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Evaluation of sustainability of a residential building using SVAGRIHA - a case of Mato Ghar

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Abstract

GRIHA, which stands for Green Rating for Integrated Habitat Assessment, is a rating system for large scale buildings. GRIHA was created to promote sustainable and eco-friendly practices in the construction and operation of buildings. GRIHA addresses various green building concepts in various phases of buildings by using five 'R', i.e., recycle, reuse, reduce, refuse, and reinvent, to determine and encourage the sustainability of a building via rating. SVAGRIHA is a green rating system which falls under GRIHA, which is a rating system for small scale buildings. The study presented in this paper applies SVAGRIHA framework for determining the sustainability and green rating of Mato Ghar. This study has applied case study approach and chosen Mato Ghar as a suitable case study residence, as the requirements for using SVAGRIHA framework is for buildings with built-up area less than 2500 sq.m. Results showed that sustainability of a residence will be higher if it has used energy conservation as a part of the building lifecycle, energy efficient planning and design, active and passive strategies, and locally available materials. The methodology and findings in this research can also be replicated to determine the green rating of other residential buildings within and outside Kathmandu valley by architects and engineers in the process of residential building design.

Keywords: *Architecture and energy, energy efficient building materials, sustainable architecture, SVAGRIHA rating system.*

1. Introduction

The word "sustainable" means continuing at a specific rate or level (Oxford University, n.d.). Sustainability is a design philosophy that prioritizes optimizing resource efficiency including energy, water, and material use, while minimizing the effects on human health and the environment throughout the building's lifecycle through improved design, construction, operation, maintenance and removal that has given rise to green buildings in present scenario. The concept of sustainability in architecture is reflected in green architecture, which develops buildings in accordance with naturally suitable, favorable living conditions and those that have the least negative effects on different environmental components (Ragheb et al., 2016). A green building is one whose construction and lifetime of operation assure the healthiest possible environment while representing the most efficient and least disruptive use of energy, water, land, and resources (Neogi & Patel, 2015). Sustainable architecture aims to create spaces that promote occupant health and well-being, efficient resource use, and reduce pollution. Green rating of building could be considered as a strategy to promote green-building through the design, construction and operations phase of any building in order to ensure minimal negative impact on the environment (Wanjiru, 2019).

Two common rating systems used to evaluate sustainable buildings are Leadership in Energy and Environmental Design (LEED) and Green Rating for Integrated Habitat Assessment (GRIHA). LEED is a collection of guidelines used to certify residential, commercial, and other kinds of buildings in both the public and private sectors with the intention of promoting healthy, durable, and environmentally sound practices (Shakya & Bajracharya, 2015). GRIHA is an environmental assessment system that aims at reducing the environmental impact of buildings and promoting sustainable building methods. GRIHA employs the five "R's" philosophy that are recycle, reuse, reduce, refuse, and reinvent which address a variety of environmental concerns related to green building design, construction and operation (Griha Council, n.d.). For Small-scale projects, including residential buildings, bungalows and small offices, Small Versatile Affordable GRIHA (SVAGRIHA) (Naik, Salvi, & Pandhare, 2020), a condensed form of the GRIHA assessment system is used. It unfolds the concept of green homes and sustainability (Gawade et al., 2021). SVAGRIHA, a simple, fast, easy and much affordable rating system and design tool, mainly focuses on small-scale buildings which has quick development and high-density occupation (Shah & Mudgal, 2019).

Nepal is a developing nation where sustainability is prioritized low in real practice during building construction (Mishra & Rai, 2017). The influence of modern building construction technology over the locally available materials and techniques might be one of the main reasons for slow implementation of choosing sustainable building construction (Thapa & Raj Tiwari, 2020). By using the modern materials and construction techniques, people are not able to explore sustainable building materials. In case of green residential buildings inside Kathandu valley, some examples include Mato Ghar, Budanilkantha, Hamro Mato Ghar Godawari, and Nirpal residence, Kamalpokhari. However, they are not taken into consideration by engineers and designers in construction process of sustainable buildings, most likely due to lack of awareness and non-familiarity about the effectiveness and performance of those kind of buildings (Mishra & Rai, 2017).

