

Sustainability Assessment of School Building: A Case of Hilly Region of Nepal

Aastha Thapa ^a, Sudarshan Raj Tiwari ^b

^{a, b} *MSESSD, Department of Architecture, Pulchowk Campus, IOE, TU, Nepal*

Corresponding Email: ^a aastha.thapa12@gmail.com, ^b srtiwari@ioe.edu.np

Abstract

Among existing buildings, schools buildings provide, first and foremost spaces and services for the acquisition of knowledge, and socialization and are essential foundations for forming of good citizens of the future. Most of the existing schools in Nepal are built without considering the sustainability aspect. At present some privately owned or funded schools have initiated a step towards sustainability and adopt green techniques to some extent, which is a positive attitude of school towards sustainability. While on the other hand the financial status of public or government school might be one of the reason that drags it off from the path of sustainability. Nowadays, Schools have started to incorporate sustainability education through their coarse study plan and through different activities like program for cleanliness, awareness campaign regarding environmental issues, issues relating to water and waste management etc. In case of Nepal, there is no any guidelines for designing a sustainable school building. But after the massive earthquake of 2015, due to heavy damage on education and health sector, Department of Education together with two partners ADB and JICA published two guideline document for school building, which were only about type design and structural design criteria for school design, which is not sufficient documentation for leading or creating school buildings towards sustainability. The thesis has focused to identify the indicators for sustainability of school building with creating framework matrix for sustainability criteria. Further, it has tried to focus on sustainability parameters and issues and the state of sustainability in school building through identification of unsustainable, partly sustainable and sustainable indicators and its possibilities that can be adapted leading school towards path of sustainability. Recommendations that support the sustainability aspect of school have been provided.

Keywords

Sustainable school, Sustainability Parameters, Green Techniques

1. Introduction

A green/sustainable school is a school that creates a healthy environment conducive to learning, while saving energy, environmental resources, and money. Most of the green schools are able to cut their utility expenditures by 25% to 50%. Till date, there does not exist widely accepted definition for green school. To some, it means green school building while for others, it means a healthy school environment. Thus, the U.S. Department of Education recently brought some clarity to this confusion by defining a green school as “a school that produces environmentally literate graduates, minimizes its environmental footprint, and has a positive impact on student and staff health [1].

Nepal, a country rich with natural and renewable resources. Now a days, in the name of development

rapid construction works had been carried out with concrete and glass materials resulting in reduction of use of local materials. In the era of glass and concrete, Green School movement could be one of the key issues for sustainable school building design for different climates. Green school often called as eco-school is a concept which focuses on reducing ecological footprint of schools, upgrade schools environmental health while pioneer sustainability within education. Green school is a notion that integrates not only schools’ environmental health but also influence students to be creative and bear responsibility to tackle problems within the locality or community. It can also be considered as the most effective agent for providing productive learning in a comfortable environment while saving energy and resources. A green school even provides recreational

choice for students such as student lead gardens, clean-up campaigns, interactive games, arts and quiz activities, self-development trainings etc. The positive impacts seen would be reduction in greenhouse gas emission, carbon foot-prints, energy saving and resource efficiency, improved students and teachers health.

Sustainability is defined by the World Commission on Environment and Development as meeting the needs of today without compromising the ability of future generations to meet their own needs. Sustainable Building is a fully integrated; “whole building” approach to design, construction, and operation. Sustainable buildings are also referred to as green or high performance buildings designed to: provide optimal environmental and economic performance; increase efficiencies thereby saving energy, water, and other resources; furnish satisfying, productive, and quality indoor spaces; use environmentally preferable materials; and educate building occupants about efficiency and conservation [2].

A sustainable project is designed, built, renovated, operated or reused in an ecological and resource efficient manner. It should meet a number of certain objectives: resource and energy efficiency; CO₂ and GHG emissions reduction; pollution prevention; mitigation of noise; improved indoor air quality; harmonization with the environment. An ideal project should be inexpensive to build, last forever with modest maintenance, but return completely to the earth when abandoned [3].

2. Problem Statement

The influence of modern building construction technology over the locally available materials and techniques might be one the main reason for slow implementation of choosing sustainable school building construction. The use of inefficient building materials and technology have further contributed in loss of thermal comfort inside the building resulting in health hazards of students and teachers, which could be found in most of the school buildings in Nepal also. The rammed earth construction are more sustainable and have higher thermal efficiency as compared to bricks and concrete materials as well climate responsive design and materials is must for maintaining the thermal performance of school and other buildings. Despite of this fact, people are still moving towards concrete construction in the name of

modernization and development. As the students spend the majority of their time in a school building during their crucial development period, schools must be a space for creative thinking, a source of inspiration and a starting point for developing a sense of awareness and responsibility. Nepal itself being rich with its natural and renewable resources, still there is lack of awareness and misunderstanding among builders and users regarding the locally available materials and proper utilization of the green energy technologies. Thus, instead of switching towards locally available material, which are sustainable, dependence on import material for construction has been increased.

