بسم الله الرحمن الرحيم

Sudan University of Science & Technology

College of Graduate Studies

Renovation for the Sustainability Of Existing Residential Buildings

Case Study: Eldibaga quarter, AlGamayer

التجديد لإستدامة المباني السكنية الحالية

دراسة الحالة : حي الدباغة ، القمايير

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By

Fatima Adil Mohmed AbdElaal

Supervisor

Prof. Saud Sadig Hassan

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“Homes are important.

They are the places where we live, pray, suffer, laugh and cry…

Places where we always want to return and remember how it was.”

Oscar Niemeyer

Dedication

This Thesis is dedicated to **my family**, my Mum, my Dad and my brothers and sisters, for their love, support and unwavering belief in me. Every time that I was in a dark mood or really tired they were with me, trying to make me smile and relax, for starting a new day with a new verve…

I truly thank my family for sticking by my side, but more than all, I want to thank them for encouraging me to be the best I could be.

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A special thanks to **my family**, for what they have done for me among my M.Sc. journey, and all my life.

This thesis was a chance for me to meet great Sudanese families, so I would like to thank **residence of Eldibaga quarter, Algamayer** for their help... They were my no. (1) Source of data, Thus I want to thank **Gubara Saeed's Family** for their support

I would also like to thank the teaching staff of **the College of Architecture & Planning - Sudan University of Science and Technology (SUST)**, because joining SUST has been for me a great chance to meet fantastic people, Thus I want to thank **Dr. Awad Saad** - Dean of the college for his encouragement.

I cannot forget to thank **my colleagues of Batch (7)** in the M.Sc. programme… Despite we couldn't spend so much time together, I was very happy to count your presence when needed.

FATIMA ADIL

Abstract

Now, we are facing the challenge of constructing in a sustainable way. However, discussions of sustainability tend to focus on new buildings while the existing building stock is often overlooked. More attention should be paid to sustainable renovation. The existing residential buildings, which have a direct relationship with people's life and environment, account for a large amount in Africa. This research focuses on the sustainable renovation of residential buildings in Sudan. The aim is to cast the shadow on the importance of sustainability in minimizing environmental impact and maximizing comfort of life, and to provide a yardstick to analyze examples of sustainable renovation.

Firstly, an understanding of sustainability and Renovation has been formed. Then a yardstick is developed for selecting, discussing and analyzing of the case study. Algamayer residential area, Omdurman, Khartoum state was selected as a case study. The case study is analyzed by the yardstick.

Finally recommendations have been stated, the most important of which are as follows:

- Renewable materials, such as mud, are the priority selection as the construction material in the renovation project, due to the consideration of reducing the impact of natural environment.
- Using prefabricated construction method, this can not only shorten construction period, but also reduce the negative influence to the surrounding environment.
- Adopting a foreign experience in sustainable renovation can be, in my opinion, the best thing to do, if similar situations are at hand.

المستخلص

الآن، نحن نواجه تحدي الإنشاء بطريقة مستدام. و لكن، نقاشات الإستدامة تميل إلى التركيز على المباني الجديدة في حين أن مخزون المباني الحالية يتم غض النظر عنه. يجب أن يولى مفهوم التجديد المستدام إهتمام أكبر. المباني السكنية الحالية و التي لديها علاقة مباشرة مع حياة الأشخاص و البيئة، موجودة بأعداد كبيرة في أفريقيا. هذا البحث يرك على التجديد المستدام للمباني السكنية في السودان. الهدف هو تسليط الضوء على أهمية الإستدامة في تقليل الأثر البيئي و زيادة رفاهية الحياة، و تقديم مديول لتحليل نماذج التجديد المستدام.

أولاً تم إستعراض مفاهيم الإستدامة و التجديد، بعد ذلك تم إنشاء مديول لإختيار و مناقشة و تحليل دراسة الحالة. تم إختيار منطقة القمايز السكنية، أمدرمان، الخرطوم كدراسة حالة. تم تحليل دراسة الحالة بإستخدام المديول.

و أخيراً تم تقديم مجموعة من التوصيات. أهمها ما يلي:

- المواد المتجددة مثل الطين، خيار له أولية كمادة بناء في مشاريع التجديد، بحكم التفكير في تقليل التأثير على البيئة الطبيعية.
- إستخدام طريقة الإنشاء مسبق الصنع، لا يقلل فترة الإنشاء فقط و إنما يقلل من الأثر السلبي على البيئة المحيطة.
- إقتباس التجربة الأجنبية في التجديد المستدام يمكن أن يكون –من وجهة نظري– أفضل ما يمكن فعله إذاما تمت مواجهة مواقف مشابهة.

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General Introduction

1.1 Introduction

The natural environment with its all recourses is the God's great gift to Man, which should be preserved and maintained for the present and future generations. The role of architecture is to provide a built environment, which is taken care for Man's safety, health and psychological and physical comfort. This built environment (building) is a part of the natural environment, what happens in the part affects the whole, and it is in a constant reaction influencing and influenced in order to provide luxury and happiness. The Buildings and construction directly and indirectly cause most of the environmental problems; they are a huge consumers of natural resources and waste producers that effect on the ecological system balance and causing from that environmental stress in the way of their consume energy and water.

Environment issue is an important aspect of sustainability. Now, we are facing the challenge of natural resource shortages, landscape and biodiversity depletion, and global climate change. There is a consensus that the construction industry has a considerable impact on the environment. It consumes both renewable and non-renewable natural resources and generates emissions and waste during construction and management of the buildings. In short, during the whole life time of building it has impact on the environment. Even though most "sustainability" issues concentrate on environmental performance, it is important to remember that sustainability is a concept with a tight connection to society (Harris, Jonathan M., et al; 2001). Because as a kind of result of construction industry, sustainable buildings, has great positive influence to peoples' daily life, which can promote social harmony and stability. Still, building can act as a cultural

carrier to promote cultural transmission, but this was not paid enough attention in the past.

Now, we are facing the challenge of constructing in a sustainable way. However, discussions of sustainability tend to focus on new buildings while the existing building stock is often overlooked. More attention should be paid to sustainable renovation. The existing residential buildings, which have a direct relationship with people's life and environment, account for a large amount in Africa. This research focuses on the sustainable renovation of residential buildings in Sudan.

Why have existing buildings been overlooked? It may be mainly because of new buildings and high-tech systems have attracted all the attention, which can provide architects and engineers opportunities to create new things. In comparison, cleaning boilers and installing new windows does not seem terribly exciting. But the author thinks it is a misunderstanding of sustainable renovation which can also be very exciting and get a huge sense of achievement and satisfaction.

Fortunately, the awareness of the importance of existing buildings is increasing. Recently, researches have shown the positive of renovating existing buildings, and point out the existing building stock is one of the key issues for sustainable building. Sunikka M. ;(2006) and Boon C. and Sunikka M.; (2004) emphasize the importance of the existing stock for CO_2 reduction, and also the reduction of the burden of demolition waste as addressed by Thomsen A. and Van der flier K.; (2009) . They also show that by following the Kyoto treaty guidelines, renovation-based strategies are a much better alternative than demolition, due to decrease environmental impact and reduced energy consumption. Awareness of the potential of the existing stock is becoming widespread among stakeholders on different levels; the European Union, national governments,

constructors, building owners, and housing associations have become interested in trying to achieve a more sustainable existing building stock.
As shown above, the trend of acknowledging the importance of renovation in Europe has birthed, renovation is still an infant, which need to be feed and grew up.

1.2 Aims of the Research

The aim of this Study is to present recent practice into sustainable renovation of residential buildings with two sub-focus:

a) To show examples of decreased environmental impact and increased comfort of life; and to provide a yardstick to analyze.
b) Communicate examples of sustainable renovation.

1.3 Research problem

- Discussions of Sustainability tend to focus on new buildings while the existing building stock is often overlooked.
- Sudan has a large stock of existing residential buildings which are in poor condition that not satisfying the sustainable needs.
- Demolition and Rebuilding nowadays becomes a social phenomenon.

1.4 Research Methodology

In this research a descriptive and analytical method is followed for Renovation for Sustainability of existing residential buildings based on books & e-books, works sheets presented in conferences. TV shows, published theses & dissertations, interviews (formal and informal) and author's observations to reach the desired results.

A yardstick has been stated based on the theoretical frame work to analyze the case study, and then conclusions and recommendations have been stated.

1.5 Organizing of the Study

- **Chapter I:** General Introduction is the starting point and leads the direction of research of the whole study.
- Theoretical frame work is divided to two parts:

a) **Chapter II:** Sustainability contains the definitions of Sustainability, Sustainable development, Sustainable building and then goes on to explain Rating systems and other similar concepts.

b) **Chapter III:** Renovation contains the definitions of Renovation, Types of Renovation, Sustainable Renovation and then goes on to explain priorities for the Renovation of housing, Finally a yardstick for case study has been stated

- Then, **Chapter IV:** presentation & analysis of the case study which shows a selected case study at Algamayer -area- Omdurman- Khartoum State and case study analysis based on the theoretical frame work and the yardstick.
- Finally, **Chapter V:** the discussions and conclusions which give a platform to express author's ideas and suggestions.

