The Delphi study

The Delphi in this study was performed in the following four stages: designing the questionnaire and its validity check, selection of experts, survey and analyzing the data.

A questionnaire was designed after the assessment categories and indicators were determined. Mostly, a two-three round of Delphi survey is sufficient to achieve consensus among invited participants. According to Skulmolski et al (2007), a 3 round of Delphi study is the most appropriate for graduate research. Nevertheless, in the cause of the research, it took much time to get the point of the second round, and panelists were reluctant to continue after an agreement was achieved. The mean values were set at 75% (>3.80). Thus it was decided to finish the study in the second round. Moreover, from other studies, it was observed, that typically surveys are concluded within two rounds.

First-round questionnaire survey had three main parts. The first section collected data on the respondent's demographics information including the background and the level of experience in the AEC industry and green building-related projects. The second section investigated nine categories with 35 related items, and respondents were asked to rate the relevance/importance of each factor on a five-point Likert scale based on 1= completely inappropriate, 2=inappropriate, 3=neutral, 4=appropriate and 5=completely appropriate. At the end of each question, respondents were asked to provide any additional assessment item which they would consider appropriate and important or felt missing. The third section intended to examine the sustainability-related issues specific to Kazakhstan construction industry. Besides, experts were asked to give some region-specific performance aspects of sustainability that would be critical for the development of the assessment framework. Copies of this questionnaire were then sent to four experts to check its validity.

After the first-round survey, the results were examined and the responses were analyzed using SPSS to evaluate the agreement among respondents' answers. Also, considering the feedback and comments from panelists some other Kazakhstan specific issues were added, replaced and eliminated from the initial set of assessment criteria, and the panelists were asked to rank whether they agree with the final set of assessment items in the second round questionnaire, in the following scale: 1=strongly disagree, 2= disagree, 3=neutral, 4=agree, 5=strongly agree.

Delphi panel of experts from Construction Industry were selected based on the following criteria: i) experience in the field of AEC and sufficient knowledge about sustainable building development; ii) holder of a professional title as a manager, architect, engineer or environmentalist/ ecologist iii) employment and membership in design and construction organization in Kazakhstan. After the selection of participants that meet the pre-defined criteria, they were contacted through email and phone calls. Out of 25 experts invited, 21 experts agreed to participate in the two-round Delphi survey. Delphi study was administered and carried out from July to October 2018, in which the experts received the questionnaire by email.

Delphi Panel participants’ demographics

Twenty-one respondents participated in the Delphi survey including nine Architects/Engineers (43%), three Owner/Facility Managers (14%), four contractors (19%), two experts from Governmental organizations (10%) and three experts from Academics (14%). Participants' demographics showed a high level of familiarity and experience with the AEC industry (Table 1).

Table 1. Background information on Delphi participants

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Organization | Position | Participant number | Percentage | Experience in the AEC industry | Number of Green Building related projects |
| Construction Organizations | Architect/EngineerOwner/ Facility ManagerContractor | 6211222 | 431419 | 10-20 years5-10 years+20 years5-10 years10-20 years5-10 years10-20 years | 3-5 projects6 projects1-2 projects1-2 projects1-2 projects3-5 projects |
| Governmental Organizations | Environmentalist | 11 | 10 | 5-10 years10-20 years | 1-2 projects |
| Academics | Professor  | 111 | 14 | 5-10 years10-20 years+20 years | 3-5 projects3-5 projects |
| Total  |  | 21 | 100 |  |  |

 Since the concept of sustainability is new to Kazakhstan and is underdeveloped, there is a deficiency of experts with extensive knowledge in sustainability and green construction. Hence, the Delphi study involved 21 (twenty-one) respondents who agreed to the authors' invitation out of the 25 invited experts that meet the pre-defined criteria.

 Statistical aggregation of Delphi survey responses

To obtain a measure of consistency in the responses, mean and standard deviation values were calculated through SPSS. Mean values were used to identify the levels of the appropriateness of assessment items, whereas standard deviation expressed the level of agreement on one item amongst the Delphi panelists. The level of agreement decision criteria was set as follows: standard deviation (SD) value from 0.00 ≤ SD < 1.00 - High level of agreement, 1.00 ≤ SD < 1.50 - Reasonable/fair level, and SD ≥ 1.50 - No agreement.