Nepal government is not focusing on long-term plans and policy related to sustainability of buildings (Tuladhar, 2011). For example, existing policies of the government of Nepal does not have mandatory rating system for sustainability. There could be a number of negative consequences if the Nepali government does not implement a mandatory rating system for green buildings' sustainability. Buildings may consume more water, energy, and other natural resources due to inefficient designs and construction practices. Buildings may not incorporate energy-efficient systems and technologies, leading to higher energy consumption and increased greenhouse gas emissions. Rating system such as SVGRIHA can be used as a tool for establishing a rating system in Nepal. This system is cost-effective, reducing the financial burden associated with green certification. This affordability encourages more residential projects to pursue green certification, promoting wider adoption of sustainable practices. SVAGRIHA covers a comprehensive range of sustainability aspects, including energy efficiency, water management, waste management, and indoor environmental quality (Naik et al., 2020). In this context, this research aims to assess sustainability of selected existing residential buildings in Kathmandu valley by applying SVGRIHA framework, which considers both design as well as construction factors.

2. Materials and Methods

2.1 Methodological framework

The methodology for this research falls under positivist paradigm, which states that reality can be measured, emphasizes objectivity and measurability to derive generalizable findings. A case study-based approach is adopted in this study. According to ontological claim of positivist paradigm, in the 'case study' based method, facts are identified by direct field observation. Case study method is carried out by emphasizing the study of a phenomenon within its real-world context. A case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context (Uprety, 2021). Field based case study has been carried out to know the sustainable parameters, mostly based on environmental and economic aspect of sustainability. Only one building, Mato Ghar in Kathmandu, is selected for case study because there are only a few number of buildings in Kathmandu that has sustainable characteristics. SVAGRIHA framework is applied to measure sustainability of Mato Ghar as it considers both design as well as construction factors into consideration (Shah & Mudgal, 2019). Figure 1 outlines the methodology.

