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# Sustainable Building Rating (SBR) System for Nepal -— A Case of Kathmandu Valley

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**Abstract**

Building construction sector is one of the largest end users of environmental resources and it consumes approximately 40% of the world's primary energy use. Nowadays, people are aware of about Green / Sustainable building that is why rating systems have been developed to measure the sustainability level of green buildings in many developed countries. This helps to certify the different aspects of sustainable development during the planning and construction stages and to incorporate best-practice experience for achieving higher certification level. The limitation of this research is based from the case study, Qualitative Analysis, Questionnaires and Interview were done with 40 expertise to fulfill the major objective which is "To develop Sustainable Building Rating (SBR) system for residential buildings of Kathmandu valley".

To get the criteria for the SBR system, different case study were done regarding different rating system of the world and case study on rated and nonrated building of Nepal. Objective was achieved by using Simple Weighted Sum method and AHP, MCDA tool and also the other specific objectives were fulfilled. After the analysis done from these tools a new SBR system was developed. To verify the research few buildings were done pilot test in the SBR system developed from the analysis, where the result were found to be positive, data can be found in the annex. This study may be useful to all the stakeholders involved in the evaluation of green building.

**Keywords**

Sustainable Building Rating (SBR) system – Kathmandu – Energy – Survey

## 1. Introduction

Energy Efficiency is one of the major topics to talk all over the world. Building energy efficiency is the first step toward achieving sustainability in buildings and organizations and it is helpful to control rising energy costs, reduce environmental footprints, and increase the value and competitiveness of buildings [1]. Sustainability is all about using the resources of today efficiently, in a manner that meets our own needs, but doesn't compromise the ability of others to meet their own needs in the future. Building energy efficiency has benefits like: Environmental Benefit, Economic Benefit, Utility System Benefit and Risk Management Benefit [2].

Energy use in buildings currently account for about 32% of the global total final energy consumption in the world [3]. Traditional buildings consume 40% of the total fossil fuel energy in the US and European Union and are significant contributors of green house [4]. To reduce the energy consumption, for the well maintenance and operation of buildings, many architects have come up with an idea of constructing Green Building, Zero Energy Building and also come up with many Building Energy rating System's Mandatory in their country like LEED, GRIHA, BREAM, etc [5, 6, 7, 8, 9].

Green building refers to a structure and using process that is environmentally responsible and resource-efficient throughout a building's life-cycle: from site to design, construction, operation, maintenance, renovation, and demolition. However, buildings are one of the major pollutants that contribute to climate change (GRIHA manual, Vol I, 2013). Hence, design should address this issue in an integrated and scientific manner. Compared with other buildings, green building construction, design and operational cost are much more expensive with tremendous environmental benefits. For example, a

2007 opinion survey by the World Business Council for Sustainable Development found that, on average, green buildings were thought to cost 17% more than other buildings [10].

Nepal doesn't have such mandatory but have many professional that can make an efficient"green building team". In conclusion, green building is a concept of building aiming at optimizing the whole range of energy demand at an affordable price.

It is also found that the energy savings of labeled buildings can increase over time. Building occupancy rates increased and the savings generated from lower energy bills provided higher property values [11]. There are also green building rating programs in use around the world and they vary in their approach with some outlining prerequisites and optional credits. It can be challenging and time consuming determining which standards, certifications, and rating programs are most credible and applicable to a particular project.

### 1.1 Site Selection

Kathmandu Valley is the largest and the most densely populated urban area of Nepal, when the energy crisis has been emerging as a major concern in the Kathmandu Valley. Around 28% of electricity produced in Nepal in the year 2005, was consumed in the Kathmandu Valley alone [12]. In Nepal, residential sector has highest energy consumption i.e. 89.1% than the other sector [13]. The recent CBS(2012) data shows that the number of individual household in Nepal is 54,23,297 with population growth rate of 1.35 per annum and average household size of 4.88[14]. The urbanization rate of the country is 3.62% [15]. Meanwhile, Kathmandu valley has most huge demographic profile. The population growth rate of the valley is 4.35%, making it one of the highest growing urban agglomerate is South Asia [16]. This is an indication for the rise of energy demand in the future in the buildings sector.

