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Design Modification for National Science and Technology Park (NSTP)

as an Eco-friendly Building

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Bachelors of Engineering in Environmental Engineering

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Declaration

We hereby declare that the content of this thesis, "Design Modification for National Science and Technology Park (NSTP) as an Eco-friendly Building" is a product of our own research and no part has been copied from any published source (except the reference standard mathematical and genetic models/ formulas/ protocols etc.). We further declare that this work has not been submitted for award of any diploma/degree. The University may also take action if the information is found inaccurate at any stage. (In case of any default the scholar will be proceeded against HEC plagiarism policy).

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DEDICATION

This thesis is dedicated

to

OUR LOVING PARENTS

AND SUPERVISOR

By virtue of whose prayers, we have been able to attain this position and whose hands are always raised for prayers, for our well-being

Abstract

Eco-friendly buildings are rapidly gaining popularity in construction industry owing to increasing negative environmental issues by conventional buildings. To establish an eco-friendly building, it is necessary that involved stakeholders such as architect, contractor, and engineers collaborate to achieve goals of sustainable construction. Like other developing countries, economic growth has placed significant pressure on infrastructure and environment. Particularly energy consumption and waste management. This research aims to propose design modifications for an eco-friendly National Science and Technology Park (referred to as NSTP) building. The baseline standards of Leadership in Energy and Environment Design (LEED) were followed to extent practicable. Autodesk Revit 2015 was used for the comparison of energy analysis between a conventional building and the modified eco-friendly building**.** Design modifications were suggested for walls and roof as part of the energy analysis. The comparison included annual carbon emissions; electricity cost, use and consumption; monthly peak demand for electricity; monthly heating and cooling loads for the building. Cost benefit analysis was carried out by comparing the total investment cost on the traditional and modified Eco-friendly building. For this purpose, estimates from Capital Development Authority (CDA), Bahria, Military Engineering Service (MES), Defense Housing Authority (DHA) and online catalogs were used for the estimation of cost. The payback period for a modified Eco-friendly building was calculated using the higher initial investment cost of modified Eco-friendly building and net cost of savings in terms of energy consumption.

Acknowledgment

We have no words to express our deep sense of thankfulness and countless gratitude to ***ALMIGHTY ALLAH,*** the compassionate and merciful, who bestowed on us His blessings and gave us courage to complete the present studies and dissertation.

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List of Abbreviations

LEED	Leadership in Energy and Environmental Design
USEPA	United State Environmental Protection Agency
USGBC	United States Green Building Council
GHG	Green House Gases
STP	Science and Technology Park
NSTP	National Science and Technology Park
NUST	National University of Sciences and Technology
IESE	Institute of Environmental Sciences and Engineering
SCEE	School of Civil and Environmental Engineering
CDA	Capital Development Authority
MES	Military Engineering Service
DHA	Defense Housing Authority
IAR	Initial Assessment Report

Introduction

Globally the human race is facing numerous environmental problems and developing countries like Pakistan also face energy crisis, all these things need to be get optimized.

Sustainability transitions have been embraced in regions throughout the world in response to climate change fears, economic decline, public health concerns and environmental degradation. There is increasing evidence to support the idea that the best way of ensuring communities can become more resilient to the effects of climate change and environmental degradation is for them to become more sustainable up to and including an ability to become carbon neutral and energy sufficient.

Conventional Building Construction refers to the traditional method of construction where the construction knowledge is passed from one generation to the other associated to the wet construction (in-situ) using reinforced concrete. Conventional buildings are also named as Brick & Block Masonry Buildings. Many people use the term Conventional Build', or building, to imply the use of masonry for the outside walls, where 'masonry' infers the use of bricks and concrete blocks for these. People constructing the conventional building by years to save their money, but they are not aware of the fact that conventional building though reduce their capital cost but it increases the long run cost by using the large amounts of energy, land, water, and raw materials for their construction and operation and the damage caused to the environment

Therefore, we offer a concept, by which everyone can save energy in their homes, offices, schools, colleges and every institution. we know that won't be very interesting but what if we tell you that using our concept you can also save money, you can reduce your energy costs and perhaps use those savings to go on the next summer vacations. In addition to this, it also ensures a good environment quality.

This is the concept of eco-friendly buildings. Now eco-friendly buildings refers not only to the structure but also the using of processes that are environmentally responsible and resource-efficient throughout a building's life cycle; from siting to design, construction, operation, maintenance, renovation and even demolition.

1.1. Problem Statement:

Built Environment is a major source of CO_2 emission, energy and material consumption, air, noise and water pollution along with solid waste; leading to global warming, energy crises and climatic changes throughout the globe. Furthermore, air and water pollution are adversely affecting the environment and human health.

1.2. Green Building:

Green buildings which are also known as eco-friendly buildings are gaining popularity as a means to promote sustainability. The concept of an eco-friendly building not only encompasses construction or structure but all the processes from initial to final stage to be environment friendly. Green buildings aim to utilize clean and green resources by generating less waste, reducing pollution to the environment, preserving greenery, waterways and natural heritage. Kibert (2004) further defines green or sustainable buildings as "the facilities which are the outcomes of sustainable construction for the purpose of promoting occupant health and resource efficiency, minimizing the impacts of the built environment on the natural ecology system". These buildings not only focus on betterment of environment but are also concerned with occupational health and safety. For a building to be environment friendly, it requires all methods and materials to be sustainable in construction as well as in operational phase (Edwards & Naboni, 2013).

Though it has some an added initial cost but operational cost of eco-friendly building is very low as it uses less energy and water so it balances the initial cost within few years. The definition of green building has been given by the United States Environmental Protection Agency (USEPA) which is:

> *"Eco-friendly building is the practice 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. This practice expands and complements the classical building design concerns of economy, utility, durability, and comfort. Green building is also known as a sustainable or high-performance building." (USEPA)*

An eco-construction or green building approach that aims to build in respect of our environment and that of future generations, while offering maximum comfort to occupants. It is also an approach that involves:

- The identification of the environmental impacts of projects throughout their lifecycle;
- The use of architectural and urban-planning techniques that prioritizes natural light, guarantee good thermal insulation of the whole building envelope and respect applicable legislation;
- The use of sustainable materials that consume little energy in their manufacture, transport and deployment;
- The promotion of the use of renewable energies and low-pollution fuels; The use of "Low energy" lighting and appliances, efficient correctly-sized heating systems (Wargocki, Rismanchi, 2008).

1.3. LEED:

LEED (Leadership in Energy and Environmental Design) was developed by US Green Building Council that provides standards for design, construction and maintenance of green buildings. It is an international certification program that recognizes best building practices and strategies. LEED works through all the phases of development, not only for homes but for corporate headquarters as well. LEED certified projects earn points on addressing sustainability issues. LEED has four ranks of certification of building.

Table 1: LEED certifications

Sr. no.	Certification rank	LEED Points	Logo
1	Certified	40-49	
2	Silver	50-59	

3	Gold	60-79	
4	Platinum	80-110	

Building get the ranks mentioned above based on the points achieved by the building. LEED certified buildings are resource efficient, using less energy and water. These building are also produce less waste and reduce greenhouse gas (GHG) emissions.

LEED credits are categories in some parameters mentioned in the figure below. Each parameter has its LEED points.

Figure 1: LEED CREDIT CATEGORIES

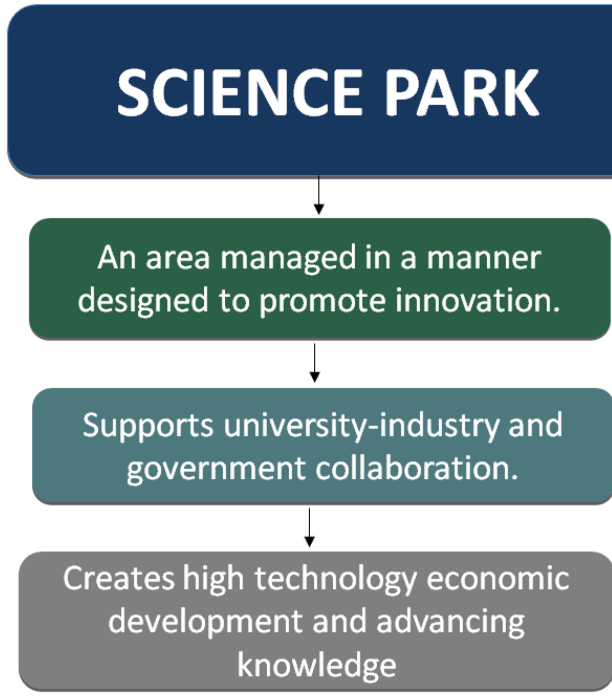
In addition to LEEDS, other internationally recognized standards include "Energy Star" governed by US Environmental Protection Agency (USEPA) that focuses on energy efficiency. It ensures reduction of energy by labeling consumer products to reduce energy consumption by 20-30%. Buildings can also receive Energy Star certification by consuming lesser energy for use and also by reducing the emissions of carbon dioxide as compared to other buildings.

Similarly, an assessment program known as the Green Globe, administered by Green Building Initiative in the US offers ways to increase sustainability of commercial buildings. This program uses ISO 14020 and 14024 for standardization. Less energy use, conservation of natural materials and fewer pollutant emission are the key factors that are necessary to earn Green Globe Certification (Council, 2008).

Another organization called Green Seal, a third-party certifier, is one of the largest US based eco-labeling organization. Its main focus is on the lifecycle of products from raw materials to production and their disposal as well as recycling. The products that meet the standards set by Green Seal are awarded the Green Seal certification.

1.4. National Science and Technology Park & Science Park:

A Science and technology park which is also known as University Research Park refers to an assigned area designed to promote innovation. It is a place that supports university-industry and government collaboration with the intent of advancing knowledge and promoting technological and economic development (Phillimore, 1999).



National Science and technology Park (NSTP) which would be constructed in the National University of Sciences and Technology (NUST) main, H-12 in the city of Islamabad, Pakistan. The main campus which is spread over an area of 706 acres has a dedicated site of 50 acres for the NSTP. NUST has taken this national level initiative with the aim to enhance and modify the research & development (R & D) and also promote linkage between the higher education institutes in Pakistan. This project was awarded to the consultants in August 2014 and work formally commenced on September 2014, but was temporarily suspended from November 2014 until September 2015. At the date of 25 February 2015, the initial assessment report (IAR) of this project was submitted and this report was formally accepted on 10 April 2015 by NUST after the comments and feedback provided by the relevant project stakeholders from the part of NUST.

