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Ecological Impact Analysis Of Buildings Using Life Cycle Assessment Approach: A Case Study Of An Institutional Building In Pakistan

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Abstract
Modern building materials and modes of building construction have accelerated the contribution towards the degradation of the environment. Buildings throughout their life cycle from material extraction to demolition generates enormous environmental impacts. The aim of the study is to assess and analyze the environmental impacts of building from raw material extraction to construction phase using the Life Cycle Assessment (LCA) methodological framework. The environmental profiling for different impact categories of a case study building has been performed. Direct and indirect energy consumption i.e., the cumulative energy used in the manufacturing of raw materials, transportation and construction and its contribution to emissions has been assessed by using Sima Pro software. Results show that the dominant contribution of the environmental impacts originates from glass and chipboard out of all selected building materials. 41891.82 kg CO2 eq emissions per m2 floor area of building have been observed to emit and ultimately contribute towards global warming. Furthermore, Results of cumulative energy demand shows most of the non-renewable energy is generated and consumed via fossils i.e., 482,336 MJ. Analysis of different impact categories show that the global warming potential accounts for 4.11E4 Kg CO2-eq, metal depletion 2.81E4 Kg, human toxicity 4.61E4 Kg and fossil fuel consumption 1.08E4 Kg. Thus, the study identifies the opportunity for use of LCA in the building industry. This would help to target hotspot areas to minimize environmental impacts and concurrently move towards sustainable development in society. Further studies with more detailed inventories for building materials are recommended.

Keywords: Building construction, Environmental impacts, Life cycle assessment, Sustainable development

Highlights:

▪ LCA Model is developed in SimaPro 8.2 software for an Institutional Building in Pakistan.
▪ Three LCIA methods of Eco-indicator 99(H) v2.10, Cumulative Energy Demand v1.09 and IPCC 2013 GWP 100a v1.03 have been utilized.
▪ Environmental Impact of building construction have been evaluated.
▪ Appropriate Materials Selections can reduce environmental Impacts.
▪ Application of green guideline must be adopted to mitigate ecological degradation.

1. INTRODUCTION

Current populations quality of life as well as the quality of life of future generations has direct and indirect long-term impacts due to Environmental degradation caused by human activities such as greenhouse gases (GHGs) emissions, natural resource consumption, and deforestation. Increased economic growth across the globe is the reason behind this fact, economic growth is adding pressure on natural resources as well as on our built environment. The construction industry is counted one among other major contributors to the global warming (Ortiz, Castells, and Sonnemann 2009), (de Lassio and Haddad 2016). Buildings consume high amount of energy during construction and use phase, which is the main source of GHGs emissions (Li, Zhu, and Zhang 2010), (Ahmed et al. 2021).

One of the main sources of greenhouse gases (GHGs) emissions are energy consumptions during building construction and maintenance phases at all stages (Frischknecht et al. 2019). Particularly, in building sectors around 40 percent of all forms of energy is used which contributes about 30 percent of GHGs emissions per year (Initiative 2009)[6]. According to the 4rth assessment report published in 2004 by international panel on climate change (IPCC), it is estimated that 8.6 billion metric tons of carbon dioxide being releases into the environment only from building construction sectors (Initiative 2009). The universities and commercial buildings are considered as highest energy consumption buildings among (Talpur, Ullah, and Ahmed 2020),(Chung and Rhee 2014). Therefore, the concept of a sustainability in construction sector is intensifying to overcome the depletion of natural resources and global warming potential (Weerasinghe and Ramachandra 2018)[9]. Henceforth, there is a dire need of a transformation in construction industry to design and build a sustainable building to minimize the global warming and essentially be release owing to conventions fossil fuel consumptions (Ahmed and Tsavdaridis 2018).

A green building is a sustainable kind of building whose design and construction throughput the life cycle during construction and operation phase has less possibility of environmental impacts and give surety of healthful environment with most efficient utilization of land, water resources, and energy consumption (Mahdavinejad, Zia, and Norouzi 2014). The concept of green building deigns, and construction comes from Arcology which is the combinations of architecture and ecology promoted by Paolo Soleri in 1960s (Rodionovskaja and Dorozhkina 2018). The aim of this concept was to promote healthy lifestyle for human with sustainable protections of natural ecosystem and energy consumptions in construction industry (Zhao et al.