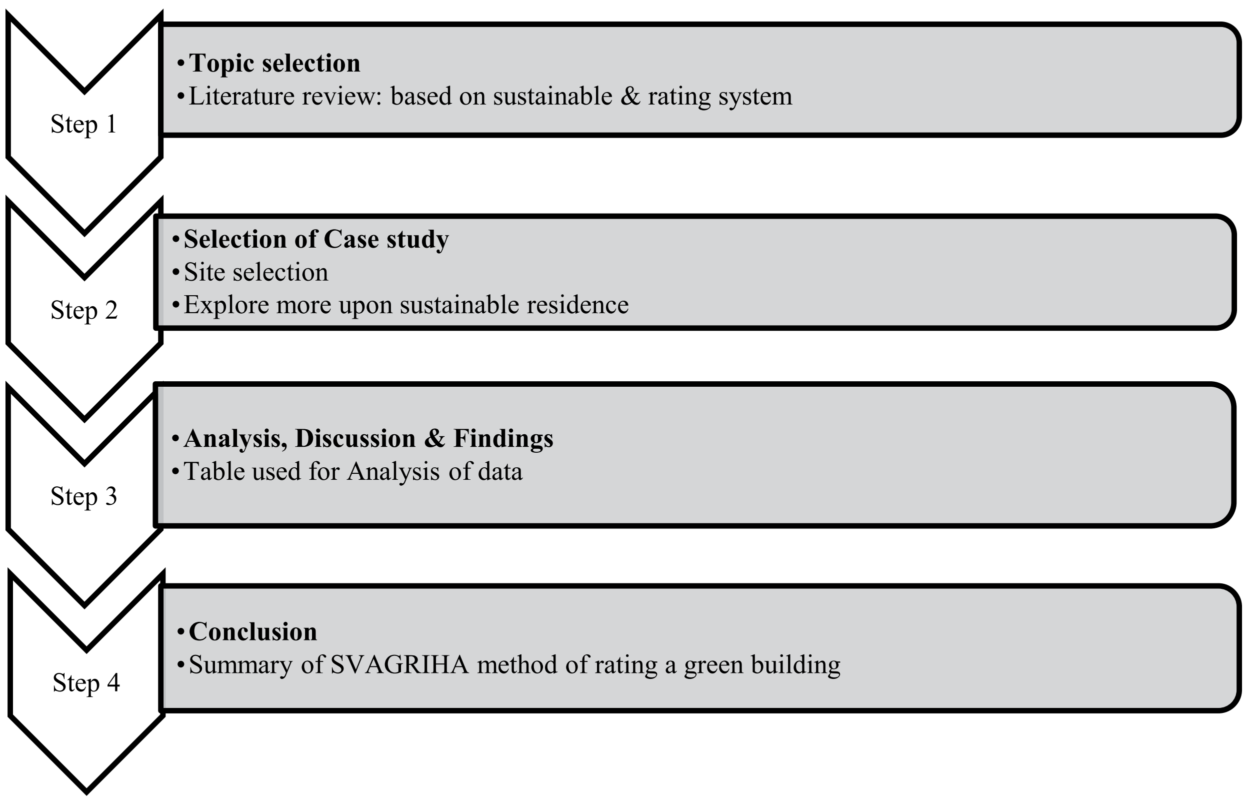

Figure 1: Steps showing the method used in the research

2.2 Selection of case study

Kathmandu valley is the largest and the most densely populated urban area of Nepal, where the energy crisis has been emerging as a major concern (Shakya & Bajracharya, 2015). There are concerns about saving the energy in building at the time of construction, maintenance, and operation. Mato Ghar (Figure 2) is the residential building selected for the case study, which is a non-rated residential building with built-up area of 210.24 sq.m. and embodies several sustainable characteristics. Mato Ghar is one of the best examples of sustainable building in Kathmandu, which lies in Budhanilkantha. It was constructed in 2010 A.D. It has a built-up area of 210.24 sq.m. This building focuses on Rammed earth construction techniques, which is a sustainable material. This building also follows sustainable techniques, such as design based on site and surrounding context, energy and environment like climate responsive building design, use of renewable energy, efficient heating/cooling equipment, and use of green materials like rammed earth and bamboo. In summary, Mato Ghar consists of several green features which is reflected in its planning, construction technique, passive and active solar energy, bio-gas and wastewater management, rain water harvesting, and green spaces (Mishra & Rai, 2017).

Figure 2: Mato Ghar

2.3 Research instrument

SVAGRIHA is a standard green rating system for small scale buildings, which is followed in India. Due to lack of rating system in Nepal, SVAGRIHA is selected because of regional context based on similarity between Nepal and India. Furthermore, SVAGRIHA V2.2 is used for buildings which have less than 2500 sq.m. built-up area, which is the case of Mato Ghar selected in this study (Wanjiru, 2019),. This instrument rates a building from one to five star, based on points achieved in by a project from 25 - 50. One star stands for the least and five stars for the highest degree of sustainability. Stars one, two, three, four, and five correspond to the scores/points in a range of 25-30, 31-35, 36-40, 41-45, and 46-50, respectively (Srinidhi et al., 2020). SVAGRIHA framework has 14 criteria, which fall under five (5) sub-groups, namely, landscape, architecture and energy, water and waste, material, and lifestyle (Table 1). These 14 criteria have to be satisfied in any building for achieving a sustainability rating.

Table 1: Green rating criteria and sub-groups in SVAGRIHA framework

S. N.	**Sub-Group (*Min – Max points to be achieved*)**	**Criterion name**	**Points allocated**	**Points achieved (to be filled)**
1	Landscape (3 – 6)	Reduce exposed, hard paved surface on site & maintain native vegetation cover on site	6	
2	Architecture and energy (11 - 21)	Passive architectural design & system	4	
3		Good fenestration design for reducing direct heat gain and glare while maximizing daylight penetration	6	
4		Efficient artificial lighting system	2	
5		Thermal efficiency of building envelope	2	
6		Use of energy efficient appliances	3	
7		Use of renewable energy on site	4	
8	Water and waste (6 – 11)	Reduction in building and landscape water demand	5	
9		Rainwater harvesting	4	
10		Generate resource from waste	2	
11	Materials (4 – 8)	Reduce embodied energy of building	4	
12		Use of low-energy materials in interiors	4	
13	Lifestyle (1 – 4)	Adaptation on green lifestyle	4	
14		innovation	2	

3. Results and Discussion

This study was conducted to assess sustainability of a residential building - Mato Ghar in Kathmandu,. According to SVAGRIHA, several sub-groups and criteria were laid out which were used to assess the sustainability of a small residential building. Results of status of sub-criteria, criteria, and sub-groups of the Mato Ghar in Kathmandu are provided in Table 2. The results are further substantiated with observations associated with sub-criteria/criteria.