1.5. Objectives:

Built Environment is a major source of CO_2 emission, energy and material consumption, air, noise and water pollution along with solid waste; leading to global warming, energy crises and climatic changes throughout the globe. Furthermore, air and water pollution are adversely affecting the environment and human health. The research study aims to propose design modifications to a conventional NSTP building in order to certify it as a green building. The study focuses on determining and assessing impacts from NSTP building components and suggesting measures that meet the eco-friendly building requirement. The objectives of this research are:

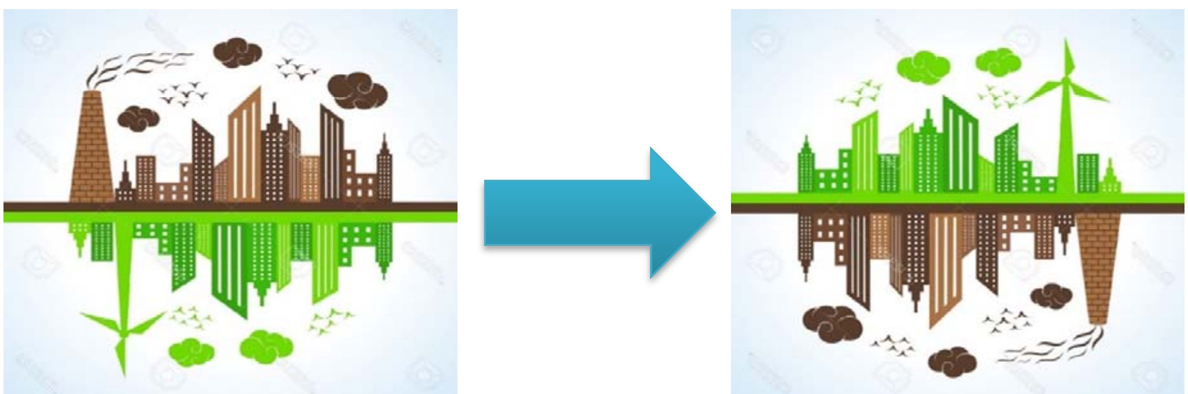
Objective 1.

- Propose design specifications and techniques in order to improve environmental quality and energy efficiency of NSTP

Objective 2.

- Perform Cost-benefit Analysis between Traditional and an Eco-friendly building of NSTP

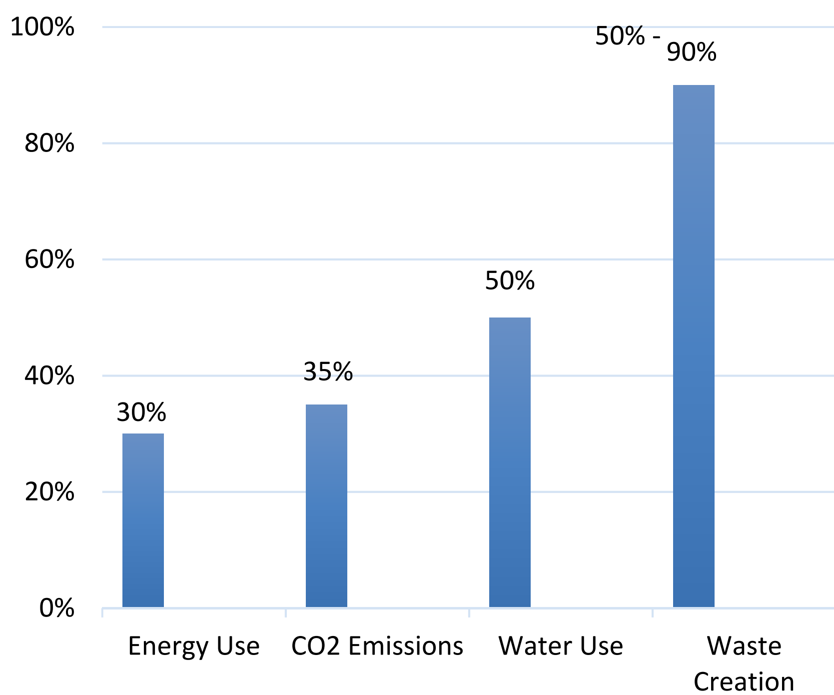
Figure 2: From conventioal to green NSTP



1.6. Significance of work:

Built environment has a major impact on human and environment health in various ways. One of them is the emissions of Carbon dioxide being generated from buildings. Now, carbon dioxide which is greatly increasing in the atmosphere, is one the major greenhouse gases that contributes to global warming resulting in increased earth's average annual temperature. Secondly, in countries like Pakistan, energy crisis affects commercial and industry work greatly and constantly damaging economy. Another issue is the water consumption, excessive water use without any controlled measures and dumping fertilizers, non-diluted lab and hospital waste and even solid waste result in contamination of natural water bodies. A similar issue is air pollution. Now, everyone in the world is inhaling some components that are not very good for our breathing system and eco-friendly buildings can control a lot of hazardous chemicals and greenhouse gas (GHG) emissions, which can result in the control of global warming. Average reduction by eco-friendly buildings are shown in the graph;

Graph 1: Average reductions by eco-friendly buildings



Literature Review

2.1. Background:

In early seventies, green building designs began to be introduced in buildings. Some examples of the buildings were, "The Willis Faber and Dumas Headquarters in England", which included the features of a glass roof; day lighted atrium, and mirrored windows. Another example is of the Greggory Bateson Building in California, which use energy sensitive photovoltaic cell, under floor rock-store cooling systems, and area climate control device.

Green buildings are also termed as intelligent buildings as these constructions provide an optimum comfort level to the building occupants by minimal use of energy through outer sources and a good integration of the building into the environment (Cociorva, Iftene, 2016).

During 1992, the idea of "Greening the White House" began to circulate. Bill Clinton, former US president gave the idea to make the White House a "model for efficiency and waste reduction" (Kibert, 2016).

To achieve the green building standards, new techniques to reduce waste, decrease the use of energy, and to use renewable resources appropriately, including the improvement of the indoor air quality. The methods being used for the greening of White House were:

- Minimizing the energy being lost through the roof, windows, walls, etc.
- Strategizing ways to make the maximum use of natural light and use energy saving bulbs when required.
- Installation of office equipment that was feasible for saving energy. More energy-efficient models were introduced in place of refrigerators and coolers.
- New recycling program was introduced for efficient management of waste.
- Usage of vehicles that utilized cleaner burning fuels

(Castro-Lacouture, Sefair, Flórez, & Medaglia, 2009).

A recent research has been performed to assess the energy consumption of residential buildings that meet the requirements of green buildings. The study was conducted on 300 such residential buildings and a reduction of 43% in energy consumption was observed. The research also shows a cost benefit analysis on the energy consumption of the residential buildings which shows significant savings in the costs of energy consumption (Zhao, McCoy, & Du, 2016).

The eco-friendly buildings also serve lower amounts of greenhouse gas emissions which are proved by the recent study on two state-of-the-art buildings in Australia and China. The study shows the relationship between emissions of gasses that are classified as greenhouse with eco-friendly buildings. There is a significant amount of reduction in the amount of greenhouse gasses being produced due to better energy consumption techniques being used in the eco-friendly buildings (Dincer, 2000).

Similarly, another study has been conducted in Japan that shows a significant reduction in the production of CO_2 and costs. The health situations have also been improved due to eco-friendly buildings. The best results obtained, show a 33% and 26% reduction in energy consumption and 38% and 32% decrease in production of CO_2. These buildings are also providing healthy environment and more cost savings (Balaban & de Oliveira, 2016).

A research was carried out on direct and indirect impacts of vegetation on the building's thermal comfort. Vegetation was introduced as green walls, green roofs and lawns. This led to positive summer effect on comfort of the building. Results also concluded that green roofs lowered the indoor temperature of upper floors, green walls have both direct and indirect impacts and lawns provide only an indirect impact by increasing the evaporation rate (Musy, Malys, Inard, 2017).

Another study conducted in Italy indicates the effect of green walls installation on the heating and cooling load of different buildings through modelling and simulation. It was observed that by covering outer layers of building with a layer of vegetation results in a higher magnitude of heating (60%), cooling (10%) as well as total energy savings (31%) were achieved for the residential facility because of possessing higher to maximum occupancy level during night (Podar, Park, Chang, 2016).

Eco-friendly buildings require serious planning and proper construction strategy. A construction process that is usually related to the construction of eco-friendly buildings is called Integrated Construction Process (Retzlaff, 2008).

An integrated construction process involves all the main stakeholders such as contractor, architect and sub-contractor to carry out their responsibilities in order to achieve sustainability during the construction phase.

A study related to this process was performed in order to develop an integrated construction process so that eco-friendly strategies and technologies can be facilitated. It mentioned the responsibilities of the major stake holders and building strategies as well as the technologies to be used in order to achieve sustainability (GhaffarianHoseini et al., 2013).

Another research was conducted to develop Integrated Construction Process (ICP) in order to help all the stakeholder to develop green strategies and practices at the construction phase, this research concluded all the step-by-step processes and responsibilities of three main stakeholders such as an architect, a contractor, and subcontractor that can help all stakeholder to achieve sustainability at the construction phase (Ahn, Jung, Suh, Jeon, 2016).

Some of the factors that were discussed included renewable energy for which solar energy, fuel cells and geothermal energy were proposed. It included natural as well as hybrid ventilation system. The design proposed a water recycling system in order to recycle rain and waste water. For construction purposes a double skin system and vacuum insulation with triple glazing window was proposed (Lee et al., 2016).

