BHUTAN GREEN BUILDING DESIGN GUIDELINES

The Engineering Adaptation & Risk Reduction Division
Department of Engineering Services
Ministry of Works and Human Settlement, Bhutan

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FOREWORD

The Ministry of Works and Human Settlement is pleased to bring out the first publication of **"Bhutan Green Building Design Guidelines"** a much needed reference at this point in time in our country.

Our Ministry undertook major internal restructuring in the Year 2012 in order to reorient the organization towards larger national concerns and also to strategize focused action plans contributing towards the vision of GNH. Our natural and the built environment in particular, need inclusive attention to bring out holistically appropriate action plans for development.

The Ministry has purposely made this Guidelines as simple as possible while attempting to appreciate and keep it in context of our unique and rich traditional environment.

Through this first Green Building Guidelines, the Ministry call on all architects, engineering professionals, contractors, developers, manufacturers and the public at large to rethink and seriously consider the need for adopting green designs and sustainable technologies.

We have now reached a critical juncture in time where architects, engineers and agencies must review, change and adapt our outlook and practices so that the built environment is not at the expense of, but in harmony with our country's innate pristine environment.

Green and sustainable approach is a sensible key action Bhutan can easily contribute towards global climate change alleviation besides contributing to the enhancement of healthy domestic construction industries. Therefore, it is sincerely anticipated that all stakeholders will take full advantage of this Guidelines and also appreciate any relevant comments for incorporation in its next edition.

Lastly, I would like to acknowledge the valuable contributions made by all in developing this document.

Tashi Delek.

Ministry of Works and Human Settlement,
Thimphu, Bhutan.

PREFACE

The Bhutan Green Building Design Guidelines is the first formal step by the Ministry of Works and Human Settlement of the Royal Government of Bhutan towards ensuring that buildings in Bhutan are designed and constructed in a green and sustainable way.

As an initial undertaking in Bhutan, the Guidelines takes into consideration the current context in Bhutan where resources, building technology and skills that are accessible to people are comparatively modest and limited. In view of this context, the Guidelines is thus drafted to introduce for the most part basic concepts of green design and construction principles and approaches that will be practical for consideration and easy application in the different parts of Bhutan.

The Guidelines therefore avoids complex energy calculations, simulation models and reliance on imported systems, equipments, and advanced construction technologies that are rarely readily available in the different regions of Bhutan, are unaffordable to most people in Bhutan, and currently have to be exported from other countries.

In the future, as Bhutan moves steadily towards a carbon neutral and zero energy built environment, and awareness of sustainable approaches in the built environment in the country develops with specialists, modern technology and systems more easily available, the Bhutan Green Building Guidelines are to be revised and adapted to take these advances and resources into account.

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INTRODUCTION

The Bhutan Green Building Guidelines is inspired by the principles of Gross National Happiness (GNH) which ensure the integration of equitable economic development with sensitive environmental and cultural conservation. It is also in line with Bhutan's pledge to tackle climate change and its commitment to remain carbon neutral for all times to come which was made at the 15th session of the Conference of Parties of the United Nations Framework Convention on Climate Change.

Over the last decade, with rapid urbanization and economic growth, the built environment in Bhutan has grown to become a sector that has one of the largest impacts on our environment. The need for green and sustainable guidelines in the building design and construction sector in Bhutan has become urgent and crucial.

Principles of green building design and construction are simple yet extremely effective ways of allowing people to become responsible with energy and natural resources while designing and building their homes, neighbourhoods, and cities. Buildings with green and sustainable design consume fewer natural resources for construction, operation, and maintenance. They have far less environmental impact than the numerous conventional concrete buildings that are currently being designed and constructed almost everywhere in Bhutan.

Till date, no formal models or guidelines exist in Bhutan for the built environment that tackle climate change or provide tangible green solutions to the built environment. The Bhutan Green Building Design Guidelines developed by the Engineering Adaptation and Risk Reduction Division of the Ministry of Works and Human Settlement is intended to meet this gap. It introduces simple practical green building design and construction principles and solutions that can be adopted in Bhutan.

The hope is that this Guideline contributes towards bringing humanity into positive balance with our natural environment and the limited resources of our country and our planet. Ultimately, the aspiration is to advance the holistic wellbeing and happiness of the people of Bhutan while also minimizing the negative impact on the natural environment by the built environment.

OVERVIEW OF THE GUIDELINES

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OBJECTIVES OF THE GUIDELINES

The Bhutan Green Building Guidelines has been prepared to inspire positive change in the built environment of Bhutan. The wish is to motivate policies, regulations, standards, and projects that will minimize negative impacts of the built environment on the natural environment of Bhutan while enhancing the positive impacts of sustainable building design and construction practices for the present and future generations. The primary objective of the Bhutan Green Building Guidelines is thus to encourage the adoption and implementation of green design and construction practices in Bhutan.

As the first Green Building Guidelines in Bhutan, the Guideline does not rely on complex calculations, and use of imported systems and appliances are not be practical or affordable in Bhutan.
It provides simple information and recommendations for local professionals, builders, owners, and institutions to easily integrate and apply principles of green design and construction into their building design and construction projects.

SCOPE OF THE GUIDELINES

a. The Bhutan Green Building Guidelines provides information, recommendations, and guidance to incorporate sustainable green principles and approaches mainly for new design and construction of buildings in Bhutan.
b. The Bhutan Green Building Guidelines which is meant as an introductory initiative is meant to serve as a springboard to inspire voluntary efforts. Therefore, at present, compliance of the recommendations will not be mandatory.
c. It should be used in conjunction with other Acts, Codes, Regulations, and Standards related to the built environment in Bhutan and associated environmental considerations.
d. The primary audience for these Guidelines is architects, engineers and other professionals of the design teams who are contracted to design and construct buildings. As the chapters in the Guidelines are compiled in a simple straightforward manner it will also be an easy reference for building owners, operators, project managers, local authorities, occupants of buildings, and the general public in Bhutan.
e. The Bhutan Green Building Guidelines will serve as a source of information for the enforcement of the Bhutan Green Building Codes should they come into enforcement.

HOW TO USE THE GUIDELINES

The Guidelines is not intended as an absolute detailed guide to green design and construction. It is intended as an introduction to basic concepts and solutions of sustainable green design practices and principles for the built environment of Bhutan.

The chapters in the Guidelines are informative in its intent rather than prescriptive. It is thus enabling rather than regulatory. It is not intended to prevent the use of any techniques, designs, material, methods of construction, or any new and innovative approach not specifically prescribed herein, if such construction, design, systems, or innovative approaches are within the objectives of the green design and construction principles. Primarily, the Guidelines are in the end meant to support new building proposals to exceed current basic conventional standards to ensure higher levels of sustainability and green practices in the built environment of Bhutan.

For convenience of presentation, the framework of the Bhutan Green Building Guidelines is divided into 10 main Sections. These Sections address and track key stages of progression generally followed in Bhutan in the design and the construction of a building starting from pre-design concerns to construction waste management strategies to sustainable operation and maintenance of completed buildings.

The 10 SECTIONS within the Bhutan Green Building Guidelines include the following:

SECTION 1: PRE-DESIGN FOR SUSTAINABILITY
SECTION 2: PLANNING AND DESIGN
SECTION 3: SUSTAINABLE SITE DEVELOPMENT
SECTION 4: GREEN MATERIALS AND RESOURCES
SECTION 5: ENERGY EFFICIENCY IN DESIGN
SECTION 6: WATER EFFICIENCY AND CONSERVATION IN BUILDINGS
SECTION 7: INDOOR ENVIRONMENTAL QUALITY
SECTION 8: GREEN CONSTRUCTION MANAGEMENT
SECTION 9: MANAGEMENT OF WASTE FROM CONSTRUCTION
SECTION 10: OPERATION AND MAINTENANCE

ADMINISTRATION AND ENFORCEMENT

The administration of the Bhutan Green Building Guidelines will be lead by the Engineering Adaptation and Risk Reduction Division of the Department of Engineering Services of the Ministry of Works and Human Settlement of Bhutan in consultation with relevant agencies and stakeholders.

The Ministry of Works and Human Settlements may identify the specific offices within the Ministry for the propagation and processes relevant to the Guidelines. These offices will subsequently formulate necessary regulations and activities to take these Guidelines forward as codes and regulations within the different sectors and Districts of Bhutan.

ASSESSMENT ROUTES AND RATING SYSTEMS

The offices identified under the Ministry of Works and Human Settlements will be responsible for formulating the assessment routes and rating systems for green building design and construction practices in Bhutan in consultation with relevant agencies and authorities.

AMENDMENT OF THE GUIDELINES

The key to success for sustainability is the ability to change and adapt. Acknowledging that sustainability is an ongoing evolving process rather than static, the Guidelines provide a starting springboard for green design and construction practices in Bhutan.

The intent is that the Bhutan Green Building Guidelines is always kept up to date by the Ministry of Works and Human Settlements. It should therefore be reviewed, revised and publicly promulgated by appropriate professionals on a 2-year cycle to allow for the integration of new and improved green design and construction ideas, strategies and technologies in the built environment of Bhutan.

GREEN BUILDING BASICS

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DEFINITION OF GREEN BUILDING

There are many definitions of the term “green building”. Some definitions stress more on the operation and performance of a building while others regard green buildings in a more holistic style to include the wellbeing and health of the occupants of the building.

The green design and construction practice goes beyond the conventional building codes and practices. It considers the entire life cycle of a building, which includes planning, design, construction, operation, maintenance, and also demolition and disposal. All aspects including the environmental, economic and social effects of a building as a whole are considered.

Buildings, which are green, are thus tailor-designed and adapted in a responsive way to their environmental context so that people, communities and ecosystems can develop and thrive side by side. Green buildings integrate consideration of resource and energy efficiency, ecologically and socially sensitive land use tactics and strategies to reduce waste, pollution and degradation of eco-systems. They are crucial in the step towards achieving sustainability for the planet and its occupants.

According to the American Society for Testing and Materials (ASTM) a green building is defined as:

“ a building that provides the specified building performance requirements while minimizing disturbance to and improving the functioning of local, regional and global eco-systems both during and after its construction and specified service life” (ASTM E2114).

The Environmental Protection Agency of the US states that:

“Green building is the process of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building’s life cycle from siting to design, construction, operation, maintenance, renovation and deconstruction.”

THE NEED FOR GREEN BUILDINGS IN BHUTAN

Studies around the world show that the design, construction, operation, maintenance, and demolition of buildings have a strong impact on communities, the natural environment, and the economy. The construction of buildings not only has impact on the immediate building sites but also impact areas beyond their immediate location. They affect forests, watersheds, air quality, transportation patterns and often the social integrity of local communities. Buildings have been shown to be responsible for around:

- 40 % of the world's total energy use
- 25 % of total timber harvest
- 16 % of fresh water withdrawal
- 50% of ozone-depleting CFCs still in use
- 30% of raw materials consumption
- 35% of the world's CO_2 emissions
- 40% of municipal solid waste destined for local landfills

According to the 2012 Bhutan Energy Efficiency baseline Study by the Department of Renewable Energy, Bhutan, buildings are one of the highest energy consumers in Bhutan. In the year 2011, they accounted for 48.7% of total energy consumption.

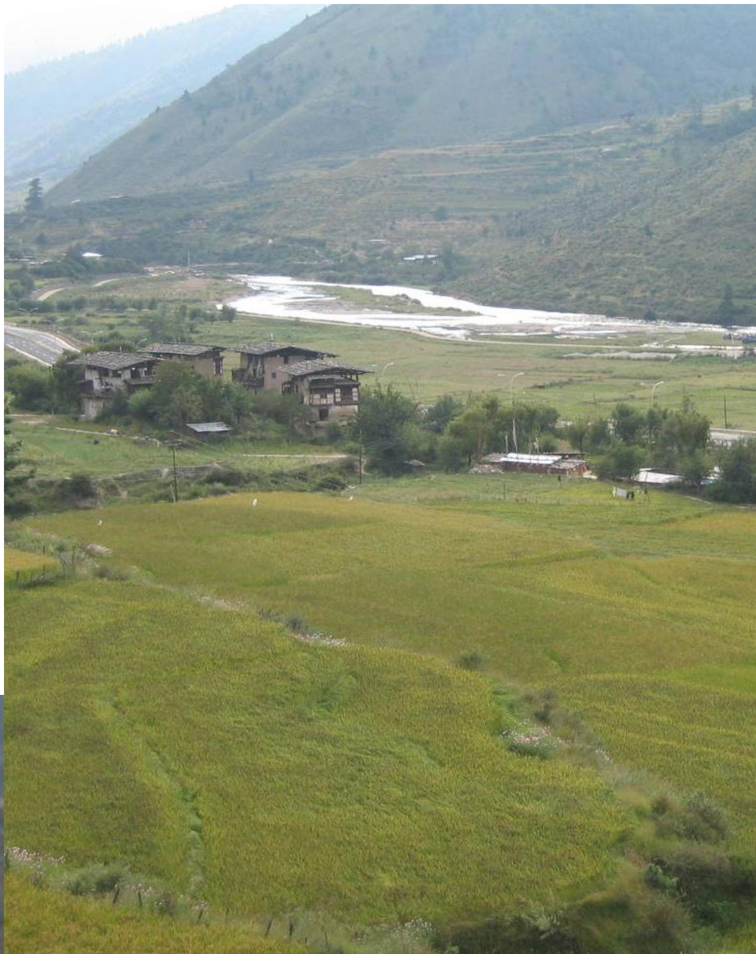
Rapid urbanization in Bhutan over the past few decades has resulted in the sector being one of the largest material resource consumers, the main contributor towards environmental degradation and the loss of many local eco-systems in the different regions of Bhutan. The problems with waste and sewerage from buildings and construction processes have swelled in Bhutan in the past decade more than any time in the history of the country. It is very clear that there is an urgent need that the current practice of design and construction of buildings in Bhutan requires far more consideration and sensitive transformation.

Although Bhutan's core principles of development found in GNH aspire towards environmental conservation, there are no specific frameworks for green building design and construction in Bhutan. The reality is that the majority of buildings designed and built in Bhutan especially in the past decade are neither green nor sustainable. Inadequate technical knowledge and skills, lack of financial incentives and mechanisms, lack of awareness, and limited market for green products are some examples of obstacles. Further, recent cultural-social norms within which Bhutanese people often generally aspire towards buildings constructed with imported materials, technology and labour in the name of modern development is also a key barrier towards the move to green buildings in Bhutan.

Green principles in the design and construction of buildings is however not new in Bhutan. Local Bhutanese vernacular traditions of building design and construction that have been practiced and passed down from generation to the next are fine and very visible examples of sustainable architecture.

The use of low energy local construction methods and natural resources coupled with designs that was adapted to respond to local climatic environment found in vernacular architecture in Bhutan embody the core principles of green buildings.

However, in the past few decades of rapid urbanisation in Bhutan, these simple yet effective vernacular building design and construction practices have been largely abandoned in favour of poorly designed modern reinforced concrete structures constructed with imported materials and labour.



Year 2005

Babesa village in Thimphu

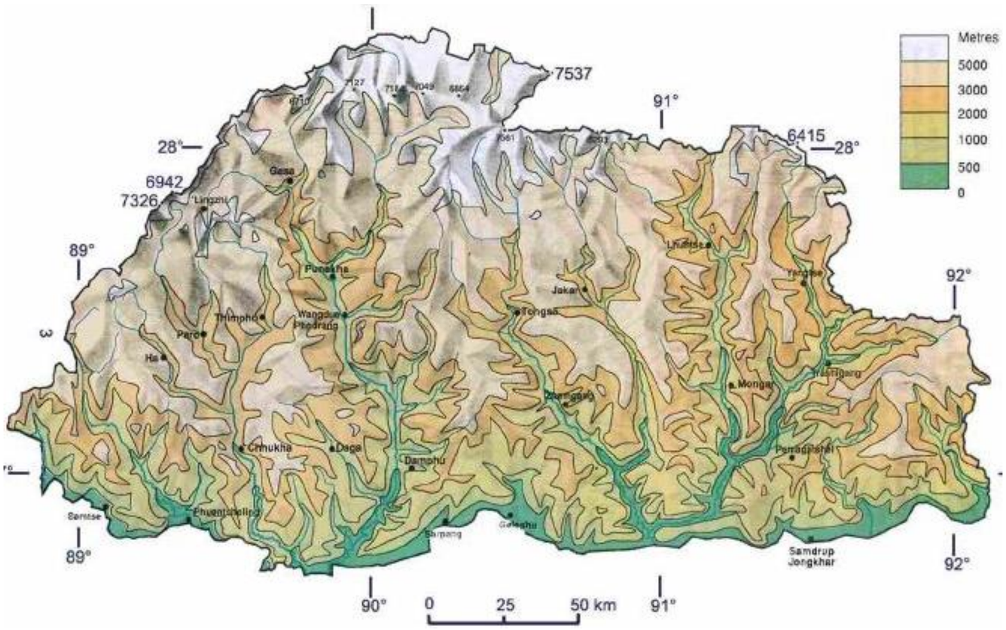
Year 2012

The same village in Thimphu

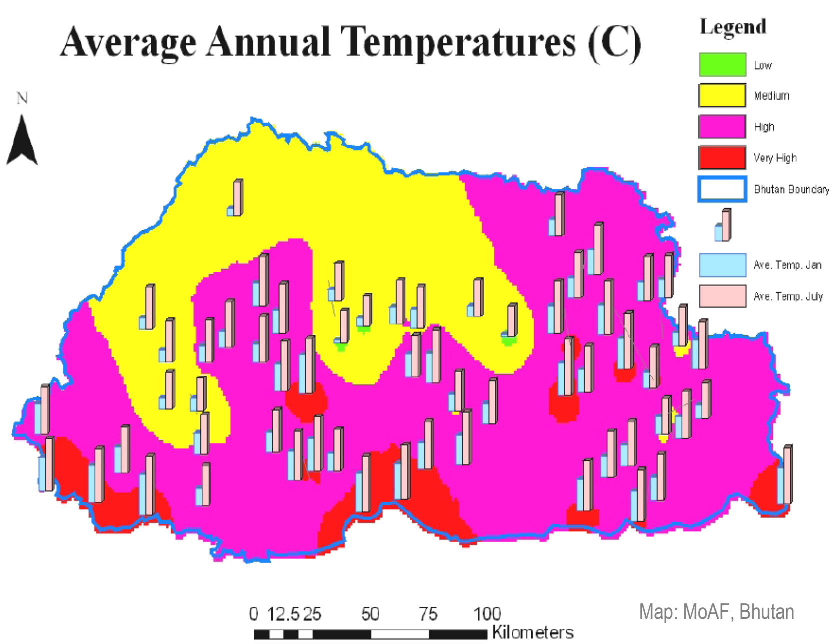
Today with the world's focus on green and sustainable objectives, the values and benefits of the principles found in local vernacular architecture are once again being acknowledged and are making a comeback in many countries around the world.

