of model prediction ability. With the help of Cp, the number of parameters can be effectively controlled to optimize the model.

Finally, Logit model and maximum likelihood estimation are used to get the decisive factors of investment and their influence weights. Among them, the maximum likelihood estimation is an important and common method to find the estimator. The maximum likelihood method uses the probability model explicitly, and its goal is to find the phylogenetic tree that can generate observation data with high probability. The maximum likelihood method is the representative of a kind of completely statistics based system spanning tree reconstruction method (Edwards M, Castruccio S, 2020).

In part 2, according to the data of the participation of colleges and universities in the sustainability assessment published on the STARS's platform, the data is divided into 11 sections with the proportion of sustainable investment ranging from 0% to 100%. The difference value of each section is 10%, and the proportion of the number of colleges and universities with sustainable investment in each section is calculated. Then, the number of universities with sustainable investment willingness in each section is counted. The Logistic and Maximum likelihood Estimation are used to get the best proportion of sustainable investment.

7.2.3 Samples and Data Sources

(1) Data source

The statistical data of this study comes from the open platform of STARS. STARS is a tracking, evaluation and rating system for campus sustainability edited by AASHE. The data currently published on STARS covers 1,004 colleges and universities in 42 countries and regions (STARS. 2019). It is currently recognized worldwide as a green campus evaluation and data sharing platform with wide application and participation (Zhu Bifeng, Ge Jian, 2016). Meanwhile, STARS, originated from North America, is a comprehensive evaluation system for sustainable campus in American universities. STARS platform basically covers all the universities in the United States that actively participate in the construction of green campus and achieve certain sustainable results. Therefore, the sample of 214 American universities selected from STARS platform can basically represent all the sustainable universities in the United States. Although there is a certain gap between the sample size of 214 universities and the number of universities in the United States, the universities that do not share data on the STARS platform can be considered to have no achievements in sustainable construction or even have not engaged. So, the data of these universities are not useful for this study and are not within the scope of this study.

In this study, universities with incomplete data related to sustainable construction on the STARS's platform are excluded. A total of 214 American colleges and universities are selected, which are distributed in 37 states across the United States (see Figure 7.2).

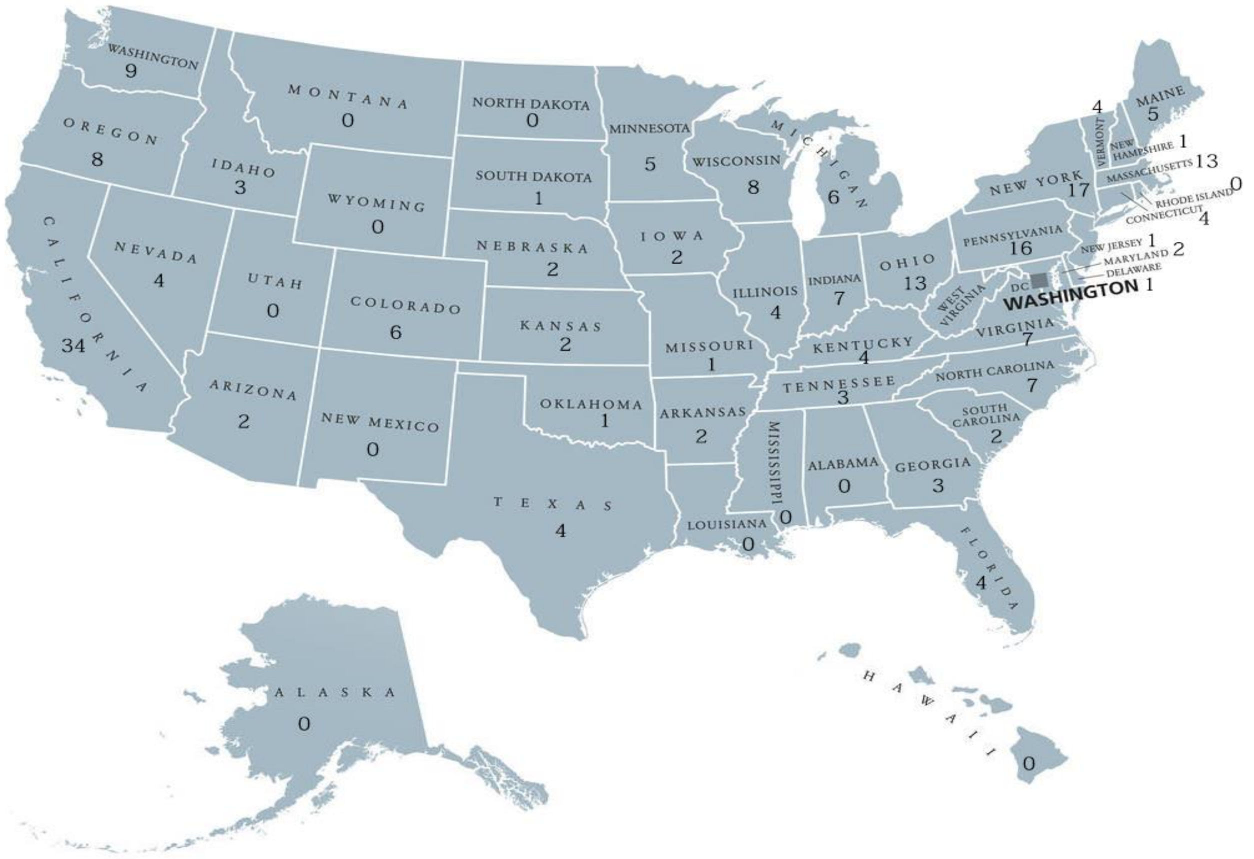

Figure 7.2: Campus Distribution Map in the United States

214 samples are distributed in 37 states and Washington, D.C. The samples are from STARS platform. And colleges and universities with complete sustainable construction data are selected. Statistics show that most of the universities are located in the east and west coastal areas of the United States, as well as in the middle, north and south are less. California has the largest number of universities for sustainable investment, with a total of 34, accounting for about 16% of the total. Next, New York and Pennsylvania have 17 and 16 universities, respectively, followed by Ohio and Massachusetts, both with 13 universities. The number of universities in other states is less than 10 (see Table 7.1).

According to statistics, there are 132 universities with sustainable investment, accounting for 61.68% of the total, 82 universities without sustainable investment, accounting for 38.32%. The reasons may be as follows: (1) there are fewer colleges and universities in the state, resulting in fewer ones making sustainable investment. (2) Because the climate in the north and south is too hot or too cold, colleges and universities need higher energy consumption to adjust the temperature of buildings, so that the cost of sustainable development is too high, and there is no excess funds for sustainable investment willingness.

Table 7.1: Distribution of 214 Universities with Sustainable Investment in the United States

State	Number of universities	State	Number of universities	State	Number of universities
Alabama	0	Louisiana	0	Ohio	13
Alaska	0	Maine	5	Oklahoma	1
Arizona	2	Maryland	2	Oregon	8
Arkansas	2	Massachusetts	13	Pennsylvania	16
California	34	Michigan	6	Rhode Island	0
Colorado	6	Minnesota	5	South Carolina	2
Connecticut	4	Mississippi	0	South Dakota	1
Delaware	0	Missouri	1	Tennessee	3
Florida	4	Montana	0	Texas	4
Georgia	3	Nebraska	2	Utah	0
Hawaii	0	Nevada	4	Vermont	4
Idaho	3	New Hampshire	1	Virginia	7
Illinois	4	New Jersey	1	Washington	9
Indiana	7	New Mexico	0	Washington DC	1
Iowa	2	New York	17	West Virginia	0
Kansas	2	North Carolina	7	Wisconsin	8
Kentucky	4	North Dakota	0	Wyoming	0

The samples include three types: community colleges, bachelor universities, and doctoral or graduate universities. Most of the universities that make sustainable investment are bachelor universities and doctoral or graduate universities, accounting for 29.9% and 67.3% of the total respectively, while there are only 6 community colleges, accounting for 2.8% (see Figure 7.3). Campuses range from 500 acre or less to more than 2,000 acre. Most of the samples are under 500 acres, with a total of 100 universities, accounting for 46.7% of the total, followed by 500-1000 acres, with a total of 52 universities, accounting for 24.3% of the total (see Figure 7.4).