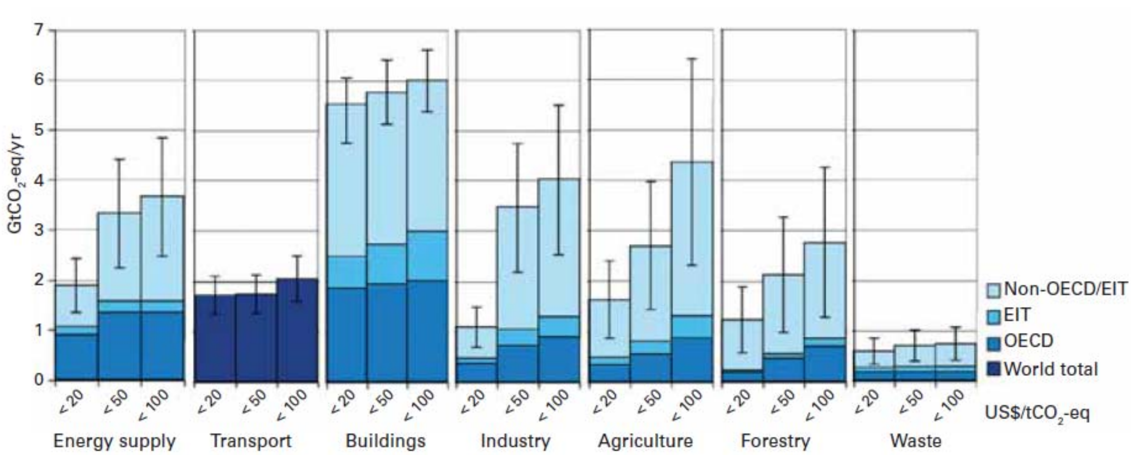
For lowering the energy demand for Heating Ventilation Air Conditioning (HVAC) systems because of higher temperatures resulting from rapid urbanization. Several sedum covered extensive green roofs are installed to lower the temperature over the roof and reduce the urban heat island effect. The study reported under normal conditions, the sedum-covered green roof exhibits a slight warming effect on its surrounding during the day, and cools down the immediate environment at night (Solcerova, Ven, Wang, Rijsdijk, 2016).

2.2. Environmental issues with traditional buildings:

Construction activities have a major impact on physical development, government policies, community activities and welfare programs. However, over their entire lifecycle, construction activities are also connected with the broader problems and issues affecting the environment, including global warming, climate change, ozone depletion, soil erosion, desertification, deforestation, eutrophication, acidification, loss of diversity, land pollution, and consumption of valuable resources such as fossil fuels, minerals and gravels (Ahn, Jung, Suh, Jeon, 2016).

The 4th Assessment Report from the Intergovermental Panel of Climate Change (IPCC) has shown that buildings have the highest energy consumption (Figure 1), resulting in greater carbon emissions that can be reduced by adopting green technologies that can be benificial both environmentally and economically (Li et al., 2007).

Graph 2: Carbon emissions reduction potential



[Figure 1] Buildings have the highest potential to reduce carbon emissions (4th Assessment Report, Intergovermental Panel on Climate Change).

Source: IPCC, 2007: 4th Assessment Report of the IPCC

40% of the World's energy is used by the building sector which is much greater than the transportation. Furthermore, in the coming years, CO_2 emissions are projected to grow faster than any other sector, with emissions from commercial buildings projected to grow fastest- 1.8% a year through 2030 (USGBC).

Resources like energy, water and raw materials are used by buildings that generate waste that causes damage to environmental health by emitting potentially harmful atmospheric emissions, and fundamentally change the function of land, and the ability of that land to absorb and capture water into the land (Buchanan & Honey, 1994).

According to the number of studies conducted by US Green Building Council, it has been reported that buildings cause damage to environment throughout its life-cycle, from material transportation, construction and demolition. An average 73% of world's energy derived by fossil fuels is consumed by buildings which are resulting in environmental degradation, also the consumption of this energy results in carbon dioxide emissions which are reported to be 38%, resulting in global warming and climate change. Buildings are responsible for not just a large percentage of the world's water use, but a large percentage of wasted water as well. It's estimated that buildings use 13.6% of all potable water, which is roughly 15 trillion gallons of water per year.

Conventional buildings affect the environment and surroundings not just in terms of construction but also in operation. In fact the use of non-sustainable construction material has a temporary negative impact, but how's it built to operate has a huge impact as well.

Conventional buildings effect the environment both in short term and long term. Following are some of the possible ways of that happening;

2.2.1. Construction materials:

The materials used in the construction of traditional buildings are produced in a non-sustainable way. These processes in the factories produce enormous amount of CO_2 emissions that are detrimental for the environment and human health.

Secondly, the moving of these materials to the construction site also requires heavy transportation, specifically in case when these materials are moved locally across the country or a shipped from overseas. This has a substantial impact on the air quality. There is a huge environmental impact associated with the extraction and consumption of raw materials for the use of building materials.

According to the USGBC, 40% of the world's raw materials are used in the construction of buildings. Also, not to forget is the extraction and consumption of the raw materials in order to manufacture these construction materials has a significant environmental impact.

2.2.2. Impacts on the air:

As mentioned previously that construction impacts the environment in terms of energy consumption both directly and indirectly through the materials that it uses. This large bulk of material consumes energy during transport. Considering this direct use and embodied energy, this sector consumes about 4.5% of the total energy consumption and construction generates over 40 million tons of carbon dioxide that contributes to global warming by adding to the greenhouse effect. Besides CO_2 Oxides of Nitrogen and acid gases are also produced, contributing to the photochemical smog and acid rain.

2.2.3. Waste from building construction and demolition:

Not just the construction but the destruction and renovation of these buildings also results in a large amount of waste. This Building waste mainly consists of concrete, metals, plastics, glass, asphalt, wood, bricks and more. This waste almost always ends up in either landfills or incinerators aggravating the space loading on the landfills and air pollution respectively. This not only just pollutes the land and the air but also the transportation required to deport this demolished material has a major environmental impact.

According to Environment Protection Agency, over 170 million tons of debris was generated in construction and demolition of buildings in the US alone in 2003. This leads to the serious consideration for the green architecture in the future.

2.2.4. Planning land use and conservation:

An ample range of environmental issues are related to the land use, planning system and the construction industry. Bio diversity on particular sites is devastated by developments and through the mineral extraction in the beginning.

Quarrying operation increases the pressure on the local road networks and neighboring uses. These constructed buildings and the natural environment has a notable impact on the hydrological system. The combined effect of urban expansion and agricultural intensification has exceeded the capacity of the land to absorb exceptional levels of rainfall.

These overall emissions result in the severe damage to the ozone layer, causing greenhouse gases to remain trapped in the earth, causing an increase in the average earth's temperature - Global warming. This increased temperature results in disturbance of natural water cycle and seasonal changes, which indicate buildings, play a vital role in climate change.

Interrelationships between the built environment and environmental issues are well defined in the given table:

Table 2: Environmental issues with conventional buildings

ISSUE	Energy use, global warming and climate change	Resources, waste and recycling	Pollution and Hazardous substances	Internal environment
Planning, land-use and conservation	➢ Transport implications ➢ Sea level rise ➢ Overheating ➢ Increased UHI effect ➢ Passive heating/cooling ➢ Flooding ➢ Biodiversity ➢ Water quality	➢ Minerals extraction ➢ Disposal of spoil ➢ Recycling derelict land ➢ Re-use of existing buildings ➢ Resources used for major infrastructure projects	➢ Pollution effect of built environment ➢ Waste disposal ➢ Maintenance of environmental quality objectives ➢ Ecosystem conservation ➢ Biodiversity conservation ➢ Contaminated land register ➢ Estate maintenance ➢ Pesticides etc.	➢ Orientation daylight and passive heating ➢ Rn-222 ➢ Electromagnetic radiation
Internal environment	➢ Energy use, heating, appliances etc. ➢ Flooding ➢ Thermal efficiency ➢ Reduced ventilation rates/less occupant control	➢ Gas from recycled sites ➢ Reduced off-gassing from recycled products	➢ Indoor pollution/ Off-gassing from materials ➢ Effect on pollution levels of reduced ventilation rates ➢ Smoking ➢ External air quality ➢ Rn-222 and landfill gases	
Pollution and hazardous substances	➢ Energy related greenhouse gases ➢ Ozone depletion ➢ Ozone creation ➢ Acidification ➢ Eco-toxicity ➢ Wastes from power generation	➢ Pollution during ➢ manufacture ➢ Waste production ➢ Pollution of primary ➢ resource ➢ Recycling contaminated ➢ land		

Resources, waste and recycling	➢ Energy in transport ➢ Energy in recycling ➢ Use of sustainable resources			

2.3. Reduction in Impacts due to green buildings:

Eco-construction or green building, proposes various possibilities of reducing the environmental impact of buildings. There are no definite set of rules for sustainable construction, but it comprises of set of various techniques, materials and technologies which enhance the performance of building and lowering the harm to environment and human health. The main goals of eco-construction are energy efficiency, limits water consumption, makes maximum use of recycled, recyclable and non-toxic materials. It also generates as little waste as possible during the construction process and subsequent occupation.

In a green building, the structural creation processes tends to mitigate or lower the damage to the environment and make efficient use of resources. This practice is growing and complements the conventional concerns of designing buildings that are economical in energy, sustainable and comfortable. A green building is a clean, sustainable building, designed with natural materials, uses little energy and renewable ones at that, is easy to maintain and available locally at a reasonable cost.

Effectively, a green building can incorporate sustainable materials (reused, recycled, recyclable, or from renewable resources) in its construction, create a healthy interior environment with a minimum of pollutants and functional landscape planning.

Eco-friendly buildings are generally designed to reduce energy consumption and make the use of resources more efficient. Eco-friendly buildings prove to be beneficial in a number of ways. These are listed as follows:

- **Energy Efficiency:** As green buildings tend to lower the energy demand by allowing maximum penetration of sunlight in the building and lowering the indoor building temperature by installation of green walls, green roofs and sustainable floors. This lowers the use of Heating Ventilation Air Conditioning HVAC systems. Also, green buildings aim to use renewable energy sources such as solar or wind for the production of electricity; therefore, this reduces an overall burden on the no-renewable energy sources such as fossil fuel.

- **Reduction in Emissions:** The use of green technology for the production of electricity such as wind or solar powering and making more use of sun light rather than electricity being produced from fossil fuels would enable us to decrease the emission of greenhouse gases such CO_2 and SO_x which contribute to acid rain. This can also help in diminishing global warming.
- **Conservation of Water:** Recycling of water and creating awareness to prevent the waste of water can help to preserve significant amount of water which can be used for different purposes. This may also be helpful for preserving potable water.
- **Storm water Management:** The management of storm water is important which can be achieved by building permeable surfaces and installing green roofs. This can help to reduce flooding and the carrying of pollutants in water from one place to another.
- **Temperature Control:** Eco-friendly buildings serve less temperature retaining buildings which can be useful in reducing the use of air conditioners that contributes more in energy cost (Troeh, Hobbs, & Donahue, 1980).

2.4. Cost effectiveness of green buildings:

Owners of green buildings reported that their Return On Investment (ROI) improved by 19.2% on average for existing building green projects and 9.9% on average for new projects

Examples include, one major hotel project spent an estimated $184,000 for building energy efficiency improvements and has realized a yearly savings of $58,035, yielding a 3.17 payback period.