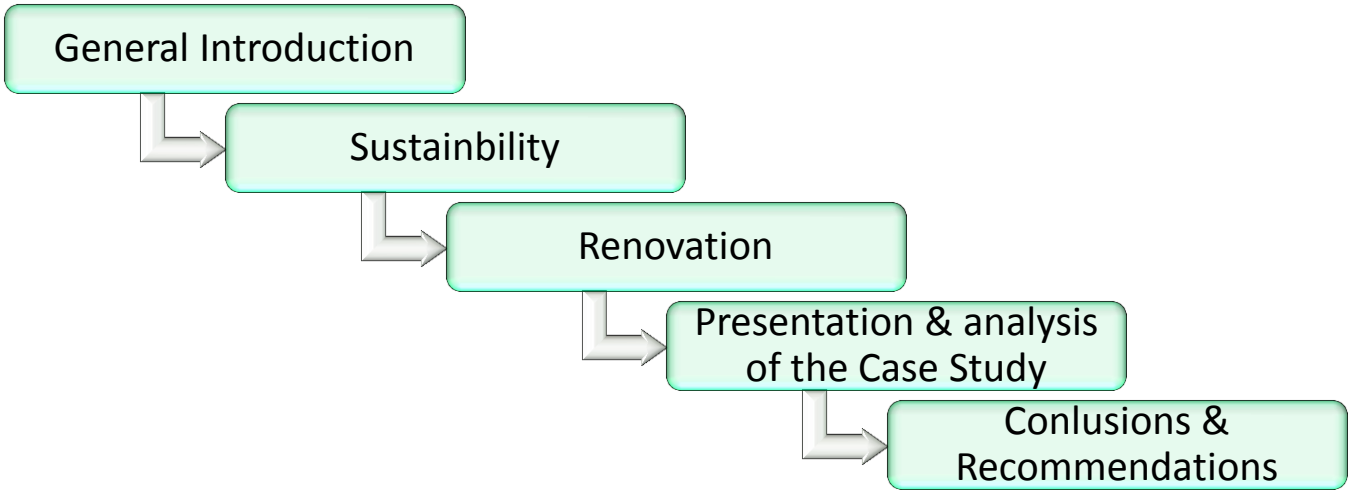


Chart (1.1) Research organization

Source: (author)

Chapter II
Sustainability

Chapter II

Sustainability

2.1 Introduction

This chapter explains the concept of Sustainability begins with the definitions of Sustainability, Sustainable development, Sustainable building and its models, and then goes on to explain Rating systems and other similar concepts.

2.2 Definitions of Sustainability

The words sustainable and sustainability are used today in many contexts and many fields. The origin of the English word sustain is in the Latin words sub (under, from below), and tenere (to hold, to hold up). To sustain, then, means to keep up, to maintain, and to prevent from sinking or falling.

In the last decades, the word sustainable has been mainly associated with ecological questions, referring to the damage caused by human civilization to the natural environment. The discussion about sustainability centers around the worry about the future of our planet, or more precisely, about the state of natural elements and the survival of animal and plant species, the continuous availability of natural resources, in particular potable water and energy sources, and the consequences of our way of life on the earth's climate.

Sustainability is not an individual problem, but rather a global matter. Considering the sustainability of the natural environment means considering our role in "holding up" the earth, of keeping its resources from being depleted (Itard et al; 2008). From a historical perspective, while ancient peoples' respect for the landscape was based on a friendly, even sacred relationship between humans and nature, modern efforts toward

sustainable development derive from the more utilitarian and anthropocentric goal of protecting nature to ensure our own survival (Thomsen A. and Van der flier K.; 2009).

Questions of sustainability are no longer limited to the field of ecology. Many other disciplines, including agriculture, transportation, industrial production, management, planning, architecture and design, are striving to incorporate sustainable goals and practices. Any activity can in fact be rethought with concern for the environmental impact and the issues of sustainability. The challenge is to focus on future generations with the intention of providing them with a world able to comply with their needs and to increase their quality of life, rather than leaving them with a legacy of unsolved problems. Even the notion of sustainable development, where Future humans are reasonably healthy; communities and nations are secure, peaceful and thriving; there is economic opportunity for all; and the integrity of the life-supporting biosphere is restored and sustained at a level necessary to make these goals possible. All four dimensions of sustainability must be addressed to achieve this vision (Anthony D., Cortese and Debra Rowe; 2004)

Sustainability is “a process that helps create a vibrant economy and a high quality of life, while respecting the need to sustain natural resources and protect the environment. It expresses the principle that future generations should live in a world that the present generation has enjoyed but not diminished.” (Clough, G. Wayne, Jean-Lou Chameau, and Carol Carmichael; 2006)

Historically, the term “sustainable” arose among those with environmental concerns, and most of the literature and assessment instruments reflect this emphasis. However, it is increasingly recognized that sustainability cannot be achieved without addressing social justice issues. There can be no sustainable communities and institutions without

social justice. So too is humane consideration toward the whole community of life an essential part of true sustainability. An academic institution committed to sustainability should help students understand the roots of today's injustices and motivate them to seek justice and humaneness in full integration with understanding the roots of environmental degradation and modeling environmentally sustainable practices (John B. Cobb Jr.; 2009)

Sustainability is an ideal end-state. Like democracy, it is a lofty goal whose perfect realization eludes us. For this reason, there will always be competing definitions of sustainability. We know these definitions will always include the well-being of people, nature, our economy, and our social institutions, working together effectively over the long term (Botta, M.; 2008)

2.3 History of the Concept of Sustainability

The concept of sustainability was originally coined in forestry, where it means never harvesting more than what the forest yields in new growth (Wiersum, K.F.; 2003). The word Nachhaltigkeit (the German term for sustainability) was first used with this meaning in 1713 (Wilderer, P.A.; 2007). The concern with preserving natural resources for the future is perennial, of course: undoubtedly our Paleolithic ancestors worried about their prey becoming extinct, and early farmers must have been apprehensive about maintaining soil fertility. Traditional beliefs enjoined thinking in terms of stewardship and concern for future generations, as expressed in the oft-quoted words of a Nigerian tribal chief who saw the community as consisting of "many dead, few living and countless others unborn" (Ike, D.N.; 2001) and (Fukuyama, F.; 2008). Perhaps there have always been two opposing views of the relation between humankind and nature: one which stresses adaptation and harmony, and another which sees nature as something to be conquered. While this latter view may have been

rather dominant in Western civilization at least in recent centuries, its counterpoint has never been absent.

Sustainability (without necessarily using the word) is a natural topic of study for economists: after all, the scarcity of resources is of central concern to the dismal science. A famous example is the work of Thomas Malthus, who published his theory about looming mass starvation (due to the inability of available agricultural land to feed an expanding population) in 1798. A theory on the optimal rate of exploitation of non-renewable resource which is still relevant today was formulated by Harold Hotelling; (1931), an American economist. The author will have more to say about his views later. A milestone in capturing the attention of global public policy was the report of the Club of Rome (Meadows, D.H.; Meadows, D.L.et al; 1972), which predicted that many natural resources crucial to our survival would be exhausted within one or two generations. Such pessimism is unbecoming in public policy which is, after all, supposed to be about improving things. Therefore, the report of the UN World Commission on Environment and Development, better known as the Brundtland Report (Gro Harlm Brundtland; 1987) after its chairperson, was welcomed for showing a way out of impending doom. It was this report which adopted the concept of sustainability and gave it the widespread recognition it enjoys today.

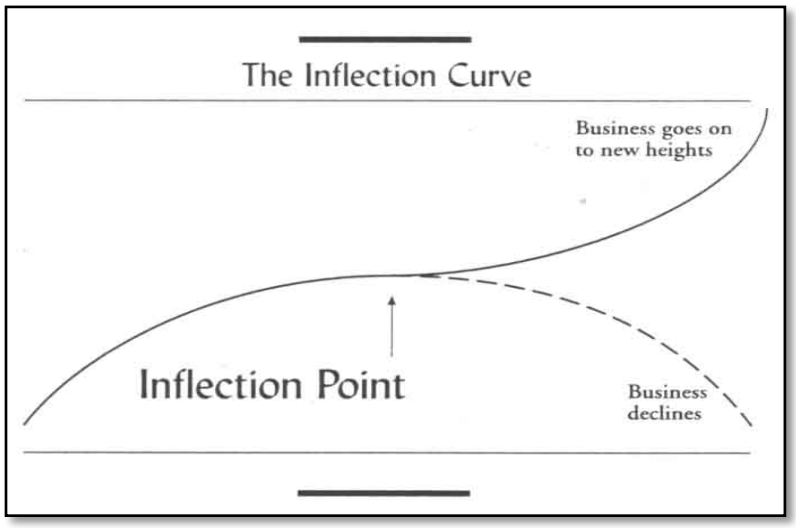


Figure (2.1): Effect of Sustainability

Source: (Botta, M. ;2005)

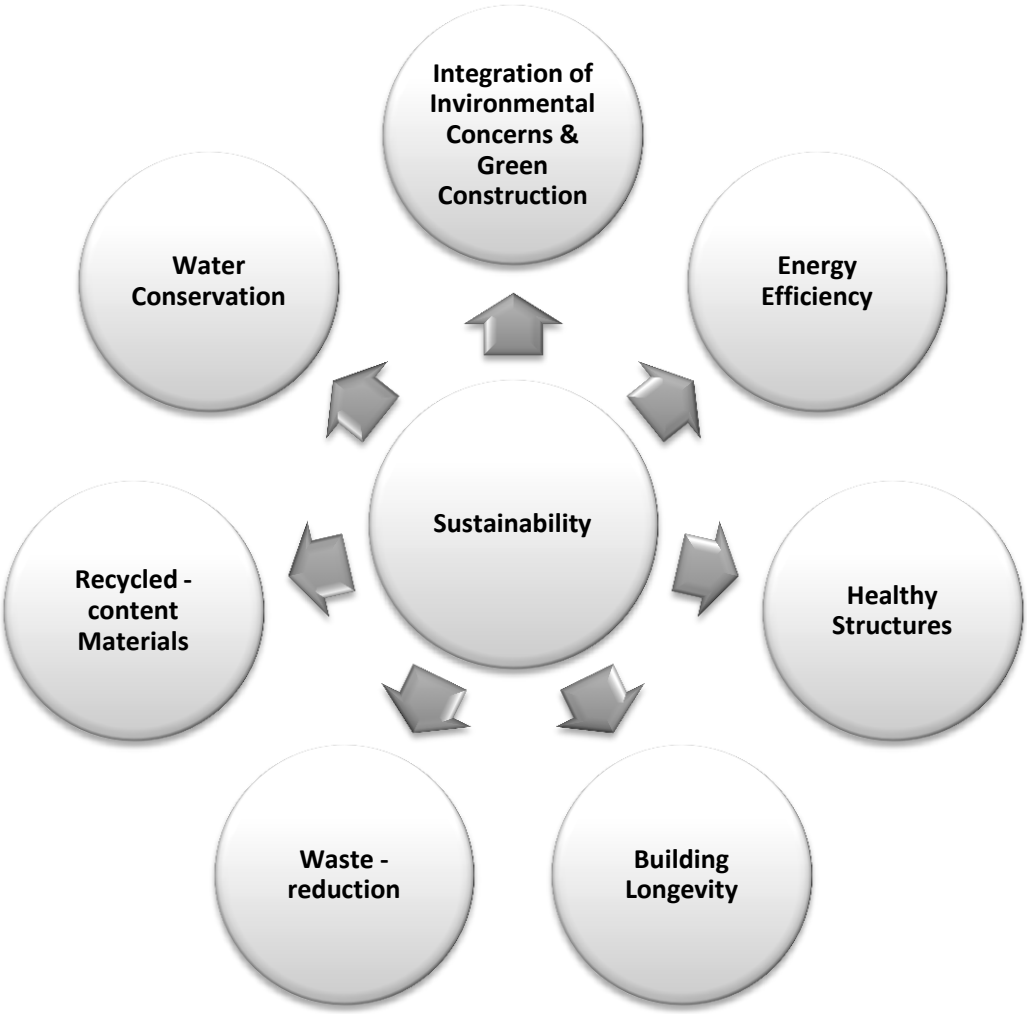


Figure (2.2): Working Principles

Source: (Botta, M. ;2005)