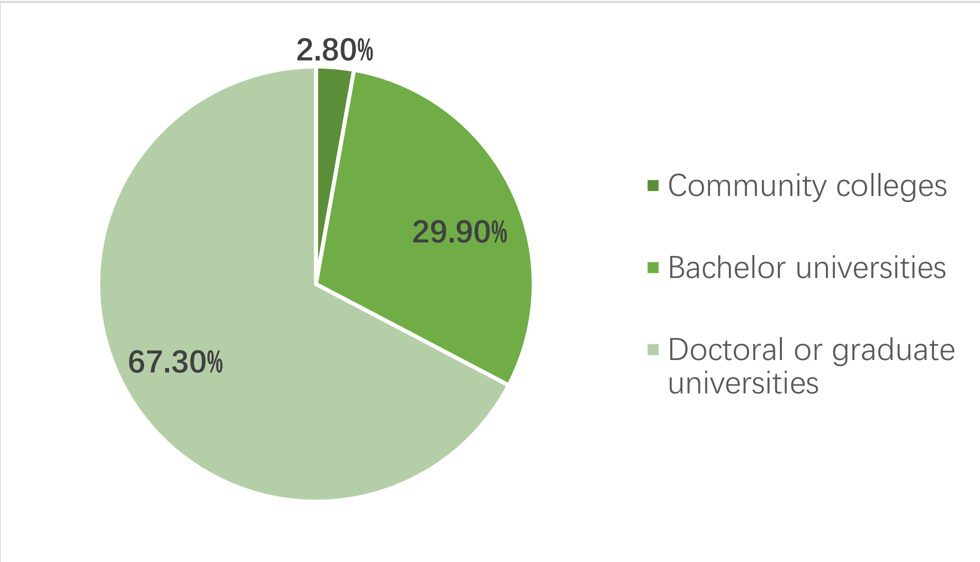

Figure 7.3: Type of 214 Universities

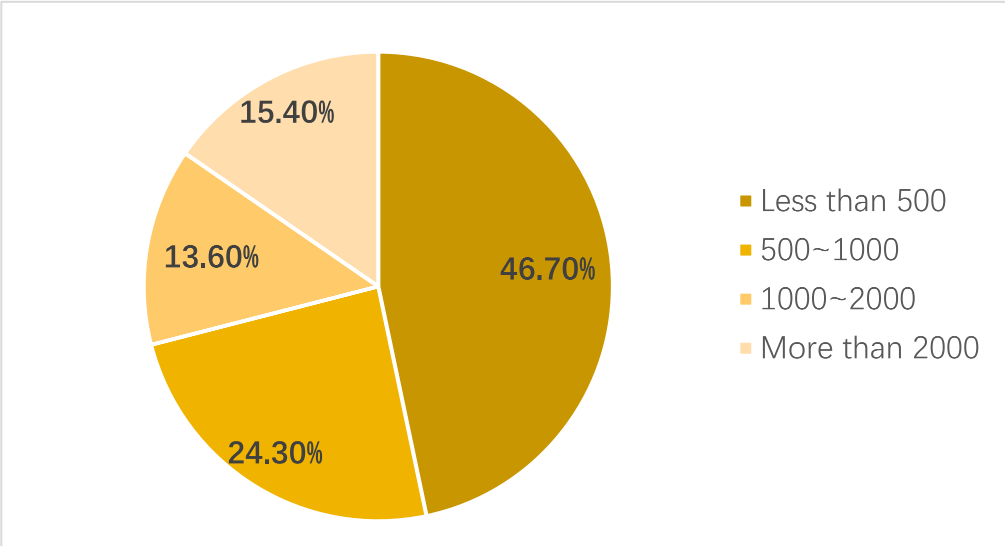

Figure 7.4: Campus area of 214 Universities

The smaller the size of the campus, the more willing it is to make sustainable investment. In terms of affiliation, both public and private are covered. Both public and private universities account for about 50% (see Figure 7.5). In terms of sustainable investment, both public and private universities attach great importance to it. In terms of IECC climate zone, most of the universities are in mixed and cool zones, accounting for 34.5% and 24.3% of the total respectively (see Figure 7.6).

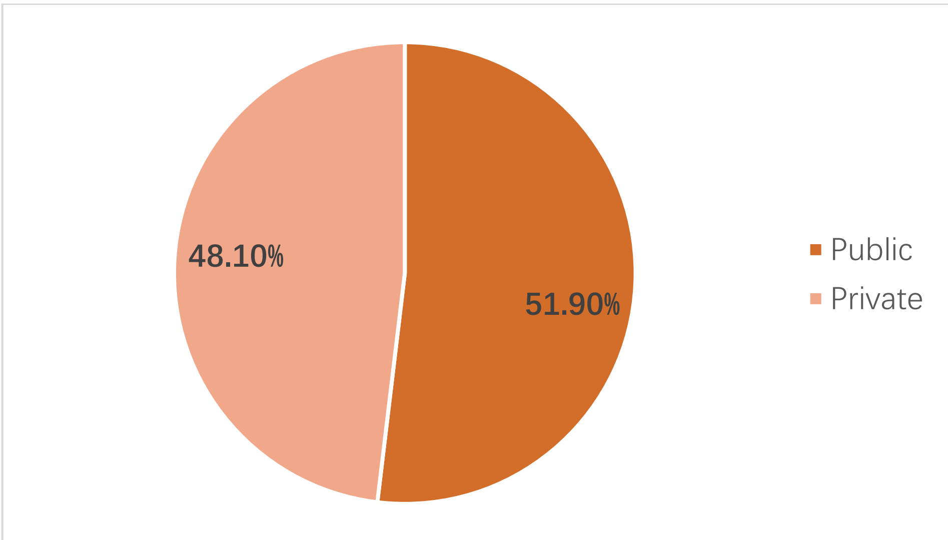

Figure 7.5: Affiliation of 214 Universities

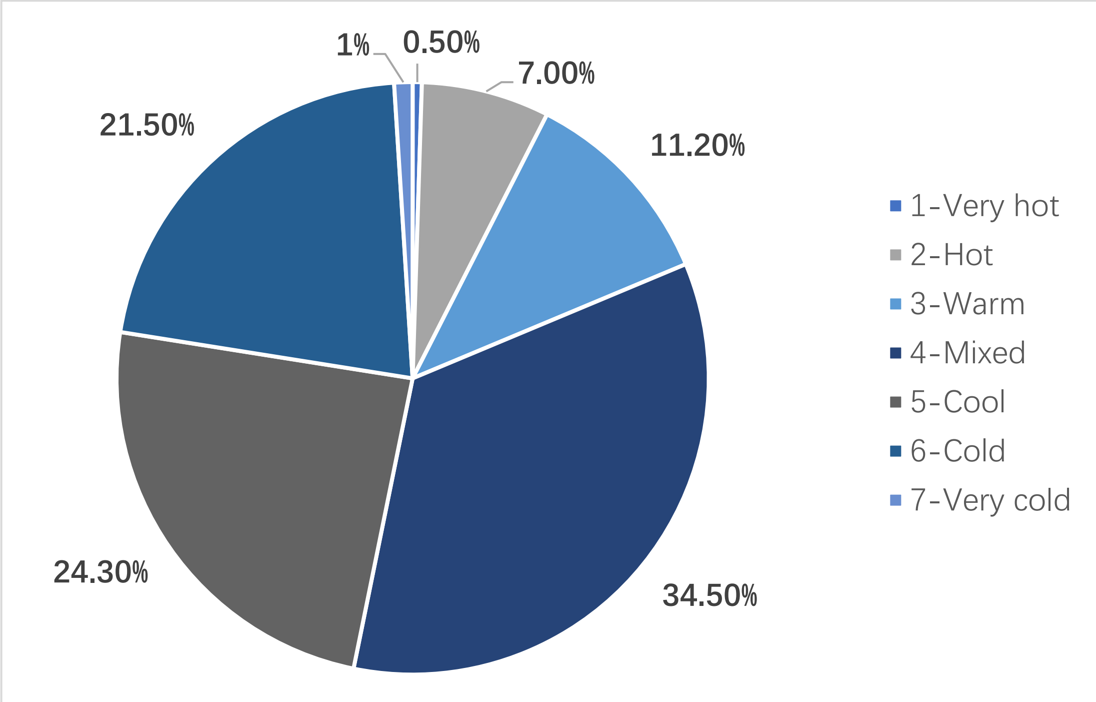

Figure 7.6: The Distribution of 214 Universities in IECC Climatic Zone

(2) Variable selection of influencing factors

The selection of influencing factors in this study comes from the evaluation terms of STARS system. According to the three dimensions of environmental protection, social responsibility and corporate governance in ESG investment, the evaluation factors are reclassified. At the same time, on the basis of the three categories, the basic information of the school is added, and finally the influencing factors' table with four categories is formed.

