

# STUDY OF SUSTAINABLE CONSTRUCTION PRACTICES: THE BHUTAN CASE STUDY

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**ABSTRACT:** Sustainable construction is the one of the measures that has been put forward to mitigate the adverse impact of construction activities on environment, economy and society. This paper presents the Bhutan's case study on sustainable construction practises. This paper presents and discusses the scope and definition of sustainable construction; Barrier to the implementation of sustainable construction; the benefits of sustainable building compared to conventional building; and various technical approaches to achieve sustainable construction. The lack of education, awareness and training were the major barrier to the implementation of sustainable construction in Bhutan.

**Keywords:** sustainable construction; green building; construction industry; sustainability.

## 1.INTRODUCTION

The construction industry has significant impact on environment, social and economy of the society. Usually building reflects this impact during its lifecycle. Construction industry has significant positive impacts which includes, providing employment opportunities, significant contribution towards national economy and provides building infrastructure to satisfy basic human requirement [1]. And similarly, construction industry plays an important role in development and urbanization.

Construction activities has huge adverse impact which includes water pollution, traffic congestion, dust, noise and waste disposal. During construction stage large quantity of natural and human resources is consumed and its impact on environment is enormous. As per the statics construction industry contributes largely on unsustainable development and its impact on environment and economy is very high. Globally construction activities account for 40% of total energy consumption ,40% of raw materials, 25 % of all timber,16% of total water consumption and 40% of natural resources extracted in developed countries. Additionally, construction industry accounts for 35% of global CO2 emission,45 to 65% of waste generation deposited in landfill and 30% of greenhouse gases is produced globally due to construction activities [2]. In order to mitigate the adverse impact of construction industry to the environment the concept of sustainable construction has arisen. This concept of sustainable construction make best use of environment friendly materials and resources, improves the indoor air quality and implements the techniques to save resources and waste generation.

Sustainable construction is one of the measures for the construction industry to move towards achieving sustainable developments considering environment, socio-economic and cultural issues [3]. This paper presents about the scope and definition of sustainable development, barrier to implementation of sustainable construction, and technical approaches to achieve sustainable construction in Bhutan.

## 2.What is Sustainable Construction?

In this 21<sup>st</sup> century, industrialization has taken a lead role. The countries development and modernization has somehow led to the impact to the environment. The constructions of the building have become the key components for the development [4]. The construction industries in the world consume about 25% of global wood harvest, 16% of water and 40% of stone, gravel and sand.

It produces about 50% of global output of GHG and the agents of acid rain. Not only that, the heavy machinery used in construction industries are still heavily depended on fossil fuel and inefficient electricity has resulted in unnecessary burning of fossil fuel accounting up to 36% of worldwide energy usage and 40% of CO2 emissions [5]. Climate change, global warming, unexpected seasonal variation and decreasing land surface as a result of rapid development has now led to the shift in focus from the development to sustainable development.

As Bhutan being a developing country, construction industries do play a vital role as well as has significant influence on the country's economy. The construction sectors in Bhutan do faces resources and cost outruns which affects the economic development and overall performance of building. Therefore, it is necessary that our country change development into the sustainable development.[6] However, Bhutan being carbon negative country and committed to Gross National Happiness objectives, it makes Bhutan to focus on sustainable and equitable development. The four pillars of GNH not only focuses on human wellbeing but also on health of our environment.[7] the sustainable construction aims on designing, constructing, maintaining, rehabilitating and demolishing the buildings throughout their lifecycle by using the natural resources efficiently as well as protecting the environment which will help in mitigating the natural disasters. Therefore, it is important to reduce the GHG emission into the environment and also the use of artificial energy to mitigate the ecological impact in the world.[8]

### 3.Sustainable Practice in construction industry

In the construction industry of the sustainable development where Sustainable construction has been regarded as a part of its subset for a sustainable practice. Therefore, According to ( Kibert and CJ (1994),[9] where it has been defined as “It is the maintaining of the healthy environment which has based on efficient resourceful of its ecological and better creation to its responsible management”. With the formulation of sustainable development of international blueprint in Brazil, Rio de Janeiro called “Agenda 21” in the year 1992 which shows the action being taken as a wide ranging throughout its globally, nationally and of its own regionally of a UN system.

The following things are in accordance to the sustainable construction of its principles by a (PA, Bowen, et al, 1997).[10]

- Renewable resource to be always in maximization
- Consumption of resource to be minimization
- Recyclable and renewable resources should be use
- Environment should be protected
- The environment should be clean, healthy and toxic free atmosphere and
- A good quality of environment to be built.