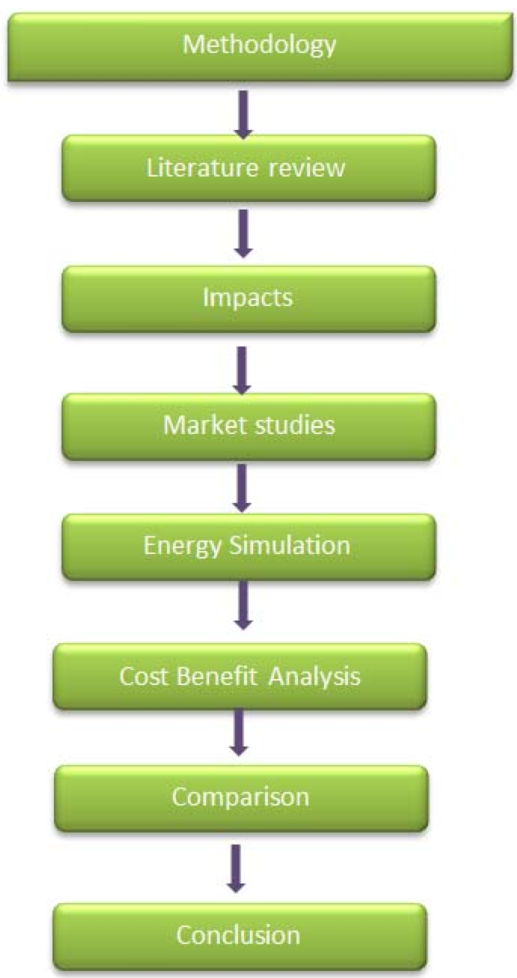
- Operating costs decreased by 13.6% for new construction and 8.5% for existing building projects
- Building value increased by 10.9% for new construction and 6.8% for existing building projects.
- Increased asset valuation: New green building projects 5%; Green building retrofits 4%.

(Yoshida, Ohashi, 2015).

Materials and Methods

3.1. Proposing Design Modification:

A modified design for NSTP was proposed by first carrying out a detailed literature review over the sustainable building practices and green materials available. All the environmental, social and economic impacts of each material were studied throughout the buildings lifecycle. Local market was surveyed to find out alternates that had lower environmental impacts and were cost-effective. Autodesk Revit 2015 was used for energy simulation, NSTP was designed twice on the software. First, with conventional material for construction and second after installation of green materials e.g. green walls and roofs, after running the energy simulation differences were identified in terms of cost of saving energy. This difference in the cost along with the initial investment of both projects was used to carry out cost benefit analysis and calculating payback period by comparing the two designs.



3.1.1. Resource Efficiency:

After carrying out a detailed literature review on the green materials for buildings, market surveys were conducted to find out what sustainable materials are locally available and what alternative material can be used for construction, furniture, flooring, windows etc.

A 2012 LCA study found that "Specifically within commercial buildings, the use and operation phase of the material and building life cycle is so dominant that the impacts of construction, demolition/disposal, and transportation are nearly irrelevant for most traditionally constructed buildings" (Keysar & Pearce, 2007).

3.1.2. Energy Conservation:

Installation of green roofs (i.e. planting vegetation on roof) and hedgerows can result in lowering the indoor temperature of building and reducing the carbon emissions released in the atmosphere (Khudhair & Farid, 2004). Green roofs and hedgerows consists of layers of different materials, each with a different R-value, it is the capacity of an insulating material to resist heat flow. The higher the R-value, the greater the insulating power. These materials collectively reduce the heat inflow in buildings through walls and roofs that reduce the indoor air temperature, resulting in lower energy demand for HVAC systems in both summer and winter season. The proposed design of NSTP consists of a curtain wall, an outer covering of the building in which the outer walls are non-structural, made up of a lighter material, lowering the construction cost. For NSTP's curtain wall glass material is used that allows natural light to penetrate deeper within the building, lowering the energy required to turn lights ON.

3.1.2.1. Green roofs:

A green roof is an extension of a conventional roof which involves the installation of a layered system of membranes, substrates and plants. Green roofs serve several purposes for a building, such as absorbing rainwater, providing insulation, and helping to lower urban air temperatures and mitigate the heat island effect (Del Barrio, 1998).

Figure 3: Traditional green roof

Following are the possible options for Green roofs:

Table 3: Characterstics of vaious green roofs

TYPE	PLANT TYPE	Characteristics
Extensive Green Roof System	-Sedums -Small Grass --Flowering Plants -Herbaceous Plants	-Little maintenance -No Irrigation required -Growing medium depth is 6 inches or less
Semi Intensive Green Roof System	-Small herbaceous plants --Grasses -Small Shrubs	-Moderate maintenance -Occasional Irrigation -Growing medium depth is 6-12 inches
Intensive Green Roof System	herbaceous plants to small trees with professional maintenance	-Advance green roof irrigation system -Growing medium depth is 6 inches or more -Plant Selection influence the maintenance for upkeep of these roofs -Requires higher nutrient system

3.1.2.2. Green Walls:

Green walls or also commonly known as vertical gardens are the outer walls of buildings covered with greenery to provide insulation and better indoor air quality of the building (Dunnett & Kingsbury, 2008).

Figure 4: Outdoor green wall

Following are the possible options for Green walls

Table 4: Characterstics of various Green walls

Available Options	Characteristics	Temperature Reduction (°C)
Direct facade greening system	Direct greening has a very small impact on environment, this type of greening is always a sustainable choice without any other material involved	1.2
Indirect façade greening	Indirect greening has influence on total environmental burden due to usage of stainless steel mesh. These impacts can be reduced by using other materials.	2.7
Living wall system based on felt layers	The LWS based on felt layers has no major footprint due to the materials involved. Materials	5.0

(Alexandri & Jones, 2008).

3.1.3. Efficient Water Consumption:

Taking measures to avoid water wastage and creating awareness among all the people especially workers to use water carefully. In order to conserve water in NSTP following measures are proposed:

- Following recommended flush volumes (proposed by Office building water efficiency guide, Singapore) shown in the table below
- To achieve the desired water efficiency, regular maintenance programs and cleaning operations are established.
- Water metering and sub-metering helps in identifying how much amount of water is being used and where is it being used, this creates best opportunities for saving water.

- Managing pressure in NSTP to reduce unnecessary high flows, lessen leaks and pipe bursts, and improve the life of plumbing fixtures.
- Installing self-closing (sensored) faucets, to reduce wastage of water and regularly inspecting for sensors if they are working properly. Also, faucets must be regularly cleaned to remove any sediment accumulation.
- Adding Organic matter to Soil before planting that not only improves the plant growth but increases the water holding capacity of water resulting in less wastage of water.
- Avoid soil compaction before plantation as this can lower the water and air circulation in soil.

  (Office buildings water efficiency guide, Jordan, 2009).

3.1.4. Storm Water Conservation:

According to National Oceanic and atmospheric Administration (NOAA) an average annual of 1142.1 mm of rainfall is recorded in Islamabad. Certain measures can be applied to conserve water reaching ground through rain.

1. Pervious Pavement: Gravels are placed beneath the soil surface around the building and trees are planted, rainwater percolates through the soil and passes through the voids between gravels that removes major amount of contaminants and reaches to the groundwater. In case of heavy rainfall, overflow pipes are installed that directs excess water towards manhole
2. Rain Barrels: These are the storage vessels above the ground. Water that runs off from the building's roof is captured into these vessels through gutter and downspout system.
3. Green Roofs: As vegetation is installed on the roof, it reduces the amount of water directed towards the storm a drain, however, portion of this water is absorbed by the plants increasing the rate of evapotranspiration.
4. Underground Storage: Underground storm water retention captures and store water collected from surrounding impervious areas. This water then infiltrates into the ground to recharge groundwater aquifers (Walsh, Papas, Crowther, Sim, & Yoo, 2004).

3.1.5. Energy Simulation:

The given design of National Science and Technology Park was drawn in AUTODESK REVIT 2015.

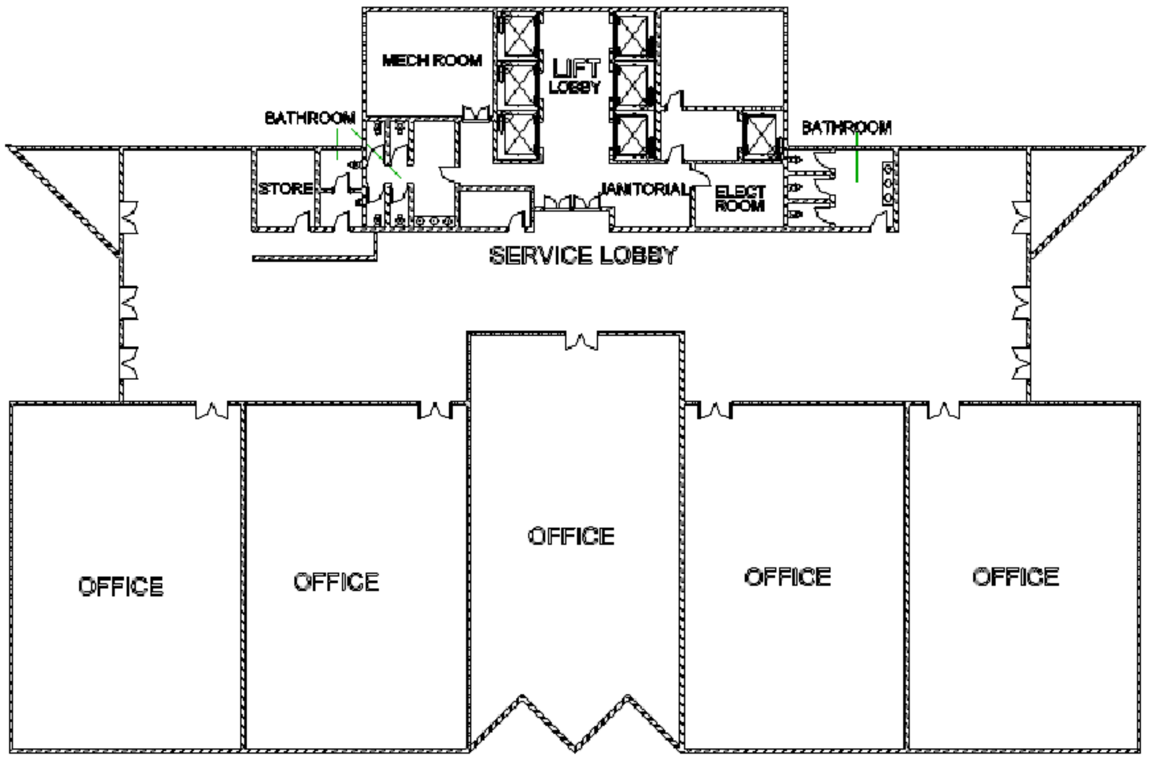
Autodesk Revit is a software used for designing buildings. It can be used to do modifications to a building by both, structurally and architecturally. For modification of roofs, walls and windows, it contains a large number of materials in its library that we can use as insulation and even measure the combined R-value (number to determine the resistance of a material). Custom materials can also be created and resistance values can be input manually. The software also comprises a huge library of different objects such as kitchen appliances, office objects, home accessories etc. which can be used to place in the rooms that have been already designed for the specific purpose. Furthermore, it allows us place cameras to get a view from that particular point from a person's point of view. The results can be rendered using the rendering tool to obtain fine quality images of the design. Once the design is complete an energy simulation can be run on the design once appropriate information about HVAC and weather station have been input. This helps us to determine the energy consumption of the building and the cost that can be saved throughout the year.