The influencing factors are assigned as variables. All variables are divided into two categories: (1) Binary variable, there are only two kinds of variable selection, such as "yes" and "no", which are assigned "1" and "0" respectively. (2) Discrete variable, which has many options and each option is independent and the values of "1", "2", "3",··· are assigned respectively. The setting and assignment of variables are shown in Table 7.2:

Table 7.2: Variable Classification and Assignment Table

Variable name	Categories	Variables	Variable options	Assignment
_COL1	Basic information of school	Types	Associate	1
			Baccalaureate	2
			Doctoral or Master's Research	3
_COL2		Campus area	Under 500Acre	1
			500~1000Acre	2
			1000~2000 Acre	3
			Beyond 2000 Acre	4

_COL3		Control	Public	1
			Private for-profit	2
			Private non-profit	3
_COL4		IECC climate zone	Very hot	1
			Hot	2
			Warm	3
			Mixed	4
			Cool	5
			Cold	6
			Very cold	7
_COL5	Environment	Has policies and/or guidelines in place to improve outdoor air quality and minimize air pollutant emissions from mobile sources on campus	YES NO	1 0
_COL6		Has a published climate action plan	YES NO	1 0
_COL7		Uses cleaning and janitorial products that are third party certified to meet recognized sustainability standards	YES NO	1 0
_COL8		Purchases total third-party certified RECs, GOs and/or similar renewable energy products	YES NO	1 0
_COL9		Recycles, donates and/or re-sold the waste	YES NO	1 0
_COL10		Has approach to materials management and waste minimization	YES NO	1 0
_COL11		Conducts an assessment of the sustainability literacy of its students	YES NO	1 0
_COL12		Conducts sustainability instruction training for new employees	YES NO	1 0
_COL13		Has one or more active student groups focused on sustainability	YES NO	1 0
_COL14		Has student-run enterprises that include sustainability as part of their mission statements or stated purposes	YES NO	1 0
_COL15		Has gardens, farms, community supported agriculture (CSA) or fishery programs	YES NO	1 0
_COL16		Has a wellness program that makes counseling, referral, and wellbeing services available to all students	YES NO	1 0
_COL17		Has a wellness and/or employee assistance program that makes counseling, referral, and wellbeing services available to all staff	YES NO	1 0
_COL18		Has a wellness and/or employee assistance program that makes counseling, referral, and wellbeing services available to all faculty	YES NO	1 0
_COL19		Provides financial incentives to support faculty members with article processing and other open access publication charges	YES NO	1 0
_COL20	Social responsibility	Provides financial or material support for the partnership	YES NO	1 0
_COL21		Provides incentives for employees to participate in community service	YES NO	1 0
_COL22	Corporate gover	Has at least one sustainability committee	YES NO	1 0

_COL23		Has at least one sustainability office	YES NO	1 0
_COL24		Has at least one sustainability officer	YES NO	1 0
_COL25		Has a formally established and active CIR	YES NO	1 0

Because there are too many variables in this study, not all variables have a significant impact on the dependent variables, and the non-significant variables will eventually cause interference to the conclusion, which makes the maximum likelihood estimation does not exist. In order to eliminate the calculation error caused by the correlation among the variables, the significant variables should be selected. In this study, C(p) method is used to find out the best model in a specific model size range to screen and monitor the independent variables.

The calculation table of C(p) is obtained through the simulation calculation. Because the smaller the C(p) value is, the better the fitting of the model is. And considering the possibility of variable combination is too much, the calculation results show that the top three variable combinations have the best fitting degree.

Table 7.3: Calculation Results of C(p)

Number in Model	Cp value	Variables in the model
4	-6.4347	_COL2 _COL12 _COL21 _COL25
5	-6.3572	_COL2 _COL6 _COL12 _COL21 _COL25
4	-5.9768	_COL2 _COL6 _COL12 _COL25

Among the three groups of data in the table 7.3, the first group has the lowest C(p) value, so it has the best fitting effect. The results show that the significant variables are: _COL2 (Campus area), _COL12 (Whether the school carries out sustainability instruction training for new employees), _COL21 (Whether the school encourages employees to participate in community service), _COL25 (Whether the school establishes CIR). The other variables are not significant in the model, so this study only needs to discuss the above four significant factors.

After screening with C (p) method, the group with the lowest C (p) value is selected, and its variable is_ Col2 school area_ Col12 school conducts sustainability instruction training for new employees_ Col21 school encourages employees to participate in community service_ Col25 school has an active investor responsibility Committee (CIR). Table 8.5 shows the sample's assignment of the above four key variables. The campus area below 500 acres is assigned as 1, 500-100 acres as 2, 1000-2000 acres as 3, 2000 acres and above as 4. The value of sustainability instruction training for new employees in university is 1, while the value of no sustainability instruction training is 0. The value of encouraging employee to participate in community service is 1, and that of no encouragement is 0. The university with CIR is assigned as 1, and without CIR is assigned as 0 (see table 7.4).

Table 7.4: The Dominant Factor Assignment of Samples Screened by C(p) Method

University	_COL2	_COL12	_COL21	_COL25
University of Minnesota, Duluth	1	1	0	1
University of Kentucky	2	1	1	0
Bucknell University	2	1	1	1
California Polytechnic State University	3	1	1	1
Evergreen State College, The	1	0	0	1
Iowa State University	3	1	1	1
Boston University	2	1	0	1
University of Wisconsin-Madison	4	1	0	0
California State University, Los Angeles	1	0	0	1
Central Washington University	1	0	0	0
Siena Heights University	1	0	0	0
Colorado College	1	1	1	1
Williams College	1	1	1	1
California State University, Monterey Bay	3	1	1	0
Appalachian State University	1	1	1	1
California State University, East Bay	2	1	0	0
Unity College	1	1	0	1
University of Miami	1	1	1	0
Amherst College	2	1	0	0
Carleton College	3	1	1	1
College of the Atlantic	1	1	1	1
Hobart and William Smith Colleges	1	0	1	0
Lehigh University	3	1	1	0
Loyola Marymount University	2	1	1	1
Luther College	2	1	0	1
Miami University	4	1	0	0
Portland State University	1	1	1	1
Southern Oregon University	1	1	1	0
Tufts University	2	1	0	0
University of California, Merced	1	1	0	1
University of California, Santa Cruz	4	1	1	1
University of Dayton	1	1	1	1
University of Maine	2	0	0	0
Calvin University	2	0	1	1
Denison University	2	1	1	0
Duquesne University	1	1	0	0
State University of New York College of Environmental Science and Forestry	4	1	1	1
University of Maryland, College Park	4	1	1	0
Western Michigan University	3	1	1	0
Cornell University	4	1	1	0

University of Illinois, Urbana-Champaign Reports	4	1	0	0
University of Louisville	2	1	1	1
Belmont University	1	1	1	0
Earlham College	1	1	0	0
Indiana State University	2	0	1	0
Illinois State University	3	0	1	0
State University of New York at Cortland	2	1	1	1
Clarkson University	2	1	1	0
Stanford University	4	1	1	1
University of Massachusetts Lowell	1	1	1	1
Carnegie Mellon University	1	1	1	0
University of North Carolina, Greensboro	1	1	1	0
University of Rochester	2	1	0	1
The Ohio State University	3	1	1	0
University of Houston	2	1	1	0
Oregon State University	3	1	1	1
Pacific University	1	1	0	0
Florida State University	3	0	1	0
California State University, Northridge	1	1	0	0
Chatham University	1	1	1	1
University of Wisconsin-Whitewater	1	0	0	0
Wellesley College	1	1	0	1
Colby College	2	1	1	0
University of Washington, Seattle	2	1	1	0
Columbia University	1	1	1	1
University of California, Berkeley	3	1	1	1
The New School	1	1	0	1
Wake Forest University	2	1	1	0
The University of Iowa	3	1	0	0
Yale University	2	1	0	1
Franklin W. Olin College of Engineering	1	0	0	0
University of St. Thomas	1	0	1	0
San Francisco State University	1	1	1	1
Muhlenberg College	1	1	1	0
Metropolitan Community College	1	1	0	1
Hampshire College	2	1	0	1
Rochester Institute of Technology	3	1	1	0
University of California, San Diego	4	1	1	1
University of Minnesota, Morris	1	1	1	1
University of California, Irvine	3	1	1	1
Villanova University	1	1	1	1
University of Connecticut	4	1	1	1
University of Colorado Boulder	2	1	1	0
Vassar College	3	1	0	1
State University of New York at New Paltz	1	1	0	0
California College of the Arts	1	1	0	0