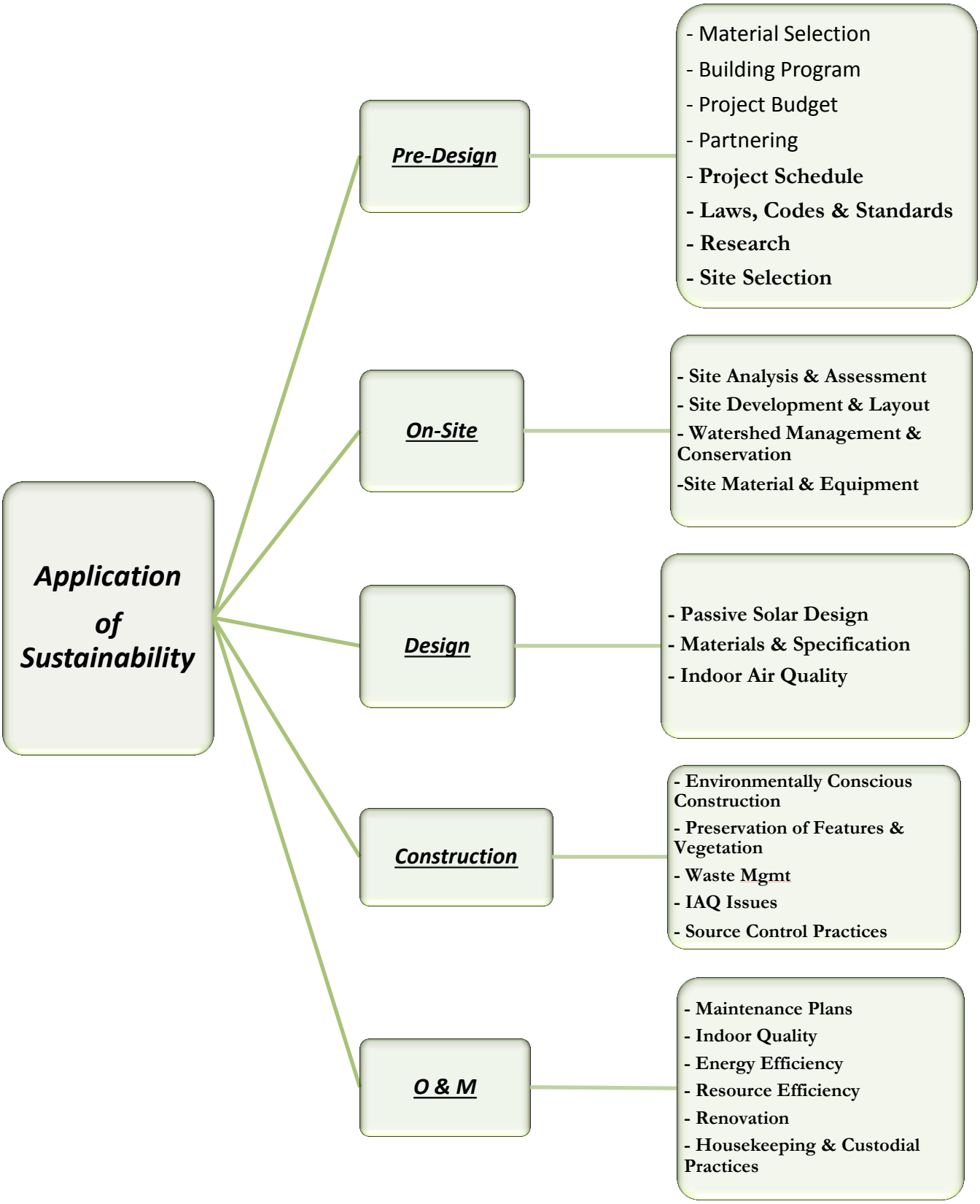


Chart (2.1): Application of Sustainability

Source: (Botta, M. ;2005)

2.4 Environmental Sustainability

The idea of Environmental Sustainability is to leave the earth in good or better shape for future generation, than we found it for ourselves (Reed, David ed.; 2004).

By this definition, human activity doesn't affect the sustainability of the environment, only when it can be performed or maintained. Indefinitely, without depleting natural resources or degrading the natural environment.

This can be done by Jonathan M. Harris; (2003):

a) Minimization of resource consumption.
b) Materials consumed would be made entirely of 100% post-consumer recycled materials or from renewable resources (which were harvested without harm to the environment and without depletion of the resource base).

2.5 Sustainability Dimensions

Typically, Sustainability is illustrated as three intersecting circles connecting Community, Economy and the Environment. But the over whelming majority of problems, issues and corresponding solutions are like ecology, three dimensional. As three dimensional problem solvers, architects are well suited to lead the change toward Sustainability (Battle, G. and Mc. Carthy, C.; 2001).

i. Economic Dimensions of Sustainability

- Creation of new markets and opportunities for sales growth.
- Cost reduction through efficiency, improvements and reduced energy and raw material inputs.
- Creation of additional added value.

ii. Environmental Dimensions of Sustainability

- Reduced waste, effluent generation, emissions to environment.
- Reduced impact on human health.
- Use the renewable raw materials.
- Elimination of toxic substances.

iii. Social Dimensions of Sustainability

- Worker health and safety.
- Impacts on local communities, quality of life.
- Benefits to disadvantaged groups e.g. disabled

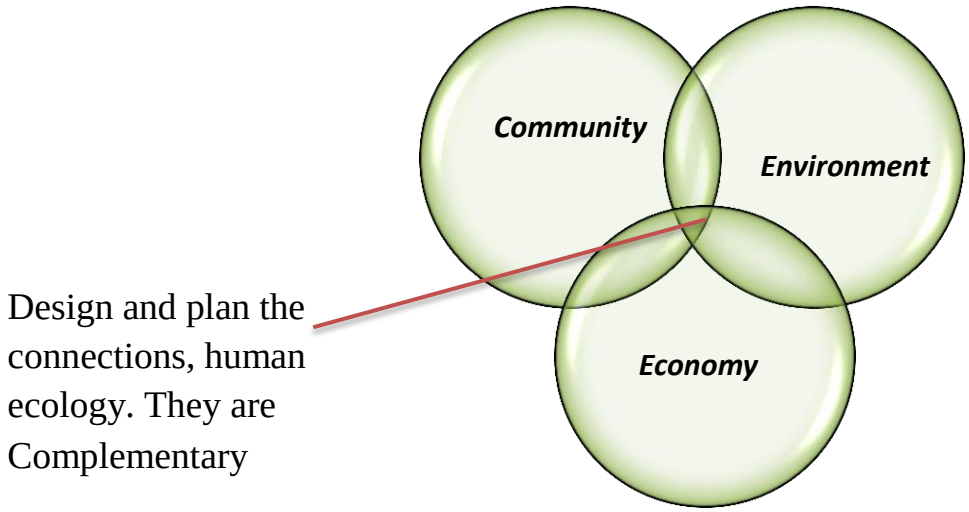


Figure (2.3): The three rings (dimensions) of Sustainability

Source: (Battle, G. and Mc.Carthy,C.2001)

2.6 Sustainable Development

- Sustainable development means different things to different people , however, the most frequently quoted definition is from the report "Our Common Future" (*) :

* This definition has been formulated by the world commission on Environment and Development (WCED) led by: Norwegian prime minister Gro Harlem Brundtland, 1987

Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts:

a) The concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given; and
b) The idea of limitations imposed by the state of technology and social organization on the Environment's ability to meet present and future needs.

2.7 Principles of Sustainable Development

Many governments and individuals have pondered what sustainable development means beyond a simple one-sentence definition. The Rio Declaration on Environment and Development fleshes out the definition by listing 18 principles of sustainability: (McKeown, Rosalyn; 2002)

i. People are entitled to a healthy and productive life in harmony with nature.
ii. Development today must not undermine the development and environment needs of present and future generations.
iii. Nations have the sovereign right to exploit their own resources, but without causing environmental damage beyond their borders.
iv. Nations shall develop international laws to provide compensation for damage that activities under their control cause to areas beyond their borders.
v. Nations shall use the precautionary approach to protect the environment. Where there are threats of serious or irreversible damage, scientific uncertainty shall not be used to postpone cost-effective measures to prevent environmental degradation.
vi. In order to achieve sustainable development, environmental protection shall constitute an integral part of the development process, and cannot

be considered in isolation from it. Eradicating poverty and reducing disparities in living standards in different parts of the world are essential to achieve sustainable development and meet the needs of the majority of people.

vii. Nations shall cooperate to conserve, protect and restore the health and integrity of the Earth's ecosystem. The developed countries acknowledge the responsibility that they bear in the international pursuit of sustainable development in view of the pressures their societies place on the global environment and of the technologies and financial resources they command.

viii. Nations should reduce and eliminate unsustainable patterns of production and consumption, and promote appropriate demographic policies.

ix. Environmental issues are best handled with the participation of all concerned citizens. Nations shall facilitate and encourage public awareness and participation by making environmental information widely available.

x. Nations shall enact effective environmental laws, and develop national law regarding liability for the victims of pollution and other environmental damage. Where they have authority, nations shall assess the environmental impact of proposed activities that are likely to have a significant adverse impact.

xi. Nations should cooperate to promote an open international economic system that will lead to economic growth and sustainable development in all countries. Environmental policies should not be used as an unjustifiable means of restricting international trade.

xii. The polluter should, in principle, bear the cost of pollution.

xiii. Nations shall warn one another of natural disasters or activities that may have harmful trans boundary impacts.

xiv. Sustainable development requires better scientific understanding of the problems. Nations should share knowledge and innovative technologies to achieve the goal of sustainability.

xv. The full participation of women is essential to achieve sustainable development. The creativity, ideals and courage of youth and the knowledge of indigenous people are needed too.

xvi. Nations should recognize and support the identity, culture and interests of indigenous people.

xvii. Warfare is inherently destructive of sustainable development, and Nations shall respect international laws protecting the environment in times of armed conflict, and shall cooperate in their further establishment.

xviii. Peace, development and environmental protection are interdependent and indivisible.