From this study, it is observed that points achieved by Mato Ghar is substantially more in 4 sub-groups: landscape, architecture and energy, water and waste, and material. In the landscape sub-group, Mato Ghar has earned high score by preserving the site's natural topography and integrating the building with the surrounding environment. This approach minimizes ecological disruption and maintains the natural landscape. In the architecture and energy sub-group, the building's design demonstrates a strong commitment to energy efficiency. This has been achieved through strategic orientation and the use of both active and passive design strategies. Active strategies include solar water heaters, while passive strategies focus on optimizing the building's layout to enhance natural lighting and ventilation. In the water and waste sub-group, Mato Ghar has implemented several sustainable practices that have resulted in high scores, which include efficient water management systems, such as rainwater harvesting and wastewater recycling, which reduce the demand on local water resources. The building's waste management practices also emphasize sustainability, possibly through the use of biodegradable materials, and effective waste segregation and recycling systems. In Mato Ghar, sustainable building practices are employed by using materials that have less energy. Mud is used for plastering walls, rammed earth is utilized for constructing walls, offering a durable and eco-friendly alternative to conventional material. Bamboo is used as a material for false ceilings, providing a renewable and lightweight option. These choices not only reduce the overall energy consumption in the construction process but also promote environmental sustainability by minimizing the carbon footprint associated with building materials. As sub-groups are the indicators of sustainability, it is indicated that the sustainability of Mato Ghar is higher in these four domains, as shown by the scores in Table 2.

Table 2: Total points allocated and achieved by Mato Ghar for different sub-criteria, criteria and sub-groups

S. N.	Sub-Group	S. N.	Criterion name	Sub-criteria	Sub-criteria point allocation	Total criteria point allocation	Points achieved	Observation	Total criteria point achieved
1	Landscape	1	Reduce exposed, hard paved surface on site & maintain native vegetation cover on site	i. All trees in the perimeter zone shall be protected.	2	6	2	All trees are being protected	6
				ii. The total number of trees on site before and after construction.	2		2	All trees are planted after planning of building.	
				iii. All new trees planted on site will be native.	2		2		
2	Architecture & Energy	2	Passive architectural design & system	i. Adopt a minimum of 2 passive design measures in building.	2	21	2	Roof cooling techniques & rammed earth techniques.	14
				ii. Active, low-energy cooling/heating systems are installed in the building.	2		1	Floor to ceiling windows openings.	
		3	Good fenestration design for reducing direct heat gain and glare while maximizing daylight penetration	i. Reduce an overall insulation through fenestration by 10%, 20%, 30% or more over the base case.	3		1	Use of see through boundary wall.	
				ii. More than 25%, 50%, 70%, 90% of the total living area falls under daylight zones.	3		3	Use of window from floor to ceiling.	
		4	Efficient artificial lighting system	Demonstrate lower LPD levels in the building design as compared to ECBC recommended LPD levels.	2		1	Use of CFL, LED bulbs.	
		5	Thermal efficiency of building envelope	When viewing the output in sq.ft./TR, the project should achieve sq.ft./TR higher than the prescribed thresholds.	1		1	Use of rammed earth thick wall, sun dried brick which helps to reduce indoor temperature.	

S. N.	Sub-Group	S. N.	Criterion name	Sub-criteria	Sub-criteria point allocation	Total criteria point allocation	Points achieved	Observation	Total criteria point achieved
		6	Use of energy efficient appliances	All the Air-conditioners, fans and geyser installed on site are 3-star, 4-star, 5-star BEE labelled (Bureau of Energy Efficiency; run by the Indian government under Ministry of Power)	3		1	Use of normal market available fan.	
		7	Use of renewable energy on site	i. Rated capacity of the renewable energy system installed on site conforms to or exceeds the thresholds [100-500m² Built up area >> 1KW	2		2	Use of solar panels and solar water heaters.	
				i. Installed capacity of solar water heaters on site is equivalent to 50%, 75% or more of the daily hot water requirement [Hot water requirement for Residence :100 liters per day]	2		2	Solar-heated water is sufficient for daily activities.	
3	Water & waste	8	Reduction in building and landscape water demand	i. Reduce the total water requirement in the building by at least 25%, 33%, 50% or more over the base case.	3		3	Water efficient equipment.	
				i. Reduce the total water requirement in the building by 25%, 50% or more over the base case (to reduce the landscape water demand through the use of native species of flora and efficient irrigation systems).	2		2	Landscape maximum area is soft cape	
		9	Rainwater harvesting	i. The total rainwater harvesting potential for the project (from the roof only) is equivalent to at least 75% of the total building water demand over 2 days	3	11	2	Rainwater harvesting through roof.	9
				i. Rainwater is recharged into the ground water aquifer and has a filtration system installed	1		1	Rainwater is used for ground water recharge.	
		10	Generate resource from waste	Zero waste generation through adoption of requisite strategies.	2		1	Biogas production. Separation of degradable and non-degradable wastage.	