Case Western Reserve University	2	1	1	0
Connecticut College	2	0	0	0
Creighton University	1	0	1	0
Indiana University Bloomington	3	1	1	0
San Diego State University	4	0	0	0
Seattle University	1	1	1	1
University of California, Santa Barbara	3	0	1	1
University of Massachusetts Amherst	4	1	1	1
University of Wisconsin-Platteville	2	1	0	0
Virginia Commonwealth University	2	1	1	0
Washington University in St. Louis	1	1	1	0
Arizona State University	4	1	1	1
Dickinson College	1	1	1	1
University of Virginia	3	1	1	0
California State University, Chico	4	1	1	0
Princeton University	2	1	1	1
University of Pittsburgh	1	1	1	1
Elon University	2	1	1	0
University of New Hampshire	4	1	0	1
Northland College	1	1	0	1
George Washington University	1	1	0	1
Green Mountain College	1	1	1	1
Susquehanna University	1	0	0	0
University of Pennsylvania	1	1	1	1
University of Wisconsin-River Falls	2	1	1	0
Ohio University	4	1	0	0
University of South Florida	3	1	1	1
University of Missouri	3	1	1	0
University of Colorado Colorado Springs	2	1	0	0
University of Wisconsin-Oshkosh	1	1	0	0
Furman University	2	1	0	1
University of Georgia	2	1	1	0
Virginia Tech	4	1	1	0
Wells College	1	1	1	0
Rice University	1	1	1	0
University of San Diego	1	1	0	1
University of Mount Union	1	1	1	0
Pennsylvania State University	4	1	1	0
George Mason University	2	1	1	0
Messiah College	1	0	1	0
Florida Gulf Coast University	3	1	1	0
Eastern Mennonite University	1	0	1	1
Emory University	2	1	0	0
University of North Carolina at Chapel Hill	4	1	1	0
California State University, Long Beach	1	1	1	0
Delta College	2	1	0	1
Haverford College	1	1	1	1

Lewis & Clark College	1	1	1	1
Portland Community College	1	1	0	0
Tennessee Technological University	3	0	0	0
University of Florida	3	0	1	0
Gonzaga University	1	1	1	0
Bentley University	1	1	1	0
Bates College	2	1	1	1
Cleveland State University	1	1	1	0
Berea College	4	1	0	1
Bard College	2	1	0	1
Middlebury College	1	1	1	1
Macalester College	1	1	0	1
Mills College	1	1	0	0
University of Oregon	2	1	0	0
The Ohio State University at Lima	2	1	0	0
The Ohio State University at Mansfield	2	1	0	0
The Ohio State University at Marion	1	1	0	0
The Ohio State University at Newark	1	1	0	0
Santa Clara University	1	1	1	1
Humboldt State University	2	1	1	1
Central Michigan University	3	1	1	0
University of South Florida St. Petersburg	1	1	0	1
Oberlin College	2	1	1	1
University of Arkansas	1	1	1	0
Northern Arizona University	2	1	1	0
Northwestern University	1	1	0	1
Smith College	1	1	1	1
University of the Pacific	1	1	1	0
Washington and Lee University	1	1	0	0
Western Kentucky University	1	1	1	0
Northern Michigan University	1	0	0	0
Baylor University	1	1	0	0
University of Vermont	4	1	1	1
Loyola University Chicago	1	1	1	0
Whitman College	1	0	1	0
Colorado State University	4	1	1	1
Sterling College	1	1	0	1
College of William & Mary	3	1	0	0
Wesleyan University	1	1	0	1
San Jose State University	1	1	1	0
Frostburg State University	1	0	1	0
University of Wisconsin-Milwaukee	2	1	1	0
University of Massachusetts Medical School	1	0	0	1
University of California, Riverside	2	1	0	1
Onondaga Community College	1	1	0	0
South Dakota State University	1	0	1	0
State University of New York College at	1	1	1	0

Geneseo				
St John's University-New York	1	1	1	1
Gettysburg College	1	0	0	0
Pittsburg State University	2	0	0	0
University of South Carolina	2	1	1	0
Western Colorado University	1	0	1	0
Maryville College	2	0	1	0
Saint Mary's College of California	1	1	0	0
North Carolina State University	4	1	1	0
Ball State University	2	1	1	0
University of Minnesota, Twin Cities	2	1	1	1
Transylvania University	1	1	1	0
Pitzer College	1	1	1	1
University of Wisconsin-Stout	1	1	0	0
Pomona College	1	1	1	1
University of Kansas	2	0	0	0
Juniata College	1	0	0	0
California State University, Channel Islands	3	1	0	0
Duke University	4	1	1	1
Saint John's University	1	1	1	1
Wartburg College	1	1	1	1
DePauw University	4	1	0	0
Goshen College	1	0	1	0
University of California, Davis	3	1	0	0
University of Northern Iowa	4	1	0	1
Brandeis University	4	1	0	0
Scripps College	4	1	0	0
University of Colorado Denver-Anschutz Medical Campus	1	1	0	1
University of Arkansas at Little Rock	4	1	0	0
University of Puget Sound	3	1	0	0
Georgia Institute of Technology	3	1	0	0
Haywood Community	4	1	0	1
Taylor University	4	0	0	0
University of California, Los Angeles	4	1	0	0
Oklahoma City University	4	1	0	0

(3) Segmentation of investment sample

The samples are segmented according to the percentage of sustainable investment in total investment (a). The value of each section ranges from 0% to 100%, and the data difference of each section is 10%, namely: 0%, > 0%~ < 10%, 10%~ < 20%, 20%~ < 30%, 30%~ < 40%, 40%~ < 50%, 50%~ < 60%, 60%~ < 70% 70%~ < 80%, 80%~ < 90%, 90%~100%, 11 grades. The cumulative proportion of the number of universities with sustainable investment is calculated by gradually accumulating the number of universities with sustainable investment in each section. Table 7.5 is obtained from the statistics data:

Table 7.5: Sectional Statistics of Sample Data

Percentage of sustainable investment (a)	Number of universities	Accumulated number of universities	Cumulative percentage of universities with sustainable investment
a=0.00%	82	82	38.32%
0.00% < a < 10.00%	108	190	88.79%
10.00%≤a < 20.00%	10	200	93.46%
20.00%≤a < 30.00%	2	202	94.39%
30.00%≤a < 40.00%	3	205	95.79%
40.00%≤a < 50.00%	2	207	96.73%
50.00%≤a < 60.00%	1	208	97.20%
60.00%≤a < 70.00%	0	208	97.20%
70.00%≤a < 80.00%	0	208	97.20%
80.00%≤a < 90.00%	0	208	97.20%
90.00%≤a≤100.00%	6	214	100.00%

7.2.4 Establishment of Calculation Models

(1) Analysis model of influencing factors

"Whether schools make sustainable investment" is set as a dependent variable, and it is a binary variable. The first choice behavior includes the following elements: Decision maker, Alternative scheme set, Attribute and Decision criterion of each scheme. The discrete choice model can include all these elements. Therefore, the economic statistical model in the discrete choice model can be used to quantify this problem. In this study, Logit model is selected.

The basic form of Logit model is to model the probability (P) of something happening,

$$\mathbf{Logit(Pi)=\beta 0+\beta 1X} \qquad (1)$$

β 0 and β 1 are coefficients of function regression, and X is independent variable. If β and X are regarded as vector form, then:

$$\mathbf{\log it(Pi)=\ln(pi/(1-pi))=\beta 0+\beta 1X1,i+\beta 2X2,i+\cdot+\beta nXn,i} \qquad (2)$$

The formula (2) is the basic form of binomial Logit.

The probability of sustainable investment of school is P1, that is, P1 = P (investment=1); correspondingly, the probability of non-investment is P0, that is, P0 = P (investment = 0). P1+P0=1.