Figure 5: AUTODESK REVIT

In this project, the building was designed only architecturally. The design was made using all the materials that are conventionally used in a building in Pakistan and a similar design was created using the best suitable and locally available sustainable materials. The energy simulation was run on both the designs and the results were compared which are shown in the result section.. Energy simulation was done through the software before and after the modification of design to study the difference in emissions, energy use and cost on an annual basis (Chaisuparasmikul, 2007).

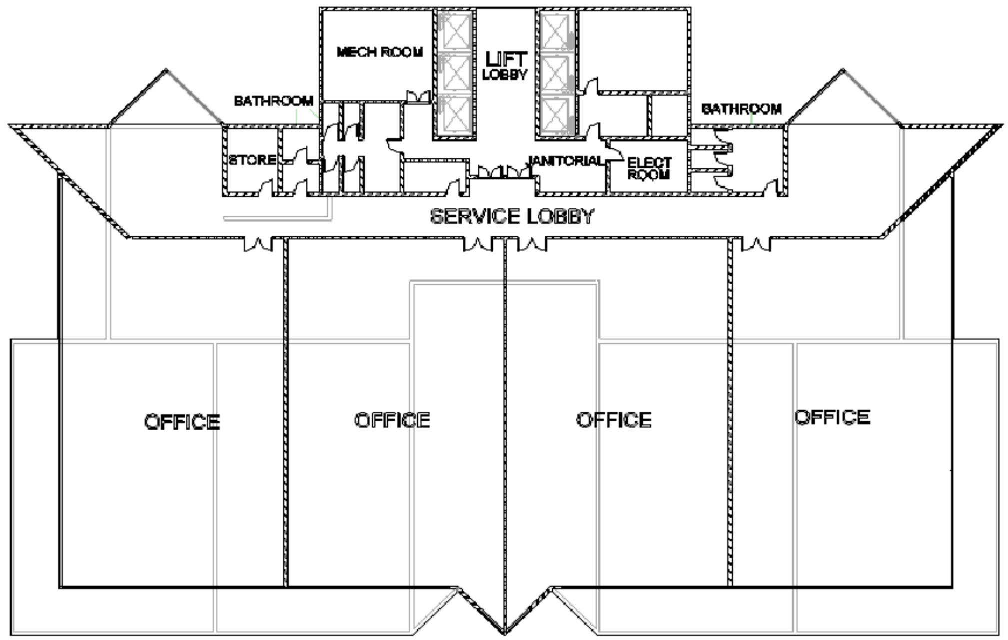
1. Plan for Ground floor with an area of 19,628 sq. ft.

Figure 6: Ground Floor Plan



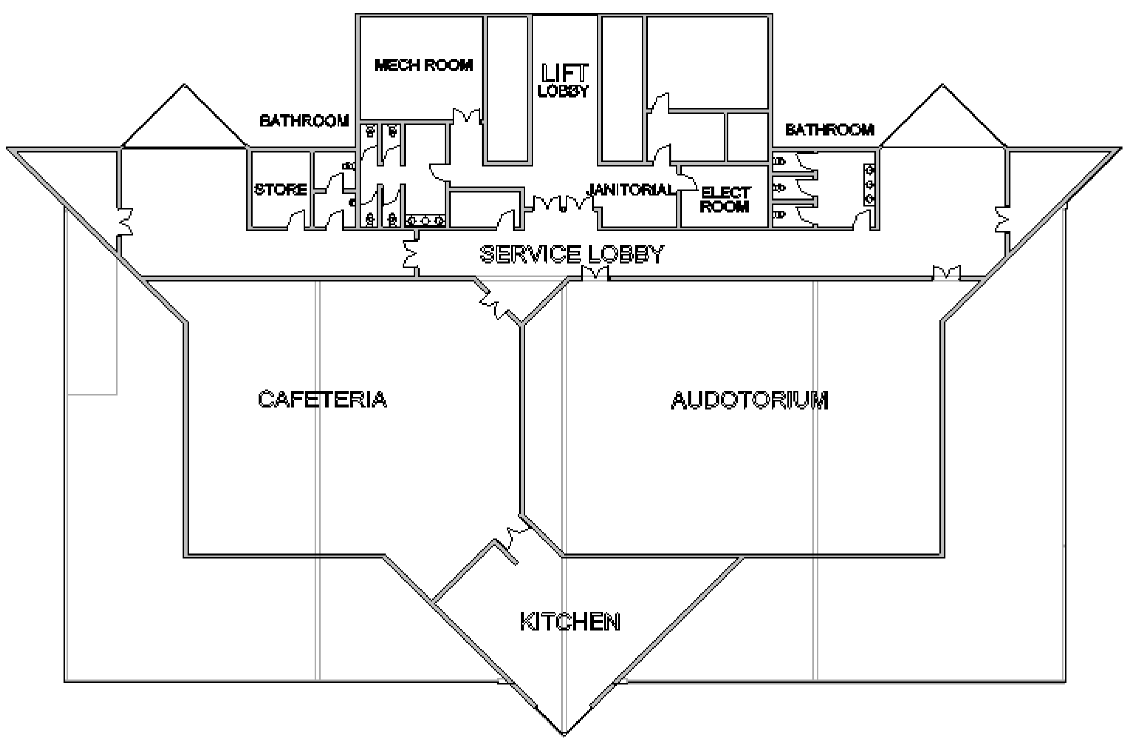
2. Plan for first to tenth floor with an area of 17,829 sq. ft. for each floor.

Figure 7: First to Tenth Floor Plan



3. Plan for Top floor with an area of 17,829 sq. ft.

Figure 8: Top Floor Plan



3.2. Cost Benefit Analysis:

For an estimation of cost, various market surveys were conducted in Islamabad to check the locally available material. Cost that was associated with materials to be installed in both conventional and Eco-friendly building of NSTP was estimated using the material price list of Capital Development Authority (CDA), Bahria town, Defense Housing Authority (DHA), and Military E services. The cost of additional material required to be installed in Green building design was estimated using the online catalogues. The cost for both buildings was compared and payback period was calculated in terms of annual savings in cost of energy (Kneifel, 2010) (Wong, Tay, Wong, Ong, & Sia, 2003).

$$\text{Payback period} = \frac{Initial\ investment}{Annual\ Savings}$$

Results and Discussions

4.1. Proposed design for NSTP:

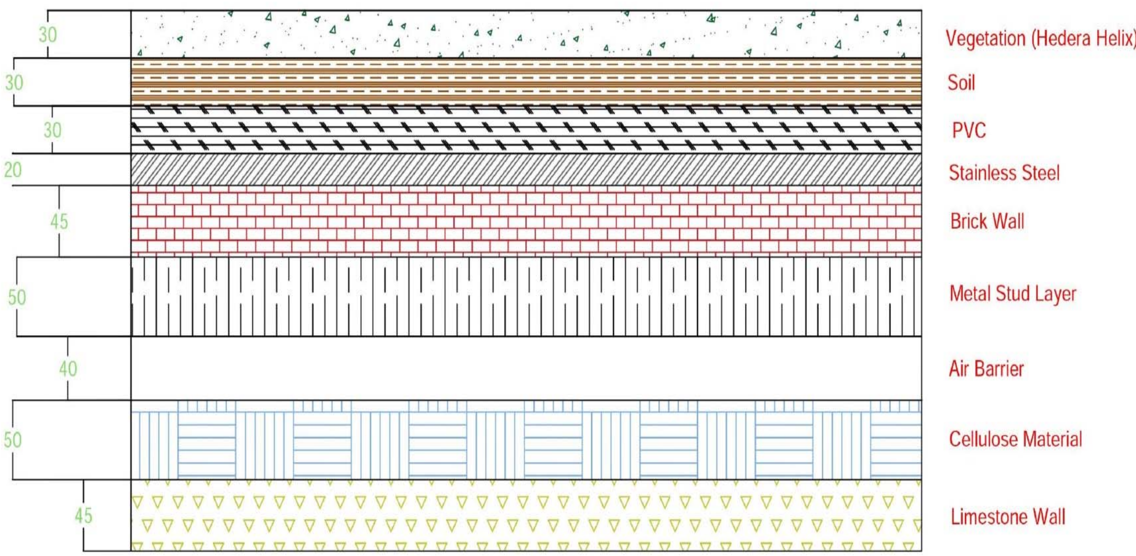
After carrying out detailed literature review and studying the current climatic conditions along with market surveys following compositions of green walls and roofs are proposed for NSTP.

4.1.1. Green walls:

The chosen option was Living wall systems based on plan layers, as it can reduce the building's temperature up to 5^0C and its lower impacts on Global Warming, Human toxicity and Fresh water aquatic eco toxicity. However, certain modifications were made and different insulations were installed based on materials that were locally available with a greater R-value. Green walls tend to reduce the indoor temperature due to multiple layers of insulations between the outer masonry (brick wall) and inner masonry (limestone wall). Cellulose material, metal stud layer, and air barrier are for insulation purpose. Whereas, stainless steel and PVC material are used as a support materials for vegetation and soil. (Dunnett & Kingsbury, 2008)

Hedera Helix was the chosen vegetation due to it being local specie and its suitable growth conditions in Islamabad. The ratio of soil to fertilizer was 2:1 and fertilizer used was the mixture of coconut, dry leaves and cow dung. A proposed Green wall design for NSTP was drawn using AutoCAD is shown below.