2.8 Sustainable building

Sustainable development is a rather ambiguous term, covering a wide variety of aspects, sustain the natural environment is the starting point of sustainable development. Unfortunately, a narrow sense, which is sustain natural environment equals to sustainable development, is still deep into many people's mind (Figure 2.4). Kibert C. J.; (2007) mentioned that with respect to sustainability, construction sector prefer to improve the performance of buildings through using hi-tech things, resulting in less consumption of energy and materials, and a good way to treat trash. Construction sector only focus on green performance and concentrate on techno-sphere and ecosphere (Cole R. J.; 1999).

Figure (2.4): Narrow sense of the concept Sustainable Building with focus on the environment

Source: (Battle, G. and Mc.Carthy,C.2001)

Then there is a shift from 'narrow' to a global perspective of environmental, economic, and social aspects of understanding of sustainable building (Cole R. J.; 1999). Kibert C. J. ;(2007) stated that sustainable building construction is about how the construction industry together with the built environment, among many sectors of the economy and human activity, can contribute to the sustainability of the earth including its human and non-human inhabitants. Cole R. J.; (1999) has argued that sustainable building projects must include a low nature resource usage and natural environment impact, and positive effects social systems, and sustain growth of economy.

Adams; (2006) presented a model with including environmental, economic and social aspects just like three pillars (3-P), to hold and support the "sustainable building" stand erect (Figure 2.5). Each "pillar" is not isolated; they create a network, and strongly connect to each other. Any change happens in one pillar results in the response of the other two. This kind of definition, which integrates three sustainable fields, is widely used

to explain sustainable building project. This is in line with the Brundt Land definition in 1987.

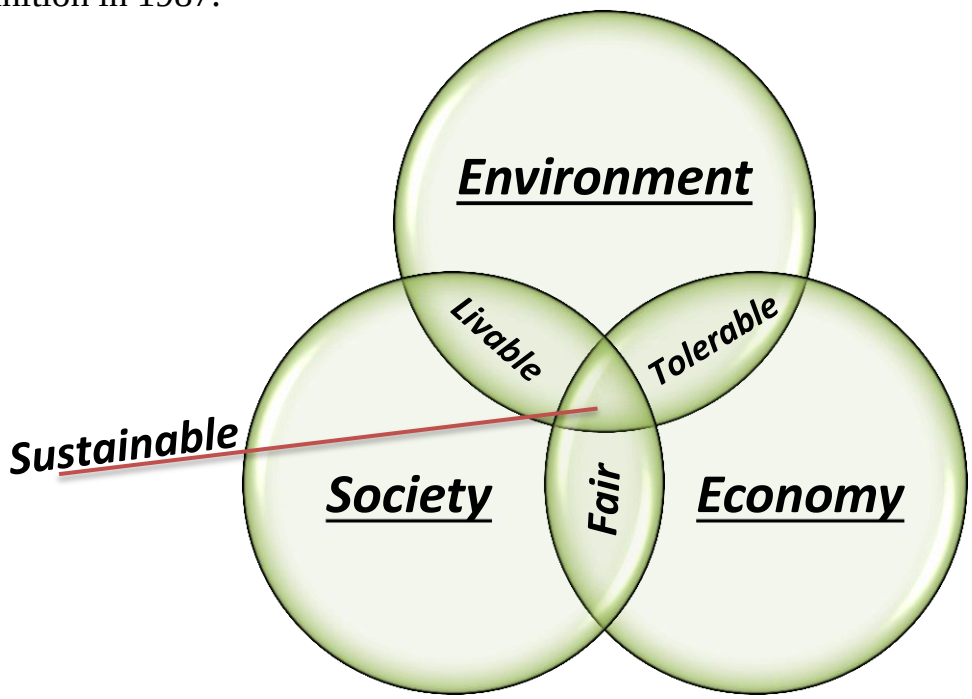


Figure (2.5): Three Pillars of sustainability

Source: (Trachte& Deherde, 2011)

Resource is a frequently used word in sustainable building. (Pearce D.; 2006) presented an understanding of sustainable building from another perspective which strong relates to the volume of resource increase or decrease. He enlarged the concept of resource, and stated that all the resources can be treating as "capitals", and there exist four main capitals, i.e. man-made, human, natural and social. Variations and transformations always happen between these capitals (Figure 2.6). Each capital is a substitution of others. Reducing one capital is not consistent with sustainability unless another capital is increased. Pearce argued that the real sustainable building is actually no more than a breakeven point, the reduced volume of one kind of resource will equal to the increase volume of other resources.

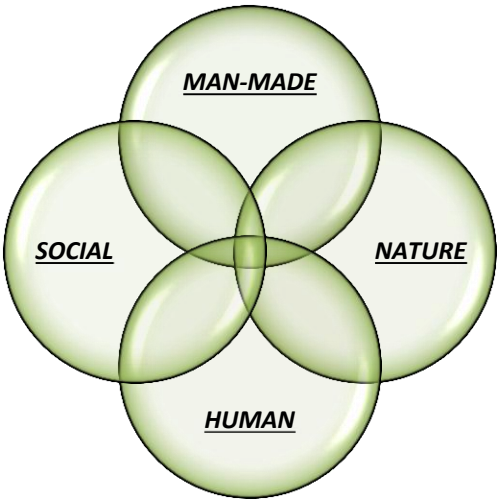


Figure (2.6): Definition of sustainable building
Based on the concept 'capital'
Source: (Pearce, 2006)

2.9 Mutable and enlarging concept

Sustainable building is a complex issue; various kinds of aspects need to be considered. New problems will continually be found one after another on the way we pursue sustainability. Consequently, the definition of sustainability is not immutable, it is mobile, and always varies, in order to become more comprehensive. Much of the literature on sustainability has therefore multiplied entities rather than narrowing them down in an effort to ensure more meaningful discourse. In the building field, the definition has shifted from 'nature only' to 'three-pillar' and to understandings from other perspectives, and this kind of shift will constantly go on. Definition and redefinition will never stop (figure 2.7)

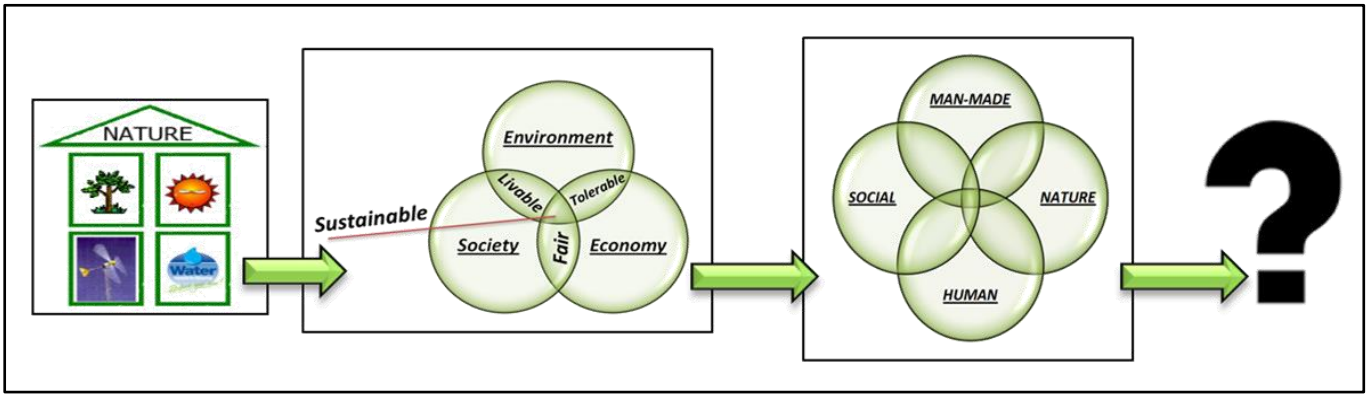


Figure (2.7): Redefinition of sustainable building goes on
Source: (The Challenge of Sustainability,2002)

2.10 Advanced Features of a Sustainable Building (Sam C. M. Hui; 1996 updated 2002)

a) Best Building Form
b) Solar & Energy Efficient Design
c) Improved Indoor Air Quality Usage of Green Materials
d) Proper Mechanical Systems
e) Efficient Lighting
f) Proper Testing & Maintenance

2.11 Rating Systems

The market place of the design and construction of high performance buildings is dynamic and evolving. Professionals throughout the world use assessment rating systems to evaluate and differentiate their product or design (Reeder L.; 2010).

Table (2.1): Rating System Source(s)
Source: (Reeder L.; 2010)

Sustainable Building Rating Systems	Development Basis
BREEAM (Building Research Establishment's Environmental Assessment method)	Original
BREEAM Canada	BREEAM
BREEAM Green Leaf BREEAM	Green Leaf™
Calabasas LEED	LEED®
CASBEE (Comprehensive Assessment System for Building Environmental Efficiency)	Original
CEPAS (Comprehensive Environmental Performance Assessment Scheme)	LEED®, BREEAM, HK-BEAM, IBI
Earth Advantage Commercial Buildings (Oregon)	Undisclosed
EkoProfile (Norway)	Undisclosed
ESCALE	Undisclosed
GBTool	Original
GEM (Global Environmental Method) For Existing Buildings (Green Globes) –UK	Green Globes Canada

GOBAS (Green Olympic Building Assessment System)	CASBEE, LEED®
Green Building Rating System – Korea	BREEAM, LEED®, BEPAC
Green Globes Canada	BREEAM Green Leaf
Green Globes™ US	Green Globes Canada
Green Leaf Eco-Rating Program	Original
Green Star Australia	BREEAM, LEED®
HK BEAM (Hong Kong Building Environmental Assessment Method)	BREEAM
HQE (High Environmental Quality)	Undisclosed
IDP (Integrated Design Process)	Original
Labs21	Original
LEED® (Leadership in Energy and Environmental Design)	Original
LEED Canada	LEED®
LEED India	LEED®
LEED Mexico	LEED®
MSBG (The State of Minnesota Sustainable Building Guidelines)	LEED®,Green Building Challenge '98, and BREEAM
NABERS (National Australian Built Environment Rating System)	Undisclosed
Promise	Undisclosed
Protocol ITACA	GB Tool
SBAT (Sustainable Buildings Assessment Tool)	Original
Scottsdale's Green Building Program	Undisclosed
SPiRiT (Sustainable Project Rating Tool)	LEED®
TERI Green Rating for Integrated Habitat Assessment	Original
TQ Building Assessment System (Total Quality Building Assessment System)	Original