Due to the increasing urbanization and modern lifestyle the energy demand has increased day by day in the residential sector which is a vital sign for the change in the consumption pattern via building energy efficient buildings. During a life cycle of a building – construction, operation process and maintenance - the energy consumption can be very high, therefore, the rating the building is necessary that people could reduce the energy consumption in construction, operation process and maintenance [17].

### 1.2 Problem Statement

In the current situation, there are mushrooming of buildings haphazardly. In Nepal, energy demand is more but the energy supply is less. Country is facing the energy crisis and for the optimizing the energy demand, residential building consume large amount of energy for the daily use therefore it must initiate to reduce energy consumption. Many architects follow LEED criteria but have no certificate for the building. Nepal has Building code just in reference to safety measures but doesn't have any Residential Sustainable Building Rating System and it is likely to have the largest environmental impact and the largest benefit from sustainable design. Rating of building helps the people to aware that how much does his/ her house consume energy and can reduce; reduce not only energy consumption but also reduces the energy expenses. Residential Sustainable Building Rating System is the solution for energy optimization for residential building of Kathmandu, Nepal.

### 1.3 Relevance and Importance of Study

Energy is the important sector for development of the nation. Nepal is facing energy crisis and due to this it has to face heavy load shedding. Among many sectors, residential sector consume large amount of energy for lighting in urban areas.

In many developed and developing countries, there is a mandatory for rating building which is specially focused on energy efficiency. These mandatory helps in reducing energy consumption pattern and also in environmental sector. Nepal is a developing country which has building code in terms of safety factor but does not have rating system. Rating a building means grading the building with marks so that people become aware that how much does his/ her house consume energy and can reduce; reduce not only energy consumption but also reduce life-cycle cost. Such mandatory also influence other people who do not have such building by converting their existing no rated building to rated building. It not only reduces energy and money but also support the nation with energy crisis.

If we go back to past we can say country had green buildings that can be rated i.e. traditional Newari houses made from locally available building materials and maintains the indoor temperature of building. The research was focus on opportunities and challenges to transfer such advanced and easy-to-use rating system in Kathmandu, Nepal.

## 2. Methodology

For the design of a rating system, the most important part of the study was the literature review. It gives the support for the thesis, which helps to make the reader understand about the rating system and how can it be done for the residential building in Kathmandu.

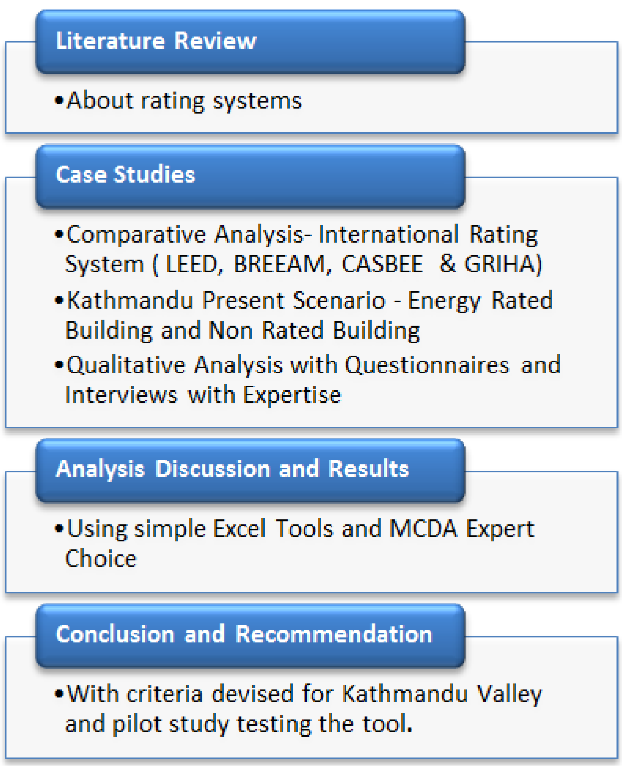


**Figure 1:** Methodology

During literature review, following case studies were done on:

1. Comparative Analysis: International Rating System (LEED, BREEAM, CASBEE and GRIHA). After the case study, comparative analysis was done with pros and cons for the favor of Kathmandu, Nepal. Some views were collected from professional architects of Nepal and Germany as well as energy planners about challenges in present and upcoming future scenario.