Establish Logit equation:

$$\mathbf{Logit=\log(Odds)=\ln(P1/P0)=\beta 0+\beta X} \qquad (3)$$

To avoid the problem of complete separation in data structure, Logistic regression equation can be established as:

$$\mathbf{Logit=\log(Odds)=\ln(P1/P0)=\beta 0+\beta 1\cdot X1+\beta 2\cdot X2+\beta 3\cdot X3+\ldots\ldots} \qquad (4)$$

Take the independent variable into formula (4) to replace X1,X2,X3……:

$$Logit=\log(Odds)=\ln(P1/P0)=$$

$$\beta0+\beta1\cdot\_COL2+\beta2\cdot\_COL12+\beta3\cdot\_COL21+\beta4\cdot\_COL25 \qquad (5)$$

(2) Analysis model of the willingness proportion

Using “admit” to represent whether the school invests, “admit = 1” to show "investment", “admit = 0” to show "not investment"; note that the “investment” probability of investors is P1, that is, P1 = P (admit = 1); the probability of “not investment” is P0, that is, P0 = P (admit = 0), P1 + P0 = 1. The expression of Log function in Logistic model is as follows:

$$Logit=In(Pi/1-Pi)=\beta0+\beta1X \qquad (6)$$

The formula of Pi and independent variable X can be obtained by deformation of formula (6):

$$Pi=1/1+e\hat{}-(\beta0+\beta1X) \qquad (7)$$

In formula (7), β 0 and β 1 are coefficients of function regression, X is the investment amount of the school for sustainable investment, assuming that the “willingness investment” of the school is WTP.

The expected value of the school's willingness investment:

$$E(WTP)=In(e\hat{}\beta5-1)/-\beta6 \qquad (8)$$

The β6 is the coefficient that answers "investment" for the maximum investment and β5 is the constant term.

7.3 Sustainable Investment Categories and Related Policies

This thesis focuses on the evaluation standard and development of sustainable campus in China and America. The research that has been undertaken for this thesis has highlighted several key points on which further research would be beneficial. Although this study attempts to analyze the problems comprehensively and scientifically, there are some small flaws due to the limitation of sample size. It is hoped that future research can make up for these deficiencies and further promote the new discovery of sustainable campus on the basis of this study, so as to continuously improve the results of this study.

According to the statistics of 214 American colleges and universities, there are six kinds of sustainable investment objects, which are sustainable industries, businesses, sustainable investment funds, CDFI, social responsible mutual funds and green revolving loan funds. Among them, the main investment objects of universities for sustainable investment are sustainable industries and sustainable investment funds, while the amount of CDFI and green revolving loan funds are relatively small (see Figure 7.7).

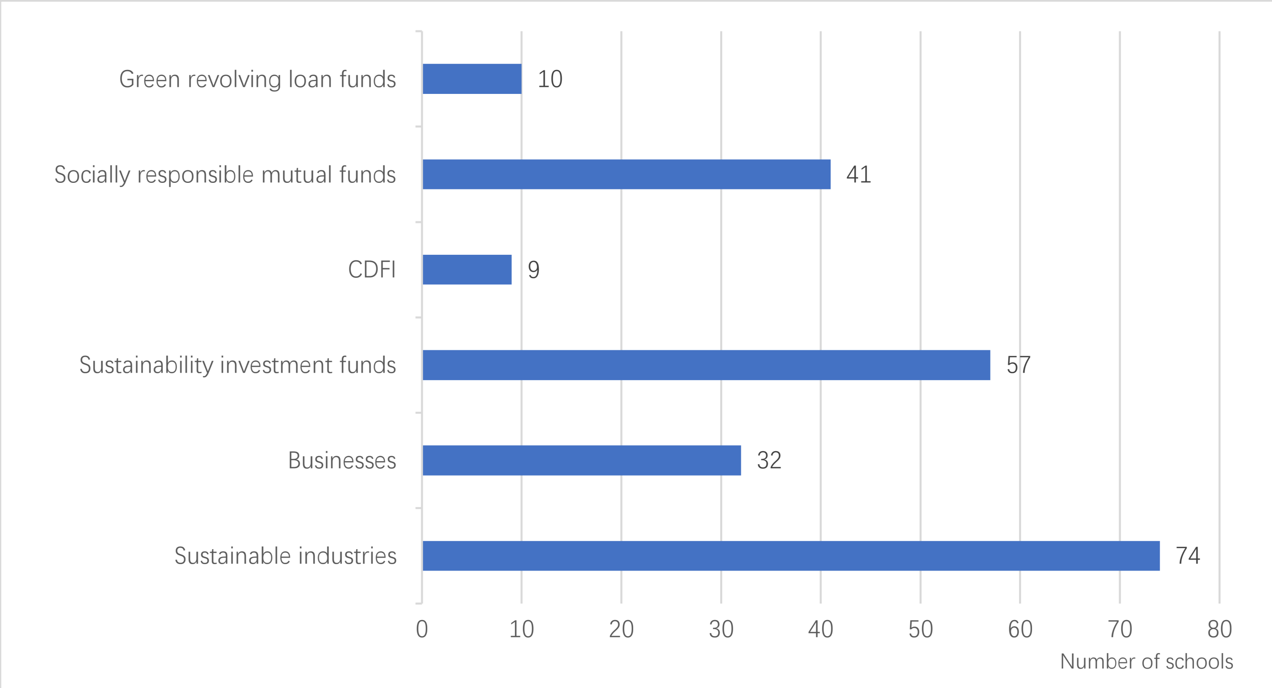

Figure 7.7: Statistics of Sustainable Investment Objects in Colleges and Universities

Investment in sustainable industries is mainly in green industries such as renewable energy, energy recovery, engineering of alternative energy devices, etc. (Michael V. Russo, 2003). Most colleges and universities invest in securities or choose a third-party external investment manager to further invest by investing in sustainable investment fund. In the future, colleges and universities can make more sustainable investment in other directions. For example: the sustainable investment of CDFI is enhanced to carry out long-term sustainable community cooperation (Qiu Huafei, Tu Minghui, 2019). University increases the input of green revolving loan funds to encourage the sustainability of campus and industry, so as to change the input of unsustainable industries to green sustainable ones (Hu Xianfu, 2014).

At the same time, in the process of sustainable investment, colleges and universities have formulated relevant investment policies as guidance to promote the development of sustainable investment. The sustainable investment policies of the sample universities are as follows: (AASHE, 2019)

●Has a publicly available sustainable investment policy (e.g., to consider the social and/or environmental impacts of investment decisions in addition to financial considerations).

●Uses its sustainable investment policy to select and guide investment managers.

●Has engaged in proxy voting to promote sustainability, either by its CIR or other committee or through the use of guidelines, during the previous three years.

●Has filed or co-filed one or more shareholder resolutions that address sustainability or submitted one or more letters about social or environmental responsibility to a company in which it holds investments, during the previous three years.

●Has a publicly available investment policy with negative screens, for example to prohibit investment in an industry (e.g., tobacco or weapons manufacturing) or participate in a divestment effort (e.g., targeting fossil fuel production or human rights violations).

●Engages in policy advocacy by participating in investor networks (e.g., Principles for Responsible Investment, Investor Network on Climate Risk, Interfaith Center on Corporate Responsibility) and/or engages in inter-organizational collaborations to share best practices.

7.4 Factors Affecting Sustainable Investment

According to the simulation of software SAS (Statistical Analysis System) 9.4, Likelihood ratio, Score and Wald are calculated to verify whether the coefficients of all variables are 0 at the same time, that is to test whether $\beta 1 = \beta 2 = \beta 3 = \beta 4 = \beta 5 = \beta 6 = 0$ exists. All three indexes are less than 0.0001 (see Table 7.6), indicating that the accuracy of the fitted model can meet the requirements.

Table 7.6: Model Reliability Test

Test	Chi-Square	DF	Pr > ChiSq
Likelihood ratio	36.9040	6	<.0001
Score	34.7330	6	<.0001
Wald	29.6941	6	<.0001

To test whether each variable in the model is significant, model reliability should be tested. The Chi-Square values of all variables are less than 0.05 (see Table 7.7), that is the variable confidence value is more than 95%, indicating they are significant. Therefore, we can determine the independent variables of this study: Campus area, School's sustainability instruction training for new employees, School's incentive for employees to participate in community service, and School has officially established active CIR.