2.12 LEED

Leadership in **E**nergy and **E**nvironmental **D**esign (LEED) (LEED®, April 2009)

- Is a set of rating systems for the design, construction, operation, and maintenance of green buildings, homes and neighborhoods.
- Developed by the U.S. Green Building Council, (USGBC) in 1998
- Nationally recognized standard for Green Building

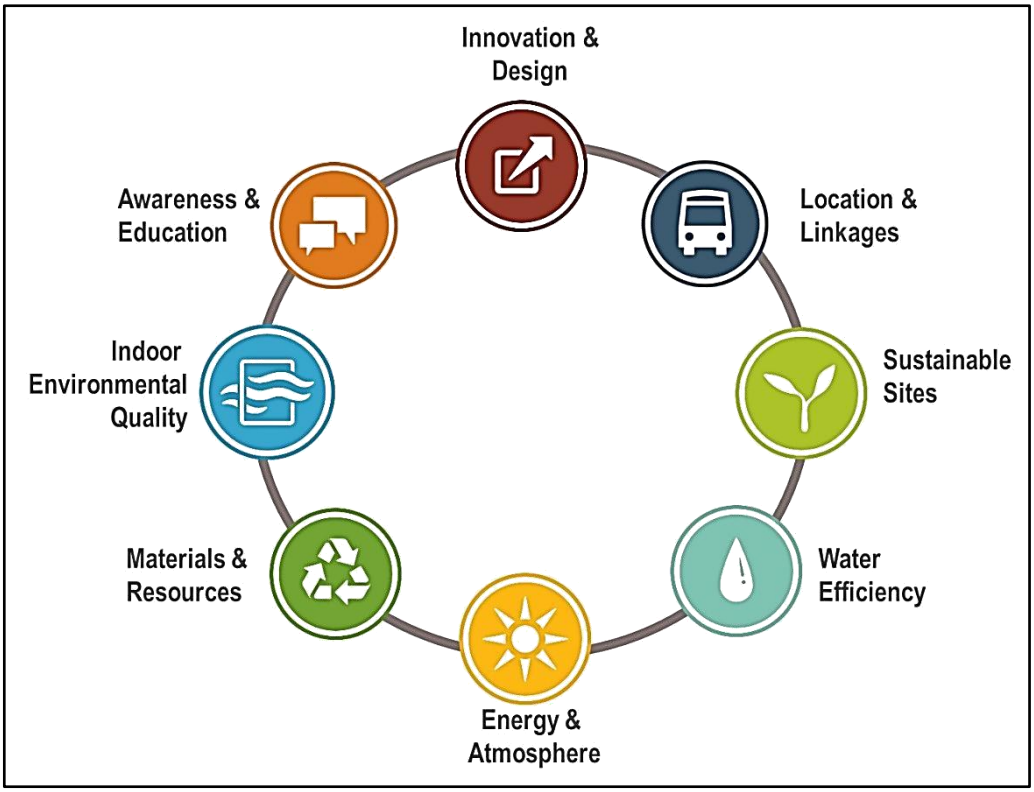


Figure (2.8) LEED Categories

Source: (LEED® Green Associate Candidate Handbook, April 2009)

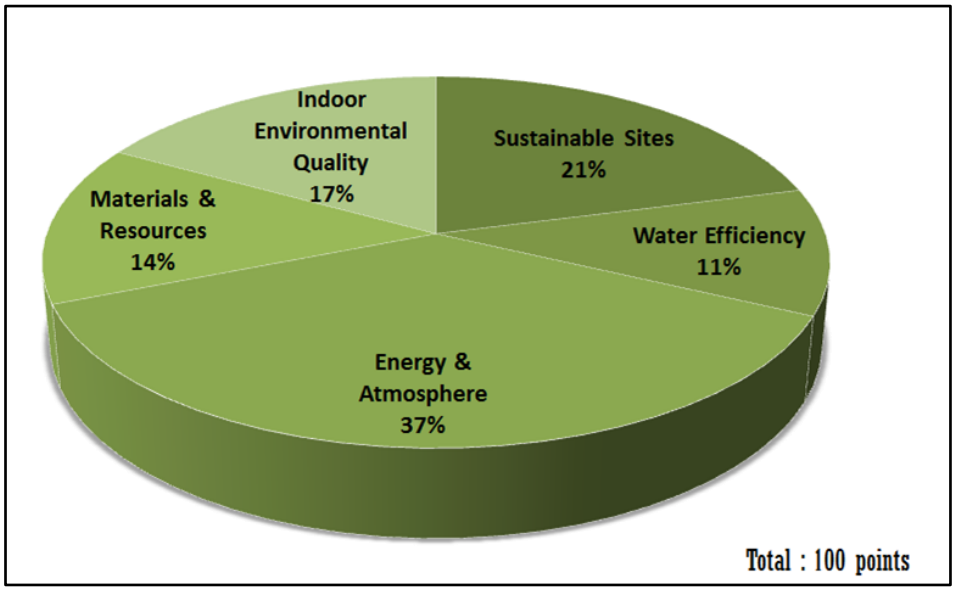


Figure (2.9) LEED Certification Scorecard Breakdown

Source: (LEED® Green Associate Candidate Handbook, April 2009)

Certified	40-49 points
Silver	50-59 points
Gold	60-79 points
Platinum	80-100 points

Figure (2.10) LEED Points and emblems

Source: (LEED® Green Associate Candidate Handbook, April 2009)

2.13 Conclusion

In this chapter Sustainability was introduced, the concept of sustainable development and its principles and finally the term of Sustainable building and its models have been discussed.

The concept of Sustainability has been introduced; Starting with it was originally coined in forestry, where it means never harvesting more than what the forest yields in new growth, then definitions of Sustainability and history of concept of Sustainability, and finally dimensions of Sustainability was introduced.

Sustainable development has been discussed in two ways; First definition of Sustainable development and then principles of Sustainable development , the most important ones are:

- Nations shall develop international laws, enact effective environmental laws and facilitate and encourage public awareness and participation since they have the sovereign right to exploit their own resources, but without causing environmental damage beyond their borders.
- The polluter should, in principle, bear the cost of pollution.
- Sustainable development requires better scientific understanding of the problems.
- The full participation of women is essential to achieve sustainable development
- Nations should recognize and support the identity, culture and interests of indigenous people.
- Peace, development and environmental protection are interdependent and indivisible.

Sustainable building and its models have been discussed in three concepts which are:

- The concept Sustainable building with focus on the environment.
- The model of the three pillars (3-P).
- Definition of sustainable building based on the concept “Capital”.

What had been discussed will be carried to the next chapter and be linked to explain the concept of Sustainable Renovation.

Chapter III
Renovation

Chapter III

Renovation

3.1 Introduction

This chapter explains the concept of Renovation, it begins with the definitions of Renovation, Types of Renovation, Sustainable Renovation and then goes on to explain priorities of the Renovation of housing, and, finally, a yardstick of analysis criteria for case study has been stated

3.2 kinds of lifespan of building

Generally, there are two lifespans existing in the construction sector (Figure 3.1). One kind of the lifespan of buildings can be described as a linear development which includes briefing, design, construction, delivering, usage and demolishment. Thomsen A. and Van der flier K.; (2009) describes the linear lifespan as a decay process, and in this process, dwellings as the gradual loss in time of the original (physical) performance capacity: the decline issues include the technical and functional qualities of the building. This process can be called from 'cradle to grave', be demolished is the destination of building. The other can be described as a cyclic revolving process of building initiative, design, construction, utilization and redevelopment or recycling (Straub A.; 2001)

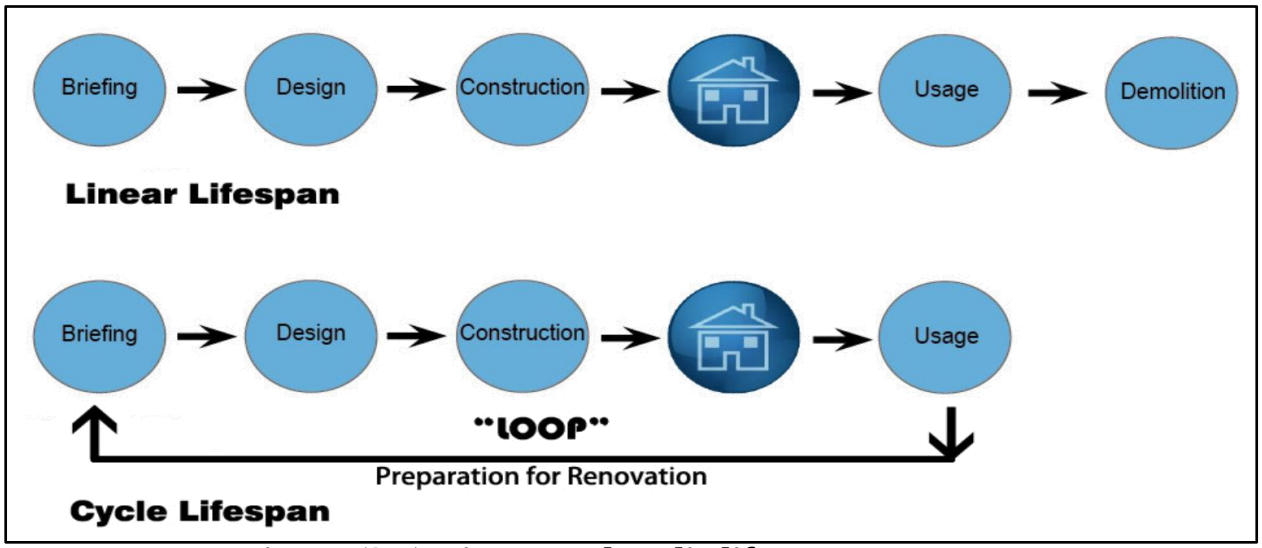


Figure (3.1) Linear and cyclic lifespans

Source: (Straub A.; 2001)

It is obvious that the buildings with a cyclic lifespan can reduce quite a lot of waste than those with a linear lifespan. At the end of their linear lifespan, considerable resources are wasted and the buildings themselves become large amount of construction trash. Although there is apparent advantage of a cycle lifespan, some buildings are inevitably demolished because mere maintenance cannot help to extend their lifespan or make them reused.