2015). Several emerging techniques and methods have been implemented to make buildings green and sustainable focusing reduction of negative ecological impacts. Those methods apply essential principle of improved indoor air quality, energy utilization efficiency, water and wastewater management, materials utilization efficiency, and operation and maintenance optimization of buildings (Yudelson 2010), (Poon 2021). By using either one or a combination of these basic principles, an environmentally friendly green building might be designed and implemented. Owing to this fact, the concept of green building designed has attracted around the globe to design sustainable buildings for healthy lifestyle (Asquith and Vellinga 2005).
The primary objective of a green building is to minimize energy and water consumptions, wastewater reuse and recycling and utilization of ecofriendly construction materials to protect indoor air pollution. The conventional building is not designed to have such facilities which make them unsustainable design and threaten the human life by releasing hazardous waste and greenhouse gases. The construction of building with conventional design concept is a common practice owing to easy availability of labor and materials at local level commonly known as Vernacular design (Matisoff, Noonan, and Mazzolini 2014). Owing to development in vernacular architecture design such as ceiling height reduction, wall thickness changes etc., make it uncomfortable for inmates therefore motivated to explore green and sustainable design for building construction to make comfortable and healthy lifestyle.
In last few decades, the concept of green buildings is gradually developed and adopted. Particularly, in the Unites States, the leadership in Energy and Environment design (LEED) initiated the green building design concept and rating framework for buildings and awareness (Zhao et al. 2015). The assessment system presents a framework for building operators and owners with a system to identify, measure, and implement the concept of green building design, construction, maintenance, and operation way outs (Matisoff et al. 2014). The certification system was categories on different basis such as gold, silver, and platinum based on the adaptation level of green building concepts (Yudelson 2010). The LEED certified buildings potentially emit 34 percent less greenhouse gas emissions, 25 percent less energy consumptions, and 11 percent less water resource (Matisoff et al. 2014). According to the Unites States green building council (USGBC), green buildings provide 27 percent higher occupant satisfaction and utilize less maintenance costs of 19 percent (Baum and Council 2007). Several research studies have been performed to investigate the performance evaluation of green buildings and it has been reported that green buildings generally reduced the ecological impacts. In the Unites States, more than 50 regional and national green building labeling programs has been initiated and implemented to promote the green building design (Epa 2019). International standards and certifications for green buildings have also been created globally, the most popular one is World Green Building Council (WGBC) which is a non-profit organization found in 2002. The agenda of this council was to encourage implementation of a green buildings globally, 200 countries registered in this council agreed to implement the green building concept (World Green Building Council 2019).
The methods for the assessment of environmental impacts of a building compress with the techniques and tools used to examine the ecological performance of a building during design and construction phase (Chung and Rhee 2014). These tools used to illustrate ecological performance of a building, energy utilization performance, and life cycle assessment (LCA)

(Hackenhaar et al. 2019). Life cycle assessment is a tool most often used by policy makers to identify the possible environmental impacts associated with process, products, or services by accumulating relationship and related environmental and energy releases and material inputs quantitatively (Yudelson 2010), (Colangelo et al. 2018). In the process of LCA investigations, quantitative environmental load associated with building materials, GHGs emissions and energy consumption are widely investigated (Ahmed and Tsavdaridis 2018) (Reiter 2010).

Unfortunately, Pakistan is listed in the top 10 countries under sever energy crisis and will become one of the water stressed country by 2040 (A,Maddocks, RS Young,2021).Despite of that, the concept of green building is still not completely adopted in Pakistan. The energy and water efficient technologies are not widely adopted in different sectors of economy, construction is one of them (Khan, Wang, and Lee 2021). Adaptation of these technologies are essential for developing countries like Pakistan to overcome the forthcoming issues of water and energy crisis. The establishment of a green building technologies in construction industry will provide economical, durable, and comfortable buildings for healthy lifestyle. Moreover, the excess emissions of greenhouse gas emissions such as CO_2 will also be reduced by adopting the green building designs (Mahdavinejad et al. 2014). The green building design is a significant research area yet to considered in construction industry of Pakistan. According to the Institute of Architects Pakistan (IAP) and Pakistan council of architecture and town planners (PCATP), green buildings are the only way out to overcome the current energy crisis (IAP, 2018), (Karoglou et al. 2019). The developed countries have transformed their policies and regulation to green buildings, Pakistan also need to adopt to save the country from looming threats of energy and water crisis. Executing the design and construction of green buildings can be implanted in Pakistan owing to presence of several climatic zones and availability of countless building materials (Farooq and Yaqoob 2019). Previously, very few studies have performed on comparative analysis of conventional and green buildings in Pakistan. Henceforth, this study is exclusive in context of Pakistan because building construction and their impact categories have never been performed in the country (Kucukvar and Tatari 2013). Life cycle assessment is not much known in the country for construction industry. Moreover, built environment and its destruction though numerous resources is imperative subject that must be overcome be integrated efforts of different industries (Testa et al. 2017).

Therefore, this study was aimed to assess and compare the environmental impacts of the green and conventional buildings scenarios using Life Cycle Assessment methodological framework. In this regard, the environmental profiling for different impact categories of a case study building has been performed. Direct and indirect energy consumption i.e., the cumulative energy used in the manufacturing of raw materials, transportation and construction and its contribution to emissions has been assessed by using Sima Pro software. The factors producing environmental impacts and potential areas was identified. The resources conservation strategies have been suggested based on LEED references guidelines.