2. Study of some representative buildings were done in some Energy Rated and Non Rated Buildings of Kathmandu Valley. For the rated building, Crystal city at Tahachal, Hama Iron and Steel building and Siddhi Poly Path Lab were chosen. These are only LEED certified building designs in Nepal. But due to high cost during construction, Crystal City at Tahachal project was canceled. Whereas, for nonrated buildings Matoghar at Budhanilkantha and Pyramid house were chosen because these two are the passive designed buildings where some of the design criteria matched with few rating system criteria.

3. Qualitative Analysis by Questionnaires and Interview Survey with Expertise, which is the most important part in the research. For the analysis questioners were done with 40 expertise that were from different sectors and organizations. The sample size for the research was determined using sample size calculator software for small population. The population size of the total expertise is about 500; this population was taken because there are about 30% from the total students who have studied elective course of this related subject and about 100 architects registered in SONA who are working in this field. The confidence level is 95% with confidence interval taken is 14.5% and the sample size determined was 40 experts.

Then the analysis was carried out using simple excel tool from the analysis were done to get the results, which criteria should be used and how much important are they during evaluation. The weightage for each evaluation criterion from the analysis will help in making a new SBR system for Kathmandu, Nepal. Using of mean weighted method in excel to weighted values and for getting rank. It was just divided weighted value by 9. Thus, scoring was done from 1to 9. Also new criteria is included in the propose criteria from the questionnaires survey and recommendation, the criteria is listed out then counted how many expertise voted/ recommended and percentage is calculated in excel, from the percentage of voting the importance was known and was incorporated in criteria. Weighted sum model is the simplest form of MCDA method which is easy to use and easy to understand. Meanwhile AHP model provides a rigid framework for analysis of criterions and comparisons of alternatives.

| | | | |
|---|---|---|---|
| Priority | a | b | c |
| Survey(n) | 2 | 5 | 9 |

Weight age = 2 / (2+5+9), 5 / (2+5+9), 9 / (2+5+9)

Weight age Priority = 2*a5*b9*c / n, n, n

Sum off= (2*a)+(b*5)+(c*9) / N = Sumproduct of (priority *n) / Sum off n

**Figure 2:** Process of Calculating Weightage Priority

After the case study, comparison analysis and questionnaires and interview with the expertise, a recommendation has been made for this research with proofs from using Simple Excel tool, it helps to choose which criteria we should use to make SBR system. Developing a SBR system was the major objective of this thesis. This recommendation will help as a support for the researchers and students who are interested in green building and its rating system in Nepal.

The research design was hence carried out step by step. It describe the overall approach of the study step by step within which some steps may be revised because of errors or for re-conformation or data unavailability.

Tools were made for this scoring criteria in excel tool for new building construction. From this scoring tool, ranking for the building design in Sustainable Building Rating can be done using this tool. Rating is done by ranking the criteria in Low (L), Medium (M) and High (H) and then the tool help to give the scoring of the house.

The scoring rank was given by dividing into four ranges; the certification name was given from the reference of name of world's highest mountains of the world that lies in Nepal in height wise order i.e.: After making the tool it

**Table 1:** Designation

| Score range | Designation |
|---|---|
| 40- 49 | "C" Certified |
| 50-69 | "L" Lhotse |
| 70-99 | "K" Kanchenjunga |
| 100-above | "S" Sagarmatha |

was tested with five buildings i.e. author's house, which is traditional newari building, then traditional house, Center for Energy Studies building and Ananda Niketan Building at IOE and then Mato-ghar.