This awareness is also slowly creeping back into Bhutan. The use of natural rammed earth normally found in local Bhutanese architecture in the construction of recently built resorts and institutional buildings in Bhutan are few examples.

In spite of its small size of area, Bhutan has three distinct climatic zones. This is due to its topography that ranges from sub-tropical conditions in the south at elevations of just around 160 metres above sea level to temperate conditions in the central regions, and harsh alpine conditions in the north with elevations of more than 7000 metres above seas level.



Topography Map: South Asian Floods



Map: MoAF, Bhutan

The diverse environmental and climatic conditions in Bhutan consequently mean that human settlements in the different zones of Bhutan require specific design considerations that are suitable to the particular climatic context.

Since green design considerations are directly related to local climate, this diversity in climatic conditions should be taken into consideration for green buildings in Bhutan. The position of Bhutan within the eastern Himalayan chain of mountains offers favourable conditions of high sunshine periods especially during the cold dry winter seasons and this advantage must be considered for the colder areas of Bhutan.

However, the reality in Bhutan is that presently there is only one overall Bhutan Building code and Architectural Guidelines that governs all regions of Bhutan. This means that the design of buildings and cities in Bhutan do not effectively take local climatic and environmental factors or regional architecture into consideration. This Guidelines provides a preliminary stepping-stone towards trying to correct this.

Several approaches can be applied to promote and accelerate the transformation toward a more green and sustainable built environment in Bhutan. Besides the development of green building codes and other required standards, incentives such as green tax breaks and subsidies, arrangement of trainings and awareness programs and provision of grants and special soft construction loans for green buildings all go a long way towards motivating and speeding the transformation towards green buildings.

AIMS OF A GREEN BUILDING

The main aims of a green building are to:

- Integrate sustainable design into project development and execution processes
- Minimize the demand on non-renewable resources
- Minimize disturbance to site conditions and eco-systems
- Maximize the utilization efficiency of resources when in use
- Maximize the use of efficient building materials and construction practices
- Optimize the use of on-site situations and sources by insightful architectural practices
- Use minimum energy to power itself
- Use efficient equipment to meet its lighting, heating, and air-conditioning needs
- Maximize the use of renewable sources of energy and materials
- Use efficient waste and water management design and operation practices
- Minimize external pollution and environmental damage
- Consider environmental impacts and waste minimization
- Reduce operation and maintenance costs
- Provide comfortable and healthy indoor conditions for its occupants
- Increase the wellbeing of people while bringing them, their needs and their activities into positive balance and harmony with the natural resources and conditions of our planet

PROS AND CONS OF GREEN BUILDINGS

Like any practice, there are pros and cons in green buildings. However, the pros far outweigh the cons. From just a reactive process simply set as marks to try to fulfill requirements set forth in project outlines, green design and construction is now appropriately becoming mainstream and proactive in the built environment of countries around the world.

PROS OF GREEN BUILDING DESIGN AND CONSTRUCTION

Besides conserving our environment and its natural resources, green design and construction offer many benefits. Some are quantifiable but there are many which may not be tangible but nonetheless are important for us. Some of the pros of green buildings are:

- Increase in the wellbeing of people by offering well designed positive spaces that are in tune with the natural environment and lighting
- Improvement in the health and life of people by offering non-toxic improved indoor air quality
- Longer life and durability of structures, which help to reduce maintenance costs and time
- Reduction of construction and demolition waste
- Better long-term economic performance and returns on investments in buildings
- Increase in innovation in design of products
- More occupant satisfaction due to sensitive design and planning
- Increase in savings for individuals, families and businesses from reduced costs for services
- Improved productivity in workplaces and schools

Pros of green buildings are detailed further in the table below:

BENEFITS OF GREEN DESIGN AND CONSTRUCTION			
	Environmental	**Economic**	**Societal**
Siting	Land preservation, reduced resource use, protection of ecological resources, soil and water conservation, reduced energy use, less air pollution	Reduced costs for site preparation, parking lots, and roads; lower energy costs due to optimal building orientation; less landscape maintenance cost	Improved site use and increased transportation options
Water efficiency	Lower potable water use and pollution discharges to waterways; less strain on aquatic ecosystems in water scarce areas; preservation of water resources for wildlife and agriculture	Lower first cost (for some fixtures); reduced annual water costs; lower municipal costs for wastewater treatment	Preservation of water resources for future generations and for agricultural and recreational uses; fewer wastewater treatment plants and associated impacts
Energy efficiency	Lower electricity and fossil fuel use, less air pollution, and fewer carbon dioxide emissions; lowered impacts from fossil-fuel production and distribution	Lower first costs, when systems can be downsized due to integrated energy solutions; lower fuel and electricity costs; reduced demand for new energy infrastructure; lowering energy costs to consumers	Improved comfort conditions for occupants; fewer new power plants, transmission lines, and associated impacts
Materials and resources	Reduced use of virgin and endangered resources, healthier forests due to better management practices, lower energy use for material transportation; reduced strain on landfills, increase in local recycling	Decreased first costs due to material reuse and use of recycled materials; lower waste disposal costs; reduced replacement costs for durable materials; reduced need and costs for new landfills	Fewer landfills and associated impacts, greater markets for environmentally preferable products, decreased traffic due to use of local/regional materials
Indoor environmental quality	Better indoor air quality, including reduced emissions of volatile organic compounds (VOCs), carbon dioxide, and carbon monoxide	Organizational productivity improvements due to improved worker performance, lower absenteeism, reduced staff turnover.	Reduced adverse health impacts; improved occupant comfort, satisfaction, and employee productivity
Commissioning: operations and maintenance	Lower energy consumption, reduced air pollution and other emissions.	Lower energy and maintenance costs; reduced costs associated with occupant/owner complaints; improved building durability and longer equipment lifetimes.	Improved occupant productivity, satisfaction, health, and safety.

Table: the U.S. DEPARTMENT OF ENERGY Study

SOME CONS OF GREEN BUILDING DESIGN AND CONSTRUCTION

Some of the cons of green buildings include general confusion, misunderstanding, and lack of awareness of green concepts and measures. Apprehension over the overall economic costs of construction and the benefits of green buildings and lack of trained professionals are some major hurdles.

However, the biggest hurdle for the move towards green design and construction often appears to be due to fear of the unknown and of change. Often authorities, professionals, builders and homeowners acknowledge the need for change in policies but during actual implementation, they have the tendency to seek out and implement what they are used to and know.

In short some of the apprehensions and myths are:

- Green buildings are really only for die hard environmentalists
- Green buildings cost much more than conventional buildings and are for rich clients
- Green buildings take longer to construct
- Design of green buildings will require specialized professionals
- Use of green material are more expensive
- Green buildings look unusual and “rustic” and are note for those with modern outlooks.

However, these apprehensions are all usually due to lack of awareness. Such myths and misunderstandings must be addressed since moving towards green design and construction is essential.

Myth:

Green buildings are really only for die-hard environmentalists

Although environmentalists initially advocated for and promoted green design and construction principles and practices, green buildings are now going mainstream all over the world. Besides benefits to our planet and local environments, in addition, green buildings offer far healthier environments and far-reaching positive benefits to people and communities. The road to green buildings no longer applies just to environmentalists. It is for everyone. It is about doing right for you, your children, for humanity and for our planet.

Myth:

Green buildings cost more than conventional buildings and are for rich clients

The common misconception that green buildings are significantly more expensive than conventional buildings is often promoted by people who are ignorant about green concepts. Although it is true that there are a few components in green building design and construction that may be a little more costly than conventional buildings, many components do not have any additional upfront cost at all. For example, using passive solar design and smart orientation in green buildings do not cost anything extra.

Many studies also show that the more expensive components of green buildings in the end lead to substantially lower operation and maintenance costs. There are significant savings in heating and cooling bills over the life of the building that more or less takes care of the initial upfront cost and more often than not works out to be far cheaper in the long term. Many attributes of green building usually bring capital cost savings to construction, while other attributes bring appreciable operational cost savings which include energy efficiency in all its forms. Besides these direct saving, the indirect savings such as improved health, less exposure to carbon emissions, and increases in productivity are indirect benefits that make a huge impact on the wellbeing and lives of people.

The US Green Building Council estimates that around 1 percent is added to the upfront cost of the building when you go green in the USA. However, for this small upfront cost, the occupants get to live in healthy buildings and save on payments for water, and energy. If green concepts are kept in the forefront during the initial planning stages of a project, there are very little reasons why one cannot build a green building in Bhutan at the same cost as a conventional building. The path towards a green building is to achieve all the benefits at a cost that is affordable by smart and sensitive planning and implementation.

**Myth:
Green buildings take longer to construct**

It is completely baseless that green buildings take longer to construct than conventional buildings. Green design and planning often simply involves substituting one material for another which is more environmentally friendly, so there is very little or no effect on the construction duration. Since green buildings involve sensitive and careful planning and management, the construction time can often be even reduced.

**Myth:
Design of green buildings will require specialized professionals**

There are usually no additional costs for the design of a green building as many green design elements are straightforward. The additional costs for hiring architects specialized in green design for more complex green projects are also slowly disappearing as green design and construction professional studies are now part of the general curriculum in most architectural and engineering schools.

**Myth:
Use of green materials is more expensive**

Since green design and construction is rapidly becoming mainstream, products are now becoming cheaper and readily available in markets around the world. Some green products are recycled and are therefore often cheaper to produce. Advances in recycling are increasing every year and costs for green materials are steadily being reduced. Green materials such as earth and bamboo are natural and do not require processing costs in factories. Green materials are also usually locally available and therefore transportation costs are less.

**Myth:
Green buildings look "rustic" and strange**

A green building comes in all shapes, designs, and sizes ranging from a small traditional family home to multi-storey modern commercial buildings. One can make any building into a green building. A green building therefore does not have to look primitive or "rustic". Since the design and construction of green buildings involves sensitive planning and special consideration to the local context of a site, green buildings can often be more aesthetically pleasing and far more pleasant than conventional standard buildings.

SOME ECONOMIC BENEFITS OF GREEN BUILDINGS

Tackling global warming is not the only policy reason to promote green building; it also makes very good economic sense. Green building and construction measures must be thought of as investments which will gain value over time and make very good long-term economic sense to the country. Green buildings are often perceived to be more expensive than conventional buildings. Although in instances especially where hardware and special materials are used, the costs for a green building may be more upfront than conventional buildings in Bhutan, the savings over the useful life of a building will make up for this initial upfront costs. For example, climate-sensitive design and energy technology use are said to cut heating and cooling energy consumption by 60 percent and lighting energy requirements by 50% in buildings in the USA. Many green building investments thus save enough money to more than pay for initial costs in the end.

Many other benefits of green design and construction are not easily quantified. This includes the improved comfort, health, and wellbeing of occupants of a green building, which translates into increased productivity, and less expenses for health issues. Studies in the USA show that employees in buildings with healthy interiors have less absenteeism and tend to stay in their jobs which can increase employee productivity by up to 16%. Sick Building Syndrome and Building Related Illness are also estimated to cost $60 billion per year in medical expenses and lost worker productivity in the U.S.A.

Recycling of waste from construction and demolition can also lead to considerable savings of landfill space which is important in Bhutan where land is scarce. For example, the Portland Trailblazers Rose Garden arena construction/demolition project in the USA saved an estimated $186,000 through waste diversion and recycling. Recycling furthermore leads to creation of new type of jobs which previously did not exist thus creating new economic opportunities to local people besides conserving the environment. Use of pervious paving and other runoff prevention strategies can reduce the size and cost of storm water management structures and flash floods while ensuring natural water tables are maintained. Losses and costly rebuilding measures are avoided by green measures.

In spite of a limited budget, many green building design measures are basically free and can be easily incorporated with no increase of up-front costs and in return these measures yield significant savings in operating costs. Some simple measures include smart design, passive solar heating and cooling measures, use of natural ventilation and lighting with sensitive consideration of the local environment while designing spaces for different functions in buildings.

SECTION 1:
PRE-DESIGN FOR SUSTAINABILITY

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Pre-design processes for sustainability are often overlooked for projects concerning the built environment in Bhutan. The tendency generally is to design and implement the project based on just the spatial requirements of clients and to then simply to tack on measures for sustainability and green practices as a mere objective of the program. In commercial private sector buildings and many publicly funded building projects pre-design measures are implemented mainly as a means to secure funding.

Since measures taken in this initial section of a project are fundamental in the direction and implementation of subsequent planning, design, construction, operation and project budget allocation decisions, this section is crucial for green design and construction in the built environment in Bhutan. The choices made in this Section will consequently have a stack effect on all aspects of the project and ultimately the project's success from a sustainable green perspective.

With environmentally sustainable principles and practices as a central tenet, Pre-design as a first step in the project should take into account the following:

1. Creating a vision and performance goal for the project
2. Sensitive Site selection for the building project
2. Outlining of the overall direction of the design and building program
3. Listing the Standards of the design and construction team
4. Forming a strong professional team for the project
4. Consideration of Codes and Legislation related to the built environment
5. Ensuring Project Budget estimation for green goals as a key component
6. Including the green intent in the entire process of the Project Schedule

The intention of the pre-design program must be to reinforce the idea that sustainability should underpin all design processes and construction activities taken for the building project.

It is also important to create a measurable vision for green building projects right from the start of the project. A vision might be to design, construct, and operate a building that achieves a certain Green Rating, or costs less to operate and maintain than similar buildings.

SITE SELECTION

Site selection refers to the choice of a site for a building. Site selection for Green Buildings is crucial to ensure that green principles and practices are incorporated right from the beginning of the project. In order to effectively reduce the overall impact of the built environment on the natural environment, it is necessary to first consider a building's position, both in terms of its location and context as well as within the site itself. On the site, the building should be designed with minimal footprint to minimize site disruption especially in areas that have fragile and unique environments.

Within a broader context, sustainable development looks to maintain as much open green space as possible within communities through the selection of previously developed land, the re-use of areas that seem unusable, and locating buildings in areas of existing development areas where infrastructure already exists rather than impacting on the environment to build additional infrastructure.

Sites should thus be developed to be compatible with the role of protecting environmental conservation values. Grey or brownfield sites that have been previously disturbed, or sites that have existing buildings and structures will be the most obvious sites for proposed new purposes or expansion of existing uses as new ecological areas will not be disturbed. However, existing disturbance and the degree of modification is only one factor to be considered.

Other features of a site and surrounding locality should also be taken into account. Experts can provide assistance in identifying a potential site's natural resources and environmentally sensitive areas.

Environmental assessment will provide a good start for identification of sites. Environmental assessment includes not only identification of the ecology of the site and its context and whether the proposal will be compatible with the existing settings but also the assessment of the physical and social management of the characteristics of the site and its immediate surrounding context. A comprehensive assessment of potential sites can help to also improve the building design and selection of ecologically sensitive final building design plan and footprint.

A **greyfield** site is any site previously developed, with at least 50% of the surface area covered with impervious material.

A **brownfield** site is a property of which the expansion, redevelopment or reuse may be complicated by the presence or potential presence of a hazardous substance,

Greenfield sites are those that have not been previously developed in any way. Development of greenfield sites should be avoided where possible.

GOOD SITE PRACTICES SHOULD:

- Integrate the building architecturally into the natural context of the site, which minimizes the appearance
- Minimize site-clearing to reduce costs
- Take advantage of natural site features, such as topography, sunlight, shade, and prevailing breezes, to promote energy conservation
- Preserve existing vegetation, which can reduce landscape maintenance costs
- Mitigate erosion to reduce topsoil loss and protect surface water quality
- Avoid the need for supplemental irrigation and fertilizer, to minimize groundwater and surface water pollution
- Manage for snow and snow melt run-off to reduce maintenance costs
- Preserving native vegetation to add character to the site and provide energy-conserving shade and wind protection. They also eliminate the waiting period for expensive new plantings to mature to provide the potential benefits of preserved vegetation.

- Carefully planned building placement should:
  - Maximize benefits for site occupants
  - Minimize storm water runoff
  - Minimize natural habitat disturbance
  - Protect open space
  - Reduce the risk of fire and erosion
  - Save energy by providing for solar energy utilization, daylighting, shading, and natural ventilation

- Maximize factors that contribute to the health and productivity of employees, such as:
  - Thermal comfort
  - Access to fresh air
  - Acoustic privacy
  - Aesthetic views
  - Functional outdoor space

Information from: LANL Sustainable Design Guide

THE DESIGN AND BUILDING PROGRAM

In normal standards of project selection for construction in Bhutan, there is not much attention given to the design and building program apart from what it will be in terms of design to the occupants or clients of the building. The normal practice is often to assume that a building can be designed and then someone may come along to make it energy efficient or green at a later stage. This is a misguided approach as initial strategic and design decisions may rule out green principles

For example, in the construction of an office for a public services agency in Bhutan, the building program usually never takes into consideration the larger impact the construction of the building could create on the surrounding community and environment. The building program simply specifies only the need of the agency for office in terms of related spaces. It seldom assesses how the construction will provide negative impacts or even positive enhancements to the community and environment. Often it is only during the construction stages that the program suddenly tackles needs for green practices.