2. METHODOLOGY

2.1 Study Area and case study building

The study area selected for this study was Jamshoro district situated in south-west edge of the province Sindh Pakistan, positioned between 25◦19’–26◦42’ N and 67◦12’–68◦02’ E, along the right bank of Indus River (Baig et al. 2009). Jamshoro is famous with the name of education city because of presence of number universities in the city including engineering, medical, and arts universities (Lashari, Bhutto, and Abro 2014). The case study building selected for study is an institutional building (Center for advanced studies in water) situated at Mehran University of Engineering Technology, Jamshoro. The construction of building completed in March 2017. The building is designed and constructed for graduate studies programs funded by US-aid for advanced studies in water taking four disciplines. The building is serving as an institution with separate block for administration. The total gross covered area is 54,721 square feet (sq. ft.), out of 163,090 sq. ft. total area of the building. The building is containing 3 number of floors i.e., ground floor with 16910 sq. ft. gross area, 1st floor with 18746 sq. ft. gross area and 2nd floor with 17201 sq. ft. gross area, without any basement. In Jamshoro Sindh building construction typology is mainly consist of concrete construction (Pathan, Marial, and Ahmed 2020). Case study building selection was based on availability of authentic data from contractors during and post construction of building.

Fig 1. Study Area (a) Site (b) Master Plan (c) Exterior View (d) Courtyard

To analyze the environmental impacts contribution of each process in the building construction, EIA model was developed by using LCA methodology. The study involved both quantitative and qualitative research methods as described in Figure 2.

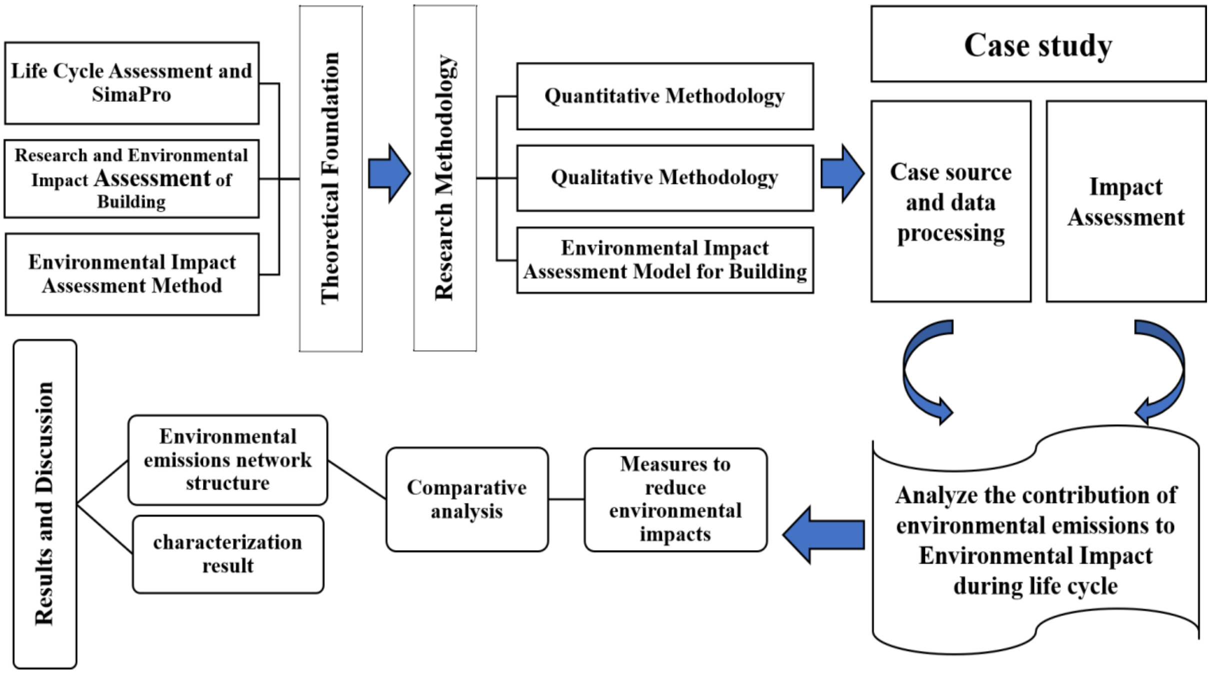

Fig 2. Methodological Framework

According to international organization for standard (ISO) 14040, Life cycle assessment usually carried out in 4 general stages such as

I. Goal and scope definition,
II. Life cycle inventory
III. Life cycle impact analysis and
IV. Interpretation of obtained results

2.1.1 Goal and Scope definition

This is the first phase of LCA in which goal and scope of study, functional unit, and boundaries of the system under study is defined. Moreover, limitations and assumptions of the study along with allocation procedure and life cycle assessment method (LCIA) is selected (Pajula et al. 2017).

a) Goal of the Study

The study goal was to assess the environmental impacts of conventional building during different phases of building construction.