Initial Set of Sustainability Assessment Categories and Indicators

The initial set of assessment items consisted of nine categories and 35 indicators. The results of the first and second round Delphi technique are presented in Table 2. From the first round, 100% agreement was reached on eight categories except social category. A new category ‘management’ was suggested by panelists. Fifteen experts (71%) pointed out that ‘management’ category was missing and suggested to add as a separate category. The panelists suggested to change indicators as follows: To include safety and inclusiveness of opportunities (SOC3) to the ‘building architectural and planning solutions quality’ category; ‘education and awareness’ (SOC2) to the ‘management’ category, and ‘user health’ (SOC1) indicator to the indoor environmental quality category. Also, new indicators were suggested as: Land use (CSI1), low-impact site construction (CSI2), natural ventilation (IEQ6), building water conservation (WE1), leak detection (WE3), water-efficient landscaping (WE4), water recycling and reuse (WE5), energy-efficient heating and cooling (EE3), greenhouse gases emissions (EE4), energy-efficient equipment (EE5), and energy savings through natural gas efficiency (EE7). For the ‘management’ category, the following four indicators were added: Environmental management certificate (MAN1), green building accredited expert (MAN2), designer’s green building experience (MAN3), and contractor’s green building experience (MAN4).

Final Set of Sustainability Assessment Categories and Indicators

The second round of Delphi aimed at validating the final set of assessment categories and indicators. In this round, no changes were suggested and it can be assumed that the overall standard deviation values demonstrate the high level of agreement among experts on the categories and indicators of the final set (Appendix A). Thus, the Delphi study could be completed after the second round. Since this study aimed to determine and explore region specific sustainability issues relevant to the local context of Kazakhstan, the unanimity among experts on each item expressed by the value of standard deviation was considered.

Analysis of the second round revealed that experts reached 100% agreement on items as ‘thermal comfort’ (IEQ1), ‘daylighting’ (IEQ2), ‘energy efficient heating and cooling’ (EE4), ‘energy-efficient equipment’ (EE5), ‘energy saving—reduction of electricity consumption” (EE6), ‘building operation and disposal impact’(WST2), ‘building total lifecycle costs’ (ECO1), and ‘annual operating costs’ (ECO2). The rest of the items had overall mean value greater than 3.80; thus, the final set of assessment categories and indicators was considered as validated.

Overall, the panelists agreed that the suggested criteria for assessing green buildings were efficient and appropriate for Kazakhstan. They felt that all the proposed assessment items were important and should be considered in the assessment framework. No other assessment items were suggested. Finally, 9 categories and 46 assessment indicators were selected as a final set.