Renovation may fill the gap between simple housing maintenance and demolition, providing opportunities for establishing closed loops for the usage of buildings. It is an important tool for usage of buildings shifting from 'cradle-to-grave' to cradle-to-cradle, which means 'Renovation' can provide opportunity for buildings to reborn through reusing some old component that still reliable, and upgrade some elements that should 'retire'. In this case, renovation can be seen as the corner stone of the 'loop'; or in other word, 'renovation' play a key role for building reusing.

3.3 Definitions of Renovation

According to Oxford English dictionary, renovation (also called remodeling) is the process of improving a structure. We understand the word' renovation' is generally used to cover modernization, remodeling, retrofitting, restoration and rehabilitation, each of which is a method for renovation.

Mostly, renovation refers to reuse an existing construction (including structure and components etc.) on the site, integrate its structure, and possibly upgrade it or extend it. It is now relatively common in the field of heritage structures as they are seen to have cultural value. While in many other existing building with little historic or cultural values, renovation is also possible to improve their quality.

According to (Latour B.; 1990), renovation design, unlike the design of a new building, has two emphases: immutable and mobile. Immutable

refers to the old, respecting the history and culture of the building, and mobile refers to the new, satisfying the modern requirements. They are equal items, putting onto each side of a balance. And for renovation of residential buildings, people occupied the residences need to be carefully thought.

3.4 Types of Renovation

There is three main types of renovation depends on actions that pay attention to like: cultural historical and socio-political actions and energy efficiency, water conservation and the use of renewable materials (Chamberlain L.;2007). These types are:

i. Careful renovation

Mainly inspired by the interest in the cultural historical and socio-political aspects of renovation, this approach proposes interventions with respect for the existing qualities of the buildings and for the needs of their actual users or inhabitants.

The main goal of careful renovation is that of preserving the character of the building as well as its values as they are perceived by its users.

ii. Environmentally-friendly renovation

Mainly motivated by ecological environmental issues, this approach proposes renovation actions that pay special attention to energy efficiency, water conservation and the use of renewable materials.

The main goal is that of preserving natural resources and avoiding environmental pollution.

iii. Sustainable renovation:

Expanding on the ideas of environmentally friendly renovation, this approach includes cultural, social, economic and institutional aspects of the renovation project.

The main goal is that of contributing to sustainable development in a wider context, with future generations in mind.

3.5 Sustainable Renovation

Recently, the concept of "sustainable renovation" has started to become part of architectural terminology, denoting an approach to renovation with the same aims as sustainable building but adapted to existing contexts of buildings and people. Many documents and programs refer to sustainable renovation to emphasize the intention of combining technical and functional improvements with social and institutional actions aimed at improving the sustainability of the building/area. Such intentions require the capacity to meet a process of change meant to decrease the environmental impact, but at the same time preserving or improving existing buildings areas, with respect and care for the existing context, as intended in careful renovation. In coherence with the aims of sustainability, it has become important to encourage democratic processes for sustainable renovation involving all the actors: owners, builders and material suppliers, technicians, authorities, inhabitants and other users.

As underlined by the working group on Sustainable Construction of the Architects' Council of Europe in 2003:

"Sustainable renovation is much more difficult to implement than sustainable new building." "Considerably less research has been directed at sustainable construction methods and techniques for retrofitting, refurbishment and renovation. This is an important concern since, in most areas of the EU; the annual rate of new building activity represents a rate of replacement or net increase of between 0. 5% and 2.0% of the total building stock"

Sustainable renovation cannot be reduced to a series of environmental actions and does not imply transferring onto existing buildings the technologies used for sustainable building.

In line with the multidisciplinary character of sustainable development, projects of sustainable renovation should include, by definition, environmental, social, cultural, economic and institutional considerations. In practice, a careful attitude and an interdisciplinary approach, considering different sustainable actions, can be assumed as prerequisites of sustainable renovation projects. Which to strip Sustainable renovation can represent an ideal target toward, even if choices and compromises must be made. A key element of sustainable renovation work is that of locating the renovation object in relation to the natural environment, to its physical context and to its inhabitants and their perception and use of the place. This can be discussed in technical terms as well as in psycho-social ones.

3.6 A scheme for sustainable renovation

The following scheme is a proposal to link common goals of sustainable renovation projects to different aspects of sustainability. The preservation of architectural culture is one important motive for renovation. Most programs for sustainable development recommend preserving and transmitting elements of culture, art and craft. Therefore, to the four components of sustainability identified by the Wuppertal Institute, i.e., environmental, social, economic and institutional, this scheme adds the cultural component defining culture, following Rapoport's anthropological definition, as "ways of life, symbols, meanings, cognitive schemata, and adaptive strategies." (Rapoport, A.; 1969) Consideration of each aspect of sustainable renovation can be found in the different goals of the renovation projects.

Table (3.1) Scheme with renovation goals
linked to the main aspects of sustainable renovation
Source: (Rapoport, A; 2001)

Aspects of Sustainable Renovation	Goals in Sustainable Renovation Projects (beside technical and functional ones)
environmental	▪ To decrease the environment impact of buildings ▪ To limit the use of energy, natural resources and un built land ▪ To support an environmentally-conscious way of dwelling
Social	▪ To provide good and affordable dwellings ▪ To facilitate social stability and integration ▪ To raise awareness about one's own living place ▪ To promote sustainable behavior
Cultural	▪ To preserve and transmit cultural objects and historical and cultural values ▪ To upgrade buildings and places while respecting their character
Economic	▪ To prolong the use of existing resources ▪ To maintain real estate values ▪ To safeguard the affordability od dwellings
Institutional	▪ To promote participation and involvement of the inhabitants ▪ To provide good management and maintenance

These aspects are explained in the following paragraphs:

a) Environmental aspects

Are found in many renovation projects geared toward decreasing the environmental impact of buildings for ecological health as well as for the inhabitants' improved comfort and health. Energy-efficient actions are taken in many projects, followed by actions for saving water (and, in general, all natural resources), for reducing the production of waste and the use of polluting or harmful materials, for improving indoor climate and comfort and for protecting and reclaiming the bio-diversity of flora and fauna in the exterior spaces. Another result of renovation is that of reusing both land and building materials by using existing buildings for a longer time, thus saving natural resources rather than engaging in demolition, new construction and/or further expansion of urban areas.

b) Social aspects

Are considered in projects where renovation work allows people and activities to continue using buildings and places while supporting or improving existing social structures and encouraging local activities. These aspects are also considered in projects where efforts are made to keep dwellings affordable to all social groups and where new dwellings are provided in under unused buildings. Many such efforts focus on improving the social stability and integration of the inhabitants, encouraging people to take responsibility for and participate in the management of their dwelling areas.

c) Cultural aspects

Are considered when renovation safeguards the character and the qualities of the buildings. This approach means preserving and transmitting culture, cultural identities, knowledge and technical skills, and social and symbolic values. Old buildings connect the present time to the times in

which they were built and may help people to relate to history. Architecture and urban structures represent, in fact, a cultural heritage, as well as the social and cultural structures of past and present civilization. These projects have educational cultural results as well: they can make people aware of historical and cultural qualities allow for experimenting with new techniques and help to disseminate information about environmental issues.

d) Economic aspects

May be considered with regard to the local inhabitants or to larger society. Economic returns of the investments are seen in lower operational costs due to lower energy and water consumption, reduction of household waste to be taken care of, more efficient use of the buildings and in lower maintenance costs. Societal savings can be calculated in the longer term in environmental balances promoting, for example, healthier living conditions, better housing management and cultural preservation.

e) Institutional aspects

Are present in the leadership of renovation projects and the in management of renovated areas when efforts are made to involve the inhabitants, to provide them with environmental information and to have them sharing the responsibility for their living areas. Better relationships between managers, housekeepers and inhabitants also help to improve housing management and maintenance of the buildings.

3.7 Systematic thinking of sustainable renovation on residential buildings

7 Dimension Model

Through the discussion of sustainable building theories mentioned on the previous chapter, such as 3-pillar and 4-capital ideas, we can conclude that sustainable renovation is a complicated issue, in which a number of entangled and interacting factors are relevant for the process. The factors,

such as natural factor, social factor, human factor etc., are in different fields.

Kain; (2003) came up a model named The MAINTRTRA (Figure 3.2), which is for localized infrastructure planning and sustainable urban development. Four kinds of capitals (mind, artifact, institution, nature) make up a network, of which, mind means human knowledge and skills affect development; artifact means issues created by human skill or agency; institutional means the aggregate of actual or potential resources; and nature means capitals that are created by bio-geophysical processes and not human action.

