Article

Prioritizing the Sustainability Objectives of Major Public Projects in the Guangdong-Hong Kong-Macao Greater Bay Area

Hongyang Li1,2, Ruoyu Jin3, Xin Ning4, Martin Skitmore5 and Tianyao Zhang6,\*

1 Associate Professor, School of Civil Engineering and Transportation, South China University of Technology, Guangzhou 510641, China. Email: cthyli@scut.edu.cn

2 State Key Laboratory of Subtropical Building Science, South China University of Technology, Guangzhou 510641, China

3 Senior Lecturer, School of Environment and Technology, University of Brighton, Cockcroft Building 616, Brighton, UK. BN24GJ. Email: R.Jin@brighton.ac.uk

4 Associate Professor, School of Investment & Construction Management, Dongbei University of Finance & Economics, Dalian, Liaoning Province, China. Email: ningxin@dufe.edu.cn

5 Professor, School of Civil Engineering and Built Environment, Queensland University of Technology (QUT), Garden Point Campus, GPO Box 2434, Brisbane, Q4001, Australia, Email: rm.skitmore@qut.edu.au

6 Research Associate, School of Geography, South China Normal University, Guangzhou, China. Email: zhangtianyao@m.scnu.edu.cn

**\*** Correspondence: zhangtianyao1@gmail.com; Tel.: +86-130-7025-0401

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**Abstract:** The relatively low level of sustainability of major public projects has been subject to criticism by the community, increasing the pressure to incorporate the concept throughout the project lifecycle and the importance of having an understanding of the perceptions of affected groups. The study undertook this task by compiling a list from the literature of the sustainability concerns associated with major public projects from their economic-social-environmental implications, identifying the relevant stakeholder groups in the Guangdong-Hong Kong-Macao Greater Bay Area and their levels of influence by interviews, and evaluating various sustainability objectives from a multi-stakeholder perspective by questionnaire survey. The results were validated through a series of interviews with purposively selected experts. The study findings indicate the need for more consideration of social concerns in Guangdong province, the proper levels of public participation in Hong Kong to avoid excessive interruptions to the pace of project procurement, and that Macao may have to experience a relatively slow development of construction in order to balance the social/environmental requirements involved. These findings contribute to both the government and construction industry at large in delivering economically, socially, and environmentally sustainable major public projects in the Bay Area and China as a whole.

**Keywords:** Sustainability; Major Public Projects; the Guangdong-Hong Kong-Macao Greater Bay Area

1. Introduction

As a national strategy of China, the development of the Guangdong-Hong Kong-Macao Greater Bay Area emphasizes the cooperation between the three regions in various respects, such as the delivery of major public projects (Huang et al., 2018). Projects of this type are constructed with an area of more than 20,000 m2 and for office, commercial, tourism, science, education, culture, hygiene, and communication as well as transportation use (Ling et al., 2014). Brookes and Locatelli (2015) list their features as large investment commitment, vast complexity (especially in organizational terms), and having a long-lasting impact on the regional economy, the environment, and society.

Despite of the large impact of infrastructure projects in the Guangdong-Hong Kong-Macao Greater Bay Areaas expected by Brookes and Locatelli (2015),, the relatively low level of project sustainability has been subject to some criticism by the community. Such recent controversial cases as the Guangzhou waste-to-energy power plant project and the Guangzhou-Shenzhen-Hong Kong high-speed rail project have even further escalated the dissatisfaction of project stakeholders over the economic, social, and environmental issues. This has increased the pressure to incorporate the concept of sustainability throughout the project lifecycle, making it important to have a better understanding the perceptions of affected groups in Guangdong province, Hong Kong, and Macao..

To address the multiple sustainability objectives raised from the mega infrastructure project in the Guangdong-Hong Kong-Macao Greater Bay Area , this study first compiled a list from the literature in terms of the sustainability concerns associated with major public projects from their economic-social-environmental implications. The relevant Guangdong-Hong Kong-Macao Greater Bay Area groups were then identified and their influencing levels were quantified through interviews. The various sustainability objectives were then evaluated from a multi-stakeholder perspective by a questionnaire survey from these three different geographical areas. The results were then validated by experts purposively selected in the last phase of the work. The study’s findings contribute to both the government and construction industry at large in delivering economically, socially, and environmentally sustainable major public projects in the Bay Area and China as a whole.

2. Literature review

2.1.

The principles of sustainable development have been implemented in various sectors, including the construction industry (Li et al., 2018). Researchers across the world have identified the sustainability objectives for construction projects. Fernández-Sánchez and Rodríguez-López (2010), for example, established the sustainable breakdown structure applicable to infrastructure projects from social, environmental, and economic perspectives, indicating that infrastructure sustainability, socially, covered areas such as culture, accessibility, participation, security, public utility, and social integration. The environmental indicators of green infrastructure projects, on the other hand, comprised soil, water, atmosphere, biodiversity, resources, and energy. Project stakeholders also pay attention to such items as costs, technical requirements, bureaucracy, social economy, and heritage, to achieve sustainability from the economic dimension (Fernández-Sánchez and Rodríguez-López, 2010). Pakzad et al. (2017) divided the key sustainability indicators of green infrastructure performance into four categories, namely (i) ecology (climate and microclimatic modifications, air quality improvement, carbon offset, reduced building energy use for heating and cooling, hydrological regulation, and biodiversity-protection and enhancement; (ii) health (improving physical, social, and mental well-being); (iii) socio-cultural (food production, opportunities for recreation, tourism and social interaction, and improving pedestrian ways and their connectivity); and (iv) economic (value of avoided CO2 emissions and carbon sequestration, value of avoided energy consumption, value of air pollutant removal/avoidance, and reducing the cost of using private motor cars by increased walking and cycling). Similar categories of construction sustainability for a variety of infrastructure projects can be found in Hatefi and Tamošaitiene (2018), Mansourianfar, M.H., Haghshenas, H. (2018), and Yang et al. (2018). Although there are slight differences between these aforementioned studies over the classifications in infrastructure construction sustainability, the consensus is that sustainable construction projects should balance the environmental, economic, and social concerns of their stakeholder groups (Li et al., 2018).

Based on the defined three major categories of construction sustainability (i.e., social, environmental, and economic aspects), a further 18 sustainability objectives of major public projects were identified through a global literature review (Urban Renewal Authority, 2001; Lu et al., 2002; Planning Department, 2003, 2006; Wang et al., 2007; Chan and Lee, 2008; Tang et al., 2008; Civil Engineering and Development Department, 2008; Tam et al., 2009; Amado et al., 2009; Jia et al., 2010; Li et al., 2010; Shen et al., 2010; West Kowloon Cultural District Authority, 2010; Liu et al., 2011; Valdes and Klotz, 2012; Teng et al., 2014; Li et al., 2015; Hou, 2016; Ahmad and Thaheem, 2017; Li et al., 2018). These were accordingly classified into the above three categories, as detailed in Fig. 1.

<Insert Fig. 1>

These 18 objectives are derived from a comprehensive review of there aforementioned studies, for example, availability of community amenities emphasized by Ahmad and Thaheem, (2017).

2.2. Review of methodology in sustainability objectives for major public projects

A multiple-phase methodology covering literature review, interview, and/or questionnaire survey has been adopted in several existing studies which focused on defining and evaluating the sustainability indicator system for major public projects. For example, Diaz-Sarachaga et al. (2017) developed a Sustainable Infrastructure Rating System by firstly defining the importance of sustainability indicators by collecting experts’ feedback. The rating system was then weighted adopting Analytical Hierarchy Process (AHP) and the Integrated Value Model for Sustainable Assessment (Diaz-Sarachaga et al., 2017). The same three pillars of sustainability (i.e., social, environmental, and economic factors) were targeted by Yu et al. (2018) in developing the Construction Project Sustainability Assessing System. Questionnaire survey approach was adopted by Yu et al. (2018) to evaluate the suitability of these pre-established sustainability indicators. Key performance indicator system was compared between different countries by Hong and Lacouture (2011) involving the Delphi approach. The literature review, questionnaire survey, and assessment of sustainability criteria was performed by Hatefi and Tamošaitiene (2018) for construction and infrastructure projects.

2.3. Sustainability of major public projects in the China context

A few existing studies can be found targeting on developing the sustainability assessment system for China’s public or infrastructure projects. For example, Shen et al. (2011) initiated the key assessment indicators (KAIs) for assessing the sustainability performance of infrastructure project in China. Adopting a questionnaire survey approach by recruiting experts from government officials, industry professionals, and clients, the study of Shen et al. (2011) served as one of the initial sustainability assessment systems in the China context. The comparative study of sustainability for infrastructure projects performed by Hong and Lacouture (2011) indicated that China’s sustainability indicator for infrastructure projects varied from that of United States, specifically in terms of special indicators of highway systems. Liu et al. (2017) concluded that there had been growing interests for sustainability in new transport infrastructure projects in China. However, so far there have been still limited development of sustainability assessment system in China context.

