A theoretical review of building life cycle stages and their related environmental impacts

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Abstract

There six life cycle stages of buildings are: raw material extraction; manufacturing; construction; operation and maintenance; demolition; and disposal, reuse or recycling. The life cycle stages of a building are all intensively involved, in that the use of natural resources, energy and water are consumed in each of them. This paper investigate the environmental impacts across each of these stages. Furthermore, the paper also highlight the role the building sector on the total global environmental impacts in terms of the building sector's contribution to waste generation, pollution, amongst others. This is done in order to encourage and to inform ways which can be incorporated into the building sector in order to reduce their impact on the environment. The study is conducted with reference to existing theoretical literature, published and unpublished research. The study is mainly a literature review/survey on the life cycle stages of a building. The key findings from the study are that energy is consumed across all the stages of a building. Environmental impact such as greenhouse gas emissions, waste generation and pollution etc. associated with a building are declared to be of a great quantity due to many and relatively long life cycle stages a building have. This study is valuable to the South African built environment, construction industry, infrastructure development and/or sustainable urban development.

1. Introduction

The Built Environment Professions Bill [1], defines the built environment as the physical world that has been intentionally created through science and technology for the benefit of man-kind. The built environment includes a diverse range of human-made infrastructure systems, including buildings, transport networks i.e. roads, bridges, railways, etc. and utilities i.e. water, power, telecommunications, amongst others [2]. Based on the definitions, it is clear that the built environment is one of the big producers of the essential systems for operations of larger cities, the systems without which according to Crawford [2]. Large cities would not function and human health and survival would be significantly jeopardized without the proper creation of the built environment.

Based on the definitions of the built environment; it can be ascertain that this sector of the economy is one of the big contributors to the environmental impacts due to the many resource usage involved in the life cycle of the constructed structures. Many human activities, including construction, have environmental consequences which can be numerous and wide-ranging [3]. In addition, Ampofo-Anti [4] argues that; in its creation and use, the built environment consumes quantities of resources. The built environment is at the origin of most of the mass and energy flows for which man is responsible [5]. Furthermore, Khasreen et al [6] inform that the built environment account for up to 50% of global carbon dioxide emissions. Moreover, the built environment dominates densely inhabited land [7]. Hence, Crawford [2] informs that the built environment is one in which considerable potential exists to make large improvements in environmental performance and reduce many of the impacts caused by human activity.

This study is undertaken with respect to buildings and not the entire built environment. The building sector has several unique characteristics in terms of its product, production, process, and the way the product is used [8]. Likewise, Prazeres [9] argues that the building/construction industry is large and most times, inefficient. Prazeres [9] informs that this inefficiencies span design, construction and the operational phase of a construction project. In addition, Crawford [2] argues that buildings are by far the most complex element within the built environment. Buildings are a significant component of the human environment and, accordingly, contribute to the economy and environmental impacts, including global climate change [10]. Buildings generate high environmental impacts during all their life cycle [11].

Furthermore, during its lifespan a building may undergo many changes in its form and function, which according to Khasreen et al [6] can be significant, or even more significant than the original product. Moreover, due to the fact that buildings differ in design and are developed for different purpose there is little or no standardization, particularly with regard to the

undertaking of the LCA for the buildings. This means that new choices and decisions have to be made for each and every new building developed. According to DEAT [12], energy efficiency reductions in the construction and operation of buildings, offers one of the single most significant opportunities to reduce man's impact on climate change.

In order to reduce the impacts and encourage a more sustainable approach within the built environment we must develop a detailed and rigorous understanding of the complex and varied interactions that exist between the natural and built environments [2]. The beginning of this understanding involves the identification of the environmental impacts that are caused by our current processes, energy sources and waste management practices as explored in this paper. Therefore, this paper investigate the environmental impacts across each of these stages. Furthermore, the paper also highlight the role the building sector on the total global environmental impacts in terms of the building sector's contribution to waste generation, pollution, amongst others. This is done in order to encourage and to inform ways which can be incorporated into the building sector in order to reduce their impact on the environment.