Another main reason for problem in implementation of school towards sustainability may be due to lack of proper and strict byelaws for school building. There are only few school buildings in Nepal considered as the sustainable school which are built as per reference and literature from foreign green or sustainable school buildings. Due to absence of proper byelaws and guidelines, there is no any check mechanism to justify and declare these school buildings as green or eco-friendly and sustainable schools. Thus with the study of some of the existing schools, we can gather a draft about the concept and condition of school buildings which claim themselves to be sustainable and some of the public school too.

3. Research Objectives

Main objective: To explore parameters of sustainability in school building so as to provide with prioritized framework for implementation in public schools and particulars in case of hilly region of Nepal.

Specific Objectives:

- To study the sustainability issues aroused in school building and further explore what approaches could be done to increase sustainability in case of existing sustainable or public school building.
- To explore the current status of implementation of green techniques in case of school buildings.
- To identify the energy used in school building and develop strategy for its conversion to renewable sources.

4. Literature Review

4.1 Sustainable Building

Sustainable buildings are also referred to as green or high performance buildings designed to: provide optimal environmental and economic performance; increase efficiency thereby saving energy, water, and other resources; furnish satisfying, productive, and quality indoor spaces; use environmentally preferable materials; and educate building occupants about efficiency and conservation [2].

Sustainable Building is a fully integrated “whole building” approach to design, construction and operation, having a high potential to make a valuable contribution to sustainable development. Sustainability is a broad and complex concept, which has grown to be one of the major issues in the building industry. The idea of sustainability involves enhancing the quality of life, thus allowing people to live in a healthy environment, with improved social, economic and environmental conditions[3]. Sustainability provides a framework that can unite the many different government policies and initiatives related to schools and local communities. But making sustainable school a reality requires a significant culture change across the whole school community. Sustainability has become an important consideration for schools in recent years [4].

4.2 Sustainable Building Principles

Globally, the building sector is arguably one of the most resource-intensive industries. The building industry is also considered as a major contributor to environmental pollution. Green building supports a built environment that is socially, environmentally and economically responsible [3]. Below mentioned are the three pillars of sustainability:

Economic Sustainability: A sustainable design may cost more but often saves operating costs throughout the life of the building through more efficient lighting and better windows, smaller and less costly HVAC, better use of materials, and reduced demolition costs[3].

Environmental Sustainability: It creates a habitat for environmental improvement; Protection of sensitive ecosystems through good construction practices and supervision. Further, it also focuses on use of local supplies and materials with low embodied energy, use of recycled/sustainability sourced products, water and

waste minimization and management[3].

Social Sustainability: It relies on a collaborative approach to building and community development, one that involves all stakeholders, reinforces social networks, and allows people of every age and ability to reside and participate in their community throughout their life[3].

4.3 Sustainable School

Sustainability is a “whole-school” approach, one that extends beyond the curriculum and addresses the entire planning and management of the school facility. School sustainability policies can reinforce what is taught about sustainability in the classroom, establish the school itself as a laboratory, improve the school’s own ecological footprint and strengthen public relations with the surrounding community. A sustainable school prepares young people for a lifetime of sustainable living through its teaching, fabric and day-to-day practices [5].

4.4 Importance of School Sustainability

Research suggests that sustainability is developed most effectively when it is put at the heart of a school. A sustainable school takes an integrated approach to sustainability, exploring sustainability through teaching and learning, values and ways of working, and engagement of local community. The whole school” approach responds to global calls to reorient the curriculum, management and practices of school education toward sustainability [5].

Sustainable schools are concerned about energy and water consumption, waste management, the food that is served, traffic, and the challenges faced by those living in its community and in other parts of the world. Sustainable schools rethink school management and governance processes, the management of school buildings and school grounds, and building partnerships between the school and the community. This creates a “holistic” approach that reflects the belief that sustainability “is not just a curriculum issue; it requires the involvement of the whole school” [5].

4.5 Benefits of School Sustainability

- Cost savings from reduced consumption of resources and improved management of the school grounds and facilities[5].