3. Research Design

3.1. Research process

The study was conducted in four phases as illustrated in Fig. 2. The first phase involved reviewing the global literature to compile a list of sustainability objectives of major public projects. For the next phase, a series of semi-structured interviews were organized to (i) confirm the suitability and practicality of various sustainable concerns (as identified in Phase 1) in the Chinese context; (ii) identify the project stakeholder groups involved; and (iii) analyze the impact level of each group quantitatively. In Phase 3, a questionnaire survey was carried out, and different sustainability objectives evaluated from a multi-stakeholder perspective. The results were then validated in the final phase by purposively selected experts.

<Insert Fig. 2>

3.2. Research methods

A combination of construction management research methods was adopted, including a literature review, interviews, and a questionnaire survey. As a summary of the literature review is reported in the previous section, the following focuses on the latter two.

3.2.1. Interviews

Interviews were carried out in each of Phases 2 and 4 to achieve different research objectives (as detailed in Fig. 1). In Phase 2, these involved 26 purposively chosen experts with a minimum of 5 years’ working/research experience in public project delivery from government departments and groups of owners/contractors/designers/NGOs/academics (Table 1). The rest (the end-user group) had been users of public projects in mainland China, Hong Kong, or Macao.

<Insert Table 1>

The major stakeholder groups of public projects were identified during this phase. Their impact levels were then assessed on a 5-point Likert scale from 1 (very low) to 5 (very high) and based on their possibility of influence (*P*) and degree (*D*) in each of Guangdong province, Hong Kong, and Macao. As required by the interviewees to preserve anonymity, their positions and organizations were not linked to their evaluations.

The comprehensive impact level (*CIL*) of each stakeholder group during public project delivery was obtained from

 (1)

where Stakeholder Group A belongs to one of groups in Table 1.

The weighting (*W*) of Stakeholder Group A in evaluating project sustainability indicators is given by

 (2)

Equivalent formulae apply to the other stakeholder groups.

Phase 4 involved a series in interviews, with 25 different participants (based on the same selection criteria as used in Phase 2) constituting the validation panel (Table 1) and invited to comment on the research results obtained from the previous phases.

3.2.2. Questionnaire survey

A questionnaire survey was conducted in Phase 3, soliciting comments from the various stakeholder groups. A purposive sampling approach was used, with potential respondents being required to have at least two years’ working experience in public project construction in Guangdong province/Hong Kong/Macao, or have been users of public projects in the region. 177 valid responses were obtained; the response rates for each stakeholder group are summarized in Table 2. The respondents evaluated the identified sustainability objectives according to a 7-point Likert scale from 1 (least important) to 7 (most important).

<Insert Table 2>

The initial mean value (*IMV*), regarding the evaluation of each stakeholder group of each sustainability factor, was calculated and then adjusted by the weighting (*W*) of each stakeholder group in determining project overall sustainability, i.e.,

 (3)

where the *Adjusted Mean Value (AMV)xy* means the adjusted mean value of item *x* as rated by stakeholder group *y*, *Initial Mean Value (IMV)xy* represents the initial mean value of item *x* as rated by stakeholder group *y*, and *Wy* denotes the weighting of stakeholder group *y* obtained through Eqs (1) and (2).

4. Results

4.1. The stakeholder groups of major public projects and their level of impact

During the first-round interviews, the expert panel confirmed that the sustainability objectives of major public projects, as identified through the literature review, were suitable and practicable with regard to the economic-social-environmental background of China and the Guangdong-Hong Kong-Macao Greater Bay Area in particular. The major stakeholders were identified as shown in Table 1. Tables 3-5 summarize the possibility of influence (*P*) and degree (*D*)values of the various stakeholders, with the calculated comprehensive impact levels (*CIL*) and their weightings (*W*) shown in Table 6.

<Insert Tables 3-6>

The rankings of the three most influential stakeholder groups in Guangdong province and Macao are same - the local government department being the first followed by the owners and operators - with slight differences regarding their respective comprehensive impact levels and weighting. A notable feature is that the impact level of the end-users was rated as 4.058 (the second highest) in Hong Kong. This stakeholder group however had a rating of 3.076 in Guangdong province, next to last on the list.

4.2 Assessment of various sustainability objectives from a multi-stakeholder perspective

The evaluations of the various stakeholder groups from Guangdong province, Hong Kong, and Macao on the economic, social, and environmental sustainability objectives based on the initial mean values (*IMV*) and project overall sustainability are listed in Tables 7, 8, and 9 respectively. The most important *economic* factor evaluated by the respondents in the three geographical areas is EC5 (value-for-money during the proposed project(s) lifecycle) by the government department and owners, with adjusted mean values of 0.960 and 0.964 for Guangdong province, 0.849 and 0.940 for Hong Kong, and 0.906 and 0.930 for Macao (Table 7). In Guangdong province, the government department (ranked 1st) and owners (ranked 2nd) are also the most positive groups promoting *social* sustainability (Table 8). Of the various factors involved, SO2 (creation of a safe, convenient, comfortable, and legible pedestrian circulation and transport network) is considered the most important and SO5 (unique local characteristics) the least important in Guangdong province. In Hong Kong and Macao, the group of owners play a key role during socially sustainable construction and most attention is paid to SO9 (effective public participation). From the *environmental* perspective (Table 9), the government department (in Guangdong province), end-users (in Hong Kong), and owners (in Macao) are the most concerned. The core issues are the prevention and mitigation measures against air, water, and noise pollution (in Guangdong province), and green design and construction (in Hong Kong and Macao).

<Insert Tables 7-9>

4.3 Prioritization of various sustainability objectives

The Adjusted Mean Values (*AMV*) of the various sustainability objectives, obtained from Eq. (3) and listed in Tables 7, 8, and 9, are ranked between/within the various stakeholder groups in each region, as summarized in Table 10.

<Insert Table 10>

From the *economic* and *social* perspectives, Macao ranks the highest of the three regionsat 6.004 and 5.852 respectively, while Guangdong province is the highest (6.291) for the *environmental* sustainability objectives, followed by economic and social issues. The ranking in Hong Kong is different, with social sustainability being the most critical and economic issues the least. In Macao, more attention is paid to achieving economic sustainability during project delivery, with environmental concern being the least.

5. Validation and Discussion

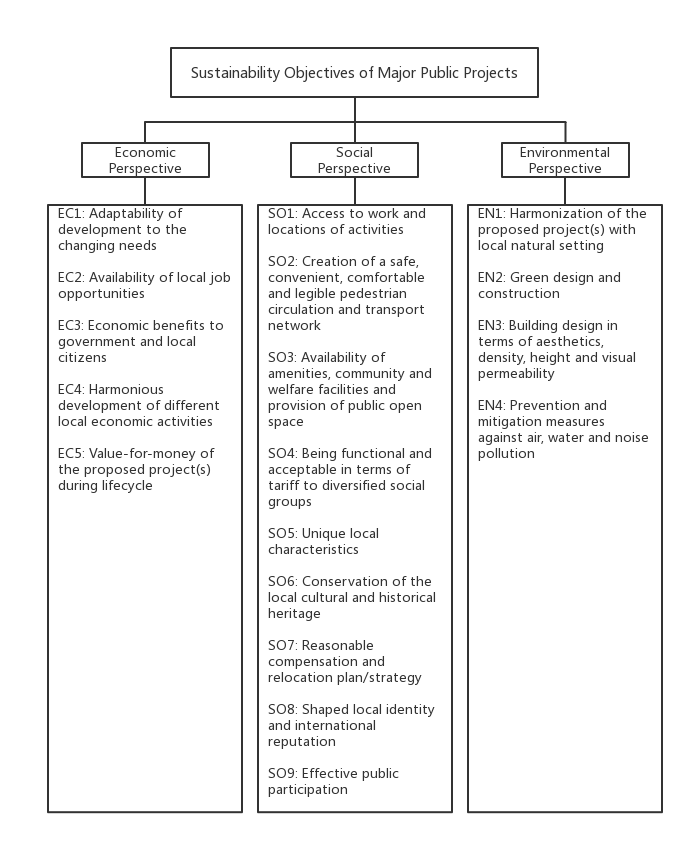
All the validation panel members considered it appropriate to divide the stakeholders in the eight Table 1 groups. The highest ranked comprehensive impact levels coming from government department/owners in all three regions was taken to confirm that administrative instructions are currently more effective than market demands to achieve sustainable project delivery economically, socially, and environmentally. The panel found the relatively low influence level of end-users in Guangdong province to be unsurprising, since end-users are traditionally ignored in construction practice in mainland China. Despite this, an apparent call has been increasingly observed for the input of end-users to be recognized by construction industry practitioners of the mainland. After all, they are true agents in realizing the economic, social, and environmental sustainability objectives involved.