b) Scope of the Study

To achieve goal different building scenarios of building named Center for advanced studies in water have taken into consideration for conducting life cycle assessment that includes materials production, building construction and usage phase.

c) System Boundaries

The system boundaries include three phases including material production, building construction and usage phase of building. In material production phase following are counted:

• Material extraction from a natural resource
• Reproduction of construction materials using a reusing technique, as well as
• Material transportation to the processing unit

Similarly, for construction phase transportation of different building construction materials to the construction site from process unit, construction of different components of the building, and energy linked with the excavation and other work done by machinery have been considered.

d) Functional Unit:

The functional unit considered in this study was 1 square meter (m^2) covered floor area of the building.

e) LCIA Method

Two methodologies are used to assess the life cycle impact: problem-oriented (midpoints) and damage-oriented (end points). Problem-oriented approaches were employed in this study, including Eco-indicator 99(H) v2.10, IPCC 2013 GWP 100a v1.03, and Cumulative Energy Demand v1.09. Via SimaPro 8.2 the assessment of environmental impacts linked with GHGs emissions, climate change, acidification potential, toxicity, and ozone depletion potential has been carried out.

2.1.2 Life Cycle Inventory

This stage includes the collection and calculation of different inputs (raw materials, energy, and water) and outputs (emissions to land, air, and water) of different unit processes. The outputs and

inputs of the complete system are represented because of this stage, which later on converted into the potential environmental impacts in the third stage of LCA known as Life cycle impact assessment (LCIA) (Pajula et al. 2017). The primary data used in this study was in the form of specific construction reports, drawing and schedule of values, obtained from building engineers and architects. Whereas secondary data used in this study was obtained from various sources including available literature on the LCA of buildings and websites. The model used for LCI in this study is shown in the Figure 3.

The inventory of the case study building contained a list of all materials used in the process, which was gathered from the building floor plans, material inventory sheet, and bill of quantities provided by engineers on site. On-site inquiry to sub-contractors yielded some inventory information. Sima Pro 8.2 is used to perform the inventory. A list of complete materials has been compiled, with additional materials segmented into manufacturing and transit throughout the life cycle. All phases of construction, usage, and dismantling have been assessed; however, the study is only concerned with the construction and use phases to determine the potential environmental implications of traditional construction.