2. Environment sustainability and quality of human life

The environment is the surroundings and the characteristics which affect human and other forms of life that exist within these surroundings [7]. The environment representing both the existence of natural resources and their fragile quality is a concept brought to public attention only in the last 30 years [7]. According to section 24 of the Bill of Rights of the South African Constitution; everyone has the right to an environment that is not harmful to their health or well-being and have the right to have the environment protected for present and future generations. Section 24 further states that it is upon the government to pass laws that; i) prevent pollution and damage to natural resources ii) promote conservation and iii) make sure that natural resources are developed while also promoting the economic and social development of people.

Human life is thus supposedly the only reason why the environmental impacts needs to be reduced because ultimately as the environment is being damaged it affects the quality of life of the people. When animals and plants are killed, and land is being degraded this affect human survival. According to Aglionby et al [13] the purpose of any construction development is to achieve economic or social advancement, thus due to environmental consequences of developments it can be ascertained that humans gain and loose in the construction developments. Furthermore, Carpenter [7], argues that the role of construction in sustainable development is a dilemma. Carpenter [7] further informs that Civil Engineering, which is the design and implementation of construction, was defined as the service of mankind; but more people and their demand for greater material advantage use more resources than nature can continue to supply. Thus, Crawford [2] informs that with the increasing adverse impacts of the built environment on the natural environment and on human health, the need to address these impacts and look for alternatives, remedies, and solutions to the current ways in which our buildings and infrastructure are designed and managed is becoming more and more crucial.

In light of buildings, they are for example developed to provide for human need such as shelter but however are found to be great contributors to the environmental impacts. Buildings are a significant component of the human environment and, accordingly, contribute to the economy and environmental impacts, including global climate change [10]. One of the ways building developments affect the environment is through the use of non-renewable natural resources such as land and minerals. In addition, the quality of many people's lives is in a critical condition because land and other resources are being depleted at a rate which is not sustainable [7]. According to Crawford [2], once non-renewable resources have been completely exploited, or at a point where they become considered too costly or difficult to extract from the earth, we will have no choice but to look for or develop alternative solutions to meet our needs. However, due to the difference in developments, Aglionby et al [13] argues that each project is built and operates in a different socio-economic, political and physical environment and therefore it may improve some lives whilst diminishing the quality of others.

Sustainable construction can be achieved with the application of tools that deal with the assessment of the whole life cycle, site planning and organization, material selection, re-use and recycling of materials, waste and energy minimization [14].

2.1 Building life cycle stages and their related environmental impacts

Crawford [2] informs that the six life cycle stages of buildings as: raw material extraction; manufacturing; construction; operation and maintenance; demolition; and disposal, reuse or recycling. The life cycle stages of a building are all intensively involved, in that the use of natural resources, energy and water are consumed in each of them. For example; energy is required for the following along the stages of a building; i) to extract raw materials; ii) to process and manufacture the raw materials in order to produce usable construction

materials or components; iii) to fit the produced components of construction materials together; iv) to ensure the usage of the building, (e.g. use of energy for cooking, lights, amongst others); v) to demolish the building (the use of equipment); and lastly vi) to dispose of the rubble from site, recycling, (transportation).

The environmental impact such as greenhouse gas emissions and pollution amongst others are associated with buildings and are therefore of great quantities due to many and relatively long life cycle stages a building have. Natural resources, energy and water are consumed across each of the life cycle stages of a building, and thereby greenhouse gas emissions and other pollutants are produced in each instance [2]. According to Horne et al [10], buildings present a classic Life Cycle Assessment problem, since they consume considerable amounts of materials and energy and therefore create impacts during at least two major life cycle phases: construction and operation.

2.1.1. The extraction of raw materials

The first stage of the life cycle of a building is the extraction of raw materials. Raw materials includes iron ore, limestone, bauxite, copper, timber, petroleum, amongst others, which are naturally embedded in the earth. These resources become processed using technologies into more useful forms to be used as building or construction materials such as steel, cement, aluminum and plastic. The extraction of natural resources represents a large impact on scarcity of non-renewable resources, while at the same time consumes other resources such as water, electricity or fuel, and also includes dumping water in the water, air and soil [11]. The continuation of the extraction of these resources will eventually lead to their depletion, unless alternative solutions for meeting our resource demand are found. Carpenter [7], argues that more people and their demand for greater material advantage use more resources than nature can continue to supply.