- Opportunities to achieve curriculum requirements, using sustainability to deliver the curriculum in ways that are relevant and real, with teachers and students working on real-life problems and outcomes[5].
- Professional and personal development opportunities for the whole-school staff and broader community[5].
- The school serving as a model for sustainability within the community, encourages participation, inclusion and interaction with community members, while promoting student voice and leadership[5].
- Creation of community partnerships, which enrich a school's program and add valuable resources, expertise and support, while connecting the school to other community initiatives[5].

4.6 School Sustainability Policy

School sustainability policies are set at the school division level that aims to create a healthy environmental, economic and socially responsible living and learning environment for all students and staff, establishing sustainability along with guidelines on the range of plans and actions that could be adopted at the individual school level. Some of the policies for sustainability issues include[5]:

- Recycling and waste reduction and management.
- Energy efficiency.
- Human resources.
- Policies on "green" procurement and supply chain management.
- Use of local food in cafeterias.
- Staff and student volunteering in local community social and environmental projects.
- Integration of sustainable development into the curriculum.
- Use of the school itself as a place to practice and measure environmental responsibility.

4.7 General Characteristics of Sustainable/ Green School

The Centre of Green School under the U.S. Green Building Council had emphasized the general Characteristics of green school that are important in

order to develop and to build the green school design. Some of the characteristics are[2]:

- Conserves energy and natural resources.
- Improves indoor air quality.
- Removes toxic materials from places where children learn and play.
- Employs day lighting strategies and improves classroom acoustics.
- Decreases the burden on municipal water and wastewater treatment.
- Encourages waste management efforts to benefit the local community and region.
- Conserves fresh drinking water and helps to manage storm water runoff.
- Encourage recycling and reduced demand on local landfills.
- Promote habitats protection.

4.8 Guidelines for Sustainable/ Green Schools

The seven categories for Sustainable Schools are sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, innovation in design, and regional priority[2]. Further green school includes design and engineering techniques to meet specific objectives which are as follows [2]:

- Locating schools near public transportation to reduce pollution.
- Placing a building on a green site so as to minimize its environmental impact and make the most of available natural light and solar gain.
- Designing irrigation systems and indoor plumbing systems to conserve water
- Designing energy and lighting systems thus conserving fossil fuels and maximizing the use of renewable resources.
- Selecting materials that are non-toxic, biodegradable, and easily recycled.
- Creating an indoor environment that provides occupants with a comfortable temperature, good air quality, lighting, and acoustics.

4.9 Factors of Green Building

Some of the factors that needs to be considered while designing a green building are mentioned below[2]:

- Location: Should be easily accessible and availability of materials near to the site location.
- Orientation: Should organically fit into the surrounding area, making best use of existing roads, sidewalks, alleys, site specific solar resources and so forth.
- Day Light: An important element of sustainable design. It is the controlled admission of natural light- direct sunlight and diffused skylight into a building to reduce electric lighting and saving energy.
- Renewable energy: Renewable energy comes from natural sources such as sunlight. Geothermal heat, wind, water and biofuels powered by feedstock.
- Rainwater harvesting: The main purpose of rainwater harvesting system is to collect and store rainwater falling on the ground which can be further used in the future.
- Waste water management: Waste water management or the lack of, has a direct impact on the biological diversity of aquatic ecosystem, disrupting the fundamental integrity of our life support systems, on which a wide range of sectors from urban development to food production and industry is dependent.

4.10 A Case study of Kopila Valley School, Surkhet

Findings from Kopila valley School[6]:

- Focused on locally available construction material.
- Good initiation in education sector for children from disadvantaged group.
- Proper orientation, day lighting, ventilation.
- Implementation of green technologies like solar system for lighting and cooking, biogas, rainwater harvesting, waste water treatment and reuse.
- Efficiency of solar PV cells and concentrated cookers had been an issue at present due to lack of technical man power.
- Panels of solar PV cells can be optional for roofing replacing the decra roof wherever possible.
- Concept of sustainable farm within school premises and training classes for farming and other extra activities for student affects positively in ones behavioral growth.

- School have implemented many indicator of sustainability resulting it to be called as green school of Surkhet.

5. Methodology

5.1 Research Paradigm

The research has main objective to explore parameters of sustainability in school building so as to provide with prioritized framework for implementation in public as well as private schools in case of hilly region of Nepal. For this, the vital source of knowledge accumulation is through literature reviews, case study from particular type of green or sustainable school, observations and comparative study of cases of existing schools. The ontology of the research is that random ongoing construction of school buildings has problems and challenges regarding sustainability of school.