Examining the environmental impact of decisions can affect the whole strategy when considering building options. Sustainability and green principles must be addressed comprehensively as an integral facet of the program philosophy and in all aspects of the building program. Green building practices should not be treated as just a separate specialist discipline to be added into the program. It needs to be fully integrated with the whole process from start to end. Within the parameters of green principles, the design and building program must be assessed and planned accordingly. This means that:

- In addition to the design space requirements of the building, the overall impact of the design and construction must be considered in a sensitive and holistic manner.
- How the design and construction will impact the local context must be channelled to ensure positive impacts on not just the occupants of the particular building but also the local surroundings and context of the site and communities near the site.
- At this stage, the parameters and framework for green design and construction needs to be defined and established firmly thus sowing seeds for overall sustainable design and construction strategies. This allows for decisions to be made and actions to be taken throughout the design and construction process following green perspectives as the key facet for the project.

A building's "life" spans its planning; its design, construction and operation; and its ultimate reuse or demolition. Often, the team responsible for design, construction, and initial financing of a building is different from those operating the building, meeting its operational expenses, and paying employees' salaries and benefits. However, the decisions made at the first phase of building design and construction can significantly affect the direction, costs and efficiencies of later phases.

> "In design and construction, it is always quicker, easier, and cheaper to change things on paper than in steel or concrete".

The conventional process for a construction project involves the initial project conceptualization, followed by pre-design, design, bid, construction, and occupancy. An environmentally responsive design process adds the elements of integrated building design, design and construction team collaboration, and the development of environmental design guidelines. These new elements must be incorporated into the project from the very beginning and carried throughout the project phases to the final occupancy of the building.

Conventional buildings often fail to consider the interrelationship among building siting, design elements, energy and resource constraints, building systems, and building function. Green buildings, through an integrated design approach, take into consideration the effect these factors have on one another. Climate and building orientation, design factors such as daylighting opportunities, and building envelope and system choices, as well as economic guidelines and occupant activities, are all factors that need to be considered in an integrated approach.

A multidisciplinary design and construction team can develop a building's functional and operational design to meet environmental and financial goals. Sustainable design has been shown to be most easily achieved through a whole-building design process. The whole-building design process is a multi-disciplinary strategy that effectively integrates all aspects of site development, building design, construction, and operations and maintenance to minimize resource consumption and environmental impacts. All aspects of a building design and construction must be considered as a single system, from the onset of the conceptual design through completion of the construction process.

All phases of design involve making various decisions. It is important to know when to make which decisions. If certain decisions are not made during the planning phases, the project will have to expend time and money later correcting conflicting design decisions, or the project will be deemed unsuccessful for not achieving the stated goals.

STANDARDS OF THE DESIGN TEAM

The development of the design and proposals for infrastructure in the context of green buildings requires sensitive and higher standards than conventional building proposals that are framed in the past in Bhutan.

If the design team does not have any appropriate training and experience in green design and construction principles then the subsequent results will not match the standards required for the development of green design and construction in Bhutan.

Therefore, the services of qualified and experienced professionals are necessary for the preparation of the design and construction proposals. They should be fully able to understand how to integrate all design and construction decisions so that the interrelationships of the different elements of the program are maintained in a holistic and sensitive way in order for practical rather than theoretical success.

The appointment of a suitable design team with a proven record of quality design and environmental sensitivity and the capacity to respond to the ecological and cultural conditions of the proposed building site should not be underestimated.

It is critical to the integration of the functions of development with the natural systems and environmental characteristics of the site. It is also essential that the whole team is involved in the design process from the beginning and is equally committed to the green approach rather than just the architect. Before ground is broken, all parties that will be involved in the project should understand that the building will be developed as a green building.

PROFESSIONAL DESIGN TEAM SELECTION

For any building project, the careful selection of the professional team of people to help you achieve the building is required. For a green building project, the client must ensure that certain standards of professional team selection are maintained. This means that for each project, the criterion for selection of the professional design team must be clearly specified right from the start of the program and within the project proposal. It should not be left only in the later stage of project contract bid evaluations as a criterion for selection of design teams as is the normal practice in Bhutan at the moment.

Professionals who are knowledgeable and experienced should be considered. A good Architect who will lead the design team and will usually lead every aspect of the building is vital to a successful project. Hiring good professionals may cost more initially but will save time, costs, hassles and stress and will usually even help to reduce costs during the construction stage which may be even more than the initial professional fees.

The selection of competent and appropriately qualified team will automatically ensure that principles of green design and construction are maintained right from the start of the project and throughout the project planning stage till the completion of the project. The standards for selection of the professional design team may be decided according to the complexities of the project.

One of the positive outcomes of the selection of an appropriate professional design team will also be that these professionals will not only provide the right guidance but will also ensure that principles and methods that may have been overlooked within the project program preparations will be subsequently be added or enhanced.

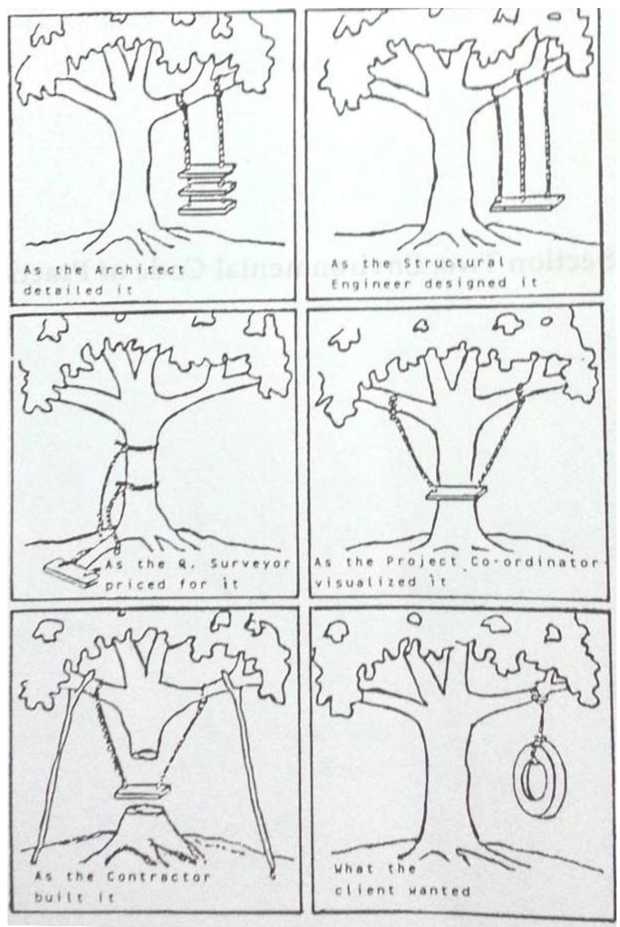

Illustration: The Building Services Research and Information Association

CONSIDERATION OF LEGISLATION AND CODES OF BHUTAN

The Guidelines should be read and applied in conjunction with all existing and applicable Regulations, Codes, Standards, Acts, and Guidelines for land, buildings, products, infrastructure, and environmental conservation. Some of the relevant Acts, policies, and regulations include:

1. Bhutan Building Rules 2002
2. Traditional Architectural Guidelines
3. Bhutan National Urbanization Strategy 2008
4. Thimphu Municipal Development Control Regulations 2004
5. Thimphu City Development Strategy 2008
6. Local Area Plans
7. Urban Structure Plans
8. Bhutan Schedule of Rates 2011
9. Land Act, 2007
10. Forest and Nature Conservation Act, 1995
11. Forest and Nature Conservation Rules, 2006
12. Thromde Rules of Kingdom of Bhutan 2011
13. Local Government Act 2009
14. The National Environmental Protection Act of Bhutan, 2007
15. Environment Assessment Act, NEC, 2000
16. Environmental Monitoring regulations of NEC
17. National Environment Strategy 1998
18. Regulation for Environmental Clearance of Projects from NEC
19. Environmental Codes of Practice (ECOP) for Storm water Drainage Systems, NEC 2004
20. Waste Prevention and Management Regulation 2012
21. The Water Act of Bhutan 2011
22. Renewable energy Policy, MoEA 2012
23. Bhutan Energy Efficiency Study by the Department of Renewable Energy, 2012

PROJECT BUDGET

In standard practices in Bhutan, there is no consideration of incorporating green design and construction principles within the budget of a project. This consideration is only incorporated or considered at a later stage usually as a singular clause during the formulation of the Design Brief while hiring the professional design team. Decisions for project budgets are also usually mainly cost led with the cheapest bids being preferred in almost all cases in the current practice. Within sustainable green practices however one has to take into account the lifetime and environmental costs of decisions and this means that the lowest initial cost is not always the best.

However, this does not mean that green design and construction needs to be more expensive than standard practices. Often the green choice can actually reduce initial costs, but even where they are increased, savings can be made over the life time of the building. Weighing up choices about specification involves assessing the payback in terms of savings of energy and reducing environmental damage in the long run

It is recommended that in order to ensure green building design and construction in Bhutan, that the requirement for the building design and construction to be green should be incorporated and enshrined within the project budget right from the initial cost estimating stage for the project to be approved by the funding authorities.

PROJECT SCHEDULE

In standard practices in Bhutan, there is no consideration of incorporating green design and construction principles within the schedule of a project. Time for this section allocated in Bhutan has also been minimal and design alternatives are hardly ever explored. This consideration is only incorporated or considered at a later stage only as a singular clause during the formulation of the Design Brief while hiring the professional design team or the construction contractor.

In order to ensure that green design and construction principles are part of the backbone of a project, activities for this consideration should be incorporated right from the start within the schedule of a project.

SECTION 2:
PLANNING AND DESIGN

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The green approach to design in architecture is not a new concept within the built environment of Bhutan. Our local vernacular architectural traditions of Bhutan are excellent examples of buildings that embody sustainability in design and construction.

With extremely sensitive and holistic approach to the environment, our local traditional vernacular buildings are located on sites selected carefully. Local and natural resources are usually used and they are designed to have orientations, spaces and forms that are in tune with the local climatic conditions, solar and daylight accessibility.

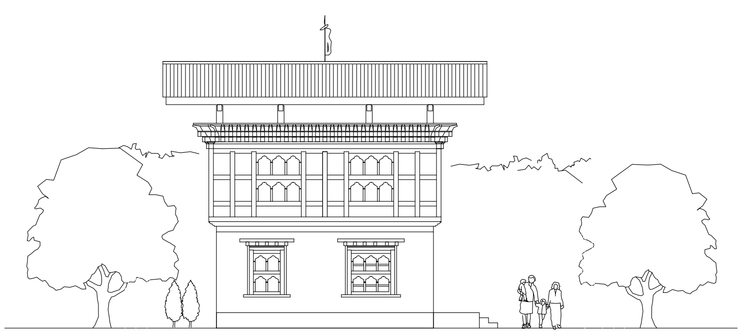
There are two main principles for green design planning. These include

1. Passive Strategies
2. Active Strategies

For Bhutan in order to achieve effectiveness through practical and cost efficient methods, passive measures as recommended as opposed to active mechanical or technical measures which uses power and fuel to operate:

The main passive measure includes:

1) Passive solar design with local climate considerations.
2) Building orientation
3) Natural ventilation
4) Natural lighting



PASSIVE SOLAR DESIGN WITH LOCAL CLIMATE CONSIDERATIONS

The basic idea of passive solar design is to allow natural daylight, heat, and airflow into a building when beneficial. The objectives are to control or enhance the entrance of sunlight and air flow into the building at appropriate times and to store and distribute the heat and cool air so it is available when required.

Many passive solar design options can be achieved at little or no additional cost. Others are economically viable over a building's life-cycle. Studies show that passive solar buildings use almost 47% less energy than conventional new buildings and 60% less than comparable older buildings. Properly designed and constructed, passive solar buildings offer many benefits to building owners and occupants, including:

- Energy Performance:
- High economic return on the incremental investment on a life-cycle cost basis and greater financial independence from future rises in energy and fuel costs.
- Greater thermal comfort, less reliance on noisy and expensive mechanical systems, solid construction (more thermal mass), sunny family friendly interiors, and floor plans.
- Low Maintenance: Reduced building maintenance costs resulting from less reliance on mechanical systems.
- Environmental conservation and less pollution: Reduced energy usage and reliance on fossil fuels.

Successfully integrating passive energy design strategies requires a systematic approach that begins in the **pre-design phase** and carries on throughout the **entire design process**. It is critical that the building owners and the design team agree to integrate passive solar design considerations during the appropriate project phases. The main design considerations include:

1) Careful siting of Buildings for solar accessibility
2) Careful siting of Buildings on the site for shading in hot climates
3) Sensitive Building orientation
4) Building massing for thermal storage
5) Designing for day lighting
6) Natural ventilation
7) Building form and sealing of building envelope where necessary

PASSIVE SOLAR DESIGN STRATEGIES

1. **Placement of Buildings on the Site**

   The buildings will be located to take advantage of the solar energy from the sun. The structures could be located more towards the northern side of the site to leave more space towards the South for gardens and views.

2. **Building orientation**

   The building should consider orientation towards solar radiation in cold places (and opposite in hot areas) to maximize exposure to the sun's heat for solar gain and light which is necessary in cold places in the many Parks of Bhutan.

3. **Insulated and air tight construction**

   The building should feature appropriate insulation levels and will have double glazing where possible to ensure no warmth from the building escapes outside and the cold doesn't seep in so there is no unnecessary heat loss. All doors and windows are to be airtight as far as possible so provisions for timber to be seasoned should be considered to prevent cracks between timber elements. Weather stripping used to close gaps around openings will also help prevent heat loss.

4. **Thermal Mass.**

   Thick stone masonry or rammed earth walls may be used to serve as thermal mass to insulate the building and to also absorb solar gains to heat the building.

5. **Orientation of rooms**

   In cold areas, all the main living areas where applicable are best orientated to the south to get as much as possible the natural benefits of the sun, while other areas like toilets, corridors, etc., could be located at the northern side. Main windows and balconies should be designed to face South and South-east for solar gain. North facing windows could be limited as there is no solar gain towards this direction.

6. **Building Form**

   The form of the buildings is best designed to try to expose as little as possible to the cold external temperatures in colder areas. Therefore it is not a sprawling or rambling building but will have a larger floor area when compared to the area of the walls and roof.

7. Building Envelope

The building envelope plays an important part in keeping out the external cold and keeping in warmer air inside the building. Therefore the building envelope is best designed to be air tight as much as possible.

8. Natural Ventilation

Natural ventilation through strategically placed window openings used for cooling and natural breezes for hot summers helps with natural ventilation therefore reducing the need for electrical appliances for cooling. Design must be sensitive and creative so that there is less dependency on fuel or power supported HVAC systems or fans.

PASSIVE SOLAR AND COOLING DESIGN

The following passive solar design strategies should be included during the building-design process.

- **Site Selection:**
  Evaluate building site options/positions for solar access and use of landscaping elements.

- **Programming :**
  Establish energy-use patterns and set priorities for energy strategies (e.g., daylighting versus efficient lighting); determine base-case conditions and conduct life-cycle cost analysis; establish an energy budget.

- **Schematic Design:**
  Maximize site potential by considering orientation, building shape, and landscaping options; conduct a preliminary analysis of representative building spaces as they relate to insulation, thermal mass, and window type and location; determine the available daylighting; decide on the need for passive heating or cooling load avoidance, lighting, and HVAC systems. Determine the preliminary cost effectiveness of options and compare the budgets.

- **Landscaping:**
  Landscaping can be aesthetic while designed as an integral part of the program by providing assistance through design use of critical shading or direction of natural air flow.

CRITICAL DESIGN AREAS TO BE USED AS A GUIDE FOR DESIGN

These include the following:

- Thermal Protection: Provides appropriate levels of insulation and minimal air leakage.
- Windows: Transmit heat, light, and air between interior space and the outside environment.
- Daylighting: Reduces lighting and cooling energy use; creates a better working environment, leading to increased comfort and productivity.
- Thermal Mass: Stores excess heat in winter; in summer, cools down during the night and absorbs heat during the day. This can help to shift peak cooling and heating to off-peak hours.
- Passive Solar Heating: Allows heat to enter the building during the winter months and rejects it during the summer months through the use of appropriate amount and type of south-facing glazing and properly designed shading devices. Most valuable in cooler climates.
- Energy-Efficient Lighting: Uses efficient lamps, ballasts, controls, and luminaries coordinated with daylight and color of interior space to provide the requisite level of light.
- Internal Heat-Gain Control: Minimizes heat gain generated by lights, people, and equipment through the use of daylighting, thermal mass, efficient equipment selection, and venting.
- Passive Cooling with Natural Ventilation: Incorporates controlled air exchanges through natural or mechanical means. Helps to increase energy performance of buildings in most locations.
- Energy-Efficient HVAC System: Reduces system load by integrating above-listed design strategies and using measures such as efficient motors, heat pumps, variable speed drives, and sophisticated building controls.

CLIMATE CONSIDERATIONS

Assess the local climate (using typical meteorological-year data) to determine appropriate envelope materials and building designs. The following considerations could be taken into account, depending on the climate type.

Hot/dry climates

In hot/dry climates use materials with high thermal mass where appropriate. Buildings in hot/dry climates with significant diurnal temperature swings have traditionally employed thick walls constructed from envelope materials with high mass, such as adobe and masonry. Openings on the north and west facades are limited and large southern openings are detailed to exclude direct sun in the summer and admit it in winter.

A building material with high thermal mass and adequate thickness will lessen and delay the impact of temperature variations from the outside wall on the wall's interior. The material's high thermal capacity allows heat to penetrate slowly through the wall or roof. Because the temperature in hot/dry climates tends to fall considerably after sunset, the result is a thermal flywheel effect-the building interior is cooler than the exterior during the day and warmer than the exterior at night.

Hot/moist climates

In hot/moist climates use materials with low thermal capacity.
In hot/moist climates, where nighttime temperatures do not drop considerably below daytime highs, light materials with little thermal capacity could be preferred. Roofs and walls could be protected by plant materials or overhangs. Large openings protected from the summer sun could be located primarily on the north and south sides of the envelope to catch breezes or encourage stack ventilation.

Temperate climates

In temperate climates, select materials based on location and the heating/cooling strategy to be used. Determine the thermal capacity of materials for buildings in temperate climates based upon the specific locale and the heating/cooling strategy employed. Walls should be well insulated. Openings in the skin could be shaded during hot times of the year and unshaded during cool months. This can be accomplished by roof overhangs sized to respond to solar geometries at the site or by the use of awnings.