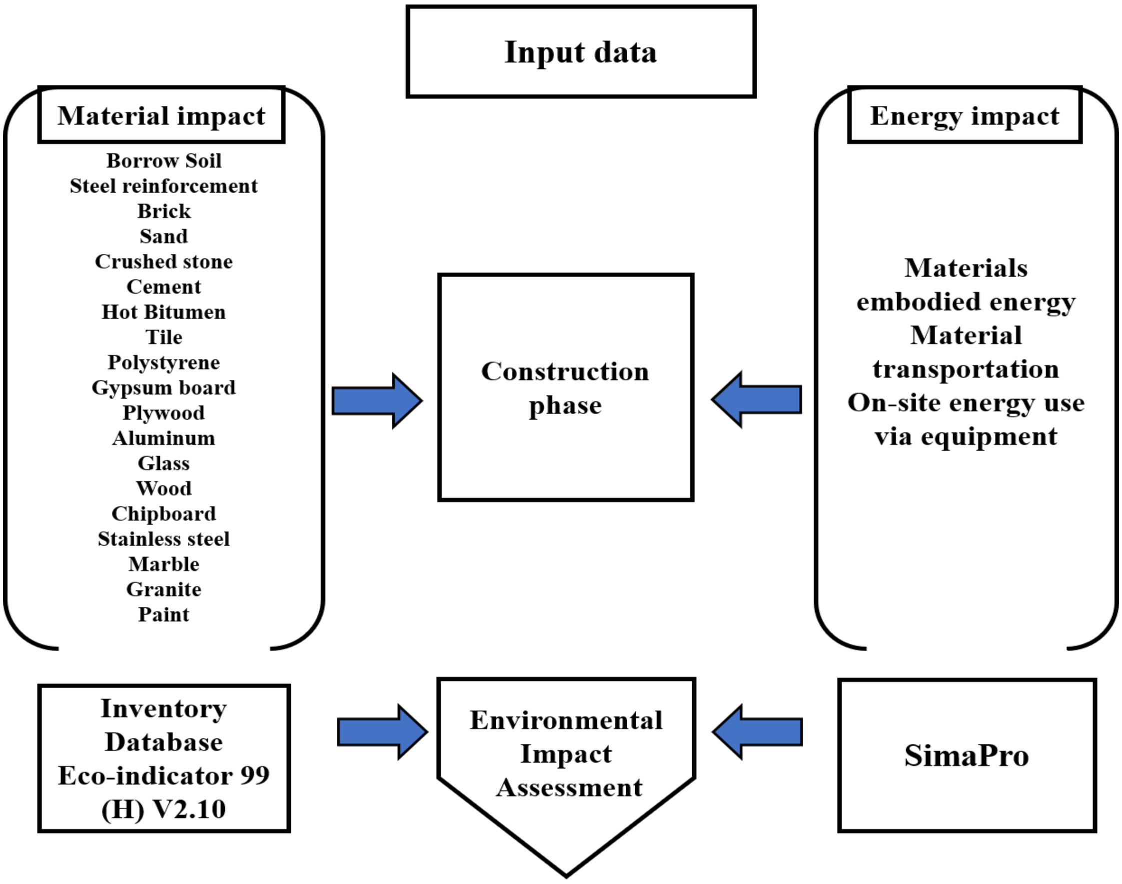

Fig 3. LCA model- Life cycle stages

a) Materials extraction and manufacturing

This step covers the extraction of raw materials, which includes mining, drilling, harvesting, quarrying, and refinement, as well as the conversion of raw materials into designed products. In the model energy used during extraction, transportation of material to the refinery or mill, converting raw material to the engineered material has been considered material embodied energy. Data for fuel consumption during extraction and converting raw materials to the engineered materials have been obtained from the Eco-invent database of Sima Pro.

b) Transportation

This stage includes three transportation phases.

- First phase includes transportation of raw materials from extraction site to the manufacturing facility.
- Second phase includes transportation of engineered materials from the manufacturing facility to the site of building construction and
- Third phase includes transportation of dismantled material from the construction site to the disposal site.

Since, in this research initial two phases of transportation and their associated impacts in the form of emissions have been included. Data for the first phase have been obtained from the Eco- invent database. However, data for second phase has been calculated by assessing the transportation mode and total fuel consumption during the whole trip (back and forth from the production plant to the building) Dividing total fuel consumption by per cubic meter functional unit, per kilometer fuel consumption by transporting vehicle has been computed.

c) Building Construction

On-site energy is used in the form of electricity to run construction equipment during the construction phase of a building and fuel for transporting materials from the manufacturing facility to the building construction site. The data related to the energy used for electricity and transportation have been obtained from the Eco-invent database.

2.2 Life Cycle Impact Assessment

All the environmental impacts that are achieved in the previous stage with the use of numerous environmental indicators at various life cycle stages have been measured in life cycle impact assessment phase of LCA (de Lassio et al. 2016). For LCIA, different LCIA methods including Eco-indicator 99(H) v2.10, IPCC 2013 GWP 100a v1.03 and Cumulative Energy Demand v1.09 have been used to assess the environmental impacts of the case study building during. Mentioned impact categories were considered for building environmental profiling. Fossil Fuel Consumption FFC; Global warming potential GWP; Ozone Depletion Potential ODP; Acidification Potential AP; Photochemical Oxidant Formation POF; Human Toxicity HT; Freshwater Eutrophication FE; Water Depletion WD; Particulate Matter Formation PMF and Metal Depletion MD. The reason for choosing these impact categories is that they are used by the US EPA to assess environmental hazards. Furthermore, the effect categories chosen for the study were linked to air and water pollution, which the World Bank (2008) recommends focusing on when evaluating various industrial environmental impacts.

2.3 Interpretation

Interpretation of the results is the final stage of LCA. This phase includes results about the system studied. The main objective of this phase is to describe results briefly, draw conclusion based on results and give future directions according to the goal and scope (Pajula et al. 2017)

3. RESULTS

The detailed results and their discussions of the results obtained in this study have been provided in this section. The life cycle assessment data obtained in this study have been presented in the form of graphs and tables.

3.1. Ecological Impact Analysis by LCA

The potential impacts of different construction materials have been evaluated in this study by selecting Eco-indicator 99 (H) V2.10 in SimaPro 8.2 software. The detailed ecological profiles of each individual impact categories are described in Table. The impacts generated per square meter (m2) area was evaluated during construction of a building. It has been observed that different materials have different impact values that was selected during impact assessment. The potential impact categories described in Eco-indicator 99 include human toxicity, particulate matter formation, eutrophication (Freshwater), water depletion, global warming potential (GWP), fossil fuel consumptions, photo-chemical ozonation potential, acidification potential, and metal depletions. The highest impact generation of global warming was found in building construction from the impact categories. The formations of impacts for various selected impact categories are elaborated in Figure 4. During the construction phase, maximum impacts are observed related to human toxicities followed by global warming potential, metal depletions and fossil consumptions. These are most often affected during building construction phase.

Table 1. Ecological profiles of a selected case study and measuring units.