The objective set lead towards qualitative case study research, so it is designed to be more explanatory and descriptive that requires the use of mixed methods. As the research is based on the qualitative method, the data is gathered through in-depth interviews, key informants interview, ethnography, direct observation and photography. Through all these studies and cases, my research will funnel up some of the guidelines regarding sustainability in case of school building in hilly region of Nepal.

5.2 Research Design

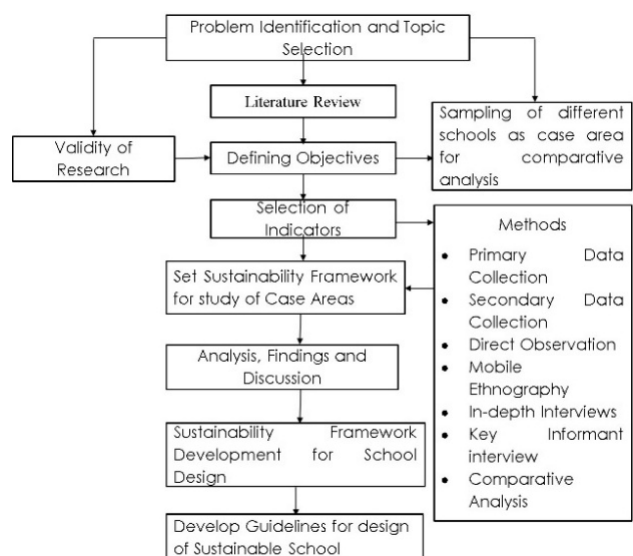


Figure 1: Flow chart of Conceptual Framework of Research Design

Literature and other sources were referred in considering parameters and indicators for environment, social and economic aspect for school. Additionally, the sustainability criteria for each indicator was developed on the basis of ground reality to make it adaptable to the context of school. Later on, the sustainability matrix was developed for analysis of the selected cases for the assessment.

6. Case Areas and its Findings

6.1 Case Area 1: Samata Shiksha Niketan “Bamboo School”

Samata is a bamboo themed schools founded by Uttam Sanhel in co-operation of Samata Samaj in over 52 districts of Nepal. For my case area, I have choosen the Samata Shiksha school of Bauddha, kathmandu which is assumed to be the first established among other Samata Schools. It is also called a bamboo school and a 100 Rupees School. The main aim of establishment of Samata Shiksha Niketan is to provide equality in education and reduce gap between rich and marginalized group.

6.1.1 Findings from Case Area 1.

- No provision for Rain water Harvesting, Sewage treatment , Waste Segregation and no proper drainage for rain water.
- Absence of green spots within and outside school premises. Still initiations seen in plantation in flower pots.
- Solar Panels for lighting- not in use at present.
- Building material used is untreated bamboo and C.G.I sheet for roofing.

6.2 Case Area 2: Bal Ujwal Sec. School, Kavrepalanchowk

Bal Ujwal is a government school located at Puranogaun Dapca at a distance of 14.1 km from Dhulikhel Bus stop. The school was destroyed in earthquake of 2015 A.D. and reconstructed by Nebraska, Adra Nepal and Rukmangat katwal Trust.

6.2.1 Findings from Case Area 2.

- Future provision for Rain Water Harvesting.
- No provision for installation of solar panels for lighting, Sewage treatment , Waste Segregation and no proper drainage for rain water.

- Space provided for plantation within school premises. Good provision for cross ventilation and sufficient day light within the classrooms.
- Building Material:
 - Stone wall (main building) with Jhingati tiles for roofing
 - Brick wall thickness (northern and southern building) -14 inches
 - Brick wall thickness (western block)- 9 inches with CGI roofing

6.3 Case Area 3: Kalika primary School, Kavrepalanchowk

Kalika is a government school located at Baseri at a distance of 2.1 km from Bal Ujwal School. The school was destroyed in earthquake of 2015 A.D. and reconstructed by Chaudhary Group, District Education.

6.3.1 Findings from Case Area3.

- Only four classrooms with other unfinished structures were observed with only 12-15 number of students in total. Building material used is prefabricated board,metal posts and C.G.I sheet for roofing.

6.4 Case Area 4: Shree Shila Devi Primary School, Dhoksan

Shree Shila Devi is a government school located at 9.2 km from Sankhu Bus stop and 2.5 km from Jarsingh Pauwa (No provision of Public transport). After the earthquake of 2015, the school was constructed under direction of superstructure and Patrizia. The school Comprises of five different building typology; The Window House, The Rock House, The Earth House, The Brick House and The Bamboo House.