Cold climates

In colder climates design air-tight and well-insulated building envelopes. The thermal capacity of materials used in colder climates will depend upon the use of the building and the heating strategy employed.

A building that is conventionally heated and occupied intermittently should not be constructed with high mass materials because they will lengthen the time required to reheat the space to a comfortable temperature. A solar heating strategy will necessitate the incorporation of massive materials, if not in the envelope, in other building elements. Where solar gain is not used for heating, the floor plan could be as compact as possible to minimize the area of building skin.

Assess the site's solar geometry: Solar gain on roofs, walls, and the building interior through window openings can be either a benefit or a hindrance to heating, cooling, and occupant comfort. A thorough understanding of solar geometry specific to the site is crucial to proper envelope design and should be applied.

BUILDING SHAPE AND ORIENTATION

- Choose the most compact building footprint and shape (as per the context of the site) that work with requirements for daylighting, solar heating and cooling, and function.

  The greater the amount of building skin in relation to the volume of space enclosed, the more the building is influenced by heat exchanges at the skin. Excluding consideration of window openings and glazing choices, if two building designs under consideration enclose the same volume, the one with the more compact plan will have greater thermal efficiency.

  A square floor plan is considered more thermally efficient than a rectangular one because it contains less surface area over which to lose or gain heat. However, this may not be the most efficient or desirable form when other considerations such as views, daylighting, passive solar heating and cooling, need for temperature variation, and occupant use patterns are included.

- Site and orient the building so as to minimize the effects of winter wind turbulence upon the envelope.

  The shape and orientation of the building shell has an impact upon wind turbulence and opportunities for infiltration through the envelope. However, an orientation that minimizes winter wind may also limit opportunities to make use of cooling breezes in summer. An understanding of the site-specific microclimate should be taken into consideration.

DRAFTING OF OUTLINE BRIEF FOR SUSTAINABILITY

The Outline Brief for sustainable green buildings should be incorporated as part of the Project schedule right from the time of the drafting of the project program and project estimate. This will ensure that sustainable principles are not left as only a special consideration within the project but are rather considered as heart of the building design and construction.

The drafting of the Outline Brief should be taken up by appropriate professionals who have the necessary training and education to ensure that the Outline Brief is not drafted and put together in a haphazard manner that will then jeopardize the project in the end and defeat the purpose of ensuring a green building not just on paper but also within the actual design, and construction.

The Outline Brief for a green building must be drafted to ensure that all design elements and construction activities are within the parameters of green design principles and goals rather than tacking green principles on as just a component of the Program.

DESIGN STRATEGY WITHIN GREEN PRINCIPLES

The normal practice in Bhutan for building design and construction projects is to incorporate green principles within the overall design strategy. However, for a green building, the design strategy must be within guided foremost by green principles rather than having green design principles tacked on as a mere component of the overall design strategy.

This ensures that all components and elements of the building are green right from the start including the allocation of activities and subsequent spaces, doors, windows, finishing, landscaping, etc.

SECTION 3:

BUILDING SITE DEVELOPMENT AND LAND USE

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The objective of site analysis during the site selection process is to identify the best site based on the physical, cultural, and regulatory characteristics of the site and its surroundings, as well as the site's adaptability to and compatibility with the proposed program. The main components for building site development and land use in the context of green buildings includes the following:

1. Survey of the ecological value of a site
2. Environmental clearance
3. Site analysis for green design and construction
4. Protection of ecological features
5. Ecological enhancement
6. Consideration of appropriate Materials, equipment and methods for site development
7. Minimising of the building footprint within the site
8. Situating new elements and buildings in context with local site conditions
9. Ensuring Sustainable landscaping design
10. Effective Storm-water management within the site
11. Sustainable parking design considerations

Some of the main principles that should guide sensitive site development include:

1. The building design should be in harmony with those beneficial site conditions and strive to save, reinforce, amplify, and improve on what is existing.
2. The main aim should be to minimize negative environmental impacts and to protect, restore and enhance the natural features and environmental quality of a site.
3. The chosen building site should add to the comfort and energy efficiency of the home built upon it

SITE ANALYSIS FOR GREEN DESIGN AND CONSTRUCTION

Site analysis is a vital step in the design process. It is a pre-design research activity which focuses on existing and potential conditions on and around the building site. It is an inventory of the site factors and forces, and how they coexist and interact.

The purpose of the analysis is to provide thorough information about the site assets and liabilities prior to starting the design process. Only in this way can concepts be developed that incorporate meaningful responses to the external conditions of the site.

Site analysis services may be performed by an interdisciplinary team or by an individual capable of directing the work of others. The skill in the initial evaluation of the physical features and quality of a site is fundamental. The designer leading a site analysis effort must be able to evaluate the site in terms of climate, topography, geotechnical and soil characteristics, utilities, natural features and surroundings, transportation and access, and other factors including historic preservation and landmarks

The typical site analysis includes the following:

1. Site location and size,
2. Neighborhood context,
3. Zoning,
4. Legal aspects,
5. Geology,
6. Physiography (natural and man-made features),
7. Hydrology,
8. Soils,
9. Vegetation,
10. Wildlife,
11. Climate,
12. Culture,
13. Pedestrian and vehicular circulation,
14. Access, utilities,
15. Historic factors,
16. Density,
17. Sensory stimuli,
18. And any other factor deemed appropriate for the particular site.

CLIMATE ANALYSIS OF A SITE

The climate analysis of a site is vital for green design strategies. The following points are usually taken into consideration:

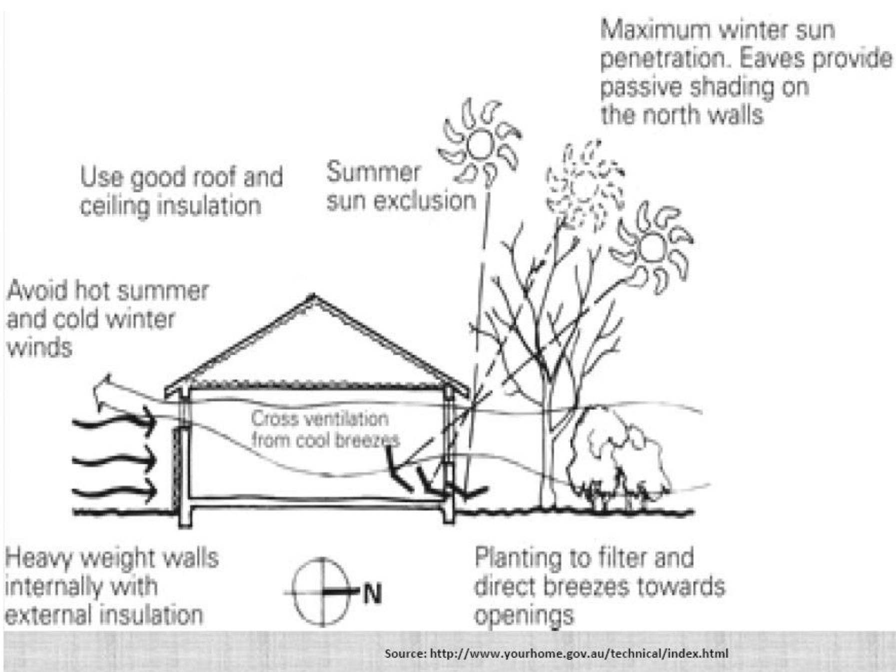
_ The path (vertical and horizontal angle) of the sun during the year

_ The annual rainfall amount and annual distribution

_ The wind intensity, direction and occurrence

_ The most likely direction of storms, cold or strong winds

_ The most common directions of good breezes.



SUSTAINABLE LANDSCAPING DESIGN

Landscaping is an integral component of any sustainable design and should be considered for integration with all other aspects of the building design, construction, and operation.

Some Measures for Sustainable Landscaping Design include the following:

1. Site Analysis Considerations
2. Natural Hydrology considerations
3. Ensuring of Soil stability, quality, and disturbance of vegetation around the site.
4. Design to use the existing topography for landscaping – don't bulldoze!
5. Minimizing negative impact on existing trees and bio-diversity
6. Use of native trees and plants. It is best to avoid the introduction of exotic plants to ensure native trees are not affected.
7. Use of climate appropriate plants for landscaping to minimize watering, pesticide use and maintenance.
8. If it does not grow and thrive well in the local climate don't plant it.
9. Consideration of Permaculture for kitchen gardens or agricultural based use.
10. Effective tree management –consider tree retention, relocation or replacement.
11. Limiting the use of impervious surfaces to allow natural hydrology.

SUSTAINABLE PARKING DESIGN CONSIDERATIONS

Parking is often a significant user of land on sites. Reducing areas used for parking as many positive benefits to the site including the following:

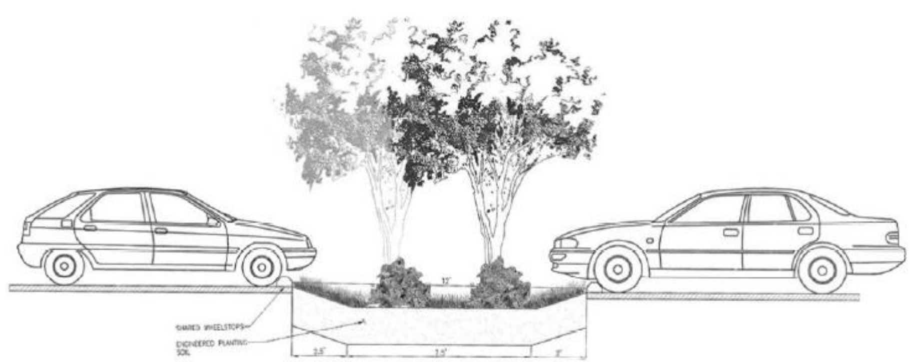
1. Reduction of polluted surface water runoff
2. Greater ground water recharge.
3. Reduced heat island effect and glare.
4. Positive opportunities for creating more natural landscapes and pedestrian friendly environments.

Green Parking design reduces runoff that is discharged into local water bodies by using:

- permeable paving and
- natural drainage landscapes.

Natural drainage landscapes include:

- Swales, rain gardens, and bioengineered planting strips that can improve water quality and reduce runoff.



STORM-WATER MANAGEMENT WITHIN THE SITE

Storm-water runoff is one of the most significant environmental impacts of a developed site. Storm-water runoff can change natural hydrologic patterns, accelerate stream flows, destroy aquatic habitats, and elevate pollutant concentrations and loadings. Developing a site can significantly alter the hydrologic cycle for the property and surrounding area. Our regulations do not address groundwater recharge and the hydrologic cycle within building sites and city planning. Steps can and should be taken to maintain the predevelopment hydrology or even to improve it.

Some of the Issues with Storm Water Management are:

1. When it rains, storm-water runoff that isn't properly managed can flow over impervious surfaces picking up pollutants along the way and washing them into our rivers and streams.
2. Storm-water runoff can also cause flooding and erosion, destroy habitat and contribute to combined sewer overflows (CSOs).

Some ways to Manage Storm Water for Sustainability include the following:

1. Storm-water management systems that mimic nature by integrating storm-water into building and site development can reduce the damaging effects of urbanization on rivers and streams.
2. The storm-water management system design shall be based, in part, on the hydrologic analysis of the building site.
3. The storm-water management system shall not redirect or concentrate off-site discharge that would cause increased erosion or other drainage related damage to adjoining lots or public property.
4. Disconnecting the flow from storm sewers and directing runoff to natural systems like landscaped planters, swales and rain gardens or implementing an eco-roof reduces and filters storm-water runoff.

Some Activities that will minimize Storm-water runoff from your property include the following:

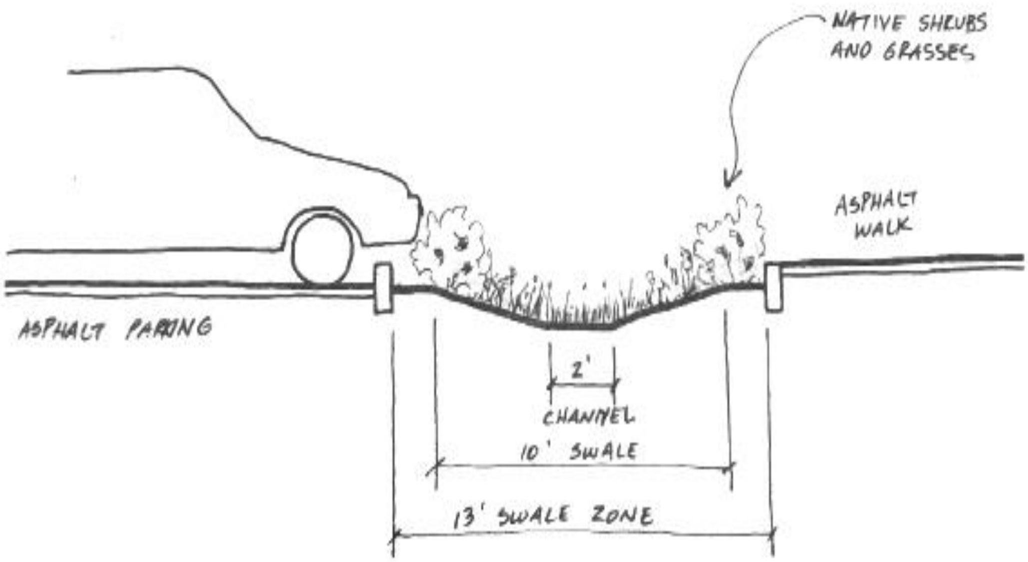
1. Limit the amount of impervious surfaces in your landscape.

2. Use permeable paving surfaces such as wood decks, bricks, and concrete lattice to allow water to soak into the ground.

3. Where possible, direct runoff from impervious surfaces across vegetated areas.

4. Allow "thick" vegetation or "buffer strips" to grow alongside waterways to filter and slow runoff and soak up pollutants.

5. Plant trees, shrubs, and groundcover. They are said to absorb up to fourteen times more rainwater than a grass lawn and they do not require fertilizer.

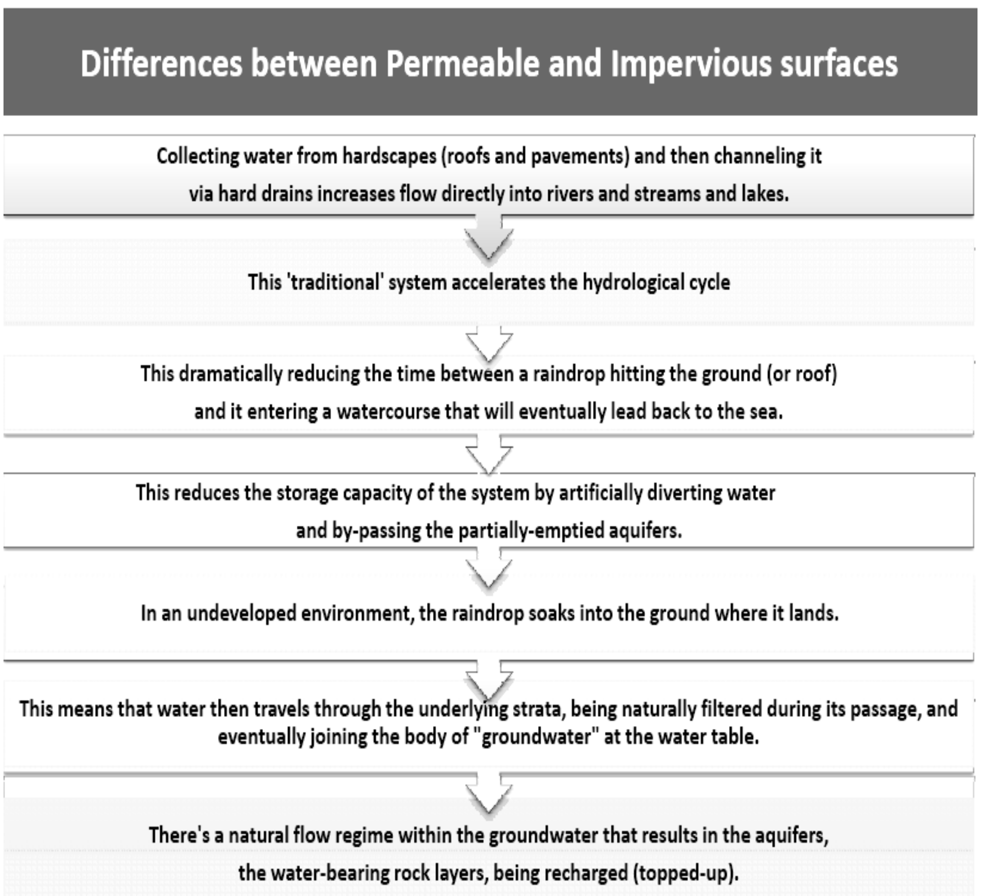


Swale Cross-Section

PERMEABLE PAVEMENTS

Permeable are pavements with surfaces that allow water to pass through voids in the paving material and/or between paving units while providing a stable, load-bearing surface.

- Permeable or porous paving systems defy conventional construction thinking which, for hundreds of years, has focused on getting surface water off and away from the pavement structure as rapidly as possible.
- The surface water is actually directed into the pavement and then stored or released into the environment in a controlled manner.
- Permeable paving is a powerful tool for maintaining and restoring natural hydrological cycles on developed sites by allowing water infiltration rather than concentrating rainwater into runoff.



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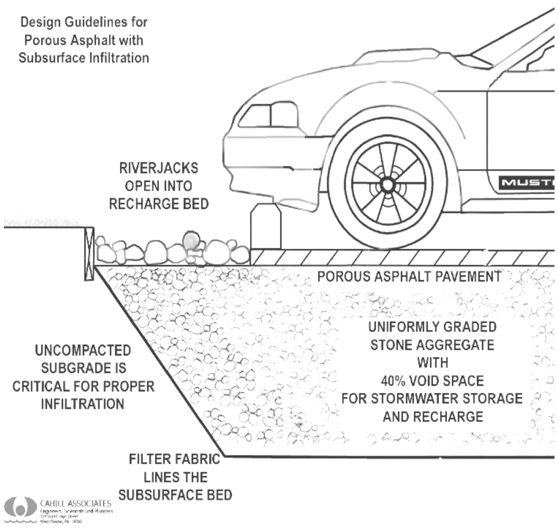
WHERE TO INSTALL PERMEABLE PAVEMENTS?