The extraction of raw materials does not only result in resource depletion but also involves the consumption of large quantities of energy and water, as well as the release of emissions and pollutants. Mining operations rely on fossil fuel based energy to power equipment and machinery and also operate the transport equipment and infrastructure necessary to transport raw materials to their place of processing or use. The use of the fossil fuel result in large contribution towards the greenhouse gases emissions and release of other pollutants, such as carbon monoxide, into the atmosphere. The environmental impact of mining continues long after the mining process has taken place, resulting in situations such as the acid rains. As well mining activities results in land that becomes obsolete. These after effects contaminate the surrounding environments, including local water supplies, with unnaturally high concentrations of chemicals and minerals. Many mining operations use chemicals to assist in the separation of valuable ores from the waste materials and these chemicals remain as residues in the tailings materials for many years. Other impacts of the mining process include erosion and a loss of biodiversity, particularly where large residual of land are cleared for open cut or in harvesting timber from forest.

2.1.2 Manufacturing

In the manufacturing stage, natural resources are converted to basic building or construction materials such as steel, plastic, and according to Crawford [2] the conversion processes to produce these materials are mostly complex. Due to the complexity of the extraction and conversion processes, large amount of energy, which is mostly fossil fuel-based is consumed and therefore large quantities of pollutants released into the air. According to Gibberd [15], the embodied energy of materials is estimated to account for between 15% and 60% of a building's life cycle energy consumption. Materials production industries have been attribute to be one of the largest fuel consumption economy [14]. For instance, Muigai et al [16], reported that on average, 39.7 Mt of raw materials are consumed per year and 4.92 x 10^9kg CO2 emissions are emitted per year to produce cement and aggregates for concrete production in South Africa alone. In addition, carbon emissions from the cement industry are estimated to produce 5% of global carbon emissions [15].

Approximately 50% of all materials extracted from the earth's crust are manufactured into construction materials and products [14]. In addition, processing of raw materials can generate a large quantity of waste and as well contaminate the surrounding environment, and according to Koroneos and Dompros [14] the waste generated during construction materials and products production accounts for 50% of the waste stream before recovery. Moreover, the manufacturing stage includes transportation of by-products to consumers and in light of the construction stage of a building, which includes transportation from manufacturers to site, meaning that more fossil fuel energy is consumed and thus more greenhouse gases emitted into the atmosphere.

For the purposes of the construction of building, the manufacturing stage may involve further material processing, for example; sawing of timber into appropriate shapes and sizes required, and/or turning basic steel in roll form into corrugated roof sheeting products [2]. This further processing of materials may have even more impacts on the environment. This is due to that industrial processing mostly requires a large

amount of water and energy which is mostly fossil fuel-based releasing more greenhouse gases into the atmosphere.

2.1.3 Construction

Construction is fitting parts or materials together to form something, that is, a built structure [7]. Construction is used interchangeably with civil engineering and they are the basis for developments in order to make better the lives of people. Construction is the phase of a structure development that follows design and according to Carpenter [7], design is supposed to take into consideration the practicalities of construction even though it is clear that construction may involve a considerable form of skills. The construction stage of buildings is one of the longest stages, mostly of buildings of multi-storeys; and it is during this stage that large quantities of materials are consumed. Therefore, basically construction in its broadest sense, is responsible for the built environment [7].