The panel felt the prioritization of the various sustainability objectives in Guangdong province (with environmental concerns being the first, followed by economic and social concerns) should be viewed from both positive and negative perspectives. On the one hand, most practitioners (especially in government departments) of the construction industry in mainland China have shifted towards the notion that the overall industry must not be allowed to develop at the cost of environment. Although ignoring environmental sustainability may speed up the development of the construction industry in the short run, has been proved to be extremely naïve, as evidenced by the Yokkaichi asthma episode in Japan during the 1950s for example. On the other hand, various so-called society-related sustainability objectives are still overlooked to some extent. Consequently, there have been such controversial cases as the construction of incineration plants in Guangdong, which was accompanied by vociferous local resistance. It was suggested that one way to cope with this, as learned from Hong Kong practice, is to increase participatory decision-making throughout the project lifecycle. This is especially important for public projects, since the core mission of delivering projects of this type ought to be to satisfy the community as far as possible. The amount of involvement of the public should be carefully designed to suit different project stages to optimize community input while not adversely influencing project progress. For Macao, it is seen as appropriate to place a greater emphasis on economic sustainable development given the *state quo* of the region. Simultaneously incorporating environmental and social concerns may be on the right track even if it slows the pace of development.

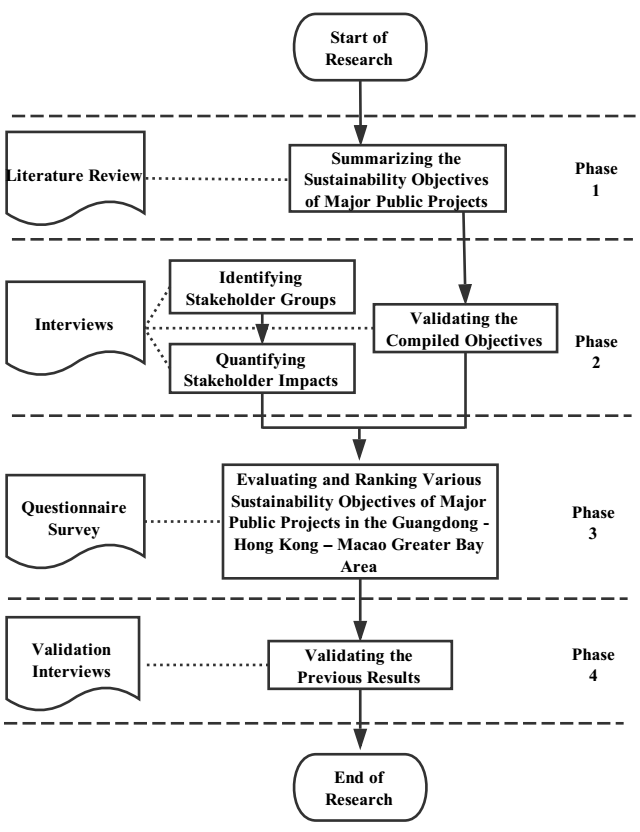
6. Conclusions

Improving the sustainability of major public projects in the Guangdong-Hong Kong-Macao Greater Bay Area is crucial for the development of the local construction industry. To cope with this necessitates the prioritization of various sustainability objectives in the region. The interviews in this study identified the major stakeholder groups of public projects (i.e. government department, owners, designers, contractors, supervising engineers, operators, end-users and non-governmental organizations) and their impact on project delivery. A questionnaire survey then assessed a list of 18 sustainability factors (compiled from a literature review) from the perspectives of the stakeholder groups in Guangdong, Hong Kong, and Macao. This led to the quantification of sustainability objectives in Guangdong province (environmental ranked higher than economic and social issues), Hong Kong (social followed by environmental and economic issues) and Macao (economic followed by social and environmental issues). The findings were then validated through a series of interviews, during which some suggestions for changes to the current approach to sustainable public project delivery in the Bay Area were proposed. These indicate the need for more consideration of social concerns in Guangdong province, the proper levels of public participation in Hong Kong (to avoid excessive interruptions to the pace of project procurement), and that Macao may have to experience a relatively slow development of construction in order to balance the social/environmental requirements involved.

Future research needs to be directed at establishing a participatory evaluation model to assess the economic-social-environmental sustainability performance of major public projects in the Guangdong-Hong Kong-Macao Greater Bay Area. Further research is also needed to examine the implementation issues involved in following the recommendations of the study. Additional work will also involve similar studies in other regions of China, with the potential for application further afield.



**Figure 1.** Sustainability objectives of major public projects



**Figure 2.** Research flowchart

**Table 1.**Profiles of the interviewees involved in Phases 2 and 4

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Group** | **No.** | **Region\*** | **Position** | **Organization** | **Research Phase Involved** | |
| **ii** | **iv** |
| Government Department | 1 | CM | Deputy Secretary-general | Provincial Bureau | ✓ |  |
| 2 | CM | Director | Municipal Bureau | ✓ |  |
| 3 | HK | Deputy Director | Government Bureau | ✓ |  |
| 4 | MC | Director | Government Bureau | ✓ |  |
| V01 | CM | Policy Advisor | Municipal Bureau |  | ✓ |
| V02 | HK | Deputy Director | Government Department |  | ✓ |
| V03 | MC | Deputy Director | Government Bureau |  | ✓ |
| Owner | 5 | CM | Deputy General Manager | Real Estate Corporation | ✓ |  |
| 6 | HK | Project Manager | Real Estate Corporation | ✓ |  |
| 7 | MC | Project Manager | Real Estate Corporation | ✓ |  |
| V04 | CM | Engineering Manager | Real Estate Corporation |  | ✓ |
| V05 | HK | Deputy General Manager | Real Estate Corporation |  | ✓ |
| V06 | MC | Project Manager | Real Estate Corporation |  | ✓ |
| Contractor | 8 | CM | Engineering Manager | Construction Company | ✓ |  |
| 9 | HK | Deputy Technical Manager | Construction Company | ✓ |  |
| 10 | MC | Engineer | Construction Company | ✓ |  |
| 11 | MC | Chief Engineer | Construction Company | ✓ |  |
| V07 | CM | Technical Manager | Construction Company |  | ✓ |
| V08 | HK | Manager | Construction Company |  | ✓ |
| V09 | MC | Senior Technician | Construction Company |  | ✓ |
| Designer | 12 | CM | Architect | Design consultants | ✓ |  |
| 13 | HK | Associate Architect | Design Consultants | ✓ |  |
| 14 | MC | Executive Director | Design Company | ✓ |  |
| V10 | CM | Principal Architect | Design consultants |  | ✓ |
| V11 | CM | Assistant Manager | Design Company |  | ✓ |
| V12 | HK | Structural Engineers | Design Company |  | ✓ |
| V13 | MC | Engineer | Design Company |  | ✓ |
| End-user | 15 | CM | End-user | N/A | ✓ |  |
| 16 | CM | End-user | N/A | ✓ |  |
| 17 | HK | End-user | N/A | ✓ |  |
| 18 | MC | End-user | N/A | ✓ |  |
| V14 | CM | End-user | N/A |  | ✓ |
| V15 | HK | End-user | N/A |  | ✓ |
| V16 | HK | End-user | N/A |  | ✓ |
| V17 | MC | End-user | N/A |  | ✓ |

\* CM: China mainland; HK: Hong Kong SAR; and MC: Macao SAR

**Table 1.**Profiles of the interviewees involved in Phases 2 and 4

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Group** | **No.** | **Region\*** | **Position** | **Organization** | **Research Phase Involved** | |
| **ii** | **iv** |
| Academia | 19 | CM | Professor | University | ✓ |  |
| 20 | HK | Associate Professor | University | ✓ |  |
| 21 | MC | Assistant Professor | University | ✓ |  |
| 22 | MC | Associate Professor | University | ✓ |  |
| V18 | CM | Director | Municipal Research Center |  | ✓ |
| V19 | CM | Senior Research Fellow | Provincial Research Institution |  | ✓ |
| V20 | HK | Assistant Professor | University |  | ✓ |
| V21 | MC | Professor | University |  | ✓ |
| NGOs | 23 | CM | Executive Director | Environmental Group | ✓ |  |
| 24 | HK | Member | NGO | ✓ |  |
| 25 | HK | Member | Environmental Group | ✓ |  |
| 26 | MC | Member | Environmental Group | ✓ |  |
| V22 | CM | Member | Environmental Group |  | ✓ |
| V23 | HK | Member | NGO |  | ✓ |
| V24 | MC | Director | NGO |  | ✓ |
| V25 | MC | Member | NGO |  | ✓ |