Table 2.The initial and final sets of assessment categories and indicators of the proposed framework.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Assessment Categories** | **Old Code** | **Round 1** | **Assessment Indicators** | **New Code** | **Round 2** | **Changes by Panelists** | **Level of Agreement** | **Add**  | **Omit** |
| **Mean** | **SD** | **Mean** | **SD** |
| Construction site selection and Infrastructure | - | - | - | Land use | CSI1 | 4.71 | 0.46 |  | High | * x
 |  |
| - | - | - | Low impact site construction | CSI2 | 4.80 | 0.40 |  | High | * x
 |  |
| CSI1 | 4.48 | 0.68 | Access to social, domestic and socio-economic facilities | CSI3 | 4.57 | 0.67 |  | High |  |  |
| CSI2 | 4.86 | 0.47 | Access to public and ecological transport | CSI4 | 4.80 | 0.40 |  | High |  |  |
| CSI3 | 4.76 | 0.43 | Greenspace | CSI5 | 4.66 | 0.57 |  | High |  |  |
| CSI4 | 4.57 | 0.67 | Landscape irrigation | CSI6 | 4.19 | 0.74 |  | High |  |  |
| CSI5 | 4.38 | 0.74 | Visual comfort | CSI7 | 3.80 | 0.98 |  | High  |  |  |
| Building architectural and planning solutions quality | BAS1 | 4.29 | 0.64 | Building architectural appearance quality | BAS1 | 4.00 | 0.77 |  | High |  |  |
| BAS2 | 4.33 | 0.73 | Building form and orientation | BAS2 | 4.57 | 0.67 |  | High |  |  |
| BAS3 | 4.71 | 0.46 | Greening the building  | BAS3 | 4.61 | 0.49 |  | High |  |  |
| BAS4 | 4.86 | 0.35 | Useful floor space  | BAS4 | 4.71 | 0.46 |  | High |  |  |
| BAS5 | 2.19 | 0.81 | Space planning quality | BAS5 | 3.90 | 0.88 |  | High  |  |  |
| BAS6 | 4.86 | 0.35 | Parking capacity | BAS6 | 4.57 | 0.59 |  | High |  |  |
| SOC2 | 4.67 | 0.483 | Safety and inclusiveness of opportunities | BAS7 | 4.80 | 0.40 |  | High |  |  |
| `Indoor Environmental Quality and comfort | IEQ1 | 4.81 | 0.402 | Thermal comfort | IEQ1 | 5.00 | 000 |  | High |  |  |
| IEQ2 | 4.62 | 0.498 | Daylighting | IEQ2 | 5.00 | 000 |  | High |  |  |
| IEQ3 | 4.67 | 0.483 | Insolation level | IEQ3 | 4.57 | 0.5 |  | High |  |  |
| IEQ4 | 4.71 | 0.463 | Acoustic comfort | IEQ4 | 4.14 | 0.91 |  | High |  |  |
| IEQ5 | 4.62 | 0.498 | Noise protection | IEQ5 | 4.71 | 0.46 |  | High |  |  |
| IEQ6 | 4.86 | 0.359 | Air pollution monitoring | IEQ6 | 4.57 | 0.59 |  | High |  |  |
|  |  |  | Natural ventilation | IEQ7 | 4.66 | 0.48 |  | High |  |  |
|  |  |  | User-health | IEQ8 | 4.54 | 0.53 |  |  |  | x |
| Water efficiency | WE1 | 4.71 | 0.463 | Building water supply/conservation | WE1 | 4.85 | 0.35 |  | High |  |  |
| WE2 | 4.62 | 0.498 | Application of innovative water-efficient equipment | WE2 | 4.71 | 0.46 |  | High |  |  |
| WE3 | 4.38 | 0.498 | Wastewater treatment | - | - | - |  | - |  | x |
|  | - | - | Leak detection | WE3 | 4.76 | 0.43 |  | High |  |  |
|  | - | - | Water-efficient landscaping | WE4 | 4.61 | 0.49 |  | High |  |  |
|  | - | - | Water recycling and reuse | WE5 | 4.00 | 0.70 |  | High |  |  |
| Energy efficiency | EE1 | 4.05 | 0.669 | Building commissioning | EE1 | 4.19 | 0.67 |  | High |  |  |
| EE2 | 4.48 | 0.680 | Renewable energy sources use | EE2 | 4.52 | 0.51 |  | High |  |  |
| EE3 | 4.71 | 0.463 | Effective use of heat in places of consumption |  |  |  |  |  |  | x |
|  | - | - | Greenhouse gases emission | EE3 | 4.52 | 0.51 |  | High |  |  |
|  | - | - | Energy-efficient heating and cooling | EE4 | 5.00 | 000 |  | High |  |  |
|  | - | - | Energy efficient equipment | EE5 | 5.00 | 000 |  | High |  |  |
| EE4 | 4.76 | 0.436 | Energy-saving—Reduction of electricity consumption | EE6 | 5.00 | 000 |  | High |  |  |
|  |  |  | Energy-saving—Natural gas efficiency | EE7 | 4.27 | 0.71 |  | High |  |  |
| Green Building Materials | GBM1 | 4.67 | 0.483 | Local/regional building materials | GBM1 | 4.38 | 0.49 |  | High |  |  |
| GBM2 | 4.38 | 0.740 | Recycled materials | GBM2 | 4.95 | 0.21 |  | High |  |  |
| GBM3 | 4.76 | 0.436 | Secondary use of recycled materials | GBM3 | 4.04 | 0.80 |  | High |  |  |
| Waste | WST1 | 4.71 | 0.463 | Construction waste management | WST1 | 4.95 | 0.21 |  | High |  |  |
| WST2 | 4.62 | 0.590 | Building operation and disposal impact | WST2 | 5.00 | 000 |  | High |  |  |
| Economy | ECO1 | 4.48 | 0.680 | Building total lifecycle costs | ECO1 | 5.00 | 000 |  | High |  |  |
| ECO2 | 4.57 | 0.598 | Annual operating costs | ECO2 | 5.00 | 000 |  | High |  |  |
| ECO3 | 4.62 | 0.498 | Affordability | ECO3 | 4.47 | 0.51 |  | High |  |  |
| Management |  | - | - | Environmental management certificate | MAN1 | 4.14 | 0.65 |  | High |  |  |
|  | - | - | Green building Accredited expert | MAN2 | 4.66 | 0.48 |  | High |  |  |
|  | - | - | Designer’s green building experience | MAN3 | 4.71 | 0.46 |  | High |  |  |
|  | - | - | Contractor’s green building experience | MAN4 | 4.76 | 0.43 |  | High |  |  |
|  | SOC3 | 4.57 | 0.676 | Education and awareness | MAN5 | 4.66 | 0.57 |  | High |  |  |