Usually Sustainable construction embraces social, economic and environment as three main dimensions and on contrast to that the conventional contrast to that is economy utility, and durability. Social dimension enhances the quality of a people’s life. Economic dimension also addresses about the employment establishment, lowering for the maintenance / operating cost, producing a greater quality of work for an environment and so on. The environmental dimensions addresses for a construction, design, maintenance/operation and the deconstruction which gives the adverse impact for the environment in the nature for a emissions, discharges of waste, land use and use of water resources etc.

The world of emergence to a sustainability world due to the adverse effects of global warming which addresses to a sustainability as one of the major global concern. Nevertheless, in the developing countries are facing enormous problems to a sustain sustainability and resulting to affecting indirectly to a developed country of lacking a knowledge of sustainability. So sharing some major problems of a developing countries that they are facing are like finance problem, human resources, systems of water supply is poor, having low income for a workers, poor education and many others.

As the quality of the human beings life has been significantly developed by the sustainable construction practice industry and the living standard easier and much comfortable way. Though there is positive impact on one hand but at the same time there is also an environmental impact due to the construction industry around the globe. In the year 2014, ( Research institute of Copenhagen) has been calculated and made an estimation that due to construction industry where around the world there is 40% of energy being consumed, CO2 emission is 30% and waste solid production of total around 40%. The construction of green being a one of the profitable in a industry to construct an assets such as a (infrastructure structure, building structure of the surroundings and structures) achieving a good potential of life quality supporting a resource in a efficiently for the natural and social environment.

#### 3.1 Factors for green construction:

In this field where the factors that has been accounted at a construction level where it covered largely to energy efficient activities mainly to minimize the environmental impacts at the time of the building operational phase to demise the costly need and for the reduction of the occupancy stage building according to the (Fieldson et al., 2009; Li and Colombier, 2009).[15]

1. Sustainable Practice: A practices which is sustainable or green to reduce impacts for environmental by the construction and the proper planning of waste management by a (Tam and Shen, 2002) for adopting a prefabrication and the uses machinery consuming efficient fuel.
2. Water and Energy saving: According to the (Zhang et al., 2011)[12] where it says that water and energy saving is a paramount in the life cycle sector which have a significantly influenced of the building. For instance implementing of a technological system being integrated in the design building like Air and lighting conditioning system, heating of energy efficient, and solar panel and recycle technologies for enhancing the quality improvement of the building, resulting to the reduction of the harmful embodied energy effects to the building.
3. Green practice facilitating: At a construction sector, all the stakeholders have properly execute for the “core green factors” at a firm level which has being a facilitating its implement practices said by a (Darnall et al., 2008).[13] It also provide a chain stages at a construction have to be robust than other sector while include a certification for environmental management system(EMS) and ISO 14001 (Estidama) by a governmental and it consist of a policies for internal assessments , plans and action need to be implemented.
4. Environmental training: Organizing a training program for a employ workers regarding the matters on the environmental issues by providing knowledge and competence on the improving awareness on construction site to have more positive attributes towards the waste management system by a ( Qi et al., 2010).[14]

#### 4.Challenges of Sustainable Building Practices

The challenges of sustainable can be divided into five distinct categories: such as Cost, information, design processes, construction processes, and materials and technology.

- Capital cost. There also is no reason for them to decide a huge amount of time during a tender to assess things, leading unavoidable to cost over-runs later in the project. Its is like picking the cheapest builder makes the difference in the quality of building. Usually the it is believed that the sustainable building are higher in cost in which it is believed because of the lack of accurate, thorough, and quantifiable information with the financial and economic impacts.
- Design process. With all required professional project for the building the design professional needs a lot time in assessing potential materials and technology.
- Construction process. With the problems mention in the design, the construction projects can also be difficult one which is because of or lack of knowledge and skilled labourers to maintain a new technologies. Needs even high numbers of labours and technology.[15]The conventional building is far more expensive than sustainable building. So one needs to spend high budget to construct a conventional building[16]

The disadvantages of conventional building is that it needs high labour numbers and plant on site and putting of formwork is time consuming. There is even difficult in quality control. Its is even difficult to do any modifications after the concrete has been cast. Weather can be a problem to curing and for the construction. Concrete must be cured before its is fully loaded. There no assured in quality control of finish surfaces.[17]