6.4.1 Findings from Case Area 4.

- Building constructed using locally available material.
- School surrounded by forest but plantation within school premises is not seen
- No provision for installation of solar panels for lighting, sewage treatment, etc.
- Waste segregation is done within school premises.
- Provision for drainage to maintain flow of water.
- Good provision for cross ventilation and sufficient day lighting within the classrooms.

7. Analysis

7.1 General Comparative Data from Case Areas

The general comparative analysis data among the four selected cases are shown in table 1. Please refer the Table 1 for details.

7.2 Findings from Matrix for Sustainability Assessment

As for sustainability matrix analysis for the research, Only three dimensions of sustainability (Environmental, Social, and Economic) are considered. Each Indicators are further classified under three criteria for sustainability:

- 1 - Sustainability not seen
- 2 - Sustainability Seen to some extent and can be improved and
- 3 - Sustainability Seen.

7.2.1 Environmental Sustainability

The matrix for indication of sustainability criteria in terms of environmental dimension are explained in Table 2.

In the Environment dimension among four schools, the number of sustainable indicators in case of Shree Shila Devi Primary School is high for sustainable (6), while in case of Samata Shiksha Niketan and Bal Ujjwal Sec.School, the sustainable indicator is partially seen and can be improved (8), while for the kalika Primary School seems to be unsustainable (9).The matrix for comparative Analysis of sustainability criteria in terms of environmental Sustainability for the selected cases of school are shown in the Table 3.

7.2.2 Social Sustainability

The matrix for indication of sustainability criteria in terms of environmental dimension are explained in Table 4.

In the Social dimension among four schools, the number of sustainable indicators in case of Shree Shila Devi Primary School is high for sustainable (3), while in case of Samata Shiksha Niketan and Bal Ujjwal Sec. School the sustainable indicator is partially seen and can be improved is 3 and 4 respectively, while for the kalika Primary School seems to be unsustainable (2). The matrix for comparative Analysis of sustainability criteria in

terms of environmental Sustainability for the selected cases of school are shown in the Table 5.

7.2.3 Economic Sustainability

The matrix for indication of sustainability criteria in terms of environmental dimension are explained in Table 6.

In the Economic dimension among four schools, the number of sustainable indicators in case of Shree Shila Devi Primary School is high for sustainable (2), while in case of Samata Shiksha Niketan and Bal Ujjwal Sec. School the sustainable indicator is partially seen and can be improved is 3 and 2 respectively, while for the kalika Primary School seems to be unsustainable (7). The matrix for comparative Analysis of sustainability criteria in terms of environmental Sustainability for the selected cases of school are shown in the Table 7.

8. Discussion

After assessing the selected schools of hilly regions of Nepal, it was observed that each cases has its own issues and necessities. The private and funded schools have funds to fulfill the requirements and necessity of school while the government schools are dependent on the grants allocated from Nepal government, which seemed to be insufficient to run the school facilities in efficient and effective order. From the study, it was observed that the condition of all government school is not the same. From the four cases selected, the three cases are of government school among which Kalika Primary School of Baseri, Kavre has the least sustainability features and also in its state of merging with the nearby school. Likewise, Bal Ujjwal Secondary School of Dapcha, Kavre can be taken as partially sustainable. Due to the limited budget and misconception on traditional method of construction being weak, they have switched towards RCC construction. Similarly, Shree Shila Devi School of Dhoksan can be considered as sustainable to some extent among the four cases. Shree Shila Devi School being a government school, after the earthquake of 2015 B.S. it was funded and rebuilt by Patrizia and Supertecture. The main focus on reconstruction of Shree Shila Devi School was on earthquake proof construction using local materials and construction technique. This school can be considered as sustainable in terms of material but lacked sustainability in case of energy sector like use of renewable sources etc. Likewise Samata Shiksha

Table 1: General Comparative data from Case Areas

Description	Samata Shiksha Niketan School	Bal Ujjwal Secondary School	Kalika Primary School	Shree Shila Devi Primary School
Owned by	Privately owned	Government	Government	Government
Building Typology	Bamboo	Stone (old building) RCC (new construction)	Load Bearing Structure (old building) Steel frame and prefabricate board (new construction)	Load bearing structure (old building) Mixed type (new construction)
Land Area	7 Ropanies	6-6.5 Ropanies	2 Ropanies	Approx.10-12 Ropanies
No. of Students	2000	465	12-15	115
Average Classroom size	14ft. by 14ft.	16ft. by 20ft. for 40-50 students in average	14ft. by 16ft.	17ft. by 22ft. for 15-20 students 15ft. by 20ft for 12-15 students