\* CM: China mainland; HK: Hong Kong SAR; and MC: Macao SAR

**Table 2.**Response rate

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Stakeholder Groups of the Chinese Construction Industry** | **No. of Questionnaires** | | | | | | | | | | | |
| China mainland | | | Hong Kong | | | Macao | | | Overall | | |
| Sent | Returned | % | Sent | Returned | % | Sent | Returned | % | Sent | Returned | % |
| Government department | 34 | 8 | 0.24 | 28 | 6 | 0.21 | 30 | 6 | 0.20 | 92 | 20 | 0.22 |
| Owners | 35 | 10 | 0.29 | 33 | 7 | 0.21 | 36 | 8 | 0.22 | 104 | 25 | 0.24 |
| Designers | 32 | 7 | 0.22 | 29 | 6 | 0.21 | 32 | 8 | 0.25 | 93 | 21 | 0.23 |
| Contractors | 39 | 9 | 0.23 | 35 | 7 | 0.20 | 40 | 9 | 0.23 | 114 | 25 | 0.22 |
| Supervising engineers | 37 | 8 | 0.22 | 31 | 7 | 0.23 | 28 | 7 | 0.25 | 96 | 22 | 0.23 |
| Operators | 29 | 6 | 0.21 | 32 | 7 | 0.22 | 30 | 7 | 0.23 | 91 | 20 | 0.22 |
| End-users | 35 | 8 | 0.23 | 36 | 9 | 0.25 | 30 | 7 | 0.23 | 101 | 24 | 0.24 |
| NGOs | 27 | 6 | 0.22 | 34 | 8 | 0.24 | 30 | 6 | 0.20 | 91 | 20 | 0.22 |
| **Total** | **268** | **62** | **0.23** | **258** | **57** | **0.22** | **256** | **58** | **0.23** | **782** | **177** | **0.23** |

**Table 3.**The influencing possibilities (P) and degrees (D) of various stakeholder groups of major public projects in Guangdong province

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Stakeholder Groups** |  | **Interviewees** | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | Mean |
| **Government Department** | *P* | 5 | 5 | 4 | 5 | 4 | 3 | 5 | 4 | 5 | 5 | 5 | 5 | 5 | 4 | 3 | 4 | 5 | 5 | 5 | 5 | 3 | 4 | 4 | 4 | 5 | 5 | 4.462 |
| *D* | 5 | 4 | 4 | 4 | 5 | 5 | 5 | 5 | 4 | 3 | 5 | 5 | 4 | 4 | 4 | 5 | 5 | 5 | 5 | 5 | 4 | 5 | 5 | 5 | 4 | 5 | 4.577 |
| **Owners** | *P* | 4 | 4 | 3 | 4 | 5 | 5 | 5 | 4 | 4 | 3 | 5 | 4 | 4 | 5 | 4 | 5 | 5 | 5 | 5 | 3 | 3 | 4 | 3 | 3 | 5 | 4 | 4.154 |
| *D* | 4 | 5 | 4 | 4 | 4 | 4 | 3 | 2 | 4 | 5 | 5 | 5 | 4 | 5 | 4 | 3 | 5 | 5 | 4 | 4 | 4 | 3 | 4 | 3 | 4 | 5 | 4.077 |
| **Designers** | *P* | 2 | 2 | 3 | 4 | 3 | 2 | 4 | 2 | 3 | 2 | 4 | 4 | 2 | 3 | 1 | 4 | 5 | 3 | 2 | 2 | 3 | 2 | 1 | 1 | 4 | 3 | 2.731 |
| *D* | 4 | 3 | 3 | 3 | 4 | 4 | 4 | 3 | 2 | 3 | 3 | 3 | 3 | 2 | 3 | 4 | 4 | 4 | 4 | 5 | 4 | 4 | 4 | 4 | 3 | 4 | 3.500 |
| **Contractors** | *P* | 3 | 1 | 1 | 1 | 3 | 3 | 3 | 4 | 4 | 2 | 3 | 3 | 4 | 5 | 3 | 3 | 3 | 2 | 3 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2.538 |
| *D* | 3 | 4 | 3 | 4 | 3 | 3 | 2 | 4 | 4 | 4 | 4 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 5 | 2 | 3 | 2 | 4 | 4 | 4 | 4 | 3.538 |
| **Supervising Engineers** | *P* | 3 | 4 | 4 | 4 | 2 | 3 | 2 | 4 | 3 | 4 | 3 | 3 | 4 | 2 | 3 | 4 | 3 | 4 | 5 | 3 | 3 | 3 | 3 | 3 | 2 | 5 | 3.308 |
| *D* | 4 | 4 | 3 | 3 | 4 | 4 | 4 | 2 | 4 | 4 | 3 | 3 | 3 | 4 | 4 | 5 | 3 | 4 | 4 | 3 | 4 | 4 | 3 | 2 | 4 | 4 | 3.577 |
| **Operators** | *P* | 3 | 3 | 4 | 2 | 2 | 2 | 3 | 3 | 5 | 2 | 3 | 4 | 3 | 4 | 4 | 4 | 5 | 4 | 5 | 4 | 4 | 5 | 4 | 4 | 4 | 3 | 3.577 |
| *D* | 3 | 3 | 3 | 4 | 2 | 5 | 4 | 5 | 4 | 2 | 4 | 4 | 4 | 3 | 4 | 4 | 4 | 4 | 2 | 4 | 3 | 3 | 4 | 4 | 4 | 4 | 3.615 |
| **End-Users** | *P* | 3 | 3 | 3 | 4 | 3 | 3 | 2 | 2 | 4 | 1 | 4 | 4 | 4 | 3 | 2 | 4 | 3 | 3 | 4 | 4 | 4 | 3 | 3 | 4 | 2 | 3 | 3.154 |
| *D* | 4 | 4 | 4 | 4 | 3 | 2 | 3 | 3 | 3 | 2 | 4 | 3 | 4 | 3 | 3 | 2 | 2 | 2 | 2 | 4 | 3 | 3 | 2 | 3 | 3 | 3 | 3.000 |
| **NGOs** | *P* | 3 | 5 | 3 | 4 | 4 | 4 | 3 | 3 | 3 | 3 | 3 | 5 | 2 | 3 | 3 | 4 | 5 | 4 | 4 | 3 | 2 | 4 | 3 | 4 | 3 | 5 | 3.538 |
| *D* | 3 | 4 | 4 | 5 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 4 | 4 | 3 | 2 | 3 | 3 | 2 | 2 | 4 | 4 | 2 | 3 | 4 | 4 | 3.192 |

**Table 4.** The influencing possibilities (P) and degrees (D) of various stakeholder groups of major public projects in Hong Kong

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Stakeholder Groups** |  | **Interviewees** | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | Mean |
| **Government Department** | *P* | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 4 | 5 | 3 | 4 | 4 | 5 | 2 | 3 | 4 | 4 | 4 | 5 | 5 | 5 | 4 | 3 | 4 | 5 | 4 | 3.731 |
| *D* | 4 | 4 | 4 | 5 | 4 | 4 | 4 | 4 | 3 | 4 | 4 | 5 | 3 | 4 | 5 | 4 | 5 | 5 | 5 | 4 | 3 | 5 | 4 | 5 | 3 | 5 | 4.192 |
| **Owners** | *P* | 5 | 4 | 5 | 3 | 5 | 4 | 5 | 5 | 4 | 4 | 5 | 3 | 5 | 3 | 5 | 4 | 3 | 4 | 5 | 4 | 5 | 4 | 5 | 4 | 4 | 4 | 4.269 |
| *D* | 4 | 4 | 4 | 4 | 5 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 3 | 4 | 4 | 4 | 4 | 5 | 4 | 4 | 4 | 3 | 3 | 4.000 |
| **Designers** | *P* | 3 | 4 | 4 | 4 | 4 | 2 | 3 | 3 | 3 | 4 | 3 | 4 | 3 | 5 | 3 | 4 | 4 | 3 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 3 | 3.500 |
| *D* | 3 | 2 | 2 | 2 | 2 | 4 | 4 | 3 | 3 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 3 | 3 | 3 | 4 | 4 | 4 | 3 | 2.962 |
| **Contractors** | *P* | 2 | 3 | 3 | 4 | 3 | 4 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 4 | 4 | 3 | 4 | 4 | 4 | 3.077 |
| *D* | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 4 | 3 | 2 | 2 | 3 | 3 | 4 | 5 | 2 | 3 | 3 | 4 | 4 | 3 | 4 | 3 | 2 | 4 | 4 | 3.154 |
| **Supervising Engineers** | *P* | 3 | 3 | 3 | 2 | 4 | 3 | 4 | 4 | 4 | 4 | 3 | 4 | 2 | 3 | 4 | 4 | 4 | 4 | 4 | 3 | 3 | 3 | 3 | 3 | 4 | 4 | 3.423 |
| *D* | 4 | 4 | 3 | 4 | 4 | 4 | 3 | 4 | 3 | 4 | 4 | 4 | 4 | 4 | 2 | 4 | 3 | 3 | 3 | 4 | 2 | 2 | 4 | 3 | 4 | 4 | 3.500 |
| **Operators** | *P* | 4 | 3 | 4 | 4 | 2 | 5 | 3 | 4 | 4 | 3 | 5 | 3 | 2 | 3 | 4 | 4 | 4 | 3 | 3 | 4 | 4 | 5 | 3 | 3 | 3 | 4 | 3.577 |
| *D* | 4 | 4 | 3 | 3 | 4 | 4 | 4 | 4 | 2 | 4 | 5 | 5 | 4 | 3 | 4 | 4 | 4 | 4 | 4 | 3 | 4 | 4 | 3 | 4 | 4 | 4 | 3.808 |
| **End-Users** | *P* | 4 | 4 | 4 | 5 | 5 | 4 | 4 | 4 | 4 | 5 | 5 | 4 | 3 | 4 | 3 | 5 | 4 | 5 | 3 | 3 | 4 | 4 | 5 | 4 | 4 | 3 | 4.077 |
| *D* | 5 | 3 | 4 | 5 | 4 | 5 | 3 | 5 | 3 | 4 | 4 | 4 | 5 | 4 | 4 | 4 | 5 | 4 | 4 | 4 | 3 | 3 | 2 | 4 | 5 | 5 | 4.038 |
| **NGOs** | *P* | 5 | 4 | 4 | 4 | 3 | 5 | 4 | 4 | 5 | 3 | 5 | 4 | 3 | 4 | 5 | 4 | 4 | 3 | 3 | 4 | 4 | 3 | 5 | 4 | 4 | 4 | 4.000 |
| *D* | 4 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 2 | 4 | 4 | 4 | 5 | 4 | 2 | 3 | 4 | 4 | 4 | 4 | 4 | 3.731 |