Figure 9: Green wall design



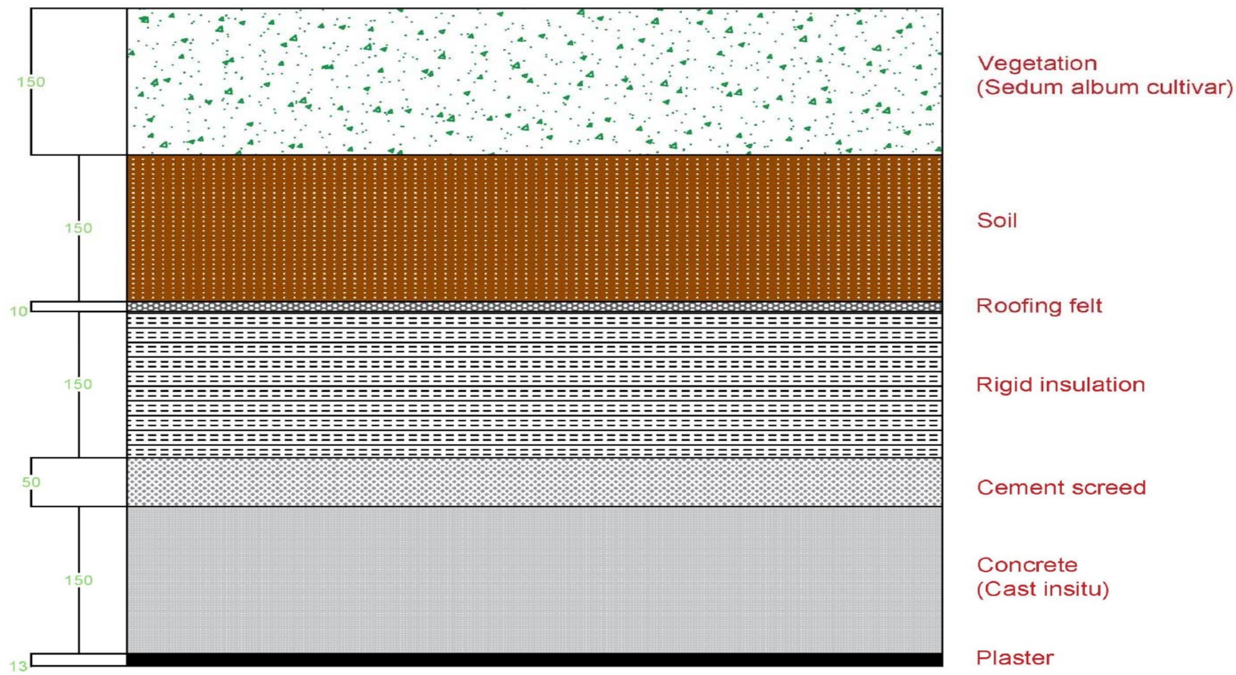
*All units are in mm.

4.1.2. Green Roofs:

The chosen option was Extensive Green Roof System, as it can reduce the building's temperature with lower maintenance and lesser water requirements for irrigation. Certain modifications were made regarding the material used as local material was preferred to reduce the emissions due to transportation. In the proposed design, roofing felt serves as a geotextile sheet beneath which rigid insulation is installed that helps in lowering the temperature of building, cement screed serves as a supporting material and concrete and plaster prevent the seepage of water into the roof. (Castleton, Stovin, Beck, & Davison, 2010) (Getter & Rowe, 2006)

Sedum album cultivars were the chosen vegetation due to it being local specie and its suitable growth conditions in Islamabad. A proposed Green roof design for NSTP was drawn using AutoCAD is shown below.

Figure 10: Green Roof Design



*All units are in mm.

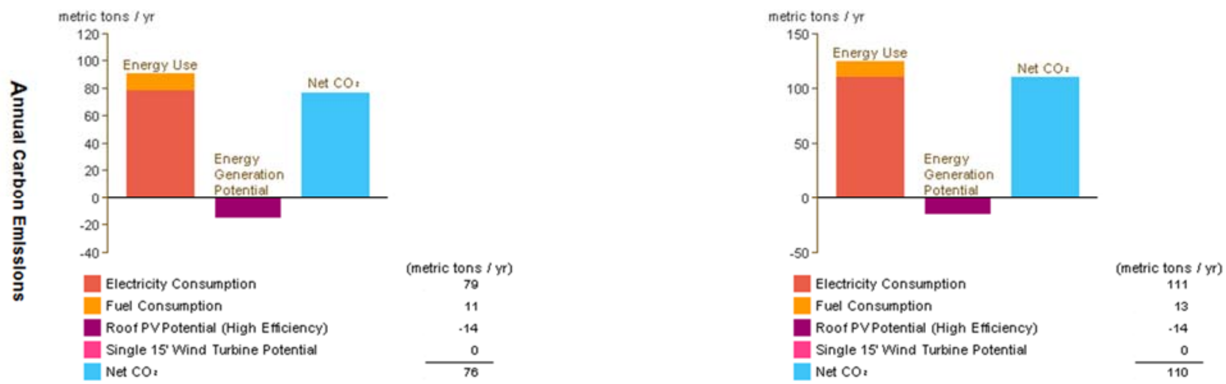
4.2. Comparison between Conventional and Eco-Friendly NSTP:

Following graphs were generated from Auto Desk Revit 2015. Energy simulation was done twice, first for a conventional building design and second when the green material and suitable insulations were installed in the same design of National Science and Technology Park. The graphs show the difference in various parameters that are discussed below. The graphs on the left side show results for an Eco-friendly National Science and Technology Park, whereas, graphs on right side are for conventional building of NSTP.

4.2.1. Annual Carbon Emission

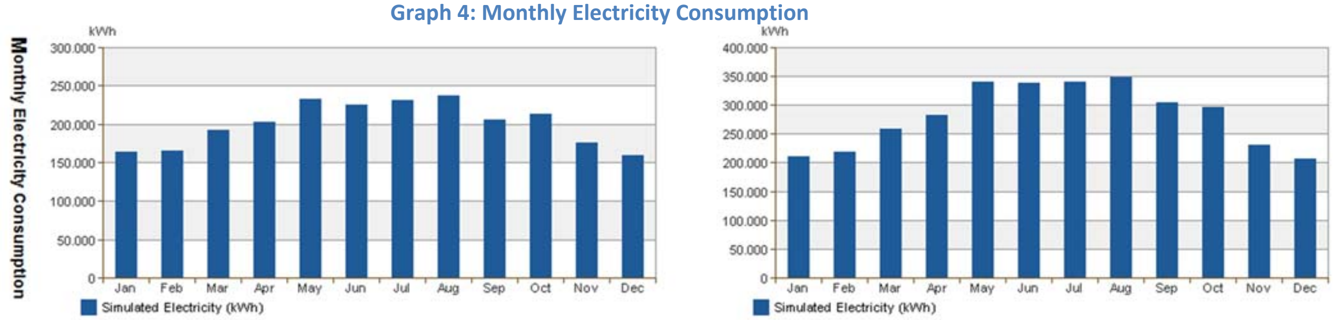
Results indicated that there was an overall 31% reduction i.e. from 110 to 76 metric tons per year in annual carbon emissions after the Conventional building was modified as an Eco-Friendly building. This reduction was due to lower energy consumption from 111 to 79 metric tons per year in eco-friendly NSTP, this was mainly because of lesser use of HVAC systems as suitable insulations are installed. However, fuel consumption increased due to.

Graph 3: Annual Carbon emission



4.2.2. Monthly Electricity Consumption:

Graph 4: Monthly Electricity Consumption



The graphs show higher demand in the months of May, June, July and August due to raised temperature of Islamabad and greater use of HVAC systems during this season. However, demand remains high during this time of the year but lesser electricity was consumed the reason being installation of suitable insulations and green walls and roofs that lower the temperature of buildings in summer especially.

4.2.3. Monthly Peak Demand:

Graph 5: Monthly Peak Demand

With an annual reduction in electricity consumption, peak electricity demand for each month was also reduced for both winter and summer season. As for the month of January, demand was nearly of 700 kW, after the modification of NSTP demand was reduced to 600 kW. Electricity demand was noted to be over 1000 kW in the month of May which after the modification was reduced to 800 kW. Greater reduction was observed in summer season was because of the earlier discussed reason, installation of green roofs and walls reduce the overall building temperature up to 5^0 C.

4.2.4. Annual Energy Cost:

Graph 6: Annual Energy Cost

An annual reduction of Rs. 95, 65,322 in energy cost was noted which is around 29% of the overall cost. The lesser energy demand and use, results in lower energy costs.

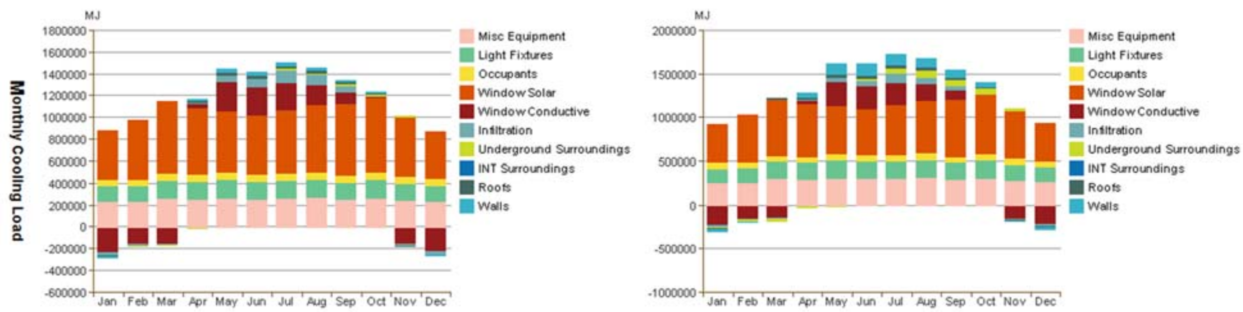
4.2.5. Annual Energy Use:

Graph 7: Annual Energy Use

In case of Annual Energy use, for both building designs, Conventional and Eco-friendly highest percentage of Electricity consumption is due to HVAC systems, however it is lower for Eco-friendly building. It is also noted that there is a reduction in energy use for lighting and Misc Equipment in terms of kWh and cost. This decrease is due to installation of more energy efficient equipment that is certified.