Categories of Impacts	Cumulative Impacts	Measuring Units
Human Toxicity	4.61E4	kg 1, 4-DB eq
Particulate matter	123	kg PM 10eq
Eutrophication (Freshwater)	26.5	kg P eq
Water Depletion	383	m3
Global Warming Potential	4.11E4	kg CO2eq
Fossil Fuel Consumption	1.08E4	kg oil eq
Photochemical Ozone Creation Potential	115	kg NMVOC
Acidification Potential	82.3	kg SO2eq
Metal Depletion	2.81E4	kg Fe eq
Ozone Depletion Potential	0.00332	kg CFC-11eq

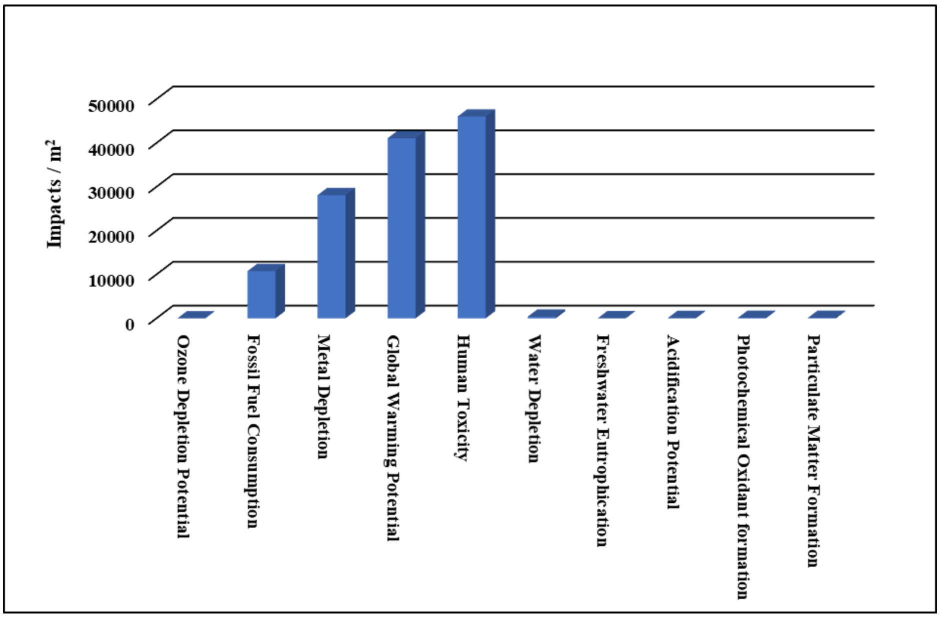

Fig 4. Generation of impacts within categories

3.2. Building Materials and Potential Contribution in Environmental Impacts

Various types of materials used in building constructions which can contribute to environmental pollutions in different ways during building contractions and their maintenance. Therefore, impact analysis of different buildings used in construction of one square meter (m^2) floor have been evaluated in this study, the results are described in Figure 5. The results of the study revealed that maximum impacts are contributed by the glass throughout the life cycle followed by the second most contributing material was chipboards.