## 3. Results and Discussions

Firstly, the criteria from GRIHA and LEED were studied and then the suitable criteria for Nepal were used in the questionnaires. Then the analysis and recommendation came from the survey was analysis to make a new proposal criteria for this study. The analysis from the survey, the result found was that Sustainable Building Rating (SBR) System should be introduced to Nepal of their own with different faculties in the team. The promotion or public awareness of these rating systems should be done only then the system will be successful.

### Result from the Data Analysis

To propose a rating system for Nepal, the Questionnaires Survey is very important part. Among the surveyed population, majority of them were architects as they are the key stakeholders followed by students and others as well. As there were only few LEED associated professionals in Nepal, their percentage is also low (See Figure 3).

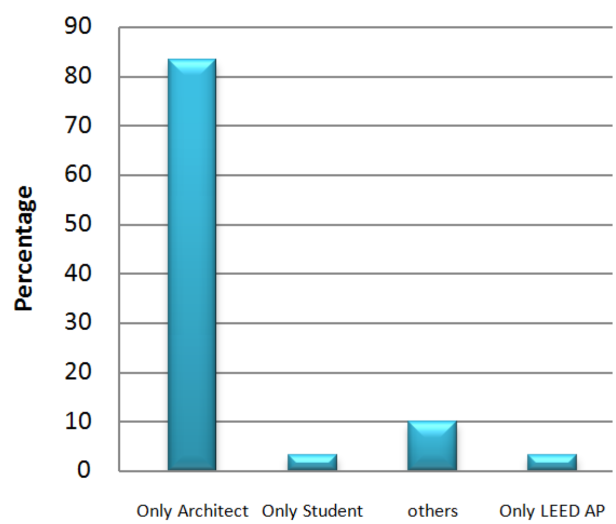


**Figure 3:** Expertise participation by green building related experience and expertise

Figure 4 shows that majority of respondents were aware about the rating system which is a good indication that the idea of rating system is getting popular. Among those, most of them were familiar with all four rating systems studied, with major familiarity in LEED as seen in Figure 5

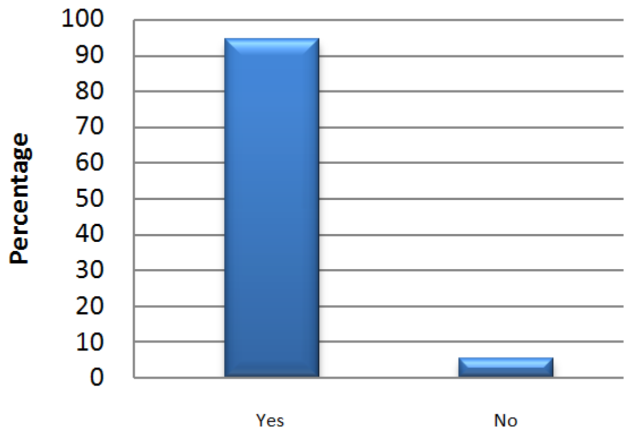


**Figure 4:** Familiarity of participants with rating system

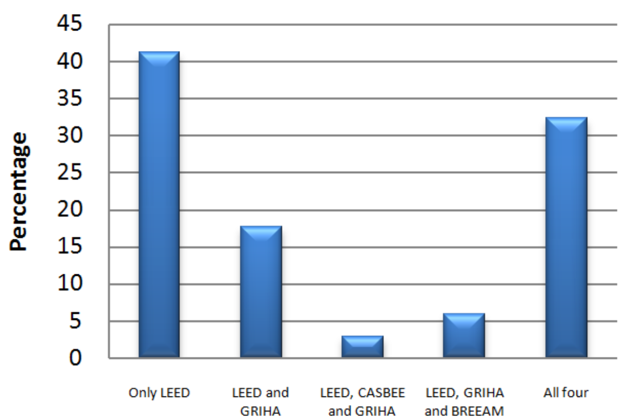


**Figure 5:** Familiar rating system

### Experience in Rating System

Although the most of respondent were familiar with rating system, only few had actually adopted in their work (See Figure 6) mostly due to reason that it might not be suitable for condition of Nepal. This shows the dire requirement for a suitable rating system based on regional requirement.