Table 7.7: Variable Effect Test

Effect	DF	Wald Chi-Square	Pr > ChiSq
_COL2	3	7.9713	0.0466
_COL12	1	7.0058	0.0081
_COL21	1	4.7013	0.0301
_COL25	1	9.0289	0.0027

According to Table 7.7, four most important influencing factors are gotten. Among them, _COL12, _COL21 and _COL25 are Binary variables, which has only two choices (Yes or No). While _COL2 is Discrete variable set with four choices (=1: campus area is less than 500Acre; =2: campus area is 500~1000 Acre; =3: campus area is 1000~2000Acre; =4: campus area is more than 2000Acre). These four variables are brought into the calculation model of Logistic, in order to study their quantitative relationship. Table 7.8 shows the maximum likelihood estimated values of each coefficient calculated by the software. When _COL2=3, the Chi-Square value equals 0.8781, that is too large. While the Chi-Square values of _COL2=2, _COL2=4, _COL12, _COL21 and _COL25 are all less than 0.04, so it is not significant when _COL2=3, its value is not considered. That is to say, when _COL2=3 (representing Campus area is 1000~2000 Acre), its Estimate value is 0, which is same as _COL2=1 (representing Campus area is less than 500 Acre).

Table 7.8: Analysis of Maximum Likelihood Estimates

Parameter	Sub-Parameter	DF	Estimate	Standard error	Wald Chi-Square	Pr > ChiSq
Intercept		1	-1.5601	0.4435	12.3733	0.0004
_COL2	2	1	0.7378	0.3900	3.5787	0.0585
_COL2	3	1	0.0704	0.4590	0.0235	0.8781
_COL2	4	1	1.2275	0.5100	5.7931	0.0161
_COL12		1	1.1099	0.4193	7.0058	0.0081
_COL21		1	0.6835	0.3152	4.7013	0.0301
_COL25		1	0.9975	0.3320	9.0289	0.0027

The Logit model of the final response is:

(i) If the campus area is more than 2000 acre (campus area = 4):

Logit = log(Odds) = ln(P1/P0) = -1.5601 + 1.2275·_COL2 + 1.099·_COL12 + 0.6835·_COL21 + 0.9975·_COL25

(ii) If the campus area between 500 acre and 1000 acre (campus area = 2):

Logit = log(Odds) = ln(P1/P0) = -1.5601 + 0.7378·_COL2 + 1.099·_COL12 + 0.6835·_COL21 + 0.9975·_COL25

(iii) If the campus area is less than 500 acre and between 100 acre and 2000 acre (campus area = 1 or 3):

Logit = log(Odds) = ln(P1/P0) = -1.5601 + 1.099·_COL12 + 0.6835·_COL21 + 0.9975·_COL25

Among them:

_COL2= Campus area;

_COL12= Whether the school carries out sustainability instruction training for new employees;

_COL21= Whether the school encourages employees to participate in community service;

_COL25 = Whether the school establishes CIR.

For the relationship between the data, "Point estimation" shows the multiple of the dependent variable increase when the item increases by 1 and other variables remain unchanged (see Table 7.9).

Table 7.9: Odds Ratio Estimates

Effect	Point estimation	95% Wald confidence limits	
_COL2 1-2	2.091	0.974	4.492
_COL2 1-4	3.413	1.256	9.272
_COL12	3.034	1.334	6.901
_COL21	1.981	1.068	3.674
_COL25	2.712	1.415	5.198

For the campus's area, the larger the area is, the more likely the school is to make sustainable investment. From table 8, it can be seen that when the campus area is less than 2000 acre (1 acre = 4046.86 ㎡), the growth of the campus area has little impact on the sustainable investment of the school. When the area is more than 2000 acre, the influence of the variable campus area on the sustainable investment of the school will be the probability of sustainable investment increased by 1.2275 (log odds), and the corresponding probability increased by e1.2275 = 3.413 times. When the campus area is more than 2000 acre, the cost of campus maintenance is too large, and the implementation of sustainable investment can help the school carry out green campus construction and make the school foundation obtain stable income, so as to reduce the economic pressure faced by the school.

As for the factor of sustainability instruction training for new employees, the probability of sustainable investment is 3.034 times higher than in the schools that do not. The school carries out sustainable instruction training for new employees, which shows that the school attaches great importance to sustainable development, so the probability of sustainable investment increases relatively.

The school with CIR is 2.712 times more likely to make sustainable investment than the school without it. The establishment of CIR means the increase and formalization of school investors, so that the school will be more stable in investment, and can see the benefits of sustainable investment for school construction and school foundation more fully. Therefore, the impact of this variable on sustainable investment in schools is more significant.

Compared with the above factors, the impact of encouraging employees to participate in community services on sustainable investment in schools is not too big, less than twice.

7.5 Proportion of Sustainable Investment

Import the statistical data into SAS9.4 for operation, and the result is shown in Table 7.10.

Table 7.10: Estimation of Calculation Parameters

Parameter	Label	DF	Parameter estimate	Standard error	t Value	Pr > |t|
Intercept	Intercept	1	0.62001	0.14141	4.38	0.0018
_COL0	Sustainable investment as a percentage of total investment	1	0.50172	0.23903	2.10	0.0652

"Intercept" here means the probability of intercept 0 is small probability (0.0018), less than 0.05, with 95% confidence level, so β 5 is taken as 0.62001. The probability of independent variable (sustainability investment) ratio coefficient 0 in total investment is also small probability (0.0652), with 94% confidence level, so β 6 is taken as 0 0.50172. So it can be concluded that the willingness percentage of sustainable investment of colleges and universities in the total investment is:

In (e ^ 0.62001-1) / - 0.50172 = 0.303

30.3% is the proportion of the sustainable investment willingness of each university to the total investment. It can be seen that the maximum affordability of universities for sustainable investment is 30.3%, and the willingness to spend on sustainable investment is not high. At present, the investment of colleges and universities is still dominated by general non sustainable projects. And about 94% of colleges and universities have less than 30% of their sustainable investment, so there is still a possibility of huge development in the future.

At the same time, with the goal of 30.3% of the sustainable willingness investment, in future developments, colleges and universities will increase the amount of sustainable investment. From the policy level, relevant sustainable investment policies within the limit of 30.3% can be make, so as to encourage colleges and universities to strengthen sustainable investment. For the universities with less than 30.3% sustainable investment, the maximum investment willingness can be achieved through policy support and increasing financial subsidies (Zhou Wen, 2019).

7.6 Conclusions

The sustainable investment of colleges and universities meets the current investment and construction of the campus, and lays the foundation for the future sustainable development of the campus. The sustainable investment of universities is closely related to ESD, which is a reflection of the social responsibility, and has a positive significance for the realization of SDGs (Zhu and

Dewancker,2021). Therefore, the research on sustainable investment willingness in colleges and universities is very important. This chapter mainly draws the following conclusions on the research of sustainable investment:

1.The sustainable investment in colleges and universities is mainly for sustainable industry and sustainable development investment fund, which is of relatively single type. In the future, the investment in CDFI and green revolving loan funds can be increased. In addition, universities promote their sustainable investment by making relevant open and transparent sustainable investment policies.

2. The sustainable investment willingness of universities is far greater than the actual investment. The willingness of universities to invest in sustainable investment accounts for 30.3% of their total investment, representing the maximum affordability of universities for sustainable investment. At present, the proportion of expenditure for sustainable investment is not high, among which about 94% of the universities have not reached the willingness amount of sustainable investment, indicating that there is still a large potential for future development of sustainable investment in colleges and universities.

3. There are four main factors that affect the sustainable investment of colleges and universities: (1) size of the school; (2) sustainability instruction training for new employees; (3) the encouragement of employees to participate in community service; (4) whether the school establishes CIR. Among them, the campus size is the most important factor. For the campus area of more than 2000 acre (1 acre = 4046.86 ㎡), the impact increment is 3.413 times. And the other three factors, the influence increment are 3.043, 1.981 and 2.712 respectively (see Figure 7.8).