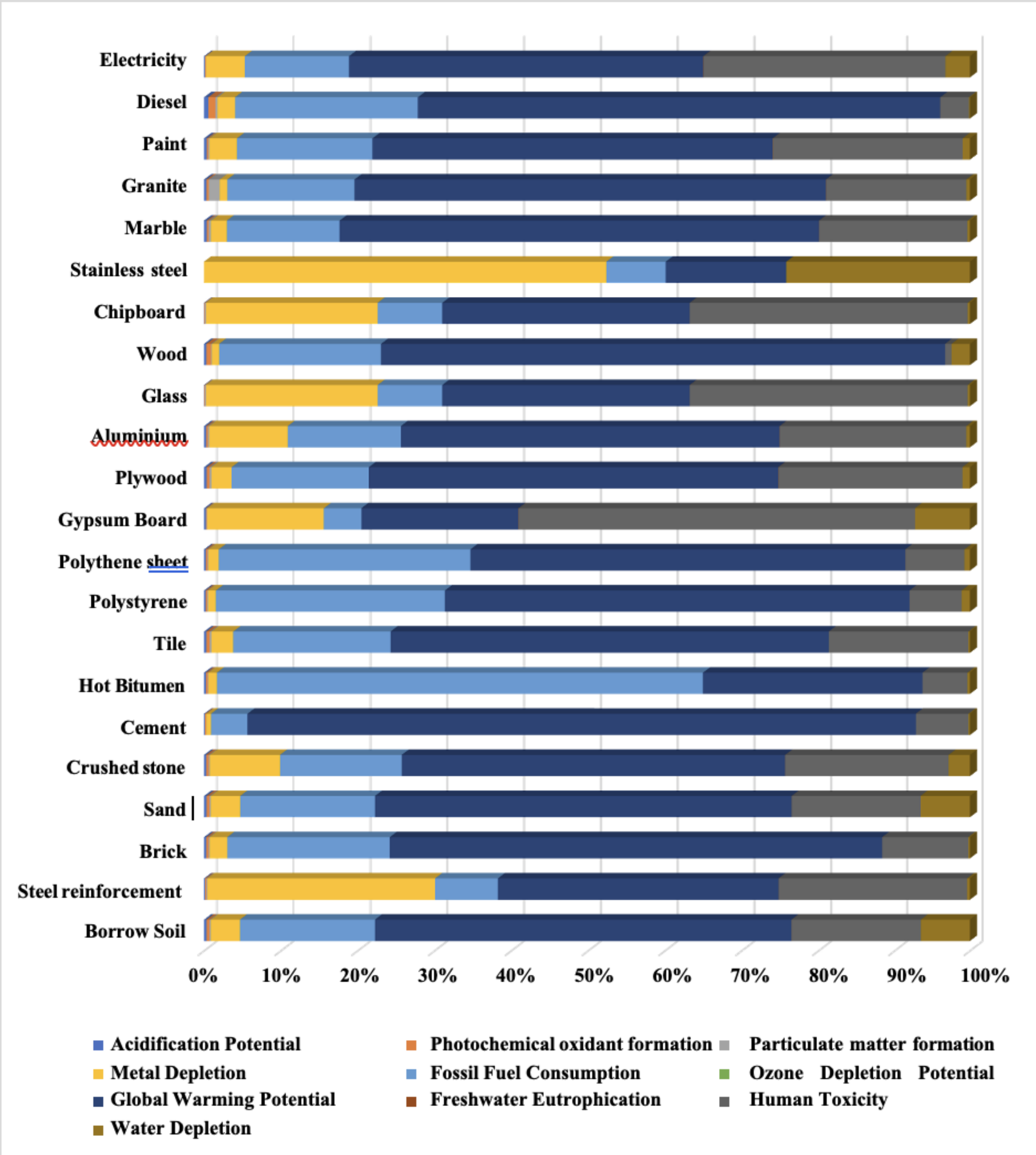

Fig 5. Impacts contributions by various building materials used in construction phase

3.3. Energy Consumption During Construction Phase

The cumulative energy consumption by difference sectors during building construction phase was evaluated using V1.09 method in SimaPro 8.2 software. The energy demand for fossil fuels, biomass, water have been calculated in measuring units of mega-joules (MJ) as described in Table 2. The maximum impacts were observed from non-renewable fossil fuels of 482336.7 MJ as compared to last for water of 19388.16 MJ. Whereas the figure 6 shows the cumulative energy demands for different sectorial bases during construction phase.

Table 2: Different sources and their cumulative energy demands during construction of building.

Categories of Impacts	Measuring Units	Cumulative
Fossil Fuels (Non-renewable)	Mega Joules (MJ)	482336.7
Biomass (Non-renewable)	Mega Joules (MJ)	65.59585
Biomass (Renewable)	Mega Joules (MJ)	64417.47
Water (Renewable)	Mega Joules (MJ)	19388.16

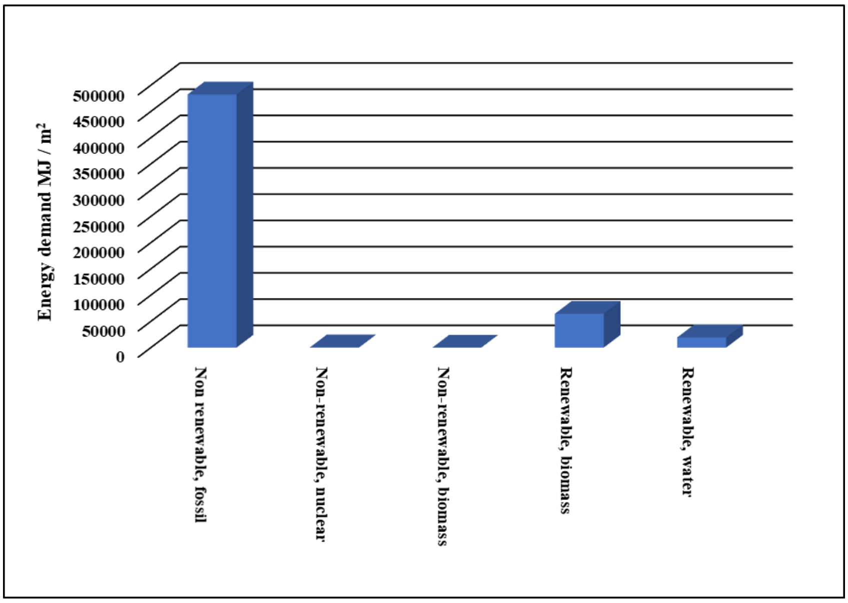

Fig 6. Different sources of cumulative energy demand during construction

3.4. Contributions of Emissions

The emissions contribution of different greenhouse gasses and their potential impacts have been investigated in SimaPro software by selecting international Panel on climate change (IPCC) method. The category indicating the potential impacts selected in the software was global warming. The results obtained from analysis of global warming potential by selecting IPCC 2013 GWP 100a is described in Table 3. The construction of 1 sq meter floor area of a case study might release the 42892.92 kg of carbon dioxide during building construction. The different building material used during construction were selected in this study for impact analysis.