Table 2: Matrix for Sustainability criteria for Environmental Dimension

Parameters	Indicators	Criteria for Sustainability		
		1 (Sustainability not Seen)	2 (Sustainability seen to some extent and can be improved)	3 (Sustainability Seen)
Location	<ul style="list-style-type: none"> Significant Site Isolation Orientation Setbacks around building 	<ul style="list-style-type: none"> Steep sloppy land Located in urban areas or isolated from both residential and urban areas. Classroom oriented totally North No setback 	<ul style="list-style-type: none"> Flat and Slope land isolated to walkable distance from both residential and urban areas Classroom placement along with the boundary wall Setback for light and ventilation 	<ul style="list-style-type: none"> Flat or slight slope located nearby residential units but isolate from urban areas Building orientation as per site such that each room gets proper light and ventilation Setback maintained from both boundary wall and building blocks.
Resources	<ul style="list-style-type: none"> Availability of Land, Water, Human Labor, Materials 	<ul style="list-style-type: none"> Resources to be imported 	<ul style="list-style-type: none"> Resources present at local level and only few resources to be imported 	<ul style="list-style-type: none"> Required resources present at local level
Waste Management	<ul style="list-style-type: none"> Concept of 3R Composting 	<ul style="list-style-type: none"> Not concerned about waste management 	<ul style="list-style-type: none"> Waste segregation done 	<ul style="list-style-type: none"> Segregating waste as organic and inorganic and treated simultaneously
water	<ul style="list-style-type: none"> Water-Management Reuse Rain water Harvesting Ground water recharge 	<ul style="list-style-type: none"> Scarcity of water No provision for reuse of water No provision for storage of rain water Land covered with concrete landscape 	<ul style="list-style-type: none"> Scarcity of water addressed to some extent Water reused for gardening and cleaning Provision for rain water harvesting but not implemented yet. Drainage for rainwater and overflow from taps but lacks recharge pits. 	<ul style="list-style-type: none"> Water available at the site Water generated in site reused to fulfil water requirement. Water demand fulfilled from rain water storage Proper drainage with ground water recharge pits
Building	<ul style="list-style-type: none"> Use of local material Reuse of material Passive Solar/ green design 	<ul style="list-style-type: none"> construction using imported materials Material once used and cannot be reused again. Haphazard planning without consideration to site context and material 	<ul style="list-style-type: none"> Construction dependent on both local and imported material. Construction material reused partly once after demolition Integration of some passive or green material with other materials. 	<ul style="list-style-type: none"> Construction using local materials. Building made from material that were already used and can be reuse again Design considering site context, and use of locally available material responding well with nature

Table 3: Matrix for Comparative Analysis in terms of Environmental Sustainability

Parameters	Indicators	Remarks			
		Samata Shiksha Niketan	Bal Ujjwal Sec. School	Kalika Primary School	Shree Shila Devi Primary School
Location	Significant Site	2	2		2
	Isolation	2	2	1	2
	Orientation	2	2	2	3
	Setbacks	1	2	2	3
Resources	Availability of land, water, human labor, materials	2	2	2	3
Waste Management	Concept of 3R	1	1	1	2
	Composting	1	1	1	2
Water	Waste-Management	2	1	1	1
	Reuse	1	1	1	1
	Rain water Harvesting	1	2	1	1
	Ground Recharge	1	1	1	2
Building	Use of local material	2	2 (old building) 1 (new building)	1	3
	Reuse of material	2	2	2	3
	Passive Solar/ Green design	2	2	1	3

Table 4: Matrix for Sustainability criteria for Social dimension

Parameters	Indicators	Criteria for Sustainability		
		1 (Sustainability not Seen)	2 (Sustainability seen to some extent and can be improved)	3 (Sustainability Seen)
Health and Comfort	<ul style="list-style-type: none"> Indoor Air Quality Visual and Acoustic Comfort 	<ul style="list-style-type: none"> Lack of fresh air Use of mechanical device for heating, cooling, lighting etc. 	<ul style="list-style-type: none"> Limited room having access to fresh air Only few rooms dependent on mechanical device and lighting during day time. 	<ul style="list-style-type: none"> Well ventilated and fresh air within classroom. Natural ventilation
Accessibility	<ul style="list-style-type: none"> Ease access and access to service 	<ul style="list-style-type: none"> School not within community periphery 	<ul style="list-style-type: none"> Access from nearby community but lacks basic infrastructure services. 	<ul style="list-style-type: none"> Accessible from nearby community with basic infrastructures too.
Safety and Security	<ul style="list-style-type: none"> Strength and stability of building Stakeholder involvement 	<ul style="list-style-type: none"> Use of material that are not certified for structural stability No involvement 	<ul style="list-style-type: none"> Use of locally available material and checked for stability. Used without precautions for structural durability. Partial Involvement 	<ul style="list-style-type: none"> Material that are locally available and proven to stable. Precautions used for structural safety and durability Involved in different activities within and out the school organized by school committee.