As for the thoughts for implementation of rating system for Kathmandu, Nepal, majority agreed upon the requirement of a region based rating system for better , however few disagreed to the idea of rating system due to hurdles like high cost and lack of specific guidelines.

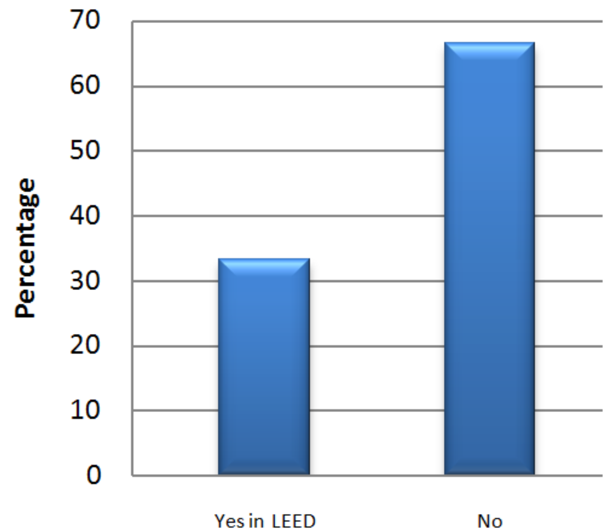


**Figure 6:** Work experience on rating system of participants

The majority respondents agreed upon the high initial cost of the rated building, which could be as much as 20% more, as seen in Figure 8. But in terms of term economy, it could be beneficial. Some respondents also claimed it could be cheaper while few were unaware about cost factor.

Figure 9 explains the reason for disagreement for a rating system due to the high cost. Majority answered that green materials are not easily available which could make the construction very expensive. While few said that material are easily available.

### Availability of Materials for Rated Building

### Criterion for rating system

The initial selection of the criteria were based on GRIHA and LEED. The new list of criteria suitable for Nepal were made after the analysis and recommendation from the questionnaires. These are listed in table 2.

After formation of SBR system Criteria SBR system's Registration process was also proposed so that it will give a idea how to register formally, registration process also after such system is made.