**Table 5**. The influencing possibilities (P) and degrees (D) of various stakeholder groups of major public projects in Macao

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Stakeholder Groups** |  | **Interviewees** | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | Mean |
| **Government Department** | *P* | 5 | 4 | 4 | 4 | 5 | 4 | 3 | 4 | 4 | 5 | 4 | 4 | 4 | 3 | 4 | 4 | 5 | 4 | 4 | 3 | 4 | 4 | 3 | 4 | 4 | 5 | 4.038 |
| *D* | 5 | 3 | 5 | 5 | 5 | 3 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 3 | 4 | 5 | 5 | 5 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 4.192 |
| **Owners** | *P* | 4 | 4 | 5 | 4 | 5 | 5 | 5 | 4 | 5 | 3 | 5 | 3 | 4 | 5 | 3 | 5 | 5 | 4 | 3 | 3 | 5 | 5 | 5 | 3 | 3 | 5 | 4.231 |
| *D* | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 4 | 4 | 4 | 3 | 4 | 3 | 4 | 2 | 3 | 3 | 4 | 4 | 4 | 5 | 5 | 5 | 4 | 5 | 4 | 4.000 |
| **Designers** | *P* | 4 | 3 | 3 | 3 | 3 | 3 | 5 | 4 | 4 | 2 | 3 | 3 | 3 | 2 | 4 | 2 | 3 | 4 | 3 | 3 | 3 | 2 | 2 | 4 | 3 | 3 | 3.115 |
| *D* | 4 | 3 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 2 | 3 | 3 | 3 | 2 | 2 | 3 | 1 | 3 | 3 | 4 | 4 | 4 | 4 | 3 | 3 | 3.192 |
| **Contractors** | *P* | 3 | 3 | 3 | 2 | 4 | 4 | 3 | 3 | 2 | 3 | 3 | 3 | 4 | 5 | 3 | 2 | 2 | 2 | 4 | 2 | 1 | 2 | 3 | 3 | 4 | 3 | 2.923 |
| *D* | 2 | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 4 | 4 | 3 | 2 | 3 | 4 | 4 | 4 | 4 | 3 | 4 | 2 | 2 | 3 | 3 | 3 | 2 | 2 | 2.962 |
| **Supervising Engineers** | *P* | 4 | 4 | 2 | 5 | 4 | 3 | 4 | 2 | 3 | 4 | 4 | 4 | 2 | 3 | 3 | 2 | 3 | 3 | 5 | 2 | 4 | 3 | 4 | 4 | 4 | 4 | 3.423 |
| *D* | 3 | 3 | 4 | 4 | 5 | 2 | 3 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 2 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 3.577 |
| **Operators** | *P* | 3 | 4 | 4 | 4 | 4 | 3 | 5 | 4 | 2 | 4 | 3 | 2 | 3 | 5 | 3 | 3 | 4 | 4 | 5 | 5 | 4 | 5 | 5 | 4 | 3 | 4 | 3.808 |
| *D* | 4 | 4 | 4 | 4 | 3 | 4 | 4 | 4 | 4 | 4 | 2 | 3 | 5 | 4 | 4 | 5 | 4 | 4 | 4 | 4 | 4 | 3 | 4 | 4 | 4 | 4 | 3.885 |
| **End-Users** | *P* | 4 | 3 | 4 | 4 | 4 | 3 | 4 | 4 | 4 | 2 | 3 | 4 | 3 | 4 | 3 | 4 | 3 | 4 | 2 | 4 | 3 | 4 | 4 | 4 | 2 | 4 | 3.500 |
| *D* | 3 | 3 | 4 | 4 | 3 | 4 | 5 | 4 | 4 | 4 | 3 | 4 | 4 | 4 | 3 | 4 | 4 | 2 | 4 | 5 | 4 | 4 | 4 | 3 | 2 | 4 | 3.692 |
| **NGOs** | *P* | 4 | 5 | 4 | 3 | 5 | 4 | 4 | 4 | 4 | 3 | 4 | 2 | 3 | 4 | 3 | 2 | 3 | 4 | 4 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 3.692 |
| *D* | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 3 | 2 | 2 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 3 | 4 | 4 | 4 | 3 | 4 | 2 | 4 | 4 | 3.500 |

**Table 6.** The comprehensive impact levels (CIL) of various stakeholder groups and their weightings (W)

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Stakeholder Groups** | **Guangdong Province** | | | **Hong Kong** | | | **Macao** | | |
| *CIL* | *W* | *Ranking* | *CIL* | *W* | *Ranking* | *CIL* | *W* | *Ranking* |
| **Government Department** | 4.519 | 0.160 | 1 | 3.955 | 0.134 | 3 | 4.115 | 0.143 | 1 |
| **Owners** | 4.115 | 0.146 | 2 | 4.132 | 0.140 | 1 | 4.114 | 0.143 | 2 |
| **Designers** | 3.092 | 0.110 | 6 | 3.220 | 0.109 | 7 | 3.154 | 0.109 | 7 |
| **Contractors** | 2.997 | 0.106 | 8 | 3.115 | 0.106 | 8 | 2.942 | 0.102 | 8 |
| **Supervising Engineers** | 3.440 | 0.122 | 4 | 3.461 | 0.117 | 6 | 3.499 | 0.121 | 6 |
| **Operators** | 3.596 | 0.128 | 3 | 3.691 | 0.125 | 5 | 3.846 | 0.133 | 3 |
| **End-Users** | 3.076 | 0.109 | 7 | 4.058 | 0.138 | 2 | 3.595 | 0.125 | 4 |
| **NGOs** | 3.361 | 0.119 | 5 | 3.863 | 0.131 | 4 | 3.595 | 0.125 | 4 |