##### 4.1 Informative challenges

There are many challenges related with a sustainable construction. These challenges are mainly for the need in balancing the main sustainability portion namely economic, social and environmental issues. In the view of Miyatake (1996), The construction needs to change the way in which all the construction activities are undertaken, such as placing much important on recycling, reuse of materials and more over reduction in the energy and natural resources use. The construction industry must maintain the right balance between environmental and economic performances. n the other hand, there are some serious challenges towards the achievement of sustainability. Bon (www.iris.ba.cnr.it) mentions that there are serious economic challenges faces by sustainable construction at the macroeconomic, meso-economic and microeconomic levels. Initially, the construction output has been reduced in developed world, secondly, even though there has been a steady growth of the output in developing countries but it must be recognised that the attainment of sustainability is considerably difficult in these countries, and the construction sector depends on the performance of sustainability measures from other sectors of the economy such as the manufacturers of construction materials and components. [5]

The Economic Issues of Sustainable Construction is such that In 1999, a symposium entitled ' Cost and Value in Green Building' was organized at the University of British Columbia, Canada. The primary goal of the two-days conference was to consider the significant cost and value issues that more importantly, promote higher environmental performance standards in building (Cole, 2000). This debate presented a impressive overview of the cost- related issues related with producing and using 'green building's, a convincing set of human, environmental and business discussions just to justify higher performance goals, approach to design and costing were presented.

Sustainable construction needs taking a long-term view in relating to the cost of sustainable buildings, keeping both the capital cost and running cost. Even though there were benefits of the green construction, the misconception of an increase in capital cost and lack of a visible market value discourages both developers and contractors.[18]

#### 5.Barriers to implementations of sustainable construction practices

The idea of sustainable construction practice is not new to ears and have been around for years but still most developed and developing countries face barriers when it comes to implementation of sustainable construction practice and Bhutan a developing country is no exception. The construction industry around the world plays a very important role in the achievement of the SDGs (Sustainable Development Goals) mainly 11<sup>th</sup> and 15<sup>th</sup> SDGs. Developing and developed countries have been trying to achieve these goals for years. However, there are barriers stopping and hindering built environment consultants to reach environments sustainability (ES) of construction projects [19]. Six components of obstructions have been identified as main barriers to implementation of environmentally sustainable construction:

##### Comp 1- Financial barriers

The influence of financial barriers has been one of the most hurdle to implementation of ES of building projects and other researchers has also recognized it as one of the major issues in construction projects. Although it is said that the benefit for long-term is worth all the hassles but initial increase in investment is not returned in terms of monetary rather it is said to be focused on environmental and social reimbursement [20]. The fear of higher costs for sustainable buildings compared to traditional buildings and the risk of unpredicted are often mentioned as a hurdle for sustainable buildings. Though, initial capital are higher but in the end building owners will benefit in longer period due to sustainable construction practice [8]. Bhutan being a developing country

with its construction industry still booming, profit and fear of high investment drives the construction industry which directly or indirectly effects the implementation sustainable construction practices in Bhutan.

### **Comp 2- political barriers**

Although Bhutan is known for its green practices there are not much rules made when it comes to implementation of sustainable construction practise nor rewards for the successful implementation. The success of sustainable construction is highly dependent on the obligation of the Government and formulation of regulations. As there are many benefits, SC is associated with sustainable design and constructions. Therefore, Government and their agencies should lead the movement by actively incorporating sustainable design and construction practices into new building projects so that individual and private firms can approach too.[20].

### **Comp 3-Leadership barriers**

A project leader or the higher management which can be an engineer or an architect designer can influence a project in major ways. Bhutan lack leaders of this kind which offsets Bhutan for implementation of sustainable construction practices. The need for management and leadership plays a crucial role in achieving operation of SC. To meet SC, managements must fulfil the demand of building projects resources and support changes that arises from implementation. Without these support, constructions project may face various hitches [20]. Just like in Bhutan the construction industry in Oman depends mainly on foreign workforce, yet from the research it was shown that there is a lack of required experience or expertise to meet the challenges amongst all the responsibilities in the sites [23].

### **Comp 4- technological barriers**

Bhutan lacks access to modern technology which includes investments in R&D of sustainable construction, lack of environmentally sustainable materials, lack of sustainability measurement tools, lack of advanced software, lack of chronic skills and shortage of labourers, technical ability etc. are the barriers which are considered as technical hurdles because they have straight impact on the accomplishment of carrying out of sustainable structure practices. Designers of building projects are not aware or confident about the issues of sustainable constructions design. It is very important that technical information on sustainable construction is made accessible to design professionals in a suitable format and to contractors as well are made responsible for implementing the design [20].