**Table 2:** Criteria weightage and points

| **Category A: Site Planning and Building Planning & Construction** | | Weightage | Points Given |
|---|---|---|---|
| Criterion1 | Site Selection (Access to Road Network) | 2.17 | 4 |
| Criterion2 | Availability of Basic Infrastructure | 2.79 | 3 |
| Criterion3 | Reuse of land | 3.04 | 3 |
| Criterion4 | Preserve and protect landscape during construction | 2.58 | 4 |
| Criterion5 | Preserve and protect landscape during construction | 2.58 | 3 |
| Criterion6 | Design to include existing site features | 2.22 | 4 |
| Criterion7 | passive Design Development (Optimize building design to reduce conventional energy demand) | 2.07 | 4 |
| Criterion8 | Disaster Risk Management | 2.46 | 4 |
| Criterion9 | Construction Technology (Use Efficient Construction Technologies) | 2.42 | 4 |
| Criterion10 | Heat Island Effect, Green Roof | 3.85 | 2 |
| Criterion11 | Alternative Transportation, Public Transportation Access | 3.50 | 3 |
| Criterion12 | Provision of accessibility for person with disabilities | 3.00 | 3 |
| **Category B: Energy and Environment** | | Weightage | Points Given |
| Criterion13 | Climate Responsive Building Design | 1.62 | 6 |
| Criterion14 | Use of Renewable Energy | 2.24 | 4 |
| Criterion15 | Efficient Heating/Cooling Equipments | 3.07 | 3 |
| Criterion16 | Passive Design to reduce the conventional energy demand (Day-lighting) | 2.06 | 4 |
| Criterion17 | Energy Efficient Lighting | 2.58 | 3 |
| Criterion18 | Optimized Transportation use during construction (Improved Cooking Stove) | 3.28 | 3 |
| Criterion19 | Solar Water Heating and lighting (Solar Water Heating) | 3.06 | 3 |
| Criterion20 | Use of Less Energy consuming equipment (Solar-power energy) | 2.94 | 3 |
| Criterion21 | Reduce air Pollution during construction | 3.40 | 3 |
| Criterion22 | Thermal Comfort by Design (Reduce Running Costs: Energy Cost/ Power Back-up/ Water Efficiency) | 2.45 | 4 |
| Criterion23 | Roof Treatment | 3.64 | 2 |
| Criterion24 | Vertical Greenery | 3.67 | 2 |
| Criterion25 | Public awareness programmes | 1.92 | 5 |
| **Total** | | | **45** |
| **Category C: Water Efficiency** | | Weightage | Points Given |
| Criterion26 | Use of Water Efficient Equipments | 2.21 | 4 |
| Criterion27 | Rain Water Harvesting | 2.12 | 4 |
| Criterion28 | Ground Water Recharge | 1.79 | 5 |
| Criterion29 | Reed Bed/ Reuse of waste water (Reduce Paved Area/ Permeable Paving) | 2.36 | 4 |
| Criterion30 | Septic Tank / Waste water treatment technology (Waste Water Treatment) | 2.24 | 4 |
| Criterion31 | Storm water design with Proper Drainage System (Protection from heavy rain/storm water design) | 2.48 | 4 |
| **Total** | | | **25** |
| **Category D: Building Materials** | | Weightage | Points Given |
| Criterion32 | Low Embodied Energy of Materials | 2.67 | 3 |
| Criterion33 | Availability of materials (Local Materials) | 1.69 | 5 |
| Criterion34 | Use of Recycled Materials | 2.47 | 4 |
| Criterion35 | Green materials (Materials with Low Environmental Impact) | 2.26 | 4 |
| Criterion36 | Reuse of materials on site (Reuse of materials) | 2.59 | 3 |
| Criterion37 | Reduction in waste during construction | 3.92 | 2 |
| Criterion38 | Use of materials for human comfort and health safety | 2.50 | 4 |
| Criterion39 | Promotion of local material | 2.42 | 4 |
| Criterion40 | Reduction of Transportation cost of materials (Transportation cost of Materials) | 2.79 | 3 |
| Criterion41 | Use of local Labor | 3.62 | 2 |
| **Total** | | | 34 |

| **Category E: Solid Waste Management** | | Weightage | Points Given |
|---|---|---|---|
| Criterion42 | Promote Composting of solid waste | 2.15 | 4 |
| Criterion43 | Efficient waste seggregation | 2.00 | 5 |
| Criterion44 | Waste Reduction during Construction (3R-Recycle, Reduce and Reuse) | 1.94 | 5 |
| Criterion45 | Storage and Disposal of waste (Re-use of Waste Water for Irrigation on Site) | 2.57 | 4 |
| **Total** | | | **18** |

| **Category F: building Operation and Maintenance** | | Weightage | Points Given |
|---|---|---|---|
| Criterion46 | Operation and maintenance | 1.97 | 5 |
| Criterion47 | Ensure Adaptability for future change in Building Use | 2.69 | 3 |
| **Total** | | | **8** |

| **Category G: Innovation and Design Process** | | Weightage | Points Given |
|---|---|---|---|
| Criterion48 | Consultation with Building expertise team (Local Labor) | 2.20 | 4 |
| Criterion49 | Audit and Validation ( Natural material) | 2.45 | 4 |
| Criterion50 | Innovation in technology to reduce energy consumption | 2.38 | 4 |
| **Total** | | | **12** |
| **Grand Total** | | | **183** |