According to Ampofo-Anti [4], key environmental impacts associated with material usage include: depletion of natural resources and releases of solid and liquid wastes and toxic emissions to air are barely addressed, whilst energy and water conservation are prioritised on the green agenda. Hence, OECD [8] informs that the construction sector is estimated to account for between one-third and one-half of the commodity flow worldwide. Khasreen et al [6] also informs that the building construction industry consumes 40% of the materials entering the global economy and generates 40-50% of the global output of GHG emissions and the agents of acid rain. During this stage, wrong choices of material specifications, suppliers and constructive technologies, as well as management failures result in waste of materials and handmade and accordingly, in environmental damages and financial losses [11]. In addition, Crawford [2], informs that on-site construction process require energy, usually in the form of electricity, to power electrical tools and operate machinery and other equipment. Furthermore, Beaumont [3] argues that almost all construction activities have an environmental impact on land resources, both directly, as social and economic consequences of their implementation. Environmental considerations in construction are inseparably linked with land resource issues. Construction thus have significant undesirable impacts on land resources, both physically and, through changed or induced land use and associated livelihood, in socio-economic context. Another source of environmental impacts during the construction stage is the transportation of materials. The transportation of building materials and components to the construction site is generally done by heavy trucks which require fossil fuels to operate. Moreover, the construction stage is associated with large consumption of water for activities such as concrete curing, dust suppression, and for cleaning purposes. Furthermore, the construction stage is also known for its huge generation of waste materials which is mostly sent to landfills. These waste materials contaminate soil and/or water where they are dumped. Some waste materials from the construction activities are incinerated, and the incineration process is one of the contributors to greenhouse gas emissions such as CO2. According to DEA [17], in South Africa, construction and demolition wastes represents 20% of total municipal waste. In addition, Khasreen et al [6] informs that the construction sector is responsible for a high percentage of the environmental impacts produced by the developed countries.

2.1.4 Operation and maintenance

Operation and use

The operation stage of buildings is most probably the longest because some buildings have a life span of over 50 years. Water and energy are required for users and equipment's such as Heat-Ventilation-Air Conditioning (HVAC), power lighting systems and electricity and telecommunications networks amongst others. Generally, the energy that is used is provided from fossil-fuel-based sources most times. In South Africa, coal is the major indigenous energy resource and it is relied upon for the generation of most of the country's electricity and a significant proportion of its liquid fuels. Other sources of primary energy are; crude oil, gas, hydro, nuclear, petroleum products, and renewables and waste. Buildings also require basic essential services such as pipelines for the provision of water and disposal of sewage waste etc. According to DEAT [12] the three stages of buildings namely construction, operations and deconstruction use approximately 15 % of the world's fresh water resources; 40 % of the world's energy; and produce approximately 23-40 % of the world's greenhouse gas emissions. In addition, OECD [8] informs that the operation of buildings alone, worldwide; accounts for around 25-40 % of total final energy consumption. The total environmental impacts of a building during its operation stage can be of the same order of magnitude as those generated during its whole life cycle [6].

Maintenance and repair

Maintenance, refurbishments can take place two times before the building is demolished. Large quantities of solid waste is generated during maintenance and refurbishments, and as well large quantities of natural resources are again consumed for new materials and thereby all the prior stages to maintenance are repeated creating even more impacts on the environment.

2.1.5 Demolition

The fifth stage of the buildings life cycle is the demolition stage. Demolition is the process of dismantling the structure, separating the components for the purpose of removing the whole building from existing. Demolition of buildings is necessary because like every other products, buildings have finite lives. In addition, due to societal considerations such as safety, health; infrastructure developments; and as well as technical advancements, buildings have to be demolished in order to make room for more useful ones that will meet the current needs and expectations of the relevant users. Demolition of large structures such as buildings create large quantities of solid waste and this lead to the very last stage where the solid waste has to be dealt with. For example, either the waste is going for incineration, the process during which large emissions of greenhouse gases are released affecting the air quality; or recycling, or waste generated is dumped in landfills where it becomes obsolete. Other environmental impacts associated with the demolition of a building is the release of greenhouse gas emissions through burning fossil fuel used for the demolition machinery as well as the transportation of waste to landfills, or materials to recovery sites [2]. Disposed materials may decompose and leach into the ground, potentially resulting in eutrophication of the surrounding environment. When organic materials such as timber decompose they may release CO2 (carbon dioxide) and CH4 (methane) into the soil and the atmosphere.

2.1.6 Recycling and re-use

Some components or materials can be reused directly from after being dismantled (such as windows, doors…). While the recovery and reuse of existing materials may be avoided or reduce some of the impacts of using new materials, the reuse of these materials is not without certain impacts of its own [2]. Some of these materials may for example, require to be re-painted and therefore they will impact the environment through paint. For materials that require re-processing, fuel will be required for transportation, energy and other resources to make up the new products and thus there is going to be environmental impacts involved in the re-processing.