### **Comp 5- Socio-cultural barriers**

Although modern Bhutan has seen some major changes in construction industry in last few decades, from mud blocks and timber to concert and steel this has not aid Bhutan in implementation of sustainable construction practices. Just like in Bhutan the socio-cultural barriers also affect the SC in Ghana. The Ghanaian construction industry has been used for over the decades and it is still being used up till the present. Though it been used for many years, it is very difficult to change their methods especially the materials that are used in the sites. Construction in Ghana prefers to use blocks and reinforce concrete and discourage any other alternative materials for the building projects and their services [21].

### **Comp 6- knowledge and awareness barriers**

Although Bhutan encourages the idea of sustainable construction practise but it has never been mainstream in Bhutan which is one of the reasons professionals lack sound knowledge and awareness. Sustainable building projects can be hindered by ignorance or lack of information about understanding sustainability. The construction industry is compose of various stakeholders with different roles (clients, consultants, and contractors) who have to work as a team to successfully complete a project. Therefore, the need to create awareness is very fundamental for sustainability of construction industry [20]. Besides all these, lack of training among engineers and professionals who are involved in construction process is another barrier for sustainable construction. As they are not trained well, they fail to meet the expectations of the clients and they fail to meet the demand of the market due to lack of awareness and knowledge that are needed for building projects [22].

## **6. How to achieve sustainable construction**

In order to achieve sustainable construction in building industry, multi-disciplinary approaches need to be adopted covering number of features such as: energy saving, improved use of material, material waste minimization, pollution and emission control. There are many solutions in which the current nature of construction activities can be improved and controlled to make it less environmentally damaging, without reducing the useful output of construction activities [24].

### **6.1 Renewable energy sources**

Due to depletion of conventional energy resources and its associated environmental issues, utilization of renewable energy has become necessary in achieving sustainability in construction industry. Utilization of renewable energy in construction industry has become priority for many countries to mitigate the impact of conventional energy resources. There are some credits for implementing renewable energy in sustainable building assessment tools. Utilization of renewable energy in construction industry helps to reduce energy consumption as well as the greenhouse gases emissions. The commonly used renewable energy sources in sustainable building includes, small scale wind turbine, solar PV, geothermal heat pump and solar heat water. Indeed, the utilization of renewable energy helps in achieving net zero energy building [1]. Therefore, utilization of renewable energy sources in construction industry has become crucial to achieve sustainability in construction industry.

## 6.2 Energy conservation

Construction industry consume energy at each stage of design, construction, operation and final demolition. During life cycle of a building, large amount of greenhouse gases is emitted to the atmosphere in different ways over different period of time. The energy consumption can be largely reduced by improving the efficiency, which is an effective way to reduce Greenhouse gases emission and to slow down the depletion of non-renewable energy resources. Energy use in a life cycle of sustainable building includes energy needed for both operational and embodied energy [24]. The various methods and strategies need to be implemented in construction sector to conserve energy and to achieve sustainability in construction. These methods include [25]:

1. **Site Selection:** Although site selection is usually based on price, a poor decision can exclude several sustainable features. Making the most out of what the site has to offer can be the difference between a high-performance building and traditional the traditional building.
2. **Orientation:** Providing proper orientation allows for passive solar gain and day lightning. In the northern hemisphere, south facing windows have the greatest exposure to the sun. West facing windows need to be carefully designed, as the low angle of the setting can cause overheating.
3. **Walls and Roof:** The building envelope is a significant in determining the amount of energy required to heat and cool the building. The problems in designing the walls, roofs and foundation is to minimize conductive heat loss or gain while minimizing uncontrolled movement of air into the building.
4. **Energy Efficient Appliances:** Using energy efficient and eco-friendly appliance is to reduce the utility cost. During purchasing new electrical appliances always need to look for BEE star rating. More stars indicate the higher efficiency of the appliances.