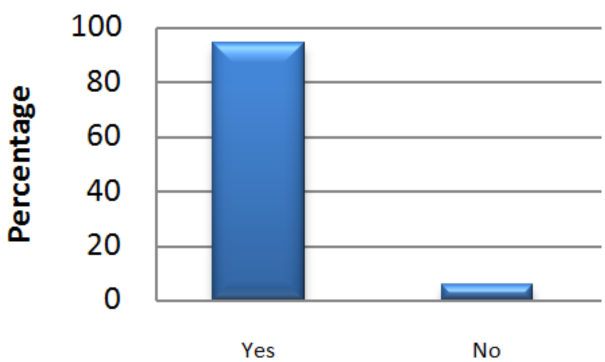


**Figure 7:** Conception on implementation in Nepal

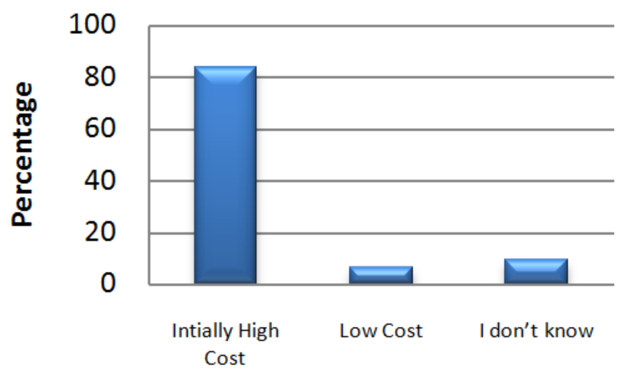


**Figure 8:** Conception on cost of rated building

### Comparison Result with using Simple Weighted Sum method and AHP, MCDA tool

Table 3 shows the ranking of each criterion derived from two methods. From both analysis, it can be seen that the major preference were given to Energy and Environment, site selection and construction planning as well as building material and water management.

Using the rating model developed from the given criteria above, five buildings were analyzed. The results from both analysis shows that Mato Ghar and Center for Energy Studies(CES) building at IOE were top ranked followed by traditional and contemporary designs (See Table 4).

Weighted sum model is the simplest form of MCDA method which is easy to use and easy to understand. Meanwhile AHP model provides a rigid framework for analysis of criteria and comparisons of alternatives. Moreover, with help of AHP analysis, the inconsistencies in the judgments of participants by consistency test such that serious inconsistencies are avoided such that meaningful results can be deducted.

## 4. Conclusion

The major objective of this research was "to develop Sustainable Building Rating (SBR) system for residential buildings of Kathmandu valley" which was achieved by using Simple Weighted Sum method and AHP, MCDA tool and also to fulfill the major objective the other specific objectives were also fulfilled to achieve major objective. Simple weightage method helped to get the

**Table 3:** Comparison Result using Simple Weighted Sum method and AHP, MCDA tool with respect to goal

| Criteria | Simple Weighted Sum | | AHP-MCDA |
|---|---|---|---|
| | Ranking | Scoring | |
| Category A: Site Planning and Building Planning and Construction | 3 | 21 | 2 |
| Category B: Energy and Environment | 1 | 33 | 1 |
| Category C: Water Efficiency | 4 | 19 | 3 |
| Category D: Building Materials | 2 | 26 | 4 |
| Category E: Solid Waste Management | 5 | 16 | 5 |
| Category F: Building Operation and Maintenance | 6 | 7 | 7 |
| Category G: Innovation and Design Process | 7 | 5 | 6 |