**Table 7** Evaluation of various stakeholder groups on the economic sustainability objectives

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Region** | **Stakeholder Groups** | **Sustainability Objectives (Economic Perspective)** | | | | | | | | | | | |
| Initial Mean | | | | |  | Adjusted Mean | | | | | Sum of Adjusted Mean (Based on Single Group) |
| EC1 | EC2 | EC3 | EC4 | EC5 | *W* | EC1’ | EC2’ | EC3’ | EC4’ | EC5’ |
| GD\* | Government department | 6.750 | 6.625 | 6.500 | 6.375 | 6.000 | 0.160 | 1.080 | 1.060 | 1.040 | 1.020 | 0.960 | 5.160 |
| Owners | 5.700 | 5.800 | 5.600 | 5.500 | 6.600 | 0.146 | 0.832 | 0.847 | 0.818 | 0.803 | 0.964 | 4.263 |
| Designers | 5.143 | 5.000 | 5.429 | 5.000 | 6.000 | 0.110 | 0.566 | 0.550 | 0.597 | 0.550 | 0.660 | 2.923 |
| Contractors | 5.333 | 5.778 | 5.444 | 4.889 | 6.111 | 0.106 | 0.565 | 0.612 | 0.577 | 0.518 | 0.648 | 2.921 |
| Supervising engineers | 5.375 | 5.625 | 5.500 | 5.000 | 6.250 | 0.122 | 0.656 | 0.686 | 0.671 | 0.610 | 0.763 | 3.386 |
| Operators | 6.000 | 6.167 | 6.000 | 5.833 | 6.167 | 0.128 | 0.768 | 0.789 | 0.768 | 0.747 | 0.789 | 3.861 |
| End-users | 5.875 | 6.375 | 6.625 | 6.125 | 6.000 | 0.109 | 0.640 | 0.695 | 0.722 | 0.668 | 0.654 | 3.379 |
| NGOs | 6.500 | 5.833 | 6.000 | 6.167 | 6.333 | 0.119 | 0.774 | 0.694 | 0.714 | 0.734 | 0.754 | 3.669 |
| Sum of Mean (Based on Single Factor) | 46.676 | 47.203 | 47.098 | 44.889 | 49.461 | N/A | 5.881 | 5.934 | 5.907 | 5.649 | 6.191 | 29.562 |
| HK\* | Government department | 6.667 | 6.833 | 6.667 | 6.500 | 6.333 | 0.134 | 0.893 | 0.916 | 0.893 | 0.871 | 0.849 | 4.422 |
| Owners | 6.143 | 6.000 | 5.857 | 6.000 | 6.714 | 0.140 | 0.860 | 0.840 | 0.820 | 0.840 | 0.940 | 4.300 |
| Designers | 4.667 | 5.667 | 5.333 | 4.333 | 5.500 | 0.109 | 0.509 | 0.618 | 0.581 | 0.472 | 0.600 | 2.780 |
| Contractors | 4.714 | 5.857 | 4.857 | 4.571 | 5.429 | 0.106 | 0.500 | 0.621 | 0.515 | 0.485 | 0.575 | 2.695 |
| Supervising engineers | 5.286 | 5.857 | 5.714 | 5.000 | 5.857 | 0.117 | 0.618 | 0.685 | 0.669 | 0.585 | 0.685 | 3.243 |
| Operators | 5.429 | 6.000 | 6.000 | 5.143 | 6.143 | 0.125 | 0.679 | 0.750 | 0.750 | 0.643 | 0.768 | 3.589 |
| End-users | 5.333 | 5.778 | 5.889 | 5.333 | 6.000 | 0.138 | 0.736 | 0.797 | 0.813 | 0.736 | 0.828 | 3.910 |
| NGOs | 5.375 | 5.250 | 4.750 | 4.625 | 6.000 | 0.131 | 0.704 | 0.688 | 0.622 | 0.606 | 0.786 | 3.406 |
| Sum of Mean (Based on Single Factor) | 43.613 | 47.242 | 45.067 | 41.506 | 47.976 | N/A | 5.499 | 5.915 | 5.663 | 5.238 | 6.031 | 28.345 |
| MC\* | Government department | 6.500 | 6.667 | 6.500 | 6.833 | 6.333 | 0.143 | 0.930 | 0.953 | 0.930 | 0.977 | 0.906 | 4.695 |
| Owners | 6.125 | 6.000 | 6.125 | 6.250 | 6.500 | 0.143 | 0.876 | 0.858 | 0.876 | 0.894 | 0.930 | 4.433 |
| Designers | 5.250 | 5.125 | 5.500 | 5.125 | 6.125 | 0.109 | 0.572 | 0.559 | 0.600 | 0.559 | 0.668 | 2.957 |
| Contractors | 5.222 | 5.889 | 5.667 | 4.778 | 6.000 | 0.102 | 0.533 | 0.601 | 0.578 | 0.487 | 0.612 | 2.811 |
| Supervising engineers | 5.429 | 5.857 | 5.571 | 5.000 | 6.143 | 0.121 | 0.657 | 0.709 | 0.674 | 0.605 | 0.743 | 3.388 |
| Operators | 5.857 | 6.286 | 6.143 | 5.857 | 6.143 | 0.133 | 0.779 | 0.836 | 0.817 | 0.779 | 0.817 | 4.028 |
| End-users | 6.000 | 6.429 | 6.571 | 6.143 | 5.857 | 0.125 | 0.750 | 0.804 | 0.821 | 0.768 | 0.732 | 3.875 |
| NGOs | 6.333 | 6.000 | 6.167 | 6.000 | 6.167 | 0.125 | 0.792 | 0.750 | 0.771 | 0.750 | 0.771 | 3.833 |
| Sum of Mean (Based on Single Factor) | 46.716 | 48.252 | 48.244 | 45.986 | 49.268 | N/A | 5.888 | 6.069 | 6.066 | 5.819 | 6.178 | 30.020 |

GD: Guangdong Province; HK: Hong Kong SAR; and MC: Macao SAR.