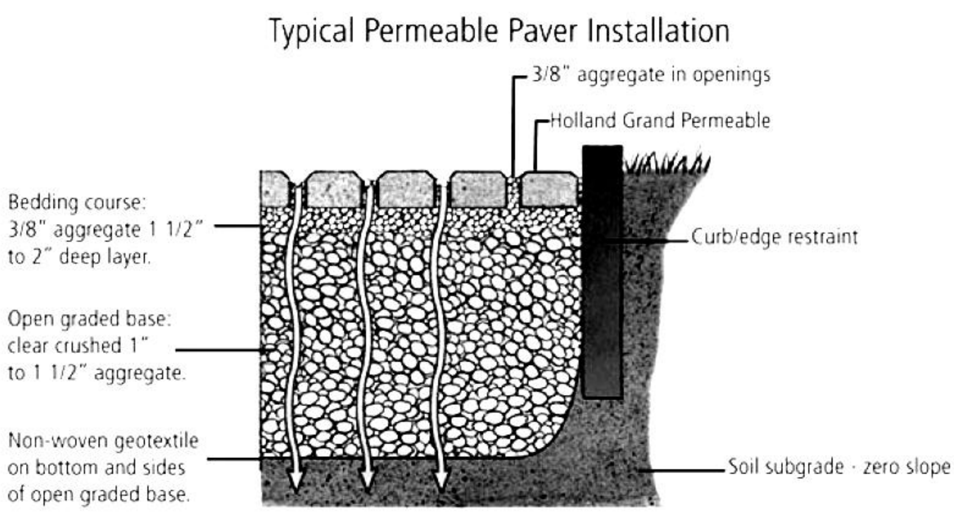


- Permeable paving is appropriate for pedestrian-only areas and for very low-volume, low-speed areas such as overflow parking areas, residential driveways, alleys, and parking stalls.

- It can be constructed where the underlying soils have a permeability of at least 0.3” per hour.

WHERE NOT TO INSTALL PERMEABLE PAVEMENTS?

- Permeable paving is not ideal for high traffic/high speed areas because it has lower load-bearing capacity than conventional pavement.
- Nor should it be used on stormwater “hotspots” with high pollutant loads because stormwater cannot be pretreated prior to infiltration.
- Permeable paving should not receive stormwater from other drainage areas, especially any areas that are not fully stabilized.



Source: internet

An Example of available permeable pavers :

Interlock Concrete's StormAbsorb™ Technology

Is said to be Easy to install

1. Construct base using local aggregate
2. Spread aggregate base, sub-base and compact
3. Install pavers at 5,000 sq. ft. (500 m2)/machine/day
4. Fill joints with small aggregate and compact, sweep fine aggregate into joints

LOCAL VERNACULAR PERMEABLE PAVEMENTS:

Traditional *dolep* pathways laid directly on the ground (without an undercoat of cement layer) is a very good example of indigenous permeable pavement that has always been used in Bhutan.

This vernacular style pavement allows surface rain water to filter and percolate into the ground rather than concentrating rainwater into a runoff thus allowing local hydrology to be refreshed.

SECTION 4:

GREEN MATERIALS

AND RESOURCES

SECTION 4: GREEN MATERIALS AND RESOURCES

Resources and Materials for the construction of buildings and related infrastructure are usually taken directly or indirectly from nature. Correspondingly, the materials from buildings are often returned to nature. Therefore, any construction has an impact on the environment and the impact unless carefully and sensitively managed is usually negative.

While considering green materials and resources, the following are the main components to take into consideration:

1. Analysis of the environmental impact of building materials
2. Selection of sustainable building materials
3. Reuse of salvaged construction materials

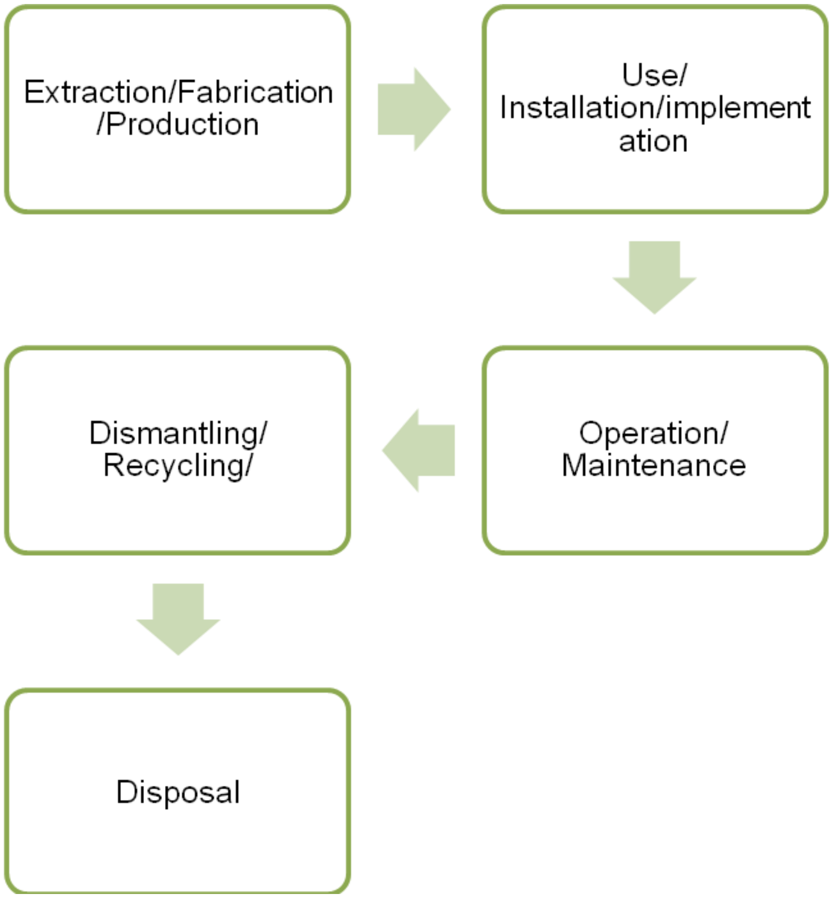
ANALYSIS OF THE ENVIRONMENTAL IMPACT OF BUILDING MATERIALS

Life Cycle Assessment is potentially the most important method for assessing the overall environmental impact of products, processes, or services. It is also sometimes referred to as Life Cycle Analysis or LCA.

Life Cycle Assessment (LCA) is a tool for assessing the environmental impacts of a product, process or service from design to disposal i.e. across its entire lifecycle, a so called cradle to grave approach. The impacts may be beneficial or adverse. These impacts are sometimes referred to as the “environmental footprint” of a product or service. The LCA for a product is a summation of the impacts of:

1. extraction of the relevant raw materials
2. refinement and conversion to process materials
3. manufacturing and packaging processes
4. transportation and distribution at each stage
5. operation or use during its lifetime
6. at the end of its useful life, final transportation, waste treatment, and disposal.
7. Any recycling or recovery operations built into the life cycle should lead to a proportionate reduction in the adverse environmental impact.

LIFE CYCLE ASSESSMENT



SELECTION OF SUSTAINABLE BUILDING MATERIALS

The main points of consideration for selection of Materials include the following:

1. Materials and resources should be locally available
2. Low Embodied Energy materials should be considered first.
3. Materials should have minimal air, land, and water pollution footprint
4. Materials should be Biodegradable as far as possible
5. Material resources should be renewable as far as possible
6. materials should increase Energy Efficiency in buildings
7. Materials should have Long life & durability
8. Materials should be Reusable & Recyclable

While selecting materials the main considerations should be for primary materials first as shown below:

1. Primary Materials:
   those found in nature, such as stone, earth, flora (hemp, jute, reed, wool), cotton, and wood.

2. Secondary materials:
   those made from recycled products, such as wood, aluminum, cellulose, and plastics.

3. Tertiary Materials:
   manufactured materials (artificial, synthetic, nonrenewable) having varying degrees of negative impact on the environment and wellbeing of people.

Bhutan Standard Bureau

In Bhutan, the Bhutan Standard Bureau (BSB), which is the National Standards Body of Bhutan currently undertakes testing of materials for construction in Bhutan. In the near future, all materials used in Bhutan could be tested not just for their structural properties but for green sustainable factors.

More information on this subject is also available at the Building Energy management Systems (BEMS) that provides data on the performance of building technical systems.

QUESTIONS TO CONSIDER WHEN CHOOSING MATERIALS FOR CONSTRUCTION

1. **Where did the Materials come from?**

   The best sources:

   - Reclaimed materials
   - Recycled materials
   - Materials that are sustainably harvested
   - Materials that are rapidly renewable
   - Materials that are natural

2. **How was the building construction material manufactured or processed?**

   The best option:

   - Select materials that were manufactured in a sustainable way with the least pollution of air, water and soil and low energy.

3. **How is the construction material transported or delivered?**

   The best option:

   - While choosing green materials the consideration of its transportation to the site from its source or factory is often overlooked. A green material may not in the end turn out to be very green is it is not locally produced or sourced as transportation amounts to use of large energy resources and production of pollution during its transportation to the site. Therefore materials chose green materials that are locally produced and do not require extensive transportation.

4. **How is the building material installed in the building?**

   The best choice:

   - Try to select materials that do not require large sources of power energy, oil or water for its installation and construction

5. **How is the material maintained after construction?**

   The best option:

- Try to select materials that are durable and do not require large sources of power energy, oil or water for its maintenance. Materials that are easily repaired are also a good choice as this means they don't have to be fully replaced.

6. **How will the materials impact the health of the occupants?**

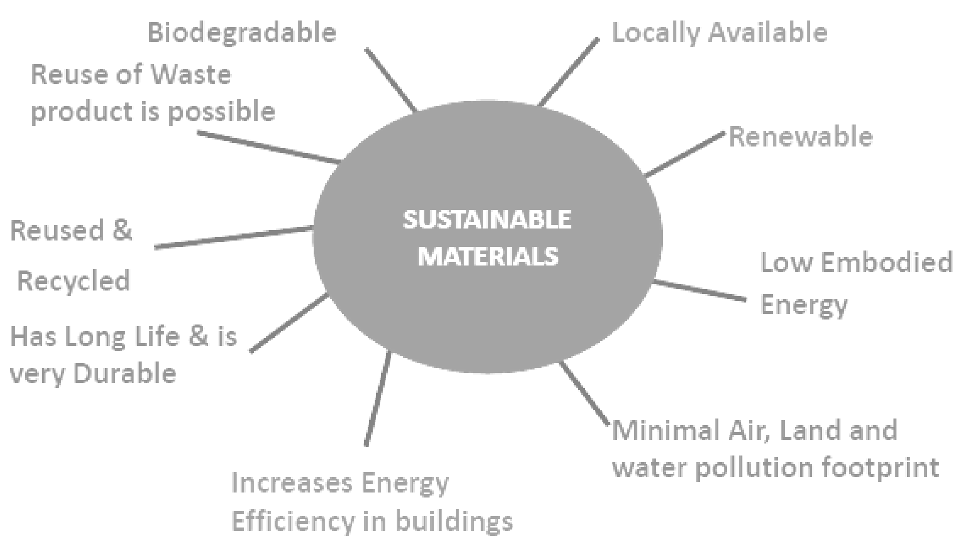
The best option:

- Try to select materials that are good for the health and wellbeing of the occupants whether they are humans or animals. Therefore, select materials that are natural as possible and do not emit toxic gases, solvents or harmful compounds.

7. **What happens to the materials when the building has to be demolished?**

The best option:

- Try to select materials that can be recycled and reused or are biodegradable. In case the material cannot be salvaged and has to be discarded as waste after demolition, take into consideration how they will affect the environment and local communities.



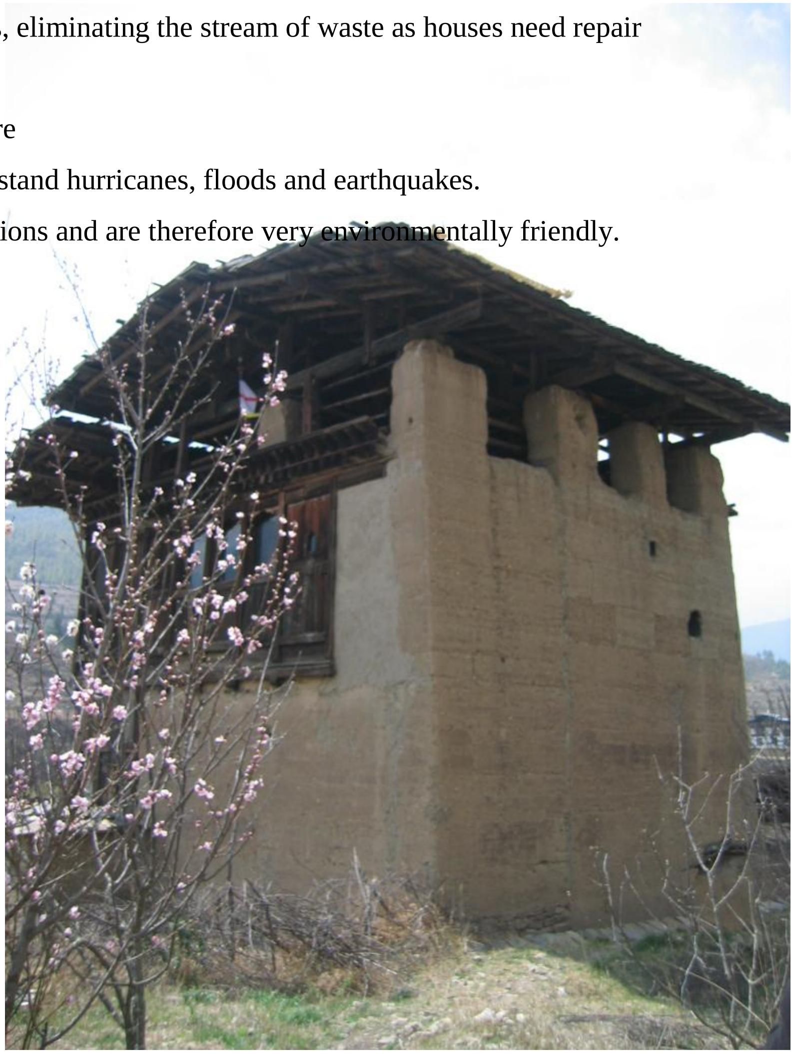
LOCAL NATURAL MATERIALS

The indigenous architecture of Bhutan embodies the use of local natural materials like earth, timber, bamboo and stone masonry.

Local Earth Buildings

Rammed earth and adobe earth brick that is commonly used for construction in rural areas of Bhutan produces structures that are strong, and durable. Earth is one of the most sustainable building materials on earth. If used correctly rammed earth building are the most sustainable material for Bhutan:

- It is locally available, and an abundant material
- It does not require a lot of energy to process, and apply
- it does not deplete any natural resources
- It is extremely durable. Modern rammed earth, stabilized with rebar and a small percentage of cement, should easily last hundreds of years, eliminating the stream of waste as houses need repair and replacement.
- Stabilized rammed earth is impervious to fire
- Built correctly rammed earth is able to withstand hurricanes, floods and earthquakes.
- Earth buildings have very low carbon emissions and are therefore very environmentally friendly.
- It is non- toxic
- In terms of energy efficiency rammed earth is an excellent material. The thick thermal mass of the walls absorbs and retains solar energy from south facing windows. Rammed earth walls with its generous thermal mass are thus a huge heat sink.
- If properly insulated, rammed earth structures will stay warm.
- In the summer the thick rammed earth structures will keep the rooms cool especially with a large overhang.
- It is said that if every house on the planet were built of rammed earth we could cut our fossil fuel use in half.



Rammed earth ratings
according to the Building Research Establishment Ltd 2012

Summary Rating	A+
Climate Change	A+
Water Extraction	A+
Mineral Resource Extraction	A
Stratospheric Ozone Depletion	A+
Human Toxicity	A+
Ecotoxicity to Freshwater	A+
Nuclear Waste (higher level)	A+
Ecotoxicity to Land	A+
Waste Disposal	A+
Fossil Fuel Depletion	A+
Eutrophication	A+
Photochemical Ozone Creation	A+
Acidification	A+
Kg of CO2 eq. (60 years)	38.0

LOCAL EARTH BRICKS / ADOBE

Another alternative local natural material used for building construction in Bhutan is earth bricks which are also known as adobe bricks. The use of adobe bricks is extremely green and there are a number of advantages.

Adobe brick production is one of the simplest and easiest construction methods. No costly tools or equipment are required and no energy or oil is used for its production. With minimal training anyone can produce adobe bricks and therefore building owners do not have to depend on manufacturing companies.

Adobe bricks are durable if constructed correctly. They are fireproof, non-toxic water resistant and biodegradable and give good thermal mass and sound insulation. Adobe bricks allow far more flexibility compared to rammed earth monolithic structures as bricks can be easily cut and molded to fit varying shapes.

In Bhutan adobe bricks are produced manually using simple wooden molds. The soil is strengthened with the use of straw and sometimes pine needle leaves and the bricks are simply left in the sun to dry.

USE OF LOCAL STABILIZED EARTH BLOCKS

The use of stabilized interlocking earth block buildings has been initiated in Bhutan by the Ministry of Works and Human Settlement and the Bhutan Standard Bureau (BSB). According to local manufacturers: while burnt clay bricks has a compressive strength of 60kg to 80kg per sq cm, which is second class, the interlocking stabilized earth block has a compressive strength of 100kg to 120kg per sq cm strong enough to be used for load bearing walls.

The proportions as per the BSB are the following:

- The ratio for Cement: Soil is 1:6.
- The ratio can go up as high as 1 of cement to 10 of soil
- The recommended water content is 25 litres for 1 bag of cement

Limitations of stabilized earth blocks:

The recommended limitations for stabilized earth blocks as per BSB are

- Recommend only for low rise structures. The maximum is 2 floors height.
- The strength is dependent on the properties of soil so care has to be used in soil selection
- The interlocking features do not provide air tightness. Minimum gap is formed due to which insects, dust and air current can pass.
- Requires minimum mortar between the blocks to maintain the horizontal construction level
- Too much mortar between the blocks jeopardizes the interlocking feature and its strength.