## 6.3 Water conservation

With the fast developmental activities across the world, depletion of water resources is becoming an environmental issue. The united nation world water development reports that water required for various purposes is becoming scare and is leading to a water crisis [24]. Building construction and its operation consumes huge amount of water and it is causing significant reduction of water table. Therefore, to achieve sustainability in construction industry various strategies and technologies needs to be implemented to save water throughout the life cycle of a building [24]. This methods and strategies include:

1. Utilizing water-efficient plumbing fixtures such as waterless Urinals, ultra-low flow toilets and urinals, water-efficient dishwashers, low-flow and sensed sinks, low-flow showerheads, and washing machines, are used to minimize wastewater.
2. Design for dual plumbing is to use recycled water for toilet flushing or a grey water system that recovers rainwater or other non-potable water for site irrigation. Gray water does not need to be treated intensively as sewage. It can be recycled in a building to irrigate ornamental plants or toilet flushing.
3. Collecting rainwater using rainwater and grey water storage for irrigation reduces the consumption of treated water. Rainwater can also be used for household activities including drinking water. Across many regions of the world people have relied on harvested rainwater for their water supply.
4. Employing re-circulating systems for centralized hot water distribution, which save water, that is typically wasted by users while waiting for warm water to flow from a warm water faucet.
5. Designing low-demand landscaping using plants native to the local ecosystem also reduces water consumption on site of construction, since these plants have been adapted to the local rainwater levels, hence it eliminates additional water required. The efficiency of water can be improved by means of underground drip irrigation systems, which reduces water loss caused by evaporation of surface water during watering or after rain.
6. **Pressure Reduction:** The flow rate is related to pressure, and the maximum water flow from a fixture operating on a fixed setting can be decreased if the water pressure is reduced. For an instance, reduction in pressure from 100 pounds per square inch to 50 psi at an outlet can result in a water flow reduction of about one-third.

## 6.4 Material conservation

Extraction and consumption of natural resources as building materials has a direct impact on natural bio-diversity due to the fragmentation of natural areas and ecosystems caused by construction activities [24]. Large amount of minerals resources is consumed in the built environment and most of these mineral resources are non-renewable. Hence it is important to reduce the use of non-renewable materials. Therefore, this should be incorporated for consideration at the project initiative and design phases, where the selection of materials is very important and the choice should be based on the materials' environmental impacts. At the construction and deconstruction phases, various methods can also be used for reducing the impacts of materials consumption on the natural environment. The sub-section discusses some of the methods to be considered to achieve material efficiency in construction industry.

#### 6.4.1 Design for Waste Minimization.

The construction sector is one of the major waste generators, which causes several environmental, economic and social problems. Waste is usually generated during construction and demolition processes. Reduction and prevention of waste in the construction industry can save considerable amounts of non-renewable resources. Waste reduction should be addressed to achieve sustainability in construction industry. This can be done by: Reducing and recovering of construction waste, Reusing and Recycling of construction waste, the storage and disposal of construction waste [24].

- a) *Reducing and recovering of construction waste:* The most effective measure to reduce the environmental impact of construction waste is by preventing its generation and reducing it as much as possible. An analysis has shown that recovery of construction waste reduces the amount of waste generation and Green House Gas (GHG) emissions, it saves energy, and reduces the use of raw materials. Recovery of useful energy and materials from wastes has been emphasized as one of the most important environmentally friendly measures for achieving energy savings to combat the pressurizing energy situations.
- b) *Reusing and Recycling of construction waste:* Recycling of products reduces the environmental impacts, particularly the use of resources and waste creation. The reusing of building materials is an alternative for the reduction of construction and demolition waste. While renovating and demolishing the buildings, it enables the recovery of building parts as functional components such as bricks, windows, tiles, in which these parts are transformed back into raw materials to processing. Designers should carry out pre-demolition audit of buildings that are being demolished to discover whether any materials or components can be reused further for new construction activities.
- c) *The storage and disposal of construction waste:* In the situations where the construction waste could not be recovered and prevented, they need to be stored in an appropriate manner and kept under control. Non-hazardous construction debris and construction debris classified as special waste are landfilled in either municipal solid waste (MSW) landfills or in landfills that only accept construction debris. Designers needs to be aware and take into consideration the policies and guidelines for material storage and disposal during the design stage of construction project.

#### Conclusion

Sustainable construction is the one of the measures that has been put forward to mitigate the adverse impact of construction activities on environment, economy and society. Sustainable construction is considered as a measure for the building industry to move towards protecting the environment. The promotion of sustainable construction practices is to pursue a balance among environment, economic and social performance in implementing construction projects. Construction industry is of high economic significance and has strong environmental and social impacts. With the growing awareness on environmental protection, sustainable construction has gained wider attention from construction industry worldwide. Implementation of sustainable construction practices has been advocated as a way in fostering economic advancement in the construction industry while minimizing impact on the environment.

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