**Table 8.** Evaluation of various stakeholder groups on the social sustainability objectives

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Region** | **Stakeholder Groups** | **Sustainability Objectives (Social Perspective)** | | | | | | | | | | | | | | | | | | | | |
| Initial Mean | | | | | | | | |  | | Adjusted Mean | | | | | | | | | Sum of Adjusted Mean (Based on Single Group) |
| SO1 | SO2 | SO3 | SO4 | SO5 | SO6 | SO7 | SO8 | SO9 | *W* | SO1’ | | SO2’ | SO3’ | SO4’ | SO5’ | SO6’ | SO7’ | SO8’ | SO9’ |
| GD\* | Government department | 4.875 | 6.125 | 6.000 | 5.625 | 4.875 | 6.250 | 6.500 | 6.375 | 6.250 | 0.160 | 0.780 | | 0.980 | 0.960 | 0.900 | 0.780 | 1.000 | 1.040 | 1.020 | 1.000 | 8.460 |
| Owners | 6.100 | 5.800 | 5.700 | 5.500 | 4.400 | 5.300 | 5.900 | 6.200 | 5.500 | 0.146 | 0.891 | | 0.847 | 0.832 | 0.803 | 0.642 | 0.774 | 0.861 | 0.905 | 0.803 | 7.358 |
| Designers | 4.857 | 5.286 | 5.571 | 4.286 | 5.286 | 5.286 | 3.714 | 5.714 | 4.857 | 0.110 | 0.534 | | 0.581 | 0.613 | 0.471 | 0.581 | 0.581 | 0.409 | 0.629 | 0.534 | 4.934 |
| Contractors | 4.667 | 5.333 | 4.667 | 4.444 | 4.222 | 4.778 | 4.111 | 4.333 | 5.111 | 0.106 | 0.495 | | 0.565 | 0.495 | 0.471 | 0.448 | 0.506 | 0.436 | 0.459 | 0.542 | 4.417 |
| Supervising engineers | 4.375 | 5.250 | 4.500 | 4.000 | 3.875 | 5.625 | 3.875 | 4.000 | 5.125 | 0.122 | 0.534 | | 0.641 | 0.549 | 0.488 | 0.473 | 0.686 | 0.473 | 0.488 | 0.625 | 4.956 |
| Operators | 6.333 | 6.167 | 6.000 | 6.000 | 6.000 | 5.667 | 5.167 | 6.000 | 5.833 | 0.128 | 0.811 | | 0.789 | 0.768 | 0.768 | 0.768 | 0.725 | 0.661 | 0.768 | 0.747 | 6.805 |
| End-users | 6.750 | 6.625 | 6.375 | 6.500 | 6.000 | 5.250 | 5.875 | 4.625 | 6.625 | 0.109 | 0.736 | | 0.722 | 0.695 | 0.709 | 0.654 | 0.572 | 0.640 | 0.504 | 0.722 | 5.954 |
| NGOs | 5.833 | 6.167 | 5.667 | 5.333 | 5.167 | 6.500 | 5.833 | 3.833 | 6.500 | 0.119 | 0.694 | | 0.734 | 0.674 | 0.635 | 0.615 | 0.774 | 0.694 | 0.456 | 0.774 | 6.049 |
| Sum of Mean (Based on Single Factor) | 43.790 | 46.752 | 44.480 | 41.688 | 39.825 | 44.655 | 40.975 | 41.081 | 45.802 | N/A | 5.474 | | 5.859 | 5.586 | 5.245 | 4.961 | 5.619 | 5.214 | 5.229 | 5.747 | 48.934 |
| HK\* | Government department | 6.000 | 5.667 | 6.500 | 6.167 | 6.333 | 6.500 | 6.333 | 6.667 | 6.333 | 0.134 | 0.804 | | 0.759 | 0.871 | 0.826 | 0.849 | 0.871 | 0.849 | 0.893 | 0.849 | 7.571 |
| Owners | 6.143 | 6.286 | 6.143 | 6.000 | 6.571 | 5.714 | 6.429 | 6.429 | 6.429 | 0.140 | 0.860 | | 0.880 | 0.860 | 0.840 | 0.920 | 0.800 | 0.900 | 0.900 | 0.900 | 7.860 |
| Designers | 5.333 | 4.833 | 5.500 | 4.833 | 6.167 | 5.167 | 5.000 | 5.667 | 5.500 | 0.109 | 0.581 | | 0.527 | 0.600 | 0.527 | 0.672 | 0.563 | 0.545 | 0.618 | 0.600 | 5.232 |
| Contractors | 5.714 | 4.571 | 5.000 | 4.571 | 5.714 | 5.429 | 4.571 | 5.857 | 4.857 | 0.106 | 0.606 | | 0.485 | 0.530 | 0.485 | 0.606 | 0.575 | 0.485 | 0.621 | 0.515 | 4.906 |
| Supervising engineers | 5.286 | 4.714 | 5.286 | 5.143 | 4.857 | 5.429 | 6.000 | 6.000 | 5.286 | 0.117 | 0.618 | | 0.552 | 0.618 | 0.602 | 0.568 | 0.635 | 0.702 | 0.702 | 0.618 | 5.616 |
| Operators | 6.143 | 5.857 | 6.143 | 6.286 | 6.286 | 6.000 | 5.429 | 5.857 | 6.571 | 0.125 | 0.768 | | 0.732 | 0.768 | 0.786 | 0.786 | 0.750 | 0.679 | 0.732 | 0.821 | 6.821 |
| End-users | 6.444 | 6.333 | 6.667 | 6.556 | 5.889 | 6.000 | 6.333 | 4.333 | 6.778 | 0.138 | 0.889 | | 0.874 | 0.920 | 0.905 | 0.813 | 0.828 | 0.874 | 0.598 | 0.935 | 7.636 |
| NGOs | 5.500 | 5.875 | 6.375 | 6.125 | 6.125 | 6.625 | 6.250 | 4.250 | 6.375 | 0.131 | 0.721 | | 0.770 | 0.835 | 0.802 | 0.802 | 0.868 | 0.819 | 0.557 | 0.835 | 7.009 |
| Sum of Mean (Based on Single Factor) | 46.563 | 44.137 | 47.613 | 45.681 | 47.942 | 46.863 | 46.345 | 45.060 | 48.129 | N/A | 5.847 | | 5.578 | 6.002 | 5.772 | 6.016 | 5.891 | 5.852 | 5.621 | 6.073 | 52.651 |
| MC\* | Government department | 5.833 | 5.667 | 6.167 | 6.333 | 6.000 | 6.500 | 6.333 | 6.500 | 6.500 | 0.143 | 0.834 | | 0.810 | 0.882 | 0.906 | 0.858 | 0.930 | 0.906 | 0.930 | 0.930 | 7.984 |
| Owners | 6.250 | 6.250 | 6.250 | 6.125 | 6.500 | 5.750 | 6.375 | 6.500 | 6.500 | 0.143 | 0.894 | | 0.894 | 0.894 | 0.876 | 0.930 | 0.822 | 0.912 | 0.930 | 0.930 | 8.080 |
| Designers | 5.500 | 4.875 | 5.500 | 4.875 | 6.125 | 5.125 | 5.000 | 5.500 | 5.625 | 0.109 | 0.600 | | 0.531 | 0.600 | 0.531 | 0.668 | 0.559 | 0.545 | 0.600 | 0.613 | 5.246 |
| Contractors | 5.778 | 4.667 | 5.111 | 4.667 | 5.556 | 5.444 | 4.556 | 5.778 | 4.889 | 0.102 | 0.589 | | 0.476 | 0.521 | 0.476 | 0.567 | 0.555 | 0.465 | 0.589 | 0.499 | 4.737 |
| Supervising engineers | 5.429 | 4.857 | 5.429 | 5.286 | 5.143 | 5.571 | 4.857 | 5.857 | 5.429 | 0.121 | 0.657 | | 0.588 | 0.657 | 0.640 | 0.622 | 0.674 | 0.588 | 0.709 | 0.657 | 5.791 |
| Operators | 6.213 | 5.834 | 6.213 | 6.169 | 6.166 | 6.236 | 5.857 | 5.977 | 6.335 | 0.133 | 0.826 | | 0.776 | 0.826 | 0.820 | 0.820 | 0.829 | 0.779 | 0.795 | 0.843 | 7.315 |
| End-users | 6.286 | 6.286 | 6.571 | 6.429 | 6.000 | 6.143 | 6.286 | 4.429 | 6.857 | 0.125 | 0.786 | | 0.786 | 0.821 | 0.804 | 0.750 | 0.768 | 0.786 | 0.554 | 0.857 | 6.911 |
| NGOs | 5.333 | 5.833 | 6.333 | 6.000 | 6.167 | 6.500 | 6.000 | 4.333 | 6.333 | 0.125 | 0.667 | | 0.729 | 0.792 | 0.750 | 0.771 | 0.813 | 0.750 | 0.542 | 0.792 | 6.604 |
| Sum of Mean (Based on Single Factor) | 46.622 | 44.268 | 47.574 | 45.883 | 47.656 | 47.270 | 45.264 | 44.874 | 48.468 | N/A | 5.852 | | 5.590 | 5.993 | 5.803 | 5.985 | 5.950 | 5.729 | 5.647 | 6.119 | 52.667 |

GD: Guangdong Province; HK: Hong Kong SAR; and MC: Macao SAR.

Table 9 Evaluation of various stakeholder groups on the environmental sustainability objectives

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Region** | **Stakeholder Groups** | **Sustainability Objectives (Environmental Perspective)** | | | | | | | | | |
| Initial Mean | | | |  | Adjusted Mean | | | | Sum of Adjusted Mean (Based on Single Group) |
| EN1 | EN2 | EN3 | EN4 | *W* | EN1’ | EN2’ | EN3’ | EN4’ |
| GD\* | Government department | 6.125 | 6.500 | 6.250 | 6.750 | 0.160 | 0.980 | 1.040 | 1.000 | 1.080 | 4.100 |
| Owners | 6.000 | 6.100 | 6.300 | 6.778 | 0.146 | 0.876 | 0.891 | 0.920 | 0.990 | 3.676 |
| Designers | 5.857 | 6.000 | 5.714 | 6.286 | 0.110 | 0.644 | 0.660 | 0.629 | 0.691 | 2.624 |
| Contractors | 5.778 | 6.111 | 5.889 | 6.000 | 0.106 | 0.612 | 0.648 | 0.624 | 0.636 | 2.520 |
| Supervising engineers | 5.750 | 5.875 | 5.625 | 6.250 | 0.122 | 0.702 | 0.717 | 0.686 | 0.763 | 2.867 |
| Operators | 6.667 | 6.500 | 6.833 | 6.667 | 0.128 | 0.853 | 0.832 | 0.875 | 0.853 | 3.413 |
| End-users | 6.500 | 6.250 | 6.625 | 6.750 | 0.109 | 0.709 | 0.681 | 0.722 | 0.736 | 2.848 |
| NGOs | 6.333 | 6.500 | 6.500 | 6.833 | 0.119 | 0.754 | 0.774 | 0.774 | 0.813 | 3.114 |
| Sum of Mean (Based on Single Factor) | 49.010 | 49.836 | 49.737 | 52.313 | N/A | 6.130 | 6.242 | 6.229 | 6.562 | 25.162 |
| HK\* | Government department | 5.667 | 6.500 | 6.000 | 6.333 | 0.134 | 0.759 | 0.871 | 0.804 | 0.849 | 3.283 |
| Owners | 6.143 | 6.286 | 6.286 | 5.857 | 0.140 | 0.860 | 0.880 | 0.880 | 0.820 | 3.440 |
| Designers | 5.167 | 5.833 | 5.333 | 4.833 | 0.109 | 0.563 | 0.636 | 0.581 | 0.527 | 2.307 |
| Contractors | 4.429 | 6.000 | 5.286 | 5.143 | 0.106 | 0.469 | 0.636 | 0.560 | 0.545 | 2.211 |
| Supervising engineers | 4.429 | 5.857 | 5.143 | 5.857 | 0.117 | 0.518 | 0.685 | 0.602 | 0.685 | 2.490 |
| Operators | 5.429 | 5.857 | 6.286 | 6.429 | 0.125 | 0.679 | 0.732 | 0.786 | 0.804 | 3.000 |
| End-users | 6.111 | 6.111 | 6.444 | 6.444 | 0.138 | 0.843 | 0.843 | 0.889 | 0.889 | 3.465 |
| NGOs | 5.625 | 6.250 | 6.125 | 6.375 | 0.131 | 0.737 | 0.819 | 0.802 | 0.835 | 3.193 |
| Sum of Mean (Based on Single Factor) | 42.998 | 48.694 | 46.903 | 47.272 | N/A | 5.429 | 6.102 | 5.905 | 5.954 | 23.390 |
| MC\* | Government department | 5.667 | 6.333 | 5.833 | 6.000 | 0.143 | 0.810 | 0.906 | 0.834 | 0.858 | 3.408 |
| Owners | 6.125 | 6.125 | 5.750 | 6.000 | 0.143 | 0.876 | 0.876 | 0.822 | 0.858 | 3.432 |
| Designers | 5.000 | 5.375 | 5.000 | 4.750 | 0.109 | 0.545 | 0.586 | 0.545 | 0.518 | 2.194 |
| Contractors | 4.333 | 5.667 | 5.222 | 5.000 | 0.102 | 0.442 | 0.578 | 0.533 | 0.510 | 2.063 |
| Supervising engineers | 4.286 | 5.714 | 5.000 | 5.714 | 0.121 | 0.519 | 0.691 | 0.605 | 0.691 | 2.506 |
| Operators | 5.286 | 5.714 | 6.143 | 6.286 | 0.133 | 0.703 | 0.760 | 0.817 | 0.836 | 3.116 |
| End-users | 5.857 | 5.857 | 6.429 | 6.286 | 0.125 | 0.732 | 0.732 | 0.804 | 0.786 | 3.054 |
| NGOs | 5.500 | 6.000 | 5.667 | 6.000 | 0.125 | 0.688 | 0.750 | 0.708 | 0.750 | 2.896 |
| Sum of Mean (Based on Single Factor) | 42.054 | 46.786 | 45.044 | 46.036 | N/A | 5.314 | 5.879 | 5.668 | 5.807 | 22.668 |