Table 3: Emissions generated during construction of building

Categories of Impacts (GWP 100a)	Measuring Units	Cumulative
Intergovernmental Panel on Climate Change (IPCC)	kg-CO_2 eq:	42892.92

4. DISCUSSIONS

The results obtained from SimaPro demonstrate the impact categories which include 11 different categories related to building environmental profile. The impact measurement such as global warming was in kilogram (kg). The results of this study predicted that around 4.11E4 kg of carbon dioxide (CO_2) might be released in environment during construction of one cubic meter of floor area. The release of this excess amount contributes to adverse impact possibly caused by global warming such as climate change. The other possible source of depletion of natural resource including metal depletion, fossil fuel consumption, and water depletion during construction of one cubic meter of floor have also investigated. The maximum impact on human toxicity was observed from above mentioned categories. The analysis shows that human health is at higher risk of negative impacts owing to excess release of environmental contaminants such as particulates matters and gaseous emissions. Generally, buildings are constructed to provide comfort to human not to harm their life. It has been reported that buildings at one side provide luxury and comfort to the human on the other side pollute the environment by releasing harmful emissions during construction and activities performed at sites.

Gases lifetime in environment and radioactive efficiencies indicates the global-warming potential of various gaseous emissions. It has been depicted from the results that the emissions into atmosphere during construction produces irreversible impacts on the environment. According to the U.S.-Environmental Protection Agencies (US-EPA), one molecule of carbon dioxide remains in environment for a long period of time for instance the increased concentration of CO_2 in environment ultimately will become difficult to be removed from environment once released.

The possible negative impacts on ecosystem from the material used in building construction contributing to gasses emissions are listed. The life-cycle assessment is a process in which inputs to the system and their possible environmental impacts are completely evaluated throughout the life cycle of products. The analysis of the results of this study proposed that metal depletion is third impact-oriented category during the building constructions. The excess utilization of natural resources which are devastating the available natural resources. Moreover, the consumption of fossil fuels in excess amount is also one the imperative contributor towards the environmental pollutions. Thus, there is a need of replacement of conventional system with sustainable emerging technologies with zero greenhouse gases emissions to overcome the possible impacts created from building constructions.

The twenty different materials used in construction have been selected from the document bill of quantities (BOQs) submitted for approvals to calculate the possible impacts and number of emissions released during building constructions. The material related data collected from the sites have been inserted in SimaPro software for selected models. The results from the models have been analyzed for each material used in constructions, respectively. The material with higher potential of pollution can be replaced and modified with less hazard materials. Analysis shows that glass produces environmental impacts during construction process, burning and molting of glass contributes towards harmful emissions in the environment. Use of glass is increasing in sustainable construction as it provides maximum day light and help in energy conservation process of building. Replacement of glass with low-e glass and thermally insulated glass can be made to reduce the impact of product. Moreover, the utilization of recyclable building materials is getting interest in building construction sectors to overcome the environmental damages.

Cumulative energy demands predicted from SimaPro shows the total energy consumption during building construction phase. The several sources given by SimaPro analysis are shown in Figure 6. The major contributor for environmental pollutions is non-renewable fossil fuels which was consumed in excess amount and contributes to global warming. Thus, the potential global warming might be reduced by replacing the conventional fuels with renewable energy sources to limit the global warming potential. Intergovernmental Panel on Climate Change (IPCC) analysis for emissions profile of carbon dioxide produced during construction phase have been analyzed with measuring unit of kilogram (kg). Around 42892.92 kg of carbon dioxide generated during construction of one cubic meter floor, as described in Table 3. This excess amount will ultimately become a primary reason of photo-chemical ozonation and global warming. It has already been reported that conventional fossil fuels are the major contributors of greenhouse gasses emissions and major contributor in global warming. Thus, there is a dire need to change the conventional practices adopted during buildings constructions to minimize the potential environmental hazards.

5. CONCLUSION AND RECOMMENDATIONS

This study focused on assessment and comparison of environmental impacts of conventional and efficient building design. LCA was used to analyze environmental impacts of conventional building during its construction phase. LCA framework and methodology have been used to calculate environmental impacts of energy consumption while construction and operational phase as discussed in previous sections.

Different impact categories have been analyzed in LCA; results illustrate environmental degradation of those factors in building construction. From selected building materials availability of environmental impacts was observed in two materials, glass, and chipboard. 42892.92 kg CO_2 eq emissions per m^2 floor area of building have been detected to release through construction phase of building and contribute to global warming. The most of energy created and used, during the construction of a building is generated via fossils approximately 482336.7 MJ, according to the results of cumulative energy demand during construction.

Green guidelines were introduced by Pakistan green building council (PGBC) in October 2016, PGBC is working on green building labelling since then. Initially only guidelines for new construction are published further work is going on differentiate categories as well. Pakistan is a country with high density of population and limited resources therefor, the green building techniques are important. This implies supportive step toward sustainable development and environmental well-being. It has been observed that, to reach at the LEED certification level there is need to further work on the selection of building materials, improved refrigerant management and indoor energy usage auditing would be helpful in achieving additional points for building certification.

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