S. N.	Sub-Group	S. N.	Criterion name	Sub-criteria	Sub-criteria point allocation	Total criteria point allocation	Points achieved	Observation	Total criteria point achieved
4	Materials	11	Reduce embodied energy of building	i. 100% of OPC is replaced by PPC (including building structure and masonry and plaster mortar).	1	8	1	Less use of cemented structure.	8
				ii. The overall embodied energy of the floor slabs, roof slabs and walls is reduced by 5% or more over the base case.	1		1	Embodied energy of mud, bamboo is less.	
				iii. The overall embodied energy of the floor slabs, roof slabs and walls is reduced by 10% or more over the base case	2		2	Embodied energy of these material is less.	
		12	Use of low-energy materials in interiors	i. 70% of the flooring is low-energy.	1		1	Parqueting and tile flooring.	
				ii. At least 70% of internal partitions/ paneling/false ceiling/in-built furniture/ doors & window-panels & frames are low-energy.	2		2	Use of rammed earth wall.	
				iii. All interior paints are low-VOC and lead-free (including no paint/plain mortar finish/whitewash/lime mortar finish).	1		1	Use of low VOC paints.	
5	Lifestyle	13	Adaptation on green lifestyle	i. Built-up area meets the prescribed threshold [Residential: 12.5 sq.m< X < 50 sq.].	2	6	1	Built up area around 50 cu.m	5
				ii. Total expected distance travelled to basic services in a year is less than 2100 km (Residential= 7-11 services, 2100 km).	1		1	School, hospital, bus-stop are within walking distance.	
				iii. Environmental awareness is created through panels/brochures/printouts etc. or Organic farming is carried out on site.	1		1	Organic farming	
		14	Innovation	For each innovation (max. 2 points)	2		2	Space in–out building. Construction of rammed earth	
Total					50	50	42		42

In Table 3, points achieved by Mato Ghar under specific criteria have been shown. The table summarizes that the highest rating points of the Mato Ghar are for the criteria like reduced exposed hard surface on site and maintained native vegetation cover on site, use of renewable energy on site, reduction in building and landscape water demand, reduced embodied energy of building, and use of low-energy materials in interiors. On the contrary, the category that has scored the lowest rating points is the use of energy efficient appliances as there were very limited use of such appliances in the Mato Ghar. In overall, the Mato Ghar has received 42 points out of 50, therefore, it can be labeled as **4-star** rated sustainable building as per the green rating system SVAGRIHA.

Table 3: Summary of points achieved by Mato Ghar for different criteria and sub-groups

S. N.	Criteria		Sub-gorup	
	Name	**Points achieved**	**Name**	**Points achieved**
1	Reduce exposed, hard paved surface on site & maintain native vegetation cover on site	6	Landscape	6
2	Passive architectural design & system	3		
3	Good fenestration design for reducing direct heat gain and glare while maximizing daylight penetration	4		
4	Efficient artificial lighting system	1	Architecture and energy	14
5	Thermal efficiency of building envelope	1		
6	Use of energy efficient appliances	1		
7	Use of renewable energy on site	4		
8	Reduction in building and landscape water demand	5		
9	Rainwater harvesting	3	Water and waste	9
10	Generate resource from waste	1		
11	Reduce embodied energy of building	4	Materials	8
12	Use of low-energy materials in interiors	4		
13	Adaptation on green lifestyle	3	Lifestyle	5
14	Innovation	2		
	Total	42		42

The sustainability status of the Mato Ghar in Kathmandu can be summarized as follows:

- Mato Ghar has focused on existing site conditions that is on actual topography of site that doesn't harm existing natural form.
- Energy efficient design has been prioritized through orientation, by both active and passive strategies like solar water heater and by planning of building (lighting and ventilation).

- Energy efficient and economic materials have been used like single panel reflectors and solar panel equipment.
- Limited conventional building materials are used, which follows the principles of eco- friendly building.
- Vernacular materials like locally sourced mud for rammed earth, bamboo etc. are used to create a sustainable building.

4. Conclusions

This study applied SVAGRIHA, a green rating criterion, to assess sustainability of a case study building, named as "Mato Ghar" located in Budhanilkantha in Kathmandu. The SVAGRIHA rated the building based on 14 criteria and five sub-groups. Overall score of the sustainability rating indicated that the Mato Ghar is 4-start rated building, with a score of 42 out of 50. Approaches such as unaltered natural topography, prioritization of energy-efficiency, use of cost-effective and energy-efficient materials, adhering to eco-friendly building principles to a large extent, and use of vernacular materials have contributed to higher degree of sustainability of the Mato Ghar.

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