GD: Guangdong Province; HK: Hong Kong SAR; and MC: Macao SAR. (similarly, hereinafter)

**Table 10.**Prioritization of Various Sustainability Objectives

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Region** | **Stakeholder Groups** | Ranking among Various Stakeholder Groups in a Specific Region/Ranking within a Stakeholder Group in a Specific Region | | | | | | | | | | | | | | | | | |
| EC1’ | EC2’ | EC3’ | EC4’ | EC5’ | SO1’ | SO2’ | SO3’ | SO4’ | SO5’ | SO6’ | SO7’ | SO8’ | SO9’ | EN1’ | EN2’ | EN3’ | EN4’ |
| GD\* | Government department | 1/1 | 1/2 | 1/3 | 1/4 | 2/5 | 3/8 | 1/5 | 1/6 | 1/7 | 1/9 | 1/3 | 1/1 | 1/2 | 1/3 | 1/4 | 1/2 | 1/3 | 1/1 |
| Owners | 2/3 | 2/2 | 2/4 | 2/5 | 1/1 | 1/2 | 2/4 | 2/5 | 2/6 | 4/9 | 2/6 | 2/3 | 2/1 | 2/6 | 2/4 | 2/3 | 2/2 | 2/1 |
| Designers | 7/1 | 8/4 | 7/2 | 7/4 | 6/1 | 6/6 | 7/3 | 6/2 | 6/8 | 6/3 | 6/3 | 8/9 | 4/1 | 8/6 | 7/3 | 7/2 | 7/4 | 7/1 |
| Contractors | 8/4 | 7/2 | 8/3 | 8/5 | 8/1 | 8/4 | 8/1 | 8/4 | 6/6 | 8/8 | 8/3 | 7/9 | 7/7 | 7/2 | 8/4 | 8/1 | 8/3 | 8/2 |
| Supervising engineers | 5/4 | 6/2 | 6/3 | 6/5 | 4/1 | 6/5 | 6/2 | 7/4 | 8/6 | 7/8 | 5/1 | 6/8 | 6/6 | 6/3 | 6/3 | 5/2 | 6/4 | 5/1 |
| Operators | 3/3 | 3/1 | 3/3 | 3/5 | 3/1 | 2/1 | 3/2 | 3/3 | 3/3 | 2/3 | 4/8 | 4/9 | 3/3 | 4/7 | 3/2 | 3/4 | 3/1 | 3/2 |
| End-users | 6/5 | 4/2 | 4/1 | 5/3 | 7/4 | 4/1 | 5/2 | 4/5 | 4/4 | 3/6 | 7/8 | 5/7 | 5/9 | 5/2 | 5/3 | 6/4 | 5/2 | 6/1 |
| NGOs | 4/1 | 5/5 | 5/4 | 4/3 | 5/2 | 5/4 | 4/3 | 5/6 | 5/7 | 5/8 | 2/1 | 3/4 | 8/9 | 3/1 | 4/4 | 4/2 | 4/2 | 4/1 |
| Mean of Adjusted Mean (Ranking among Three Types of Sustainability Objectives) | **5.912** | | | | | **5.437** | | | | | | | | | **6.291** | | | |
| HK\* | Government department | 1/2 | 1/1 | 1/2 | 1/4 | 2/5 | 3/8 | 4/9 | 2/2 | 3/7 | 2/4 | 1/2 | 3/4 | 2/1 | 3/4 | 3/4 | 2/1 | 3/3 | 2/2 |
| Owners | 2/2 | 2/3 | 2/5 | 2/3 | 1/1 | 2/6 | 1/5 | 3/6 | 2/8 | 1/1 | 4/9 | 1/2 | 1/2 | 2/2 | 1/3 | 1/1 | 2/1 | 4/4 |
| Designers | 7/4 | 8/1 | 7/3 | 8/5 | 7/2 | 8/5 | 7/8 | 7/3 | 7/8 | 6/1 | 8/6 | 7/7 | 6/2 | 7/3 | 6/3 | 7/1 | 7/2 | 8/4 |
| Contractors | 8/4 | 7/1 | 8/3 | 7/5 | 8/2 | 7/2 | 8/7 | 8/5 | 8/7 | 7/2 | 7/4 | 8/7 | 5/1 | 8/6 | 8/4 | 7/1 | 8/2 | 7/3 |
| Supervising engineers | 6/4 | 6/1 | 5/3 | 6/5 | 6/1 | 6/4 | 6/9 | 6/4 | 6/7 | 8/8 | 6/3 | 5/1 | 4/1 | 6/4 | 7/4 | 6/1 | 6/3 | 6/1 |
| Operators | 5/4 | 4/2 | 4/2 | 4/5 | 5/1 | 4/4 | 5/7 | 5/4 | 5/2 | 5/2 | 5/6 | 6/9 | 3/7 | 5/1 | 5/4 | 5/3 | 5/2 | 5/1 |
| End-users | 3/4 | 3/3 | 3/2 | 3/4 | 3/1 | 1/4 | 2/5 | 1/2 | 1/3 | 3/8 | 3/7 | 2/5 | 7/9 | 1/1 | 2/3 | 3/3 | 1/1 | 1/1 |
| NGOs | 4/2 | 5/3 | 6/4 | 5/5 | 4/1 | 5/8 | 3/7 | 4/2 | 4/5 | 4/5 | 2/1 | 4/4 | 8/9 | 4/2 | 4/4 | 4/2 | 4/3 | 3/1 |
| Mean of Adjusted Mean (Ranking among Three Types of Sustainability Objectives) | **5.669** | | | | | **5.850** | | | | | | | | | **5.847** | | | |
| MC\* | Government department | 1/3 | 1/2 | 1/3 | 1/1 | 2/5 | 2/8 | 2/9 | 2/6 | 1/4 | 2/7 | 1/1 | 2/4 | 1/1 | 1/1 | 2/4 | 1/1 | 1/3 | 1/2 |
| Owners | 2/3 | 2/5 | 2/3 | 2/2 | 1/1 | 1/5 | 1/5 | 1/5 | 2/8 | 1/1 | 3/9 | 1/4 | 1/1 | 1/1 | 1/1 | 2/1 | 2/4 | 1/3 |
| Designers | 7/5 | 8/3 | 7/2 | 7/3 | 7/1 | 7/3 | 7/8 | 7/3 | 7/8 | 6/1 | 7/6 | 7/7 | 5/3 | 7/2 | 6/2 | 7/1 | 7/2 | 7/4 |
| Contractors | 8/4 | 7/2 | 8/3 | 8/5 | 8/1 | 8/1 | 8/7 | 8/5 | 8/7 | 8/3 | 8/4 | 8/9 | 6/1 | 8/6 | 8/4 | 8/1 | 8/2 | 8/3 |
| Supervising engineers | 6/4 | 6/2 | 6/3 | 6/5 | 5/1 | 6/3 | 6/8 | 6/3 | 6/6 | 7/7 | 6/2 | 6/8 | 4/1 | 6/3 | 7/4 | 6/1 | 6/3 | 6/1 |
| Operators | 4/4 | 3/1 | 4/2 | 3/4 | 3/2 | 3/3 | 4/9 | 3/3 | 3/5 | 3/5 | 2/2 | 4/8 | 3/7 | 4/1 | 4/4 | 3/3 | 3/2 | 3/1 |
| End-users | 5/4 | 4/2 | 3/1 | 4/3 | 6/5 | 4/4 | 3/4 | 4/2 | 4/3 | 5/8 | 5/4 | 3/4 | 7/9 | 3/1 | 3/3 | 5/3 | 4/1 | 4/2 |
| NGOs | 3/1 | 5/4 | 5/2 | 5/4 | 4/2 | 5/8 | 5/7 | 5/2 | 5/5 | 4/4 | 4/1 | 5/5 | 8/9 | 5/2 | 5/4 | 4/1 | 5/3 | 5/1 |
| Mean of Adjusted Mean (Ranking among Three Types of Sustainability Objectives) | **6.004** | | | | | **5.852** | | | | | | | | | **5.667** | | | |

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