2.2 Major environmental impacts associated with the building life cycle stages

2.2.1 Natural resource depletion

Natural resources are those naturally embedded in/on the earth and these include, land, minerals, water and air. The value that we as humans put on these resources depends on their availability, accessibility, usefulness and our necessity for them [2]. Natural resources are crucial for human survival and therefore it is in our best interest to make sure that we do not interfere with the earth's ability to produce/provide these natural resources for us.

However due to the growth in population, demand for natural resources increases year by year and that contributes to the depletion of non-renewable natural resources such as minerals. As the world's population increases and many previously under-developed countries invest heavily in infrastructure, demand for natural resources continues to grow [2]. In addition, Carpenter [7] and Crawford [2] argue that natural habitat is being depleted and species are being extinguished; water sources are rapidly being contaminated; mineral resources are being exploited at a very fast rate; land is being devastated by mining, harvesting, resource extraction processes, waste handling and disposal, soil contamination and toxic effluents from chemical processes. Land and water are amongst the other natural resources available on the earth essential for providing food for human consumption, for harnessing renewable energy such as solar, wind, biomass and growing timber [2]. Carpenter [7] informs that land and water resources suitable for agriculture are in increasingly short supply. According to Crawford [2], the excessive and wasteful consumption of natural resources is a habit that was developed at a time when resources were considered to be in abundance; that reserves were not thought of as being in danger of exhaustion.

The built environment products such as buildings take up large areas of land and they remain like that for a long period of time. In their operation time, buildings still contributes to the demand on natural resources in many ways such as water consumption for cooking, cleaning, sewage services, etc. In addition, buildings require a great amount of resources for them to become possible. According to Carpenter [7], most materials required for construction are locally abundant, but that these materials are supplemented by raw materials or manufactured elements that have to be purchased from outside. The liquid and gaseous carbon fossil fuels that are most easily gained are those most likely to become depleted first.

Reducing the impacts associated with design, construction, operation and management of the built environment will take a concerted effort on the part of the many stakeholders involved across all of the stages of the built environment life cycle [2].

2.2.2 Waste

The Department of Environmental Affairs [17] South Africa, defines waste as any substance, whether or not that substance can be reduce, re-sued, recycled, and recovered- i) that is surplus, unwanted, rejected, discarded, abandoned, or disposed of; ii) which the generator has no further use of for the purposes of

production; iii) that must be treated or disposed of; iv) that is identified as a waste by the Minister of the Gazette, and include waste generated by mining, medical or other sector; v) but a by-product is not considered waste; and any portion of waste, once re-used, recycled and recovered, ceases to be waste.

The DEA [17] further informs the three types of waste namely; general waste, hazardous waste, and building and demolition waste. General waste refers to waste that does not pose immediate hazard or threat to health or the environment, and includes; i) domestic waste, ii) building and demolition waste, iii) business waste, and iv) inert waste. Hazardous waste is any waste that contains organic and inorganic elements or compounds that may, owing to the inherent physical, chemical or toxicological characteristics of that waste have a detrimental impact on health and the environment. Building and demolition waste as any waste excluding hazardous waste, produced during construction, alteration, repair, or demolition of any structure, and includes; i) rubble, ii) earth, rock, and iii) wood displaced during that construction, alteration, repair, or demolition.

Barron [18], informs of three categories of waste namely; solid waste, atmospheric waste, and liquid waste. Solid waste is for example: municipal waste (commercial and residential wastes), mining and quarrying waste such as tailings, C&D waste (rubble, waste concrete, etc.), industrial waste (biodegradable waste, chemical wastes), agricultural waste (waste fertilizers, slurries and manures, straw, canes and vegetation). Solid wastes are mostly collected and disposed of in bulk. This type of waste is mostly discarded into landfills, for incineration, or recycling. Atmospheric waste includes smoke and escaping gases, (from material refinery processes). This gases invade the atmosphere unless devices are installed to reduce emissions. Liquid waste includes sewage, industrial effluents, cooling water (such as for power generation) and radioactive liquid wastes. Liquid wastes are discharged to soakaways or into water courses or sewers, usually subject to regulations as to what may be discharged.