Machines:

Currently two main machines are used in Bhutan. This includes the HI-CSEB Block machine from Thailand and the AURUM press 3000 from India. The CSEB machine produces blocks of maximum size of 300 x 150 x 96mm and can produce around 500 per day on an average. The AURUM Press 3000 has the capacity for maximum block sizes of 245 x 245 x95 mm and can also produce around 500 bricks per day.

Pilot House Construction in Thimphu by BSB S using HI – CSEB 245

SECTION 5

ENERGY EFFICIENCY IN DESIGN

SECTION 5: ENERGY EFFICIENCY IN DESIGN

The following actions are means to reduce energy consumption:

- At the beginning of the planning process, a determination should be made to avoid energy-intensive or unnecessary operations.
- Passive means are superior than active means (use of energy consuming appliances) and should be always the first option.
- The design proposal should consider incorporating measures to minimize energy use by design and operation.
- Application of the best principles of siting and architectural design to reduce energy demands by passive solar design.
- Feasibility of the use of primary renewable energy sources such as solar, wind, biogas, and geothermal to satisfy the justifiable energy needs of the resort.
- Installing efficient appliances and taking measures to minimize the need and use of energy-consuming utilities (air-conditioning, water heaters, high-level artificial lighting).
- Use of energy meters to monitor and illustrate energy consumption to aid in conservation.
- In addition, considerable electrical and thermal energy can be saved through facility design that incorporates daylighting and the other passive energy-conserving strategies appropriate to the local climatic environment.
- Natural lighting should be used wherever possible. Lighting design should be based on standards of reduced general lighting with task lighting and highlighting for specific functional considerations rather than lighting all areas equally.
- Where artificial light is needed, LED or regular and compact fluorescent lighting should be used. Fluorescents use 75% less electricity and the average life is 10 times longer than incandescents, reducing maintenance and transportation costs. The environmental payback is immediate.
- In all cases, the need for energy-intensive mechanical air-conditioning of facilities can be effectively eliminated by appropriate use of principles of site planning and building interior and exterior design considerations.

USE OF PASSIVE SOLAR DESIGN STRATEGIES FOR BUILDINGS

Use of passive solar design strategies are nothing new, however with the dependence and focus on appliances and mechanical systems, they are often forgotten. For a green building in Bhutan, passive solar design strategies should be the first consideration as this does not cost anything extra, and is low tech. It also saves us from the dependence on appliances and energy sources which not only cost money but are often transported from other countries and therefore not environmentally friendly.

In passive solar building design, windows, walls, and floors are designed in a careful and sensitive manner with reference to the sun and landscape to collect, store, and distribute solar energy in the form of heat in the winter and reject solar heat in the summer to allow for heating and cooling.

This is called passive solar design or climatic design because, unlike active solar heating systems, it doesn't involve the use of mechanical and electrical devices. Passive solar design depends on direct gain systems, indirect gain systems or isolated gain systems. These systems can be used on their own or combined together and depend on how elements in a building are heated directly or indirectly by the sun.

These systems are enhanced by thermal mass of walls and floors. Thermal mass and energy storage are key characteristics of passive solar design. They can provide a mechanism for handling excess warmth, therefore reducing the cooling load, while storing heat that can be slowly released back to the building when needed. The thermal mass can also be cooled during the evening hours by venting the building, reducing the need for cooling in the morning.

Some simple and effective considerations for Passive Solar Design are:

- Site Climate Analysis:
    - The path (both horizontal and vertical angles) of the sun falling on the building site during the year.
    - The wind intensity, occurrence and direction towards the building and away from the building.
    - The common direction of good breezes for ventilation and cooling.
    - The annual rainfall amount and its distribution through the year on the site.
    - The direction of storms, and cold winds hitting the site.
- Placement of the building on the site.
- Orientation of the windows of rooms towards or away from the path of the sun depending on heating or cooling needs
- Building form and thermal mass to store energy in the house.
- Natural ventilation.
- Solar shades design in summer with consideration of the angle of sun on the site.
- Use of landscaping (trees and vegetation) for shading and protection.
- Use of colours on the building and rooms – light or dark depending on the heating and cooling needs.

SITE-ADAPTIVE DESIGN CONSIDERATIONS

The concept of sustainability considers an approach to the relationship of site components that is different from conventional site design for a building. With the sustainable approach, site components defer to the character of the landscape they occupy so that the experience of the landscape for the building is very important.

Ecological knowledge is at the core of sustainable design. Instead of only human functional needs driving the site design, site components respond to the indigenous spatial character, climate, topography, soils, and vegetation.

For example, the design considers the constraints of existing landforms and tree locations, and the aim is to maintain the character of existing landscape as far as possible.

Natural buffers and openings for privacy and protection are preferred rather than those artificially produced through exotic planting and clearing.

The consideration for the soil of a site is usually hardly taken into consideration in Bhutan. Green design considers top soil as a valuable, living resource that should be protected as far as possible. Through careful planning and sensitive construction practices, valuable soil as well as trees and other plants can be preserved and incorporated within the design.

Natural Characteristics

It is important to understand natural systems and the way they interrelate in order to work within these constraints with the least amount of environmental impact while also taking advantage of their benefits. Like nature, design should not be static but always evolving and adapting to interact more intimately with its surroundings. The following natural characteristics could be considered in the design:

- **Wind**

  The major advantage of wind is its cooling aspect. The orientation of rooms and outdoor places should be designed to take advantage of cooling wind movements for natural cooling and ventilation.

- **Sun**

  While taking advantage of passive solar energy for heating, where sun is abundant, it is also necessary to provide shade for human comfort in hot regions and during summer. The most economical and practical way is to use natural vegetation, slope aspects, or introduced simple shade structures.

- **Rainfall**

  Rainfall should be captured for a variety of uses and this water reused for secondary purposes (e.g., flushing toilets, washing clothes). Wastewater or excess runoff from developed areas could be channeled and discharged in ways that allow for groundwater recharge instead of soil erosion. Minimizing disturbance to soils and vegetation and keeping development away from natural drainage ways protect the environment as well as the building.

- **Topography**

  Protection of native soil and vegetation are critical concerns in high slope areas, and sensitive design, elevated walkways and point footings for structures are design solutions that may be considered for this problem.

- **Geology and Soils**

  Designing with geologic features such as rock outcrops can enhance the sense of place in the building and landscape design and brings people in direct contact with the natural resources of a place which helps to increase general wellbeing. Soil disturbances should be kept to a minimum to avoid erosion of fragile tropical soils and discourage growth of exotic plants. If limited soil disturbance must take place, a continuous cover over disturbed soils with erosion control netting (such as natural coconut fiber netting) could be considered where feasible.

Vegetation

Exotic plant materials, while interesting and beautiful, are not good for healthy native ecosystems and best not considered for any landscape design. Use of native plant species are encouraged to encourage biodiversity and to protect the nutrients held in the biomass of native vegetation. Native planting should be considered for incorporation into all new developments on a 2:1 ratio of native plants removed.

Organic Kitchen Gardens may be incorporated within the landscaping design provided that only native food is grown. Incorporation of conventional grass lawns and typical ornamental shrubs are not environmentally friendly due to their high water and pesticide use, and the pollution generated from mowing. They should be avoided as far as possible.

- **Enhancement of Visual Character**

  Natural views and beauty should be used in design whenever possible. Creation of onsite visual intrusions (road cuts, utilities, etc.) should be avoided where possible, and views of offsite intrusions controlled in a more sensitive manner.

  Natural appearance could be maintained by using native building material, hiding structures within the vegetation, and working with the natural topography.

- **Preservation of natural drainage systems**

  For green planning and design the location of the built environment is very important. Locate buildings, roadways, and parking areas in a more perceptive manner so that water flowing off the developed site during extreme storm events will not cause environmental damage and result in excessive contamination of the watershed from silt, oils, automobile fluids, and other pollutants. It is environmentally friendly to allow precipitation to naturally recharge groundwater rather than through fast moving drains.

  The use of simple swales and dry retention ponds to maximize infiltration and minimize runoff is a good consideration for the environment.
  One should try to maintain or restore the pre-development stable, natural runoff hydrology of the site throughout the development or redevelopment process and not just on paper during the design stage. Post construction runoff rate, volume, duration, and temperature should strive to not try to exceed predevelopment rates.

DOORS, WINDOWS, AND OPENINGS

- Windows, doors and openings in buildings have a very large impact on the comfort of a building and energy efficiency.
- Openings provide physical access to a building, create views to the outside, admit daylight and/or solar energy for heating, and supply natural ventilation.
- Size and position doors, windows, and vents in the envelope should be designed carefully with sensitive consideration of daylighting, heating, cooling and ventilating needs for energy efficiency.
- The form, size, and location of openings may vary depending on how they affect the building envelope.
- The negative impact of door openings upon heating or cooling loads can be reduced with airlocks.
- Shade openings in the envelope during hot weather to reduce the penetration of direct sunlight to the interior of the building. Use of design solutions such as overhangs or deciduous plant materials on southern orientations to shade exterior walls during warmer seasons should be considered. This could even save more than half the air conditioning energy needs and bills in a building if designed well.
- Shade window openings or use light shelves where applicable to minimize thermal discomfort from direct radiation and visual discomfort from glare.
- Select proper glazing for windows rather than going for curtain walls or large windows without consideration of the orientation of the sun, climate needs and the functions of the rooms.
- Where financially feasible, better glazing options such as double glazing or double window shutters could be considered.
- The use of advanced windows that have glazing that alters with changing conditions, such as windows with tinting that increases under direct sunlight and decreases as light levels are reduced could be taken into consideration where they are available without having to be transported from far-off countries.

THERMAL EFFICIENCY

Thermal efficiency of a building and its elements is an important consideration for good energy efficiency in the design of a building. The following are simple considerations:

- In general, design walls, roofs, and floors of adequate thermal resistance to provide human comfort and energy efficiency. The consideration should always be through use of passive methods as a first option.
- Roofs especially are vulnerable to solar gain in summer and heat loss in winter therefore the design and consideration of materials in a roof should not be neglected.
- Corroborate and determine the building function and amount of equipment that will be used as sensitively as possible. The type of activity and the amount of equipment in a building affect the level of internal heat generated. This is important because the rate at which a building gains or loses heat through it skin is proportional to the difference in air temperature between inside and outside.
- While insulation is essential, insulating materials that require chlorofluorocarbons (CFCs) or hydro chlorofluorocarbons (HCFCs) in their production, (ozone-depleting compounds) should not be used.
- Consider environmentally sensitive insulating materials made from recycled materials such as cellulose or wool, if such items meet the project's performance and budgetary criteria.
- If the framing system is of a highly conductive material, consider the installation of a layer of properly sized insulating sheathing to limit thermal bridging where possible. This will make a huge positive difference on the energy efficiency of a building.
- The colour and reflectivity of the building envelope and roof is often neglected and forgotten during the design. In hot regions towards the Southern parts of Bhutan with significant cooling loads, consider the selection of exterior finish materials with light colors and high reflectivity. However be careful to also consider the impact of decisions upon neighboring buildings. A highly reflective envelope may result in a smaller cooling load, but glare from the surface can significantly increase loads on adjacent building occupants and be very uncomfortable for people.
- Moisture buildup within the building envelope is also another consideration that is often neglected in Bhutan. To prevent this, a vapor-tight sheet of plastic or metal foil, known as a vapor barrier, could be placed as near to the warm side of the wall construction as possible. For example, in areas with meaningful heating loads, the vapor barrier should go near the inside of the wall assembly. This placement can lessen or eliminate the problem of water-vapor condensation.

- Weather-stripping is a simple but very effective method which is not used in Bhutan. Consider weather-stripping of all doors and placement of sealing gaskets and latches on all operable windows where feasible. Careful detailing, weather stripping, and sealing of the envelope eliminate sources of convective losses and increase the energy efficiency of a building very effectively.
- Heat transfer across the building envelope occurs as either conductive, radiant, or convective losses or gains. To help with this problem, specifying construction materials and details that reduce heat transfer will make a big impact. Building materials conduct heat at different rates. Metals have a high rate of thermal conductance. Masonry has a lower rate of conductance; the rate for wood is lower still.
- While developing construction details, thermal transfer considerations should be taken into account where possible. Consider the following principles in construction detailing:
  - To reduce thermal transfer from conduction, develop details that eliminate or minimize thermal bridges.
  - To reduce thermal transfer from convection, develop details that minimize opportunities for air infiltration or exfiltration. Plug, caulk, or putty all holes in sills, studs, and joists.
  - Consider sealants with low environmental impact that do not compromise indoor air quality.
- Solar controls are necessary in hot places and during summer to mitigate heat gain in a simple way through design. Consider the incorporation of solar controls on the building exterior to reduce heat gain.
- Overhangs are effective on south-facing facades while a combination of vertical fins and overhangs could be designed on east and west exposures and, in warmer areas during summer months, on north-facing facades.
- Besides the building design, landscaping is also vital. Coordinate the building design strategy with landscaping decisions. For example, a shade of a tree on a building could help reduce the cooling loads by almost 40%.
- Integration of passive solar heating, cooling, and thermal storage features, along with daylighting, into a building can yield considerable energy benefits and added occupant comfort. Incorporation of these items into the building design can lead to substantial reduction in the load requirements for building heating and cooling mechanical systems. The passive solar measures need to be evaluated during the design process.

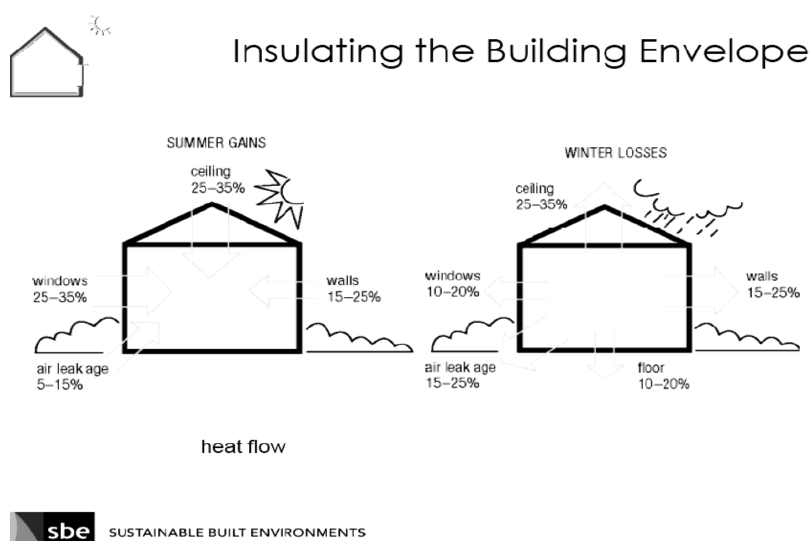
- Direct gain through south-facing glass is the most common method of thermal gain. Therefore avoid glazed curtain walls that face south in hot areas as the cooling loads will rise substantially.
- Passive solar cooling strategies include cooling load avoidance, shading, natural ventilation, radiative cooling, evaporative cooling, dehumidification, and ground coupling could be considered within the design. Passive design strategies can minimize the need for cooling through proper selection of glazings, window placement, shading techniques, and good landscaping design. However, incorrect daylighting strategies can produce excessive heat gain.
- Minimization of cooling loads should be carefully addressed through proper design for both solar and conventional building design.

BUILDING ENVELOPE DESIGN FOR SUSTAINABILITY

The building envelope, or "skin," consists of structural materials and finishes that enclose space, separating inside from outside. This includes walls, windows, doors, roofs, and floor surfaces.

Research shows that sealing your building envelope is the one of the most cost effective way for improving the energy efficiency of a building. The following could be considered for energy efficiency through the building envelope:

- The design of the building envelope is a major factor in determining the amount of energy a building will use in its operation.
- One of the most important factors affecting envelope design is climate. Hot/dry, hot/moist, temperate, or cold climates will suggest different design strategies –this should be presented in the proposal. Specific designs and materials can take advantage of or provide solutions for the given climate.
- The envelope must therefore be designed to balance requirements for ventilation and daylight while providing thermal and moisture protection appropriate to the climatic conditions of the site.
- A second important factor in envelope design is what occurs inside the building. If the activity and equipment inside the building generate a significant amount of heat, the thermal loads may be primarily internal (from people and equipment) rather than external (from the sun). This affects the rate at which a building gains or loses heat.
- In keeping with the whole building approach, the entire design team should integrate design of the envelope with other design elements including material selection; daylighting and other passive solar design strategies; heating, ventilating, and air-conditioning (HVAC) and electrical strategies; and project performance goals.



- Building volume and siting also have significant impacts upon the efficiency and requirements of the building envelope. Careful study would be required to arrive at a building footprint and orientation that work with the building envelope to maximize energy benefit.

- Show sensitive use of form, size, and location of the openings vary depending upon the role they play in the building envelope. Sensitive design of window glazing can be used to affect heating and cooling requirements and occupant comfort by controlling the type and amount of light that passes through windows. This could be presented in the proposal.

- Decisions about construction details also play a crucial role in design of the building envelope. Building materials conduct heat at different rates. Components of the envelope such as foundation walls, sills, studs, joists, and connectors, among others, can create paths for the transfer of thermal energy, known as thermal bridges that conduct heat across the wall assembly. Wise detailing decisions, including choice and placement of insulation material, are essential to assure thermal efficiency and this must be included within the design proposal.

PASSIVE SOLAR HEATING

Passive solar heating is necessary for most parts of Bhutan since we have very cold winters. To reduce the dependence on bukharis, heaters and other appliances that use a lot of energy, passive design is a simple way that costs nothing to ensure that you stay warm inside a building during the cold months in Bhutan.

The following may be considered:

- Consider Analyzing building thermal-load patterns.
  An important concept of passive solar design is to match the time when the sun can provide daylighting and heat to a building with those when the building needs heat. This will determine which passive solar design strategies are most effective.