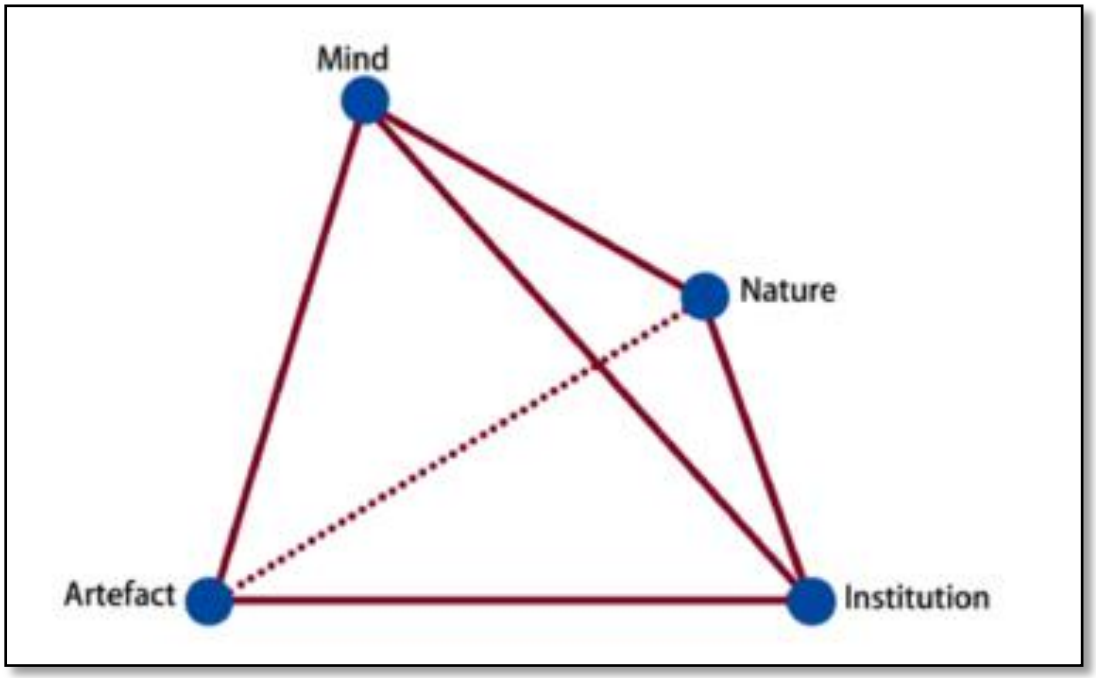


Figure (3.2): The MAINTRTRA

Source: (Kain, 2003)

Lomas K. J.; (2009) argued that lots of problems will be met in the process of Sustainable renovation on residential buildings; in this case, renovation must be an interdisciplinary work, which involves many people who work in different fields to deal with those problems. Inspired by the understandings of sustainable building and the theories mention before, we

come up with a 7-dimensional model of the sustainable renovation on residential buildings which generate a network for sustainable renovation. The model (Figure 3.3) has a pentagonal roof, with each corner representing an aspect of “environmental”, “technological”, “architectural” “social”, and “cultural (emotional)”, and all of them are under the heading of “mind” and closely related to “economic”. Under this roof is sustainable renovated building.

The dimensions of the 7-dimensional model of sustainable renovation are explained in the following paragraphs:

a) Mind: policy and awareness

Mind plays a leading role in the field of sustainable renovation on residential buildings. There are two kinds of minds in this field. For every people who involved in this field, mind shows itself as the sustainable awareness. And for the decision-makers such as government, policy is the form of their mind. In most cases, local and national governments are important players in the renovation process of the housing stock. Sometimes, other people involved like specialists, consultants and house owners also greatly affect this process. If sustainable renovation appears positively to people, they will do it consciously. Meanwhile, policy can help or even enforce people to have a mind to work on sustainability. Moreover, mind enables the other six dimensions complement each other instead of working separately.

b) Economic

It is unwise to pay too much, but it is worse to pay too little. When you pay too much, you lose a little money- that is all. When you pay too little, you sometimes lose everything; because the thing you bought is incapable of doing the thing it was bought to do John Ruskin (1860), as quoted in Sustainable Construction, (Lom Halliday S.; 2008). Expense of sustainable

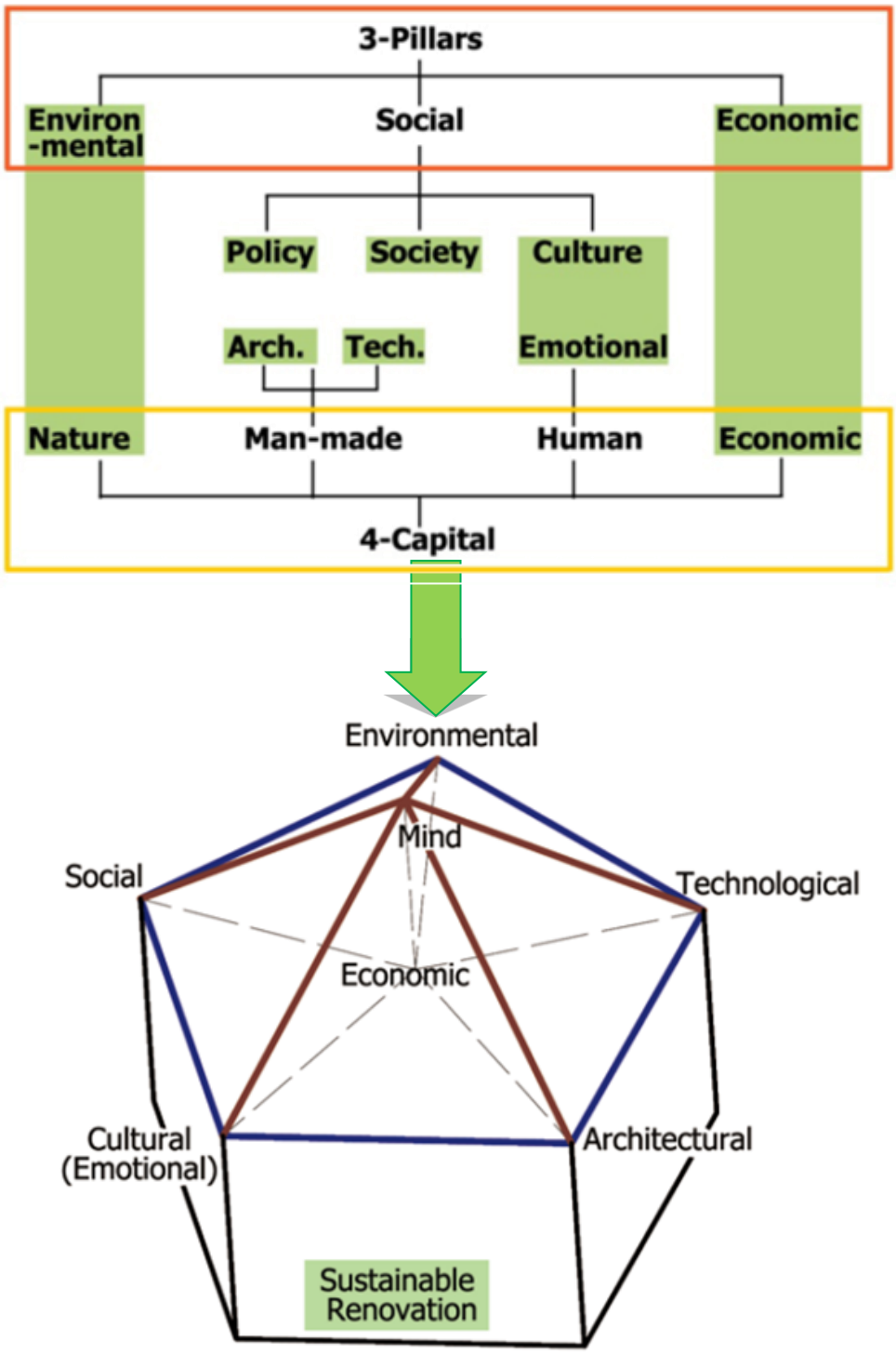


Figure (3.3): Development of 7-dimensional model of sustainable renovation

Source: (Lomas K. J.; 2009)

Renovation should be reasonable and must be affordable to people and not too expensive (Chwieduk D.; 2003). The meaning of "expense" should be based on the consideration from lifecycle perspective rather than only the construction period. As to the field of renovating residential buildings, economic goal can achieved through purchasing products with reasonable price, good house management, energy efficiency, low operational cost etc.

c) Environmental

Renovating existing building obviously saves energy, natural resources and building materials, and minimizes construction waste as well. To run the renovation in a sustainable way, environmental aspects need to be more carefully considered. To realize environmental goal, sustainable renovation should rely on wisely use of resources such as the land use, use of renewable construction materials, the extraction of materials, the manufacturing of products, the assembly of products into buildings, the maintenance and replacement of systems, and the ultimate disposition of waste, building systems, noise, air quality, etc.

d) Technological

Sustainable renovation on residential building often adopts some technical strategies such as HVAC technologies, energy saving technologies, etc. to achieve its goals of efficient use of resource. Choose a proper and affordable technical strategy usually can lower operational energy consuming, which is an important issue.

e) Architectural

The basic function of residential building is to provide a place for people to live in. Sustainable renovation on residential building is a strategy to enhance this function through a comfort and aesthetic form and environment, both inside and outside building. During the design process, architects should concentrate on Layout flexibility; Space utilization; Grouping of function; Design for deconstruction; Architectural aesthetic.

This is not only based on architects' idea, but also an understanding of the occupants` behavior and emotional needs. Any attempts to improve the environmental performance of housing stock could not be separated from improvements to its occupants' living conditions.

f) Cultural & Emotional

Sustainable renovation is concerned with much more than can be measured a large part of it is the cultural/history question and people's emotional issue such as neighborhood relationship, memory of residents, and aesthetic. In the field of common residential buildings, it is more about an emotional conserving issue. Usually, it represents the memory of people and influences people's feeling of happiness and satisfying. So these needs for happiness, security, belonging, etc. should be taken into account. Sustainable renovation not only refers to the physical entities, but also to cultivating a good humanistic environment. When people walk out from home, they have to blend into the social network. A good community environment and harmonious neighborhoods will have positive influence on people's mood. What is worth to mention is if a residence is a historical building, its culture identities should be considered during renovation.

g) Social

Social sustainability is a core topic of designing built environments that are not overly complex but serve as a social facilitator and symbol that affect security or social segregation (Canter D.; 2008). Residence renovation allows people continue using buildings and upgrade living condition. It is a kind of embodiment of facilitating the social safety and equity that contemporary people and future generations can have a safe and comfortable home which can promote social stability. Sustainable renovation on residence is a need for investments to stabilize social systems (Sassen S.; 2001) or for freedom of choice that enables people to realize their capabilities (Sen A.; 2001). Good example and data collection and

popularization are what some social organization should do, which is a part of foundation for renovation development.

All the seven dimensions are closely related, complementing each other and influence renovation efficiency. Sustainability dimensions are inseparably connected, i.e. usage of innovative technologies in building renovation can satisfy ecological and economic needs, or cultural and architectural dimensions encourage social needs satisfaction. All in all, it is about ensuring a better quality of life for everyone, now and for future generations.

3.8 Sustainable baton as a relay race

Since the early 1990s, a substantial part of policy analysis for a sustainable built environment has been dedicated to exploring the effects of life-cycle thinking (Chau K. C.; 2000). Rather than treating each stage in the life cycle of a building or construction in isolation, sustainable renovation emphasized the interconnections between the individual stages.