So basically waste is whatever people wish to get rid of according to Barron [18]. However what is considered waste to one person may be useful to another. Human activities generate enormous quantities of waste that is often incinerated or discarded in landfill sites, with a small proportion of this recovered for other use. Waste generation in every country is relatively high due to the continuous growth of population in each of the countries. The attempt in the improvements of the standard of living is also one of the reasons for high waste generation because the demand for resources in order to ensure the improved standard rises and thereby leading to increased waste generation. Waste production occurs across every sector; all the way from mining (raw material extraction), through to all the sectors that make use of the extracted material to the disposal of the manufactured products, built structures such as buildings for instance. This includes therefore; energy production sector, agricultural sector, manufacturing, construction, household, and demolition sector. Waste disposal is constantly taking up land in most countries, and these will lead to most of the country eventually running out of land. The wealth of a community and the extent of rural or industrial development affect the type and quantity of waste produced [18]. Furthermore, Barron [18], informs that in middle countries such as the Eastern Europe some large tracks of land have been laid waste by the indiscriminate dumping of chemical waste. However, according to Crawford [2] in countries such as Australia and Ireland, undeveloped land is in great abundance and therefore the value placed on it is not often as great as in other countries, and incineration of waste rarely occurs.

The built environment is one of the sectors that contribute largely to waste generation in any country. This is largely happening in developing countries because of the view that there is still big room for growth. Growth in this instance refers to the construction of more houses, office buildings as well as more roads in order to improve the standard of living of the people, hence developing. However, most developing countries do not have much regard of the waste that construction is generating toward the immediate available land. The construction industry contributes directly and indirectly to the quantities of waste generated by a community. The industry contributes indirectly through the use of materials that have required the extraction of raw materials as well as manufacturing processes. The processes that the construction materials undergo to become usable in that regard have their own contribution to waste generation. The construction process itself also contributes to waste generation. The uses of the constructed structure as well as its maintenance along its life also have great contribution to waste generation. Lastly, the demolition of the built structure which probably has greater contribution to waste than the other stages involved in the built environment. Crawford [2], informs that in Australia construction and demolition waste represents 42% of generated waste, of which 43% is disposed of in landfills. The remainder is accounted for by municipal waste (27%) and industrial waste (29%). According to DEA [17] in South Africa construction and demolition wastes represents 20% of total municipal waste.

DEA refers to the building and demolition waste as any waste excluding hazardous waste produced during construction, alteration, repair, or demolition of any structure, and includes; rubble, earth, rock, wood displaced during that construction, alteration, repair, or

demolition. In addition, the DEA [17] sees building and demolition which is used interchangeably with construction and demolition (C&D) waste; as not hazardous waste, according to Crawford [2], the disposal and treatment of waste can have significant environmental consequences.

Barron [18], highlight the interrelation amongst, solid, atmospheric and liquid wastes. Barron [18] interpret the relationship as thus: “incineration to reduce solid waste disposed as landfills produces emissions to the atmosphere. These emissions may have a considerable particulate and lethal gas component; while treatment to reduce the pollutant content of emissions leads to the production of other solid waste requiring disposal. The treatment of industrial effluents and sludge results in the production of a contaminated liquid, requiring disposal to a sewer, as well as solid waste”.

Waste disposal requires funds, it affects public health and it is damaging the environment. In developing countries it is common to see waste dumped on street corners, in ditches and in open culverts and in richer areas residents may be provided with containers or disposing off waste materials etc. for disposal by local municipalities [18]. However, the problem with waste that is disposed of in ditches or on corners for example leads to health problems and some of the waste also lead to water resource pollution, the water which may be used by poor and rich people alike. Animals and birds scavenge for food among openly disposed rubbish. Humans may see that as an opportunity to look for recyclable materials. In industrial areas not subject to effective environmental control chemicals may be poured on to the ground or discharged into open sewers to mix with the other. This type of waste can leach into the surrounding environment causing long-term and potentially irreversible changes to local ecosystems, contaminating water supplies and potentially poisoning humans and wildlife. A considerable proportion of waste disposed of in landfill is inert and the environmental consequence of its disposal is that is that it takes up land.

2.2.3 Pollution

Pollution is the introduction by man into the environment of substances or energy liable to cause hazards to human health, harm to living resources and ecological systems, damage to structures or amenities, or interference with legitimate use of the environment, [18]. Pollution affects land, air, or water and it may have global effects such as climate change or local impacts such as killing fish.