- Design the building's floor plan to optimize passive solar heating.
  Orient the solar collection surfaces, for example appropriate glazing in windows and doors, within 15 degrees of true south, if possible. Because of the solar path, the optimum orientation for passive solar buildings is due south. South-facing surfaces do not have to be all along the same wall. For example, larger windows can project south sun deep into the back of the building. Both the efficiency of the system and the ability to control shading and summer overheating decline dramatically as the surface shifts away from due south.

- Identify appropriate locations for exposure to beam sunlight where applicable
  Overheating and glare can occur whenever sunlight penetrates directly into a building and must be addressed through proper design. A "direct-gain" space can overheat in full sunlight and is many times brighter than normal indoor lighting, causing intense glare.

- Consider locating thermal mass so that it will be illuminated by low winter sun angles. Building design should incorporate a sufficient amount of correctly located thermal mass to effectively contribute to the heating requirements and provide cooling benefits in the summer.

PASSIVE SOLAR COOLING

In the Southern regions of Bhutan, summers can get very hot and the dependence on air-conditioning which consumes huge amounts of energy is rapidly increasing. There is little consideration for passive design for cooling.

Often the same design is used in hot and cold places without any differences in the design or materials in a building. Therefore the exact design and materials used in a building found in Thimphu is found in Phuentsoling which has far hotter summers. The consideration of different passive solar design considerations for hot and cold areas of Bhutan must be taken into consideration by architects, engineers and planners.

For hot regions in Bhutan the following may be simple ways to consider passive cooling in a building to reduce the dependence on air-conditioning appliances and energy loads:

- Design buildings for cooling in summer. Minimization of cooling loads should be carefully addressed for both solar building and conventional energy-efficient building design. Design strategies that minimize the need for mechanical cooling systems include proper window placement and daylighting design, selection of appropriate glazing for windows and skylights, proper shading of glass when heat gains are not desired, use of light-colored materials for the building envelope and roof, careful siting and orientation decisions, and good landscaping design.
- Consider one or more shading strategies where applicable.
  Fixed shading devices, which are designed into a building, will shade windows throughout the solar cycle. They are most effective on the south-facing windows. The depth and position of fixed shading devices must be carefully engineered to allow the sun to penetrate only during predetermined times of the year. In the winter, overhangs allow the low winter sun to enter south-facing windows. In the summer, the overhangs block the higher sun.
- Plant trees and/or bushes to shade the windows at the right time of day and season. Deciduous vegetation is often an attractive and inexpensive form of shading, because it follows the local seasons, not the solar calendar.
- In the warm south, where more shading is needed, trees leaf out earlier, while in the cold north, where solar heat is beneficial late into spring, trees wait until the weather warms up before they leaf out. Trees can be strategically planted on east and west sides to block the rising and setting sun.

- Bushes can be positioned to block undesirable low sun angles from the east or west, and deciduous vines trained to grow over trellises make easily controlled shading systems.
- Evergreen trees trimmed so that their canopies allow low winter sun underneath but block the high summer sun can be very effective.
- Properly placed vegetation can also guide air flows toward buildings for natural ventilation and can block cold winter winds. Vegetation and groundcover also contribute to evaporative cooling around a building.
- Vegetation used for shading could be properly located so as not to interfere with solar gain to buildings in winter. Deciduous trees can reduce winter solar gain by 20 percent or more and should not be placed in the solar access zone.
- Also it should be noted that plants and trees require maintenance, pruning, watering and feeding. As they grow they change their shading pattern, and they can be damaged or killed, leaving the building exposed. This should be taken into consideration while planting different types of vegetation for shading purposes.
- Design the building to take advantage of natural ventilation. Natural ventilation uses the passive stack effect and pressure differentials to bring fresh, cooling air through a building without mechanical systems. This process cools the occupants and provides comfort even in humid climates. Buildings using this design will incorporate operable windows or other means of outdoor air intakes.
- Other features include fresh air inlets located near floor level, use of ceiling fans, and the use of atriums and stairwell towers to enhance the stack effect.
- Consider radiative cooling in appropriate climates. Radiative cooling, also known as nocturnal radiative cooling, uses design strategies that allow stored heat to be released to the outside. This strategy is particularly effective in climates and during seasons of the year when the daytime-nighttime temperature differences are meaningful.
- Night flushing of buildings uses radiative cooling principles. Building thermal storage serves as a heat sink during the day, but releases the heat at night, while being cooled with night air.

- Consider ground coupled cooling. Ground coupling is achieved by conductive contact of the building with the earth. The most common strategy is to cool air by channeling it through an underground tunnel.
- Consider evaporative cooling strategies. This cooling method works when water, evaporating into the atmosphere, extracts heat from the air. Evaporative cooling is most appropriate in dry climates.

THERMAL STORAGE:

- Determine if excess heat should be stored or vented.

- Thermal mass in a passive solar building is intended to meet two needs. It should be designed to quickly absorb solar heat for use over the diurnal cycle and to avoid overheating. It should provide slow release of the stored heat when the sun is no longer shining.

- Depending upon the local climate and the use of the building, the delayed release of heat may be timed to occur a few hours later or slowly over days. Careful selection of the thermal storage medium, its location in the building, and its quantity are important design and cost decisions.

Choose one or more thermal storage strategies:

- There are two basic thermal storage strategies using thermal mass. “Direct” thermal storage materials, such as concrete masonry or tiles, are placed directly in the sunlight so that intense solar energy enters them quickly. “Diffuse” thermal storage materials are placed throughout the building. They can absorb heat by radiation, the reflectance of sunlight as it bounces around a room and via air heated elsewhere in the building (e.g., sunspaces and atria). Several storage strategies are presented below.

- Consider tile, stone, or masonry floors for heat storage where possible. Flooring using these materials, exposed to direct sunlight, is probably the most common form of thermal storage selected for passive solar buildings.

- Masonry materials have high thermal capacity; their natural dark color aids in the absorption of sunlight. They also provide an attractive and durable floor surface, are widely available, and readily accepted by contractors and building occupants. Masonry’s effectiveness can be inhibited if occupants place furniture and carpets over the floors. To address this, use masonry floors only in the areas where direct heat gain and storage is required.

- Consider a Trombe wall-a south-facing masonry wall covered with glass spaced a few inches away. Sunlight passes through the glass and is absorbed and stored by the wall. The glass and airspace keep the heat from radiating back to the outside. Heat is transferred by conduction as the masonry surface warms up, and is slowly delivered to the building some hours later.

- Trombe walls can provide carefully controlled solar heat to a space without the use of windows and direct sunlight, thus avoiding potential problems from glare and overheating, if thermal storage is inadequate. The masonry wall is part of the building's structural system, effectively lowering costs. The inside, or discharge, surface of the Trombe wall can be painted white to enhance lighting efficiency within the space. However, the outside large dark walls sheathed in glass must be carefully designed for both proper performance and aesthetics.

- Consider water-storage containers for thermal mass. Water has a very high thermal capacity, about twice that of common masonry materials. Water also has the advantage that convection currents distribute heat more evenly throughout the medium. Creative solutions that could be considered are enclosing water containers in seating boxes under south windows or using water as an indoor feature such as a large tropical aquarium, pond, or pool.

INTEGRATION OF NATURAL DAY LIGHTING INTO THE DESIGN

The use of natural daylight instead of artificial lighting is obviously the most sustainable and efficient way of saving energy in buildings. Living and working spaces should have an acceptable level of illumination without using artificial lighting during daytime by designing windows and skylights that are orientated to maximise the natural light without glare or overheating.

Daylighting is the practice of bringing natural light into a building interior and distributing it in a way that provides more desirable and better-quality illumination than artificial light sources. This reduces the need for electrical light sources, thus cutting down on electricity use and its associated costs and pollution.

Studies substantiate that daylighting creates healthier and more stimulating work environments than artificial lighting systems and can increase productivity up to 15 percent.

Daylighting significantly reduces energy consumption and operating costs. Greater use of daylighting can also provide advantages for the environment by reducing power demand and the related pollution and waste byproducts from power production.

Daylighting requires the correct placement of openings, or *apertures*, in the building envelope to allow light penetration while providing adequate distribution and diffusion of the light.

Design Process for Daylighting

- Establish daylighting performance objectives and requirements.
  The designer should establish required illumination levels to meet the needs of the building occupants and the tasks they perform. These levels have been reduced significantly over the past decades because it is now generally accepted that illumination can be reduced in situations where the quality of light is high and background surface reflectance is optimal.

- Analyze lighting performance needs using the following procedures:
  - Perform a solar-path analysis for the latitude at the site;
  - Perform preliminary aperture-optimization studies (optimal window-to-floor ratio, optimal skylight-to-floor ratio);
  - Determine the design illumination levels for various program functions based on international and local assessments.

- Establish basic daylighting parameters as part of the building design.
  - Establish the location, shape, and orientation of the building on the site based on daylighting performance objectives as part of an integrated passive solar heating and cooling strategy.
  - Establish fenestration design objectives based on optimization studies.
  - Establish energy-efficient artificial illumination systems based on design illumination levels and energy-efficiency targets.
  - Consider a preliminary life-cycle cost-benefit analysis of daylighting systems as an integrated part of the total building system. Consider qualitative benefits such as increased productivity and reduced absenteeism, as well as the direct costs of design systems when assessing costs and benefits.
  - Specify details for lighting systems and products.
  - Specify glazing materials based on climate, fenestration position, and solar orientation, maintaining the highest possible luminous efficacy and daylight factor.
  - Based on a solar-path analysis, determine the type and location of, and control methods for, shading systems that minimize or eliminate direct sun in work areas and moderate excessive brightness.
  - Specify control systems, including photo-sensors, control zones and occupancy sensors, based on control strategies where applicable.
  - Incorporate flexible, ongoing capabilities for monitoring lighting conditions, including lighting-energy consumption and lighting operation hours by zone.
  - Determine the method for reviewing and analyzing field-monitoring data and performing associated responsibilities where possible.
  - Confirm that specified practices and materials are installed properly during construction.

ENERGY-EFFICIENT LIGHT BULBS

Energy-efficient light bulbs compared to conventional bulbs can substantially reduce energy costs.

Compact fluorescent light bulbs (CFLs)

Compact fluorescent light bulbs (CFLs) use less than a quarter of the energy required to power a conventional light bulb for the same amount of time, and last ten times longer. Each CFL will save between 500 kg and 1 ton of carbon dioxide (CO2) emissions in its lifetime. Although they currently still cost more than conventional light bulbs, the amount of money spent on replacing light bulbs is reduced. CFLs are said to last for around 10000 hours, where a conventional incandescent bulb lasts just 1 000 hours on average. Although CFLs come with these handling and disposal issues, the large energy savings they achieve compared to incandescent light bulbs are of greater overall environmental benefit.

Some limitations that need to be considered when using CFLs:

- On/off cycling: CFLs are sensitive to being switched on and off frequently, and this reduces their rated lifespan.
- Dimmers: Not all CFLs can be used on dimmer switches. They can however be used with a timer or a three-way fixture. However with advances in production technology, some manufacturers, have recently introduced ‘dimmable’ CFL bulbs to the market.
- Outdoors: CFLs can be used outdoors, but should be covered or shaded from the elements. Low temperatures may reduce light levels.
- Retail lighting: CFLs are not spotlights. Retail store display lighting usually requires narrow focus beams for stronger spotlighting. CFLs are better suited for area lighting.
- Hazardous waste: CFLs contain small amounts of mercury. Although the mercury poses no threat while in the bulb, it is a problem for the environment, and the bulbs must therefore be disposed of at a hazardous waste disposal facility.

Light-emitting diodes (LEDs):

Another new technology that is even more efficient than CFLs is light-emitting diodes (LEDs). Advantages of LED bulbs over CFLs are:

- LEDs use a fraction of the energy a CFL uses.
- • have a longer lifespan.
- • can shine brighter.
- • have many different applications.
- are currently the best green lighting technology available.

OUTDOOR LIGHTING

- When lighting an outdoor space, keep in mind that light pollution can be a problem.
- Good examples of light pollution and its negative effects are high school football fields, retail centers and parking lots.
- In this type of diffuse lighting where lamps light a large surface area, light pollution occurs when the excess light spills over onto nearby houses, lighting the streets and backyards and generally creating a nuisance for the surrounding neighbors.

MATERIALS/FINISHES FOR EFFECTIVE LIGHTING

Materials and finishes can have huge impact on lighting in your space. The materials used within a facility need to be considered when designing a lighting plan.

The following are a few points that should guide materials and finishes for effective lighting:

- Painting a room a dark color can make it look smaller. That dark color can also absorb more light, forcing your eyes to adjust to lower light levels.
- Rooms painted a light color help a person perceive the space as larger and aid in lighting.
- In addition, keeping reflective surfaces to a minimum can also help. Unexpected glare from floors and windows can affect the lighting of the space.
- Another useful technique is to light the walls in your space. At lower wattages, lighting the walls can increase the perception of brightness.

USING RENEWABLE ENERGY SOURCES IN BUILDINGS

References and information for this consideration can be found with the Department of Renewable Energy of the Ministry of Economic Affairs, which is the lead agency for these considerations of active renewable energy sources in buildings.

- Renewable energy resources, such as sun, wind, and biogas conversion should be considered.
- Solar applications range from heating of hot water to electric power production with photovoltaic cells.
- Wind-powered generators can provide electricity and pumping applications in some areas.
- The Biogas conversion process is sustainable as it reduces gas or electricity costs and eliminates the release of wastewater effluent into water resources.
- The availability, potential, and feasibility of primary renewable energy resources must be analyzed early in the planning process as part of a comprehensive energy plan.

Solar Panels at the IT Park , Thimphu

SECTION 6:
CONSERVATION OF WATER IN BUILDINGS

SECTION 6: CONSERVATION OF WATER IN BUILDINGS

Green design principles respect water resources with diligence whatever the natural distribution. The Guiding principle for water conservation is to use best practice and cost effective measures to avoid and then minimize energy and water use.

The main Goals of Water Design and Management Measures include the following:

1. Sustainability:
   To ensure availability for future generations, the withdrawal of fresh water from an ecosystem should not exceed its natural replacement rate.
2. Energy conservation:
   Water pumping, delivery and waste water treatment facilities consume a significant amount of energy. In some regions of the world over 15% of total electricity consumption is devoted to water management.
3. Habitat conservation:
   Minimizing human water use helps to preserve fresh water habitats for local wildlife , as well as reducing the need to build new dams and other water diversion infrastructures.
4. Reduction of water waste and consumption per capita.

There are 6 key Phases in Water Design and Management Measures.

These include:

1. Water Source
2. Water Storage
3. Water Treatment
4. Water Distribution
5. Water Use
6. Water Recycling

WATER CONSERVATION MEASURES

Some Water Conservation Measures include:

1) Provide details of water supply and use, including measures that will first avoid and then minimize water use.
2) This should include, use of energy and water efficient appliances, fittings and timers.
3) Use waterless toilets (composting toilets where feasible.
4) Provide bulk potable water (in designated drinking water tanks) to minimise the need for bottled water.
5) Using water of lower quality such as reclaimed wastewater effluent, gray water, or runoff from ground surfaces for toilet flushing or irrigation of vegetative landscape or food crops. These uses do not require the level of water quality as that needed for internal consumption, bathing, or washing.
6) Flush toilets are the largest inside user of water. To conserve water, the maximum permissible water use per flushing cycle is 1.6 gallons. Double flush units also save water
7) Efficient shower fixtures should be rated for a maximum flow rate of 2.5 gpm at 80 psi. Instead of a hot water shower, tempered water using a solar thermal collector may be a good median
8) Commercial appliances used in kitchen and laundry areas should also be water-savings models.
9) Garbage disposals should not be used as they are water consumptive and exert a huge load on the wastewater treatment facilities.

WATER-SAVING TECHNOLOGY FOR THE HOME

Water-saving technology for the home includes:

1) Low-flow shower heads sometimes called energy-efficient shower heads as they also use less energy,
2) Low-flush toilets and composting toilets.
3) Dual flush toilets includes two buttons or handles to flush different levels of water. Dual flush toilets use up to 67% less water than conventional toilets.
4) Rain water can be used for flushing toilets.

5) Tap Aerators, which break water flow into fine droplets to maintain "wetting effectiveness" while using less water. An additional benefit is that they reduce splashing while washing hands and dishes.

6) Wastewater reuse or recycling systems, allowing:
- Reuse of graywater for flushing toilets or watering gardens
- Recycling of wastewater through purification at a water treatment plant.

7) Rainwater harvesting

8) High-efficiency clothes washers

9) Weather-based irrigation controllers

10) Garden hose nozzles that shut off water when it is not being used, instead of letting a hose run.

11) Automatic taps is a water conservation tap that eliminates water waste at the tap

12) Water can also be conserved by landscaping with native plants

Rain water collection chains used in a house in Punakha

PROTECTION OF WATER SOURCE

1) Extreme efforts should be made to protect existing and potential groundwater sources from contamination.
2) Use of groundwater is probably the least energy-intensive because renewable energy sources (wind, photovoltaic) can be used to pump the water to a hillside storage reservoir for distribution by gravity. This type of system has so many advantages from both an environmental and economical perspective that the source can be developed up to several miles from the final use point.
3) Fresh surface water can be used when groundwater is not available from streams, rivers, and lakes.
4) In those areas where there is a lack of water, rain catchment becomes an option as a stand-alone supply of water or a supplement to a limited ground or surface supply. Rainfall catchment from the roofs of structures is a recognized option for water supply, provided the necessary treatment processes are used prior to distribution. Care should be used in selecting a roofing material. Rainwater collected from ground surfaces can be used for secondary uses such as toilet flushing and irrigation of food crops.

WATER TREATMENT

1) The type(s) of treatment required will depend on the source of water and the quality of source water and must follow the law of the land including water assessment tests.
2) Treatment of groundwater is to be accomplished by simple measures that do not contaminate the natural environment.
3) The recommended filtration processes would be slow sand filtration or cartridge filtration. Only the water used for drinking, washing, and cooking would need to be completely treated. Dual distribution systems are required - one for drinking water and one for lesser quality uses such as toilet flushing.
4) The slow sand filter is an old technology that has recently reemerged. No chemical additions or additional power are required and operations and maintenance requirements are low. However, a certain land area is required for the filter basin.