Table 5: Matrix for Comparative Analysis in terms of Social Sustainability

Parameters	Indicators	Remarks			
		Samata Shiksha Niketan	Bal Ujjwal Sec. School	Kalika Primary School	Shree Shila Devi Primary School
Health and Comfort	Indoor Air Quality	2	3	2	3
	Visual and Acoustic Comfort	2	2	2	3
Accessibility	Ease access and access to services	3	2	1	2
Safety and Security	Strength and Stability of building	2	2	2	3
	Stakeholder involvement	1	2	1	2

Table 6: Matrix for Comparative Analysis in terms of Economic Sustainability

Parameters	Indicators	Criteria for Sustainability		
		1 (Sustainability not Seen)	2 (Sustainability seen to some extent and can be improved)	3 (Sustainability Seen)
Maintenance	<ul style="list-style-type: none"> Frequency of maintenance 	<ul style="list-style-type: none"> 4/5 times in a year 	<ul style="list-style-type: none"> Relatively maintenance once a year or minimum maintenance during operation 	<ul style="list-style-type: none"> No maintenance till 2/3 years from date of operation
Affordability	<ul style="list-style-type: none"> Initial Cost Life span 	<ul style="list-style-type: none"> High construction cost and maintenance 	<ul style="list-style-type: none"> Partially costs during construction and maintenance 	<ul style="list-style-type: none"> Low-cost construction and longer life span
Materials	<ul style="list-style-type: none"> Locally Available Imported Materials 	<ul style="list-style-type: none"> All materials are imported and no dependence on locally available ones 	<ul style="list-style-type: none"> 40-60 % of materials locally available and partially imported or vice-versa 	<ul style="list-style-type: none"> Maximum use of locally available material that are sustainable in nature
Renewable Energy Technology	<ul style="list-style-type: none"> Passive and active Solar Rain Water harvesting Waste Treatment Biogas 	<ul style="list-style-type: none"> Not installed 	<ul style="list-style-type: none"> Not working or stopped using it after some years Future provision for using it 	<ul style="list-style-type: none"> Installed and good working condition
Employment	<ul style="list-style-type: none"> Job opportunity Skill Development training 	<ul style="list-style-type: none"> Completely isolated from community and no any training involvement for local community 	<ul style="list-style-type: none"> Partially involvement of community interaction, awareness and workshop conducted by school 	<ul style="list-style-type: none"> Involvement of community people in development and operation of school and active participation in development and other activities of school

Table 7: Matrix for Comparative Analysis in terms of Economic Dimension

Parameters	Indicators	Remarks			
		Samata Shiksha Niketan	Bal Ujjwal Sec. School	Kalika Primary School	Shree Shila Devi Primary School
Maintenance	Frequency of Maintenance	1	2	2	3
Affordability	Initial Cost and life span	2	2	2	
Materials	Locally Available and Imported Materials	2	2	1	3
Renewable Energy Technology	active Solar design	2	1	1	1
	Passive Solar design	2	1	1	3
	Rain Water Harvesting	1	2	1	1
	Waste Treatment	1	1	1	2
	Biogas	1	1	1	1
Employment	Job opportunities and skill development training	1	2	1	2

Niketani of Bouddha is the privately owned school founded by Uttam Sanjel in co-operation of Samata Samaj. The Bamboo structure and its initiation in providing education towards disadvantaged group in just a hundred rupees is the main center of attraction for Samata School. The Samata School chooses bamboo and mud as the construction material not because they were aware about sustainability but to reduce the material and construction cost. Thus the analysis shows that knowingly and unknowingly some schools are sustainable to some extent while other schools have switched from local material to modern RCC structures. This study can be a reference for criteria for future school construction program and a basis for design of sustainable school. However, this research is unaccountable for the study of temperature data, quantity estimate of materials and life cycle analysis of building for further research areas. The school should not only focus within the classroom and educational system but also needs to extend its path towards sustainability through awareness and sustainable practice among teachers, students and the neighborhood.