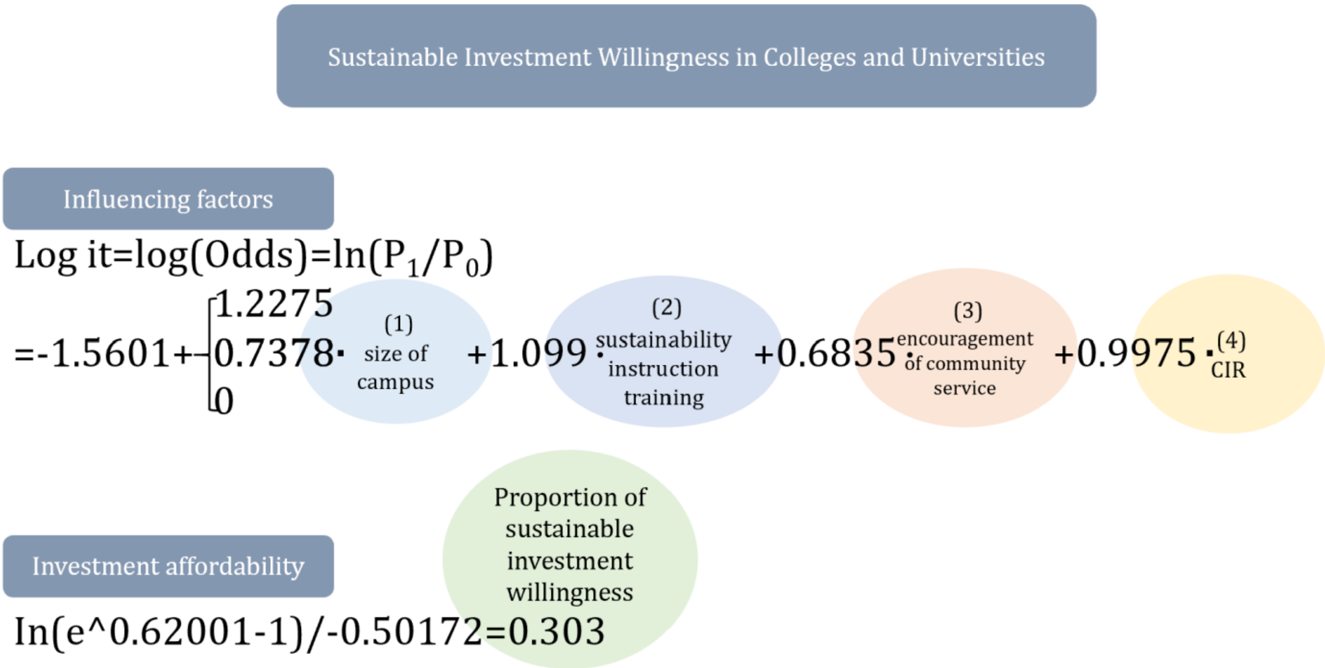

Figure 7.8: Main Conclusions of Sustainable Investment Willingness

Based on the conclusions of this study, the following policy implications are proposed:

1. At present, the research on sustainable investment in colleges and universities is still very limited and single. In view of this situation, more policy research is needed to further refine the rules and characteristics of sustainable investment.

2. As far as the proportion of sustainable investment in the total investment is concerned, it is low with only 30.3%. Colleges and universities can strengthen the education of sustainable concept, formulate long-term sustainable development plan, in order to increase the proportion of sustainable investment willingness (Pan Yongming, et al., 2018). The government can guide and support the sustainable investment of universities by formulating reasonable investment policies for sustainable related industries.

3. At present, the actual sustainable investment of the majority of universities has not reached their own investment willingness, in which there is a huge gap and potential for future development. Future research can focus on this problem, analyze the reasons for the differences, and find the balance between willingness and actual investment, so as to better guide the formulation and implementation of policies (Zhou Jin, Huang Kai, 2020).

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CHAPTER 8

CONCLUSION AND RECOMMENDATION

CHAPTER 8 CONCLUSION AND RECCOMENDATION

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This Chapter has drawn a summarized result of sustainable campus development based on comparative study. The summary of this research starts with the evaluation standards and case studies of sustainable campus in two countries. Then, the implications of research methods and significant results are pointed out. Finally, a future direction for studying on this topic is combined for this part.

8.1 Summary of Key Findings

8.1.1 The Comparison of Three Standards

(1) The development of sustainable campus related policy documents is consistent with the development of campus. The sustainable campus evaluation standard in America is independent of the green building evaluation standard with developing in parallel. China's sustainable campus evaluation standard based on the green building evaluation standard, is developed from the campus energy conservation policy.

(2) There are great differences between the evaluation standards of China and America in organization & participation mode, evaluation method and content. STARS adopts a "bottom-up" organizational model and has a high degree of participation. The Standard is implemented by the way of "top-down" administrative order, and the participation of the whole school is not as good as STARS. As for the standard evaluation method, STARS adopts the open self-evaluation mode, which ensures the freedom and characteristics of the participating universities. The Standard adopts the scoring method of combining control items and scoring items, which ensures the minimum level of sustainable campus and encourages the adoption of more appropriate construction measures. In terms of the content of evaluation, the Standard does not cover as many fields as STARS, such as Food & Dining, Purchasing, Diversity & Affordability, Investment & Finance. There is a huge difference between the two standards in terms of scores, STARS has a large proportion in terms of Academic and Engagement. While the Standard sets most of the scores in terms of Buildings and Planning.

(3) There are 17 evaluation categories in STARS, which are generally suitable for evaluating green campus construction in China. The degree of sustainable construction in each evaluation category is basically the same as the satisfaction degree of teachers, students and employees. At present, the advantages of green campus construction in China lie in academic sustainability and "software" construction of campus services and activities. However, the application of environmentally friendly technologies and "hardware" facilities such as campus buildings, indoor air quality, energy, grounds, waste, are obviously insufficient, which can not meet the requirements of the standards, and can not meet the daily needs of teachers, students and employees. This will

become the focus of work which urgently need to be promote in the next step of China's green campus construction.

(4) There are four main categories of inappropriateness in STARS: Public engagement, Coordination, Planning & Governance, Water and Health, Wellbeing & Work. The former two need to adjust the specific scoring points and their proportion; the latter two should change or remove the specific evaluation content and focus.

(5) At present, the main deficiencies of sustainable campus evaluation standard in Japan are as follows: ① The evaluation standard is not comprehensive, and the evaluation objects are the campus buildings and their surrounding environment. ② Lack of unified management and complete "Green building -Sustainable campus" evaluation system. ③ The construction achievements are scattered, incomplete and lack of systematic summary. The future development of its evaluation standard should pay attention to the combination of diversity & unity and internationalization & localization, that is, continuing its own development characteristics, the evaluation standard is reformed according to its own advantages. And a unified sustainable campus evaluation standard covering the connotation of the international mainstream sustainable campus is established, so as to promote the development of the global sustainable campus evaluation system, participate in solving global sustainable development problems.

8.1.2 The Development of Sustainable Campus in Three Countries

(1) There are great differences in the development process of sustainable campus between China and America. The United States has always been committed to deepening the concept of “green” and forming a comprehensive connotation of sustainable campus. While China has transformed from "energy saving" campus, focusing on energy saving and green building construction.

(2) According to the overall average score of 356 universities participating in the STARS assessment, the global sustainable campus is still in the medium development level. Buildings, Energy, Food & Dining and Investment & Finance will become the focus of sustainable campus in the future. From 2019 to 2020, the areas most involved by the global innovative and high impact projects are Public engagement, Energy and Campus engagement. These projects have made innovation and contribution to the sustainable development of global sustainable campus in these areas.

(3) The G-value in 2016 of Zhejiang University in China is 0.019163 $MtCO_2 / m^2$, significantly lower than that of other four American universities, showing that the construction of energy-saving monitoring platform implemented by China has remarkable energy-saving effect. The policy’s promotion and implementation of China's energy conservation monitoring system plays a positive role in promoting campus energy conservation. With the increase of energy demand brought by the development and construction of the school, the follow-up data has a rebound trend. Although the

policy still has great energy-saving effect, the future development is not optimistic and the development potential is insufficient.

(4) The construction of Chinese green campus is still in the preliminary stage, and the overall construction level is weak. Some of China's first-class universities are leading the construction of the whole green campus, whose level has reached the world's middle. The campus construction focuses on academic and education, and is seriously deficient in installation construction such as infrastructure and environmentally friendly utilization, which can be regarded as the direction of future efforts. The construction of China's green campus in the next stage can be comprehensively promoted from the three aspects of participation in universities, staff care and investment. Meanwhile, first-class universities can actively explore environmental monitoring, green building construction, renewable energy utilization, waste recycling and water resource reuse in combination with their own scientific research advantages. However, Zhejiang University's S-values of sustainability’s four categories are all lower than that of the four American universities. It can be seen that there is still a big gap between the overall sustainability of Chinese case university and American comparative universities.