WATER STORAGE

1) Water storage methods should not adversely affect the natural environment.
2) Water storage must be designed to ensure the special aspects of the aesthetics of the natural environment are not disturbed.
3) Gravity storage of any water product (raw, finished, reclaimed) should be used wherever possible. Gravity storage enables wind and photovoltaic pumping systems to be effective. Because these pumping systems work at relatively low pumping rates, the gravity storage tank acts as an accumulator to store water for heavy demand periods or for days when the wind does not blow or the sun does not shine. Photovoltaic pumping systems can also be used.
4) Another means of transferring raw water from a source to a storage tank at a higher elevation without electrical or hydrocarbon input is the hydraulic ram. The hydraulic ram is a self-acting impulse pump that uses the momentum of a slight fall of water to force a part of the water to a higher elevation. A hydraulic ram is noisy, but the noise can be successfully mitigated with the use of sound-attenuating materials in an enclosure. The hydraulic ram is well suited for areas where electrical power is not available and where an excess supply of water is available.
5) As a gravity storage tank will be located in an elevated location, visual quality will be important. Multiple smaller tanks may be easier to screen than one large tank. Multiple tanks also provide greater flexibility in operation. Tank materials should be noncorrosive and sectioned for minimal transportation requirements to the tank site.

WATER DISTRIBUTION

1) Most distribution systems are either buried or placed at grade. At-grade distribution systems affect the site and vegetation minimally during construction. Burying has the advantage of protecting against accidental breakage, but leaks are more difficult to locate on a buried distribution system. Leak detection and repair is imperative when dealing with such a precious resource as water.
2) Dual distribution systems are very effective in that different qualities of water can be delivered to different use points. Pipe contents should be color coded so that cross-connection problems can be prevented.
3) No distribution methods should cause large scale destruction to the natural environment.
4) Water distribution methods should not disturb the natural quality of the site.

SECTION 7:
INDOOR
AIR QUALITY

SECTION 7: INDOOR ENVIRONMENTAL QUALITY

Although maintaining high indoor air quality is an important factor of green buildings since people spent a majority of their time inside buildings, the consideration of indoor air quality is often neglected in the design and construction of buildings in Bhutan.

Indoor air Quality is most simply described as the environmental conditions inside a building. It therefore does not refer to the air quality alone, but the entire environmental quality of a space, which includes air quality, access to daylight and views, pleasant acoustic conditions, and occupant control over lighting and thermal comfort.

Indoor air quality is affected not just by air and ventilation considerations but also by the type of materials and finishes that are used within a building. For example, there is a large scale use of synthetic wood varnishes, solvents. Spirits, polishes and paints without any considerations of the harmful effects of these materials. Some adhesives, and varnishes are said to cause even nerve and liver damage in the long term. Asthma and allergy problems are on the rise in Bhutan. Besides these solvents and polishes, materials such a panels, ply boards have to also be taken into consideration as many of them are manufactured with harmful adhesives.

Americans spend a majority of their time indoors; not surprisingly, studies have shown an increase in worker productivity when improvements are made to a space's IEQ. Building managers and operators can increase the satisfaction of building occupants by including thoughtful IEQ details in the design and operation of a space.

For healthy indoor air quality the following could be considered:

1. Natural cross ventilation design strategies should be incorporated to ensure fresh air quality with minimal reliance on mechanical operations for air quality.
2. Analysis of Indoor Air Pollution could be considered with subsequent use of effective pollution defenses, and filters
3. The Design of HVAC Systems should be effective to promote improved air quality
4. Choosing Zero- Or Low-Emission Finish Materials for the building
5. Use of Low VOC Materials, Paints & Adhesives

Examples of CHEMICALS SOURCES IN BUILDING MATERIALS TO AVOID:

Some toxic chemicals to avoid are the following:

1. ***Benzene***
   found in synthetic fibers and plastics: highly toxic to red blood cells

2. ***Acetone***
   found in masonry, caulking, wall coverings, strippers, adhesives, polyurethane, stains, and sealers: flammable and strong odor

3. ***Toluene***
   found in adhesives, paint remover, paint: flammable and may cause lung damage

4. ***Dichloromethane***
   found in solvent in paint remover and adhesive paint aerosols: may cause cancer, heart attacks; a known water pollutant

5. ***Ethylene glycol***
   found in solvent in latex paint: may cause damage to blood and bone morrow

- ***DEHP***
  found in plasticizer used in wall covering and floor covering to keep vinyl flexible: known carcinogen

- ***Dioxin***
  found in PVC products: very toxic; low levels cause cancer; disrupts endocrine functioning

- ***Formaldehyde***
  found in plywood, particleboard, adhesives, fabric finishes, and carpet padding: known carcinogen; may cause allergic reactions or asthma attacks

- ***4-PC,***
  A natural result of binding latex to carpet: it may cause allergic reactions

SECTION 8:
GREEN CONSTRUCTION MANAGEMENT

SECTION 8: GREEN CONSTRUCTION MANAGEMENT

The key objective for sustainable construction is to
leave the landscape visually
and environmentally
in the condition closest to
how it was before the construction.

A planned green design is a great step towards sustainability in buildings Bhutan. However, it will mean absolutely nothing if the construction is then not as it was intended to achieve green buildings. Green construction management is achieved through the 4 essential elements:

1. Consideration of the Qualifications of the Construction team
2. Environmentally Sensitive Construction practices
3. Protection of site during construction
4. Conservation of resources during construction processes
5. Effective Construction Waste Management

QUALIFICATIONS OF THE CONSTRUCTION TEAM

A great deal of pressure is currently placed on design teams to achieve low carbon and green buildings. For construction companies to turn plans into reality and meet the design objectives, it is vital that the site team has the correct knowledge and skills. Having these skills ensures quality in project delivery and helps to minimize the environmental impacts of the construction process and the building in use, as well as meeting the intentions of the building designers.

In order to ensure that the green design details and specifications are effectively carried out on site during the construction it is imperative that the construction team understands the concepts of green design and construction. Therefore, it is important to ensure that the different levels of the construction team right from the management level to the day workers level have an understanding of green design principles and objectives of the project.

The Project should be lead by a professional who has the relevant training and experience of green building design and also construction management depending on the level of complexities of the design and specifications. The project management should further ensure that the team for the construction are instructed or informed right from the beginning on the specifications of the project so that implementation does not take place in an ad-hoc manner that compromises green design and green construction principles.

ENVIRONMENTALLY SENSITIVE CONSTRUCTION PRACTICES

The construction methods employed should ensure that each step of the building process is focused on eliminating unnecessary site disruption (e.g., excessive grading, blasting, clearing) and resource degradation (e.g., stream siltation, groundwater contamination, air-quality loss). For the project to be successful in sustainability there should thus be no residual signs of site cutting, construction, and environmental damage. The main task for sustainability during the construction process consists of:

a) Constructing the building so it will perform as intended and
b) Protecting the environment as much as possible throughout the process.

The following are necessary for sustainable site development:

1) Development of detailed construction documents with accurate and clears specifications.
2) Development of systems for informing and training contractors and sub-contractors about unfamiliar materials and construction methods.
3) Development of detailed construction schedule with specification of activities, material staging and sequences of work on site.
4) Details of systems to be used during construction to ensure development is in accordance with approved sustainable plans,
5) Use of construction equipment that meets best-practice emission standards.
6) Professional supervision on the site as per the specifications and design. The construction on site has to be supervised by professional engineers, architects, and relevant consultants of a minimum of 3 years of practical experience in construction supervision.
7) Contractors and subcontractors must be trained and experienced in sustainable construction or supervised by professionals trained and experienced in sustainable construction.
8) All undisturbed soil and vegetation located outside specifically designated construction limits should be fenced or otherwise protected (e.g., drop cloths, tree barriers).
9) Where disturbance occurs, the site should be restored as soon as possible.
10) All topsoil from construction area should be collected for use in site restoration.
11) Preplanning of the construction process to identify alternative methods that minimize resource degradation.

12) Flexibility in revising construction plans should be allowed to change materials and construction methods based on actual site impacts.

13) Resource indicators are to be developed to allow for monitoring to ensure that resources are not being adversely affected.

14) Development and adoption of an erosion & sediment control plan for the project site during construction to keep sediment on site

15) Disruptions of wildlife travel or nesting patterns are to be avoided by sensitive siting of development.

PROTECTION OF SITE DURING CONSTRUCTION

The site development and construction should minimize site disturbance zones by the following:

1. A plan that protects as much of the site as possible, including vegetation, land contours, and drainages should be considered by the project team.
2. The plan should indicate areas of the site to be used, including staging areas, storage areas (for materials and excavated materials), and the building site.
3. Consider any site clearing that may be necessary to meet fire risk reduction.
4. Elements to protect should be clearly marked in the site plan. If necessary provide pictures and images.
5. Avoid damaging existing vegetation, especially to mature stands of trees. Damage to trees, both above and below ground, can occur during construction activities.

The following guidelines help preserve existing trees:

6. Install fences around trees to protect them from construction activities.
7. Avoid trenching and digging near roots. (Roots can grow at distances one to three times the height of the tree.)
8. If trenching cannot be avoided, then place the trench directly under the tree, as this damages the fewest roots and does not unbalance the tree. (If major roots from one side of a tree are severed, the tree could fall or blow over.)
9. Avoid compacting soils containing tree roots to prevent decreasing the soil oxygen level, which inhibits root growth.
10. Avoid placing additional soil on the ground or changing the surface grade over the tree root systems, as that can smother the roots.
11. Carefully choose which trees to remove, since removal of tall neighboring trees can expose other remaining sun-and wind-sensitive trees to the elements and cause damage such as sunscald to trunks and branches. Where necessary, consider relocating and planting trees, shrubs, and other flora that could be restored as landscaping on this project or another project.
12. Be sure to select plants that are able to tolerate transplanting; and become familiar with the best method for trans-planting and care of the species chosen.
13. Locate all construction trailers and parking areas for construction equipment and employees where they will cause the least damage to the site and vegetation.

14. Specify areas in which to receive materials. All materials entering the site should have a designated site storage destination prior to their arrival. Often, materials entering the site are “dropped” haphazardly at any point that looks open. The more materials are moved, the greater the possibility for damage to the materials and the site and the potential for wasted funds.
15. Identify access paths for construction vehicles and general public access. If possible, these paths should correspond to areas that will eventually be paved or covered with other hard surfaces for the project.
16. Consider laying down preliminary paving in areas that will be permanently paved later. This will reduce dust and erosion from construction activities and traffic.
17. Use best management practices for storm water and silt management. Consider creating storm water management practices, such as piping systems, retention ponds, or tanks, which can be carried over after the building is complete.
18. During construction, the areas available for builder’s access are to be tightly defined.
19. A daily clean-up of the building site at the end of the day is to be strictly enforced to minimize impact on the environment.

CONSERVATION OF RESOURCES DURING CONSTRUCTION PROCESSES

Construction of a building uses a lot of energy, water, and other resources, beyond those that end up in the building itself. By paying attention to these resource flows, contractors can adopt procedures that are more efficient and less polluting.

Some basic but effective examples include:

1. Monitoring of energy and water use for construction.
2. Providing incentives or place the utility and water bills in the contractor’s name to encourage conservation.
3. Use of lighting during construction only in active areas of the site. This saves energy and protects the night sky from light pollution.
4. Turning all lights off when work is at a halt.
5. Operating security lighting on motion sensors

SECTION 9:

MANAGEMENT OF WASTE FROM CONSTRUCTION

SECTION 9: MANAGEMENT OF WASTE FROM CONSTRUCTION

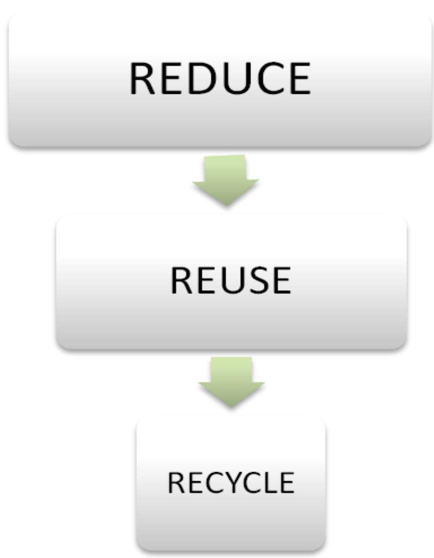
Construction activities always generate significant quantities of solid waste. The primary intent of sustainable construction waste management practices is to conserve resources by minimizing the amount of material disposed of in landfills.

The consideration of management of waste from construction of buildings is being considered far more sensitively in Bhutan in the recent years especially with the current trend of rapid construction and urbanization in Bhutan. In the past, since only natural materials were used construction, waste was not of much consideration as the excess materials or waste could be either recycled or were biodegradable and nontoxic. The fact that many of the new constructions are now being carried out with modern materials have increased waste that is non-biodegradable and toxic in Bhutan.

One of the main aims of green design and construction is to minimize and avoid construction waste. For construction waste management, the best strategy s to start right from the design stage where materials and specifications can be targeted to ensure less construction waste.

The 3 R's hierarchy is one of the most common and simple ways to responsible construction waste management:

THE 3 Rs' HIERARCHY
FOR CONSTRUCTION WASTE MANAGEMENT



CONSTRUCTION SITE WASTE MANAGEMENT STRATEGIES

It is important for a Construction Waste Management Plan to be in place before even starting any construction on site. The Construction waste plan will be in line with the regulations put in place by NEC or other relevant authorities including City Offices.

A Construction Waste management Plan should include the following:

1. Waste handling requirements should be included right from the start in all project documents. This makes it clear from the beginning that waste prevention and recycling is expected from all crew members and subcontractors of the construction team.

2. An analysis of project waste could be made right from the start of the project. This will facilitate the construction waste management plan and strategies.

3. Identification of what materials will be recycled and handled for recycling should be carried out by the construction project team.

4. Disposal methods should be identified and the construction team informed about the different disposal methods.

5. The recycling and trash bins should also be near each other so that trash is not thrown into the recycling bins.

6. Bins for toxic waste should be in a supervised or locked area.

7. Leadership in Construction Waste Management should be identified and placed in the project.

8. Once space for recycling and disposal activities has been designated, the plans must be strongly communicated to the construction crew and any subcontractors. Everyone will need to know how materials should be separated, where materials should go, and how often the materials will be collected and delivered to appropriate facilities. This is very essential as most construction crew members in Bhutan are not familiar with waste management.

SECTION 10:
OPERATION
AND MAINTENANCE

SECTION 10: OPERATION AND MAINTENANCE

After design and construction of a green building, steps should be taken to ensure that the operation and maintenance of buildings also follow green principles and standards.

The building must therefore operate and be maintained at the same or higher level as was designed, approved, and constructed, thus ensuring continual sustainability.

This is most effectively met if there is continual and appropriate maintenance of buildings and landscape around, adequate training of staff, creation of awareness programs and use of local resources for operation. Frequent monitoring is also essential for effectiveness.

This can be against the proposals made and improvements on the proposals approved for design, construction and operation.

Some of the key elements to be considered are:

- *Energy Water and Waste Management*
- *Sustainable House Keeping within the building*
- *Awareness on Sustainability for occupants*
- *Appropriate training of operators and maintenance teams.*
- *Hiring of trained team for maintenance and operation.*

Sustainable House Keeping

- Besides the building, the operation of services must be planned and encouraged to be sustainable at all possible areas. This includes drawing on local resources for food and use of eco-friendly natural interiors, utensils, appliances, and housekeeping provisions including bio-degradable non toxic cleaning items and composting of waste.
- The staff for operations and maintenance should be trained to understand sustainability principles.

ENERGY, WATER AND WASTE MANAGEMENT

- The proposal could propose and implement provisions for planned inspection every 6 months and maintenance as required of all energy, water and waste management systems. If possible, they should be upgraded as new technology becomes available.

- Waste prevention requires training the operators, educating all users of the system, and performing diligent maintenance. Most waste problems have been created because attention has not been paid.

- Conventional disposal systems are designed for ease of use with the user having little idea of how the systems operate or where the waste goes.

- Because waste prevention represents a change in the way activities are carried out, it requires an extra effort especially in the beginning to ensure that these practices are maintained until they become routine.

- In situations with high turnover of occupants, continuous training and awareness programs would be very effective.

- Preventing waste means taking a measure of responsibility for activities. Fostering a sense of responsibility is an important element of environmentally sound development.

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ANNEXURES:

ANNEXURE 1: RECOMMENDATIONS ON INCENTIVES

To encourage Bhutanese individuals/firms to incorporate green design in their constructions the following incentives could be considered in Bhutan.

Sl. No	Recommendations
1	Fast Track /green channel of Approvals for Green Designs and use of natural local materials
2	Tax rebates, credits and discounts or tax exemptions on green materials and products.
3	Privileged and fast tracked connection to public utility networks
4	Soft Construction Loans at a lower interest rate
5	Grant programs for assistance with design.
6	Free Technical design assistance
7	Personal Tax Income Incentives
8	Property tax exemption for 2 to 7 years for green projects depending on green points.
9	Free or Subsidized green training to all Architects, Engineers and Builders.
10	Corporate tax incentives – fast track FDI for green projects
11	Additional FAR (Floor Area Ratio) for those who achieve full green points.
12	Refund of approval/permit fees or full tax deduction for those who achieve green design after construction.
13.	No sales tax for the first sale or purchase of for green designs and green construction.
14	Awards for best Green Design and Construction to Architect, Contractor and Client.
15	50% tax deductions on rent for those who lease green buildings for the first 2 years.
16	First preference by Government offices when they lease private spaces for offices or functions, conference etc. if the design, construction, and operation is certified green.
17	Easy Access to local materials

Annexure 2: Rating Tools and Systems from around the world.

List of some assessment tools and rating systems from around the world

Name	Year developed	Countries
Green Star	2003	Australia New Zealand South Africa
BREEAM (Building Research Establishment's Environmental Assessment Method)	1999	United Kingdom Netherlands
LEED (Leadership in Energy and Environmental Design)	2000	United States Canada India
CASBEE (Comprehensive Assessment System for Building Environmental Efficiency)	2002	Japan
German Green Building Council (DGNB) Certification System	2009	Germany Austria Denmark, Switzerland
IGBC Rating System	2001	India
Green Globes	2004	North America