4.2.6. Monthly Cooling Load:

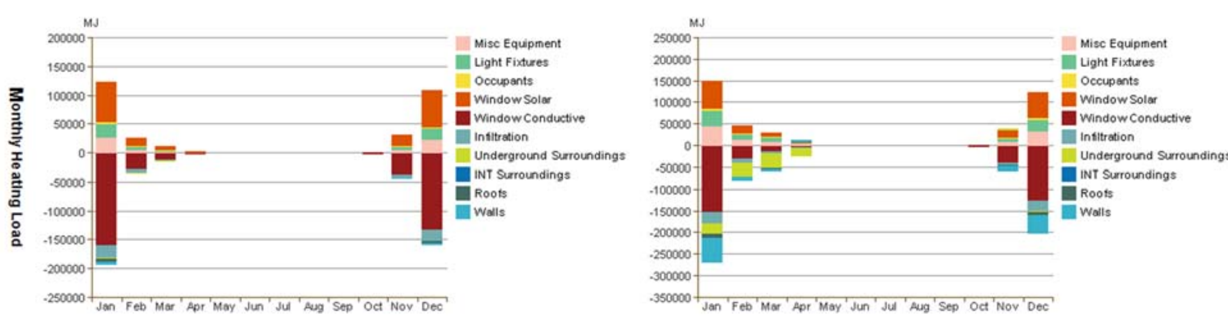
Graph 8: Monthly Cooling Load



Zero line in the above given graphs indicate the comfort zone. For both building designs, cumulative cooling loads occur to be largest from the month of May to September due to elevated temperature in Islamabad. Greater cooling loads indicate greater demand for HVAC systems to bring the building temperature to a comfortable level. The greatest contribution in increased cooling load of NSTP is window solar, misc. equipment and light fixtures. However, due to insulated walls and roofs lesser cooling load is observed throughout the year in Eco-friendly building than the tradition building of NSTP.

4.2.7. Monthly Heating Load:

Graph 9: Monthly Heating Load



Similar to the graph of monthly cooling load, zero line of monthly heating load also indicate the comfort zone that is to be reached. The greater negative values for the month of December and January are due to lower temperatures during this time of the year. This indicates the amount of heat that is to be gained by the building through HVAC systems in order to reach a comfortable temperature for building. Building temperature is mainly lowered due to window conductive and walls but due to presence of green walls in Eco-friendly NSTP, lesser building heat is lost through building, therefore, lowering the heating demand of building.

4.3. Final design for NSTP building:

Figure 11

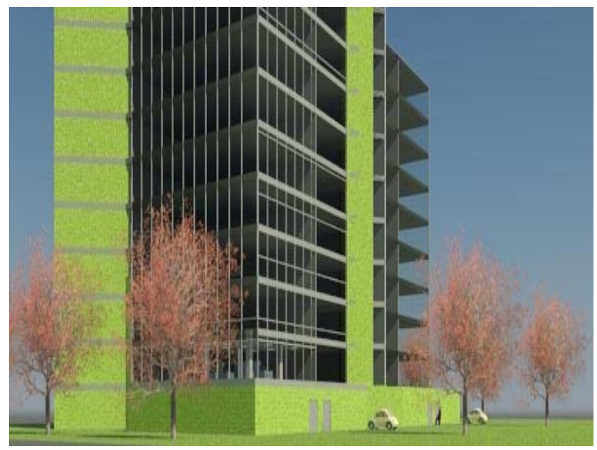
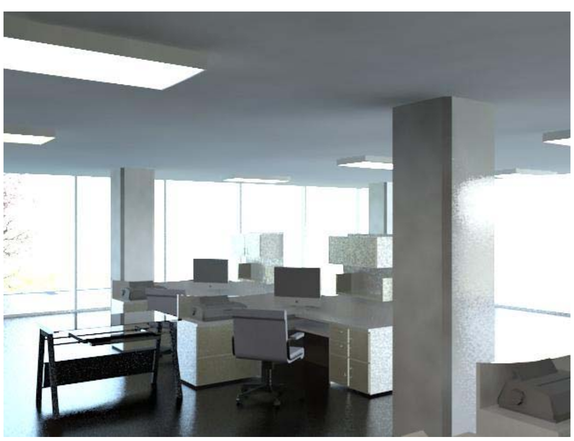


Figure 12



These are the final exterior and interior building design proposed for an eco-friendly NSTP, designed on Autodesk Revit. Internal 3D model of the building like office, kitchen and some working areas of the building were also developed as only floor plans are present without any details about the interior structure.

4.4. Cost-Benefit Analysis:

4.4.1. Cost Estimation for Green Roofs:

Sedum Album Cultivar's annual spread is 12 inches and so to cover an area of 17,820, the required number of the plant species will be 17800.

Table 5: Estimated cost for green roof

Material	Price in Rupees
Sedum Album Cultivar	2670000 (150each)
Soil	3 / sq ft
Roofing Felt	8 / sq ft
Rigid Insulation	210 / sq ft
Cement Screed	712 / sq ft
Concrete (Cast in situ)	417 / sq ft
Plaster	20 / sq ft
Total	4370697

Total of Four Million, Three Hundred Seventy Thousand, Six Hundred Ninety-Seven Rupees is to be invested.

4.4.2. Cost Estimation for Green Walls:

Hedera Helix is 1.2inch wide and so to cover an area of the required number of the plant species will be 30040

Table 6: Estimated cost for green wall

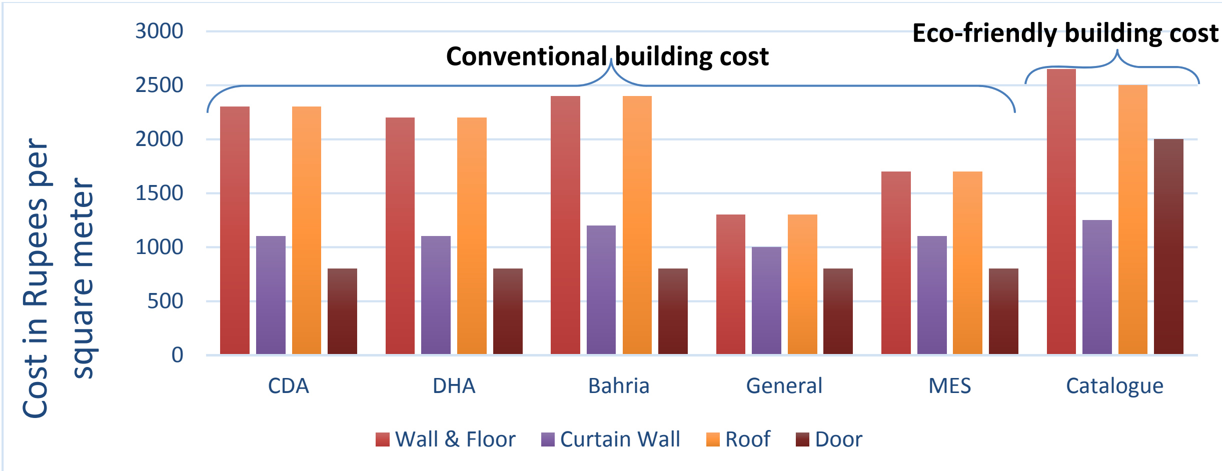
Material	Overall cost in Rupees
Hedera Helix	6008000 (200 each)
Soil	2,70,378
PVC	15,321,42
Stainless Steel	45,753,966
Brick Wall	9,025,217,64
Metal Stud Layer	2,703,780,00
Cellulose	11,626,254
Limestone Wall	9,433,1880
Total	13,323,507,84

One billion, Three hundred thirty-two million, Three hundred fifty thousand, Seven hundred Eighty-four Rupees are to be initially invested.

4.4.3. Payback period:

Costs of all the materials involved in construction of National Science and Technology Park were estimated, it was observed that the initial investment cost for Eco-friendly National Science and Technology Park was much greater than that of a traditional National Science and Technology Park, however, the lower operating cost of Eco-friendly building indicates that it is providing a long-term benefit in terms of lower carbon emissions and electricity cost. As per square feet, general cost was observed to be lowest i.e. Rs. 1300, MES rates being a little higher were observed to be Rs. 1700/square feet, however, rates of CDA, DHA and Bahria were observed to be very close enough and were approximately Rs. 2300-2400/square feet. The cost of NSTP to be an Eco-friendly building that was estimated using the online catalogues turned out to be highest which was approximately Rs.3250/Square feet. Total initial investment required for NSTP to be an Eco-friendly building is Rs. 6,53,751,100. On the basis of annual savings in terms of electricity cost, payback period was calculated which turned out to be 36 years.

Graph 10: Cost benefit Analysis



Conclusion and Recommendations

5.1. Conclusion:

Various anthropogenic sources are contributing to damage the Environment; buildings being one of them, therefore, Eco-friendly buildings are trending to promote the concept of sustainability resulting in lower pollution levels as compared to normal buildings. In case of a New Construction Building, total 110 points can be achieved. By adopting the measures proposed by the above conducted research, **61 points** can be earned by NSTP and it can be a **Gold Certified** Green Building. All of the LEED credits achieved by us are given the tables below.

Table 7

Credits	Points
SS Credit 1-Site Selection	1 point
SS Credit 2-Development Density	1 point
SS Credit 4.4-Alternative Transportation: Parking Capacity	1 point
SS Credit 6.1-Storm water Management: Rate and Quantity	1 point

EA credit 1-Optimize Energy Performance	1-10 points
EA credit 2.1-Renewable Energy: 5%	1 point
EA credit 2.2-Renewable Energy: 10%	1 point
EA credit 2.3-Renewable Energy: 20%	1 point
EA credit 3-Additional Commissioning	1 point
EA credit 4-Ozone Protection	1 point
EA credit 6-Green Power	1 point
EA credit-Advanced Energy Metering	1 point
MR Credit 3.1-Resource Reuse: 5%	1 point
MR Credit 3.2-Resource Reuse: 10%	1 point
MR Credit 5.1-Regional Materials: 20% manufactured regionally	1 point
MR Credit 5.2-Regional Materials: 50% extracted regionally	1 point
MR Credit 6-Rapidly Renewable Materials	1 point

Table 8

Roof credits	Points
SS Credit 7.2-Heat Island Effect: Roof	1 point
EA credit 1-Optimize Energy Performance	1-10 points
EA credit 4-Ozone Protection	1 point
MR Credit 5.1-Regional Materials: 20% manufactured regionally	1 point

EQ Credit 1-Carbon Dioxide (CO_2) Monitoring	1 point
EQ Credit 7.2-Thermal Comfort: Permanent Monitoring System	1 point
EQ Credit-Construction Indoor Air Quality management Plan	1 point