(5) The significance of Stanford's green campus lies not only in its own achievements, but also in its leading role in universities around the world. Through the construction and innovation of campus, 10 SDGs relating to education, energy, climate, water, production and sustainable community have been implemented. In order to achieve the common sustainable development of human beings, it provides a better solution path from the perspective of campus, and has a high promotion value. Stanford's green campus development model can be summarized as four characteristics: ①It is based on its own scientific research. ②It is in depth from the aspect of environmental friendliness. ③The participation of students, teachers, residents and local government is realized. ④It is to realize sustainable investment form complementary development with the community.

(6) The development of sustainable campus in Japan mainly focuses on the sustainability of the buildings in the campus, focusing on the relationship between the buildings and the environment. For the path of realizing sustainable campus, Kitakyushu Science and Research Park, a typical representative of Japan, responds to SDGs through the construction of eight aspects: Academic, Campus education, Architecture, Energy & Monitoring, Water resources, Ecology, Transportation and Regional development. Its action of sustainable campus construction covers all 17 goals of sustainable development. The construction of Kitakyushu Science and Research Park is a major feature of the path of realizing sustainable campus in Japan. It organically combines education, scientific research, industry and urbanization, and puts forward the integrated development mode of Industry & Education & Research. At the same time, through the rational use of natural resources and distributed new energy, the energy consumption can be reduced to the greatest extent, so as to realize the efficient use of energy. For the sustainable development of industrial progress and urban

development in the future, the function of Kitakyushu Science and Research Park has gone beyond the simple building energy conservation and emission reduction, and more focused on the efficient utilization of urban resources.

(7) Based on the data of sustainable investment from 214 universities in the United States, the sustainable investment willingness of colleges and universities indicates that: (1) Most colleges and universities take sustainable industry as their investment object, and promote their own sustainable investment by making a series of sustainable policies. (2) The maximum affordability of sustainable investment of universities is 30.3% of the total investment, and about 94% of universities ' actual proportion of sustainable investment is lower than this willingness value. (3) The most important factors affecting the sustainable investment are: ① size of the school; ② sustainability instruction training for new employees; ③ the encouragement of employees to participate in community service; ④ whether the school establishes CIR (Committees on Investor Responsibility).

8.2 Implications

8.2.1 Implications for Chinese and Japanese Evaluation Standard

The Chinese and Japanese evaluation standard should pay more attention to the overall connotation of sustainable campus and better connect with the world on the basis of keeping campus energy saving and green building as the core content.

In the evaluation method, the combination of control items and scoring items can be continued to use. The proportion of scoring items can be appropriately increased, so as to encourage more innovation and practice. In terms of evaluation content, the evaluation clauses in the areas of Food & Dining, Purchasing, Diversity & Affordability and Investment & Finance should be added. Among them, the Investment & Finance field can be refined on the basis of STARS to formulate its own evaluation. In the area of Food & Dining, clauses to ensure food safety and health are mainly added. In order to ensure the common development of all areas, it is necessary to balance the proportion of the scores in each area of sustainability, especially in the areas of Curriculum, Research and Engagement.

China and Japan should change the way of issuing the evaluation standard based on administrative orders, actively publicize the concept of sustainability, mobilize all teachers, students and staff to participate in the sustainable construction of the campus, forming a construction mechanism of public participation and feedback optimization.

At the same time, their green campus national standard also needs to check the omissions and make up the deficiencies, closely combined with China's characteristics, so as to build a rich green campus system, and establish their own exclusive sustainable plan. At present, the national standard of green campus evaluation in China and Japan is still in the stage of discussion and research. This study suggests that STARS can be used as a blueprint for their national standard, using the internationally commonly used total score calculation method. The research results of this study on the suitability of STARS can be used as a reference to determine the evaluation scope of national standards. Meanwhile, the evaluation points and weights of individual indicators can be adjusted to make it more in line with national conditions and current needs.

In addition, green campus evaluation standard is not only a technical standard, but also a development planning. Standard setting should be integrated into the core concept of people-oriented, with a long-term concept of sustainable development. From the point of view of users' demand side, while monitoring campus energy consumption, we should pay more attention to the indoor environment quality of buildings and the degree of environmental friendliness. The guidance of teachers and students on energy use behavior mode are strengthened, while the sustainable life learning and working methods are advocated. Improving the sustainable development of campus hardware facilities as the carrier, the real overall upgrading can be achieved by thinking from many aspects, such as energy saving, low carbon environmental protection, efficient resource allocation, green industrial planning, economic sharing and life.

8.2.2 Implications for Global Sustainable Campus Development

The construction of campus energy saving plays an important role in promoting the sustainable development of campus. The construction of green campus only depends on the implementation of energy-saving supervision system, so the future development prospects are not good. A number of Chinese universities, represented by Zhejiang University, need to formulate new policy guidance based on the current construction achievements, expand the technical application direction of regulatory system and the innovation of specific energy-saving technologies.

With the continuous development of global green campus sustainable connotation and construction requirements, the overall concept of sustainable development in green campus should be established. Especially in the policy-making, the government and relevant departments should be detailed and all aspects of the overall consideration. Based on the national conditions and the characteristics of the university itself, the early development can focus on the development of advantageous projects of each university, so as to form a breakthrough point for the construction of green campus. With the formation and continuous improvement of advantage projects, the advantages will be transformed in time to drive the development of weak and difficult projects.

Energy saving is an important part of the whole green campus, but the sustainability of campus should not only stay in the level of energy saving. The sustainability of campus should be based on both physical facilities construction and sustainable management planning, which provides a clear direction for the future green campus construction policy. For the construction of green campus in the future, campus buildings, water resource utilization, waste disposal and sustainable investment in campus have become the key objects of sustainable development in the future.

The construction of green campus will be designed as a development mode changed from a single triangle framework composed of SDGs, STARS and universities to a compound triangle framework composed of SDGs, universities and communities on the existing basis, greatly expanding the way to realize SDGs. On this basis, with the continuous development and construction, the framework can continue to grow in the future, compounding more triangular frameworks in terms of scale and categories.

The four factors that influence sustainable investment can be regarded as an important construction point for promoting sustainable investment in the future, and on the other hand, they can also be regarded as the main characteristics of judging sustainable investment in colleges and universities. On this basis, the implementation plan of promoting sustainable investment in batches is formulated.

8.3 Future Research

This thesis focuses on the evaluation standard and development of sustainable campus in China, Japan and America. The research that has been undertaken for this thesis has highlighted several key points on which further research would be beneficial. Although this study attempts to analyze the problems comprehensively and scientifically, there are some small flaws due to the limitation of sample size. It is hoped that future research can make up for these deficiencies and further promote the new discovery of sustainable campus on the basis of this study, so as to continuously improve the results of this study.

In the future, this research can be further deepened in the following aspects:

(1) For the research of evaluation standards, on the basis of the existing evaluation standards of America, China and Japan, more national evaluation standards can be added for analysis and discussion, such as EcoCampus of the United Kingdom and relevant sustainable campus evaluation standards of Australia, in order to obtain more diversified research results and standard optimization strategies.

(2) In this thesis, two Chinese universities, two Japanese campuses and one American university are studied in details. In the future, more cases of universities in these countries can be added. More university cases from other countries can further enrich the case base of sustainable campus construction and help to grasp the development characteristics of global sustainable campus. For the construction of sustainable campus in China and Japan, taking more cases can further make classification according to the characteristics of different colleges and universities, and help to put forward appropriate optimization strategies for colleges and universities at different stages of development.

(3) This thesis discusses the relationship between the sustainability of campus and energy consumption. Future research can continue to conduct more in-depth research on campus energy consumption, in order to establish a multi-dimensional quantitative index system of campus sustainable evaluation, which will help to comprehensively and objectively analyze the environmental friendliness of sustainable campus. The research on energy consumption can be carried out from the aspect of campus carbon footprint tracking investigation to explore the internal development relationship and mathematical logic between low-carbon campus and sustainable campus.

(4) Exploring the realization of global SDGs has always been an important topic in the field of sustainable development research. This thesis attempts to study how to realize SDGs from the perspective of campus. In the future, the sub goals of SDGs and the inherent development potential of campus construction can be deeply analyzed, so as to put forward targeted construction strategies for a specific goal.

(5) The research of sustainable investment willingness is based on the major universities in the United States, so the research results are for the United States. Although it has a certain reference value for other countries, the pertinence is not strong. In the future, this study can carry out detailed research on universities in different countries and regions, and comprehensively analyze and compare the sustainable investment problems of universities in different countries.