Pollutants are released from modern energy-generation processes (coal, gas, and petroleum-based); from refining and processing of raw materials such as steel from minerals etc.; from industrial processes; and from leaching of hazardous chemicals and contaminants from waste disposed of in landfills, sewerage treatment plants and other waste disposal site [2]. Emissions related to energy generation and manufacturing pollute the air we breathe, impact global climate and impact the health of animals and plants [19].

The extraction of natural resources and many industrial processes are responsible for realising a considerable amount of pollutants into the environment and significant contamination of waterways and soil. Water may be polluted by anything which is toxic, pathogenic or affects its taste or appearance. Discharge of nutrients, for instance in sewage, sewage sludge, agricultural slurries and wastes from food industry, may cause eutrophication and the blooming of toxic algae. Concentrations of minerals and pollutants in water supplies can have health implications for those that rely on this water for survival. The biological imbalance can also be detrimental to organisms and marine life that live in these waterways, causing indirect impacts on those that might rely on these for food. The contaminations of surface waters usually occurs as a result of discreet discharges or through contaminate runoff; but groundwater polluted by disposal of liquid and solid wastes can diffuse contamination into the surface water bodies that it recharges. In light of the built environment, operation of constructed works can affect the quality of water both beneficially, as at water treatment plants, and adversely as when ill-controlled or poorly drained irrigation produces saline conditions.

Local air pollution is a health hazard. Longer distance transfer result in acid deposition that can kill growth or attack structures whilst the net global increase in certain gases, including otherwise non-polluting carbon dioxide, causes the greenhouse effect. The effects of acid deposition are frequently felt many thousands of miles from their country of origin. Toleration of acid deposit and its consequences depend on the levels of existing acidity in surface water and on soil mineralogy, texture and land use. Air pollution is mostly caused by dust or by smoke and gas from combustion or chemical processes. The particulates released from industrial process as well as other sources, such as the combustion of fossil fuels, are also a major source of air pollution and result in human health impacts and climate change. The smog released from car exhaust is associated to causing respiratory problems in humans and is also linked to the increased lung diseases such as asthma. The effects of air pollution are both cumulative over time and complex as to combination of different pollutants.

The attempt to reduce the impact of pollution in one medium may increase the impact in another. For example; the emission of particulates may be controlled through water sprays, and this will created contaminate water which must then be treated,

2.2.4 Climate change and global warming

Of the many environmental impacts of development, the one with highest profile is global warming [6]. Human induced global warming is the result of increased concentrations of human-produced greenhouse gases in the atmosphere. Greenhouse gases absorb and emit solar radiation and the rate at which this occurs has an influence on global temperatures. Global impacts of greenhouse gas emissions include destruction of stratospheric ozone by chlorine. As these gases build, the ability for long-wave heat escape from the Earth is reduced, thus increasing the temperature of the air within our atmosphere. Thinning of the ozone layer reduces protection against ultraviolet radiation and thus increases risk of sunburn, skin cancers and eye cataracts. The main pollutants concerned are chlorofluorocarbons (CFC's), halons, methyl bromides and chlorinated solvents, which have been or can replaced by less destructive alternatives in applications such as refrigeration, fire-fighting or pesticides.

However, the main cause of global warming are greenhouse gases which include: CO2, which is the most common and has been rising with population and economic growth and increasing energy demand; Methane (CH4) occurring in much smaller amounts than CO2 but much more potent in effect; Nitrous oxide (N2O) from burning fossil fuels and biomass and CHC's when still in use; water vapour, whose effect is not yet well understood and may or may not be significant. Many of this greenhouse gases exist naturally in the atmosphere and are produced from the Earth's ecosystems.

Greenhouse gases contributed through human activity are known as anthropogenic emissions. Human activities that contribute the greatest include burning fossil fuels, clearing of land and forest, certain farming practices (such as the use of fertilizers), industrial processes and waste decomposition.