9. Conclusion

Sustainability assessment helped to understand the state of sustainability in school building through the identification of unsustainable, partly sustainable and sustainable indicators. The guideline documents provided for school building about type design and structural design criteria alone is not enough. Rather criteria documents for school sustainability needs to be incorporated in the school design guidelines. After the analysis from the study, the building with local construction material seems to be more appropriate, environment and user friendly when compared with RCC buildings. From the analysis of four different cases, Shree Shila Devi School of Dhoksan seems to have adopted sustainability to some extent when compared with other three cases of school but lacks in adoption of green features and technologies. From the study, it is observed that majority of the school has mentioned about future provision on installation of green techniques (Solar Pv cells, Rainwater Harvesting, water and waste management and others) but lack of fund seemed to be the hindrance in its installation. Installation of green technique alone does not lead towards sustainability, rather easy maintenance and availability of man power also needs to be considered. Sustainability in school to some

extent can also be done through small changes like planting greenery with involvement of students and teachers, awareness among students and teachers regarding sustainability education. Farther, from the study of all the cases taken it is concluded that sustainability criteria for one school might not fit with the other one due to issues as financial, availability of land, resources and man power, etc. Thus guidelines needs to be in favor of both public and private school and also the existing schools needs to initiate step towards sustainability. Sustainability in case of school does not solely depends on the resources and physical infrastructures but also depend on the awareness level among users so awareness regarding sustainability issues is important.

10. Recommendations

- The grants provided for construction of classroom alone is not sufficient but grants/fund allocated needs to incorporate other facilities such as creating green zones, installation for renewable energy technology etc. The guideline for school should mention that the schools needs to have open spaces or space for plantation along with the building blocks.
- The school building needs to have proper orientation with setbacks around the buildings such that each block gets proper day light and well ventilated with provision of cross ventilation.
- There is misconception that RCC buildings are stronger compared to local material. Awareness is needed to make clear that even the construction from local materials can be made stronger considering proper design techniques with skilled man power. The government and local authority needs to promote locally available material and provide such skilled technical man power who can guide labors with construction of building material available at local level.
- Provision for rain water harvesting is must. The concept of re-use of water needs to be initiated with provision for storm water collection or ground water recharge system.
- During design and construction of school building, concept of passive design or green design needs to be prioritized.
- Sustainability of school can be maintained by increasing awareness level among teachers,

students regarding sustainability.

Case Area 1.Samata Shiksha Niketan School:

- Drainage needs to be maintained for rain water as the ground gets flooded during rainy season.
- Provision for cross ventilation is must within classroom.
- Provision for sewage treatment and segregation of waste needs to be implemented.
- Very few green spots are seen within school premises. Thus greenery needs to be added within school premises.
- Energy usage towards renewable energy needs to be prioritized.

Case Area 2.Bal Ujjwal Secondary School:

- Drainage needs to be maintained well.
- Provision for segregation of waste needs to be done.
- Energy usage towards renewable energy needs to be prioritized.
- They have provision for rain water harvesting but grant provided has not been sufficient for its installation.The grants provided for school shouldnot be limited to classroom but also needs to be able to cater other supporting activities of school.

Case Area 3.Kalika Primary School:

- Provision for installation of solar panels for lighting, rain water harvesting etc. needs to be done.
- Emphasize on locally available material for construction of school building
- The school needs to be easily accessible from the nearby community.

- Gap between the school authority and user community needs to be minimized by organizing monthly meeting and conducting awareness program and acts.

Case Area 4.Shree Shila Devi Primary School:

- Provision for installation of solar panels for lighting, rain water harvesting etc. needs to be done.
- Involvement of community is must for sustainability of school.
- Sustainability awareness needs to be equally distributed among teachers, students and the community people.

References

- [1] Campaign for Environmental Literacy. Is becoming a green school right for your school. Technical report, National Association of Elementary School principals, 2019.
- [2] Nur Hidayatuljamilah Ramli, Mawar Haji Masri, Mohd Zafrullah, Haji Mohd Taib, and Norhazarina Abd Hamid. A comparative study of green school guidelines. *Procedia-Social and Behavioral Sciences*, 50:462–471, 2012.
- [3] Peter O Akadiri, Ezekiel A Chinyio, and Paul O Olomolaiye. Design of a sustainable building: A conceptual framework for implementing sustainability in the building sector. *Buildings*, 2(2):126–152, 2012.
- [4] Jane Wilkinson. Leading sustainable school building projects. Technical report, National College for School Leadership, 2019.
- [5] Anne MacDiarmid Natalie Swayze, Carolee Buckler. Guide for sustainable schools in manitoba. Technical report, International Institute for Sustainable Development (IISD) and Manitoba Education, 2011.
- [6] Aastha Thapa. Green school movement-a case of “kopila valley school” surkhet, September 2019.