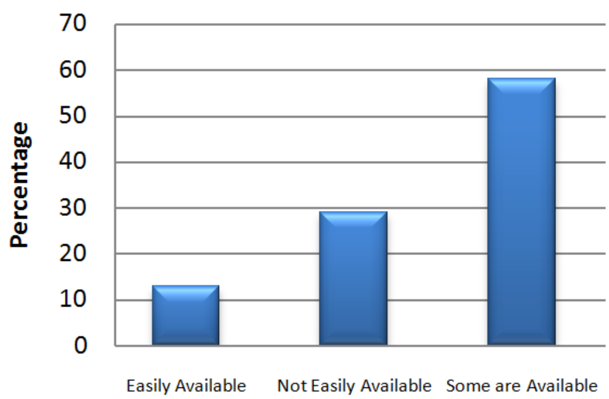


**Figure 9:** Conception on material availability

**Table 4:** Comparison Result using Simple Weighted Sum method and AHP, MCDA tool with respect to alternatives

| Alternatives | Simple Weighted Sum | | AHP-MCDA |
|---|---|---|---|
| | Ranking | Scoring | |
| Mato Ghar | 1 | 127 | 1 |
| CES Building | 1 | 127 | 2 |
| Ananda Niketan | 2 | 104 | 3 |
| My house | 3 | 64 | 4 |
| Contemporary House | 4 | 59 | 5 |

scoring for all the criteria and category for SBR System. Whereas, AHP, MCDA tool helped to verify the tool and to provide a rigid framework in context to Kathmandu Valley. The other specific objectives was to study and compare various building rating systems of the other countries and devise appropriate model suitable for Kathmandu valley which was done through literature review of LEED, CASBEE, GRIHA and BREEAM, rating systems of the developed country. These criteria for SBR system were developed from these case studies of international rating system.

Another Specific objective was Case study and compare rated and nonrated buildings of Kathmandu valley. Few rated buildings were studied done by Ar. Bibhuti Man Singh and Ujjwal Man Shakya and few non rated buildings which were built considering LEED criteria which helped to get idea about rating system's importance. These buildings were chosen for the case study to see the current trend in building as and the importance of making SBR system for Kathmandu. From the comparison from these both rated and non rated building it was found that passive design building is the good option for the Kathmandu valley which should be incorporated in building byelaws.

After the literature review and case study on few rated and nonrated buildings of Nepal, the questionnaire was prepared specially focused on LEED and GRIHA. The last specific objective was to do questionnaires survey to green building expert of Nepal to develop SBR system of Kathmandu valley. Questionnaires formed were filled with 40 green building related professionals who helped to achieve the objective. Only then use of such tools were use to analyze and get the SBR system for Kathmandu Valley.

To verify the research few buildings were done pilot test in the SBR system developed from the analysis, where the result were found to be positive, data can be found in the annex. Comparison of result of both tool, simple weightage method and AHP, MCDA tool were done and were found that there are few different result but can be considered as positive result. AHP, MCDA tool helped for verification of the research can go further. Main thing was that the SBR system for Kathmandu is formed and the scoring tools can also be used. From the pilot test of five buildings it was found that Mato Ghar scored top rank from both the tools. In Energy and Environment they focused on passive design, renewable resources, they also focused on water treatment plant, solid waste management, they also focused on locally available materials and 3R's.

## 5. Recommendation

Since, this research is not 100% right to be called as the end so; it can be done further with few recommendations like:

- To get result according to the demand of peoples.
- More pilot tests can be done to get more accurate results comparing rated and non rated building.
- Can be helpful to the government for implementation for public by reduction in taxation for residential buildings just like in USA, etc developed countries so that more users can be found.
- If we see this current situation occurring in Nepal, India blockage will also have less effect in fuel crisis. With the help of SBR system, if more focused in natural energy then it will be more efficient.
- Buildings should be more free ventilated rather mechanical ventilated i.e. use of indoor air quality system in a building.
- This research is basically academic based but many organizations like UN Habitat and DUDBC has also made few guidelines regarding green building.
- This study may be useful to all the stakeholders involved in the evaluation of green building that can also be government.
- There has been a fashion of getting score for a building so that helps in buying and selling purpose, rating system are more commercialized around the world nowadays. The proposed criteria can be changed now more to passive design and considering building bye laws of Nepal.
- Since, Nepal had faced this massive earthquake in this year 2015, so earthquake resistant building should be given more emphasis just like Japan, for this the criteria can have more criteria on earthquake resistant technology and design. Even in the public awareness, the awareness of earthquake resistant can get more Score.

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