A local and possibly global warming effect of energy generation and use is waste heat, whether from steam power stations, factories or municipal or domestic heating systems. The emission of greenhouse gases at the power stations used to produce energy accounts for 25.9 % of global greenhouse gas emissions. Industry follows with the proportion of emissions at 19.4 %. Energy is a basic requirement of current human civilizations, a central necessity for many industrial processes and transportation systems, and crucial for the provision of amenities such as heating and lighting in our buildings.

There is also a complex interrelationship between air temperatures and other climatic processes including that the increasing concentration of greenhouse gases in the atmosphere and the resultant increases in global temperatures lead to a rise in sea level, severe flooding and droughts, an increased incidence of disease. These changes have significant potential to result in catastrophic consequences for millions of people living in the most susceptible of the world, particularly those in low-lying and tropical areas. Without significant reductions in global greenhouse gas emissions, the effects of global warming will continue to impact on our everyday live and potentially our very existence. According to Khasreen et al [6], it is necessary to reduce greenhouse gases emissions by 50% or more in order to stabilise global concentrations by 2100. Tyndall Centre has suggested that a 70% reduction in C02 emissions will be required by 2030 to prevent temperature rising by more than 1 degree celcius.

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Text must be fully justified. A format sheet with the margins and placement guides is available in Word files as <format.doc>. It contains lines and boxes showing the margins and print areas. If you hold it and your printed page up to the light, you can easily check your margins to see if your print area fits within the space allowed.

3. Research methodology

The research was conducted with reference to existing theoretical literature, published and unpublished literatures. The study is mainly a literature survey/review and looks at the literatures relating to the environmental impacts of buildings across their entire life cycle. The concept of environmental impacts reduction has attracted enough attention and still is unto this day. Sometimes people realize that that their activities are impacting the environment but they do not really know how severe such an impact or impacts are on the environment. Therefore, reviewing literature on the impact of buildings on the environment comes as a highlight, reminder and for some people new knowledge of what their activities cost the environment.

4. Conclusion

The building sector is one of the largest sectors in any community and thereby greatly contributes towards the environmental impacts. The building sector contributes to the environmental impacts for example; through the emissions of Greenhouse gases by burning fossil fuels during transportation of materials during the construction activities; or incineration of solid waste that is generated from construction as well demolition activities. Buildings comprise of six life cycle stages, i.e. extraction of raw

materials, manufacturing, construction, operation and maintenance, demolition, and disposal. They produce considerable amount of environmental impacts across each and every stage.

However, the increase in the awareness of natural resource depletion and environmental impacts has led to a great number of tools that were specifically established and developed to reduce the impact of human activities on the environment. Life cycle assessment (LCA) is one of these tools and it was developed to determine the holistic environmental impact of a product or service or activity or process. That is; LCA evaluates the life of a product, etc. from -cradle to grave- i.e. from the extraction of raw materials all the way to the disposal of such a product, etc. The concept –cradle to grave- is referred to as life cycle assessment, which is developed as one of the tools to help reduce the impact of a product on the environment by looking holistically at the life of such a product and thereby encouraging and informing better alternative ways and materials to reach such a product with fewer amounts of environmental impacts. However, the six life cycle stages of a building makes the undertaking of LCA for the buildings almost impossible or more than LCA may be required to really understand the environmental impacts of a building; because a it involves a great number of stakeholders; companies, personnel, legislations, etc.

The use of LCA in the building sector may ensure a great reduction in the environmental impacts of buildings and thereby less harm or prone to harm of human and habitat life. LCA will ensure sustainability of buildings. Sustainability or sustainable development is now closely looked in relation to the reduced environmental impacts. It is no longer just about developing the lives of the people but however developing these lives while also taking care of the environment. Sustainable development can therefore be defined as any development that improves the lives of people and at the same time does not negatively affect the quality of life of the future generation. Sustainable buildings in this instance must meet the required sustainable building practices according to applicable legislation/s, etc. For example; building a house that ensures good quality of life for the people whilst contributing less to the environmental impacts and that is during the whole life cycle of that building; from cradle to grave. Sustainability therefore encompasses sustaining the lives of the people, and the environment by; ensuring sustainable natural resources usage, sustainable usage of the end product, and sustainable disposals of the product after reaching its life warranty. Sustainability of buildings should therefore be seen in each and every its stages.

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