Table 9

Wall Credits	Points
SS Credit 7.1-Heat Island Effect: Non-Roof	1 point
EA credit 1-Optimize Energy Performance	1-10 points
EA credit 4-Ozone Protection	1 point
MR Credit 1.1-Building Reuse: Maintain 75% of Existing Walls, Floors and Roof	1-2 point
MR Credit 5.1-Regional Materials: 20% manufactured regionally	1 point
EQ Credit 7.2-Thermal Comfort: Permanent Monitoring System	1 point
EQ Credit 5-Indoor Chemical & Pollutant Source Control	1 point
EQ Credit-Acoustic Performance	1-2 points

There are also some general credits which we gained through our research. That credits are mentioned in the given below table:

Table 10

General Credits	Points
EQ Credit 1-Carbon Dioxide (CO_2) Monitoring	1 point
EQ Credit 2-Ventilation Effectiveness	1 point
EA credit 1-Optimize Energy Performance	1-10 points
EA credit 2.1-Renewable Energy: 5%	1 point
EA credit 2.2-Renewable Energy: 10%	1 point
EA credit 2.3-Renewable Energy: 20%	1 point
EA credit 6-Green Power	1 point
EA credit-Advanced Energy Metering	1 point
EQ Credit 8.1-Daylight and Views: Daylight 75% of Spaces	1 point
EQ Credit-Construction Indoor Air Quality management Plan	1 point
EQ Credit-Construction Indoor Air Quality Assessment	1 point
LT Credit-High Priority Site	1-2 points
IN Credit-Innovation	1-5 points
RP Credit-Regional Priority	1-4 points
SS Credit 6.1-Storm water Management: Rate and Quantity	1 point
EQ Credit 8.1-Daylight and Views: Daylight 75% of Spaces	1 point

5.2. Recommendations:

Adopting a few more strategies such as solid waste management, innovative wastewater technologies can lead NSTP achieve more points that can earn it a Platinum Certification with minimum harm to environment and human health. Every parameter of the building like green roofs, walls, windows and doors etc. itself a project so we recommend that instead of selecting the project for the whole building, select one parameter of the building for research in undergraduate final year project.

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Appendices

There are many LEED credits which can be achieved to certify the buildings on the international standards and list of these credits are given in the tables below; also we place the green buildings names of the Pakistan and their certification level in the table. And there is another table which includes the world analysis of the building i.e. count of the green buildings in some developed countries.

LEED credits for sustainable Site:

	Points
SS Prerequisite 1-Erosion & Sedimentation Control	Required
SS Prerequisite-Construction Activity Pollution Prevention	Required
SS Prerequisite- Environmental Site Assessment	Required
SS Credit-Open Space	1 point
SS Credit 1-Site Selection	1 point
SS Credit 2-Development Density	1 point
SS Credit 3-Brownfield Redevelopment	1 point
SS Credit 4.1-Alternative Transportation: Public Transportation Access	1 point
SS Credit 4.2-Alternative Transportation: Bicycle Storage & Changing Rooms	1 point
SS Credit 4.3-Alternative Transportation: Alternative Fuel vehicles	1 point
SS Credit 4.4-Alternative Transportation: Parking Capacity	1 point
SS Credit 5.1-Reduced Site Disturbance: Protect or Restore Open Space	1 point
SS Credit 5.2-Reduced Site Disturbance: Development Footprint	1 point
SS Credit 6.1-Storm water Management: Rate and Quantity	1 point
SS Credit 6.2-Storm water Management: Treatment	1 point
SS Credit 7.1-Heat Island Effect: Non-Roof	1 point
SS Credit 7.2-Heat Island Effect: Roof	1 point
SS Credit 8-Light Pollution Control	1 point

LEED credits for Energy and Atmosphere:

	Points
EA Pre-requisite 1-Fundamental Building Systems Commissioning	Required
EA Pre-requisite 2-Minimum Energy Performance	Required
EA Pre-requisite 3- Building-Level Energy Metering	Required
EA Pre-requisite 4-CFC Reduction in HVAC&R Equipment	Required
EA credit 1-Optimize Energy Performance	1-10 points
EA credit 2.1-Renewable Energy: 5%	1 point
EA credit 2.2-Renewable Energy: 10%	1 point
EA credit 2.3-Renewable Energy: 20%	1 point
EA credit 3-Additional Commissioning	1 point
EA credit 4-Ozone Protection	1 point
EA credit 5-Measurement and Verification	1 point
EA credit 6-Green Power	1 point
EA credit-Enhanced Refrigerant Management	1 point
EA credit-Advanced Energy Metering	1 point
EA credit-Demand response	1-2 points

LEED credits for Innovation:

	Points
IN Credit-Innovation	**1-5 points**
IN Credit-LEED Accredited Professional	**1 point**

LEED Credits for Regional Priority:

	Points
RP Credit-Regional Priority	1-4 points

LEED Credits for Water Efficiency:

	Points
WE Pre-requisite-Outdoor Water Use Reduction	Required
WE Pre-requisite-Indoor Water Use Reduction	Required
WE Pre-requisite-Building-Level Water Metering	Required
WE credit 1.1-Water Efficient Landscaping: Reduce by 50%	1 point
WE credit 1.2-Water Efficient Landscaping: No Potable Use or No Irrigation	1 point
WE credit 2-Innovative Wastewater Technologies	1 point
WE credit 3.1-Water Use Reduction (20%)	1 point
WE credit 3.2-Water Use Reduction (30%)	1 point
WE credit-Cooling Tower Water Use	1-2 points
WE credit-Water Metering	1 point

LEED Credit for Material and Resources:

	Points
MR Prerequisite 1-Storage & Collection of Recyclables	Required
MR Prerequisite- Construction and Demolition Water Management Planning	Required
MR Prerequisite-PBT Source Reduction-Mercury	Required
MR Credit-Building Life-Cycle Impact Reduction	1-5 points
MR Credit-Building Product Disclosure and Optimization-Environmental Product Declaration	1-2 points
MR Credit 1.1-Building Reuse: Maintain 75% of Existing Walls, Floors and Roof	1-2 point
MR Credit 1.2-Building Reuse: Maintain 100% of Existing Walls, Floors and Roof	1-2 point
MR Credit 1.3-Building Reuse: Maintain 100% of Shell/Structure and 50% of Non-Shell/Non-Structure	1 point

MR Credit 2.1-Construction Waste Management: Divert 50% From Landfill	1 point
MR Credit 2.2-Construction Waste Management: Divert 75% From Landfill	1 point
MR Credit 3.1-Resource Reuse: 5%	1 point
MR Credit 3.2-Resource Reuse: 10%	1 point
MR Credit 4.1-Recycled Content: 5% (post-consumer + 1/2 post-industrial)	1 point
MR Credit 4.2-Recycled Content: 10% (post-consumer + 1/2 post-industrial)	1 point
MR Credit 5.1-Regional Materials: 20% manufactured regionally	1 point
MR Credit 5.2-Regional Materials: 50% extracted regionally	1 point
MR Credit 6-Rapidly Renewable Materials	1 point
MR Credit 7- Certified Wood	1 point

LEED Credits for Location and Transportation:

	Points
LT Credit- LEED Credit for Neighborhood Development Location	5-16 points
LT Credit-Sensitive Land Protection	1 point
LT Credit-High Priority Site	1-2 points
LT Credit-Surrounding Diversity and Diverse Users	1-5 points
LT Credit-Access to Quality Transit	1-5 points
LT Credit-Bicycle Facilities	1 point
LT Credit-Reduced Parking Footprint	1 point
LT Credit-Green Vehicles	1 point

LEED Credits for Indoor Environmental Quality:

	Points
EQ Prerequisite 1-Minimum IAQ Performance	Required
EQ Prerequisite 2-Environmental Tobacco Smoke (ETS) Control	Required
EQ Credit 1-Carbon Dioxide (CO_2) Monitoring	1 point
EQ Credit 2-Ventilation Effectiveness	1 point
EQ Credit 3.1-Construction IAQ Management Plan: During Construction	1 point
EQ Credit 3.2-Construction IAQ Management Plan: Before Occupancy	1 point
EQ Credit 4.1-Low-Emitting Materials: Adhesives & Sealants	1 point
EQ Credit 4.2-Low-Emitting Materials: Paints and Coatings	1 point
EQ Credit 4.3-Low-Emitting Materials: Carpet	1 point
EQ Credit 4.4-Low-Emitting Materials: Composite Wood	1 point
EQ Credit 5-Indoor Chemical & Pollutant Source Control	1 point
EQ Credit 6.1-Controllability of Systems: Perimeter Spaces	1 point
EQ Credit 6.2-Controllability of Systems: Non-Perimeter Spaces	1 point
EQ Credit 7.1-Thermal Comfort: Compliance with ASHRAE 55-1992	1 point
EQ Credit 7.2-Thermal Comfort: Permanent Monitoring System	1 point
EQ Credit 8.1-Daylight and Views: Daylight 75% of Spaces	1 point
EQ Credit 8.2-Daylight and Views: Views for 90% of Spaces	1 point
EQ Credit- Enhanced Indoor Air Quality Strategies	1-2 points
EQ Credit-Construction Indoor Air Quality management Plan	1 point
EQ Credit-Construction Indoor Air Quality Assessment	1 point
EQ Credit-Acoustic Performance	1-2 points

LEED Projects in Pakistan:

Certified	Pre-Certified	Registered
Citibank Dolmen, Karachi- ID+C v3- Gold 2016	**Mega Corporation Tower,** Karachi- C&S v3- Silver 2014	**Coca Cola master plan,** Multan- BD+C v3
Coca Cola plant, Multan- BD+C v3- Silver 2016		**Soorty Green Factory,** Unit 13, Nooriabad- BD+C v3
Artistic Milliners, Karachi- BD+C v3- Gold 2014		**Soorty Green Factory,** Karachi- BD+C v3
New Consulate Compound, Karachi- BD+C v3- Silver 2014		**NEC-SDA,** Islamabad- BD+C v3
		NEC-CSX, Islamabad- BD+C v3
		NEC-NOB/NOX, Islamabad- BD+C v3
		NEC master plan, Islamabad- BD+C v3
		World Bank office, Islamabad- BD+C v3

Top 10 LEED projects:

Countries	Registered	Certified
U.S	31,231	21,988
China	1,353	592
U.A.E	755	129
Brazil	731	228
India	393	287
Turkey	345	89
Mexico	316	115
Germany	273	142
Canada	211	382
Chile	203	89
Pakistan	**13**	**4**