Lom Halliday S. ;(2008) presented an interesting idea, which is a "sustainable baton" (Figure 3.4); he stated that the whole building renovation process is a kind of relay race which covers many stages, including briefing, information collection, design, construction and usage. In the briefing stage, someone decides to start a renovation process. Important/interesting here is why a renovation process started. The information collection stage is to analyze the building's characteristics and cogitate how much of the existing facility can be reused and how those elements influence the design approach. The design stage is complex, including discussion, decision making and solution selection. In this stage, many people in different fields are involved, and the 7-dimensions should be fully considered. The following stage is construction during which on-site and off-site management are very important. In the last stage of usage, occupiers should be well informed of how to use their renovated home

properly. Sustainability is just like a "baton" delivered during each stage. The interconnection between stages is as important as the stage itself to keep sustainability throughout whole renovation process. Thus it is necessary to fully consider all stages that involve in renovation process, and safely deliver the sustainable baton at every stage.

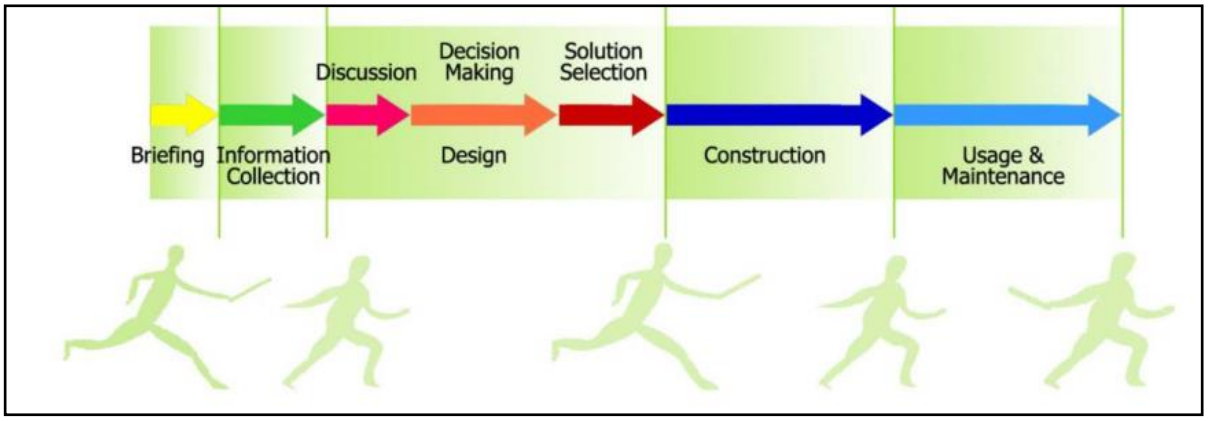


Figure (3.4): Sustainable baton transferred in the whole Process of renovation

Source: (Lom Halliday S.; 2008)

3.9 Participants in sustainable renovation process

The application of the measures directed towards achieving sustainable renovation, requires close cooperation among various professionals, policy-makers and other stakeholders (Bakens W.; 2003). Figure (3.5) shows some key players involved in the process:

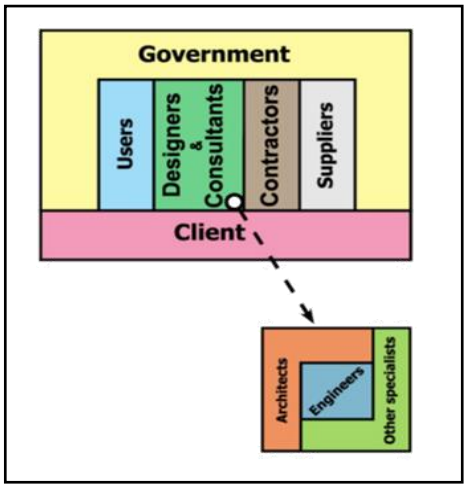


Figure (3.5) Participants in sustainable renovation process

Source: (Bakens W.; 2003)

The participants in Sustainable Renovation process are explained in the following paragraphs:

a) Government

Is an important player for sustainable renovation because they are the rule-makers and can create the institutional environment for sustainable renovation, the positive policies issued by government can incent sustainable develop or vice versa.

b) Client

Is the one who starts and plans a renovation process, pays for it, make the final decision and chooses the designers, consultants, contractors and suppliers, their attitude and ideas will determine the direction of whole project.

c) Designers and consultants

Are not only refers to architects, but also engineers and other specialists. Other specialists include such as building archaeologists or restorers for historical investigations, social experts and even professional photographers. They should form a trans-disciplinary team, and have close cooperation with each other.

d) Contractors

Have responsibility to create good site environment, reduce impact to surrounding environment and increase the productivity of site work through advanced managerial method. Suppliers, as the partner of contractors, should well cooperate with contractor, such as transport material to site in time and keep quality of material in a high level. What is more, suppliers have to remember that they also have responsibility to lower the emission and impact during the transportation.

Before a renovation process, users should be well communicated so that they can understand the benefit of renovation. Cooperation relationship should setup during the design process between designers and occupiers, in

order to have a better understanding of the existing building. (Pearce D.; 2006) stated that residents' opinion sometimes is better than scientific research. After renovation, occupiers should be given enough information to use new installed equipment in a right way to realize sustainability. To make progress for sustainable renovation at all levels, it is vital to cover all the 7 dimensions, think of entire process, and consider all the stakeholders and players involved in this process (Figure 3.6).

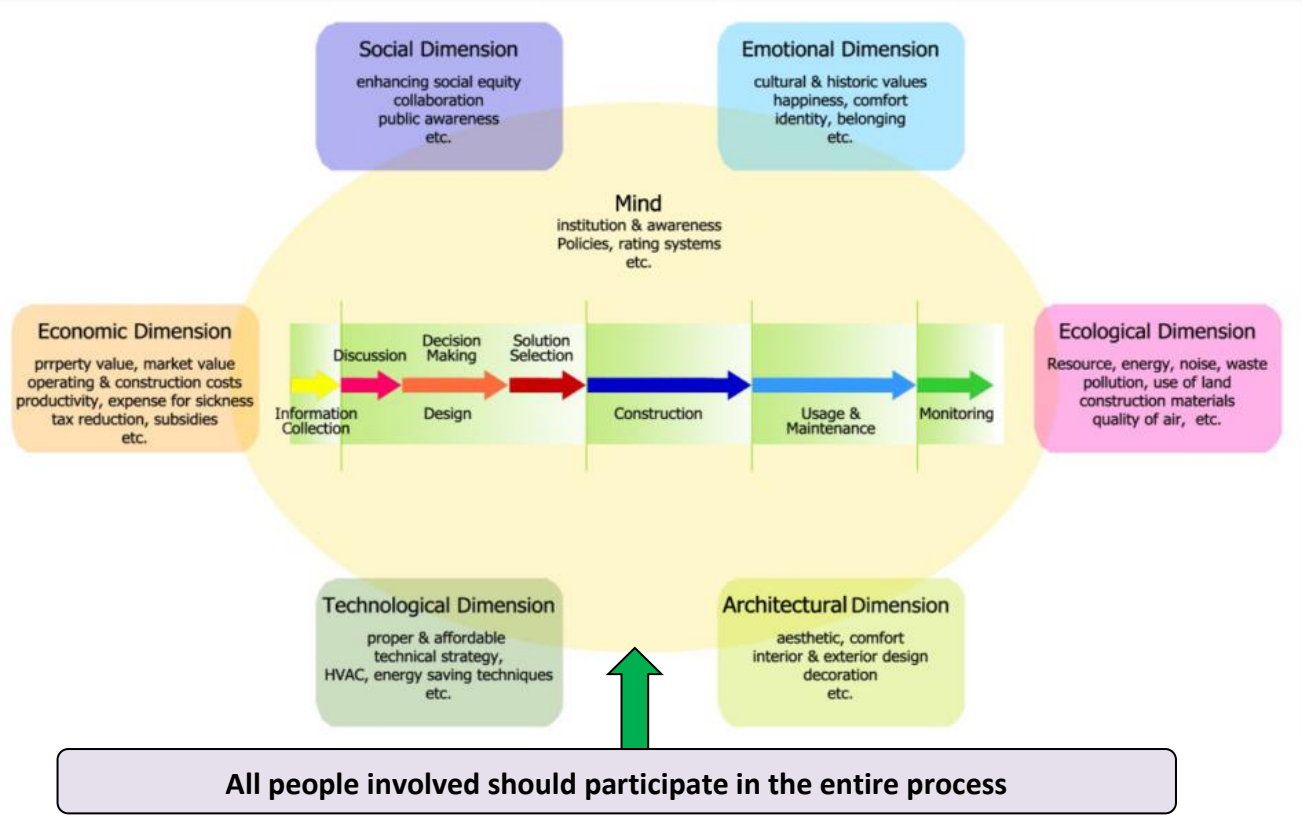


Figure (3.6) Systematic thinking of sustainable renovation

Source: (author)

3.10 Driving force & Barriers

i. Benefit

Sustainable renovation on residential building is initially motivated by the needs of minimizing the resource input as well as waste and maximizing the comfort of life. McAllister and Fuerst (2008) suggest that developers, occupiers, and owners may obtain a verity of benefits that are associated

with sustainable building renovation. According to McAllister, other benefits are also important driving force for sustainable renovation.

Through minimizing the energy consumption and resource input, lower operating, maintenance and construction costs can be gained. Increasing living comfort can add value to the property. Space is more valuable, providing potential for higher rental growth or improving marketability. It reduces healthy risk caused by dust, noise, smell, resonance, smoke, excessive heat or cold, radiation or moisture, avoiding extra expense for sickness such as compensation costs. Since many people choose to work at home, a comfortable living environment, giving people a good mood can increase people's productivity, which results in the economic benefits. Preservation of cultural and historical elements has educational and social effects, rising public awareness. Social equity, which increasing the comfort of life, also contributes to the social stabilization.

ii. Barriers

The main barriers for sustainable renovation on residential buildings relate to policy, information, culture, technique.

Renovation incentive policies have generated one after another, but some of them have poor communication with economic advantages will negative influence the institutions carry out (Lutzkendorf and Lorenz, 2007). Owners sometimes have a narrow sense to understand benefit; most of them have a short-term perspective and prefer immediate low cost. Since they consider more about cost, residents' feeling and emotion usually always is neglected, which will enhance investors to despise renovation. And they have very limited budgets for technical research. The R&D expenditure in construction sector in Europe is lower, just 0.3% (average is 2.0%) (Bremer and Kok, 2000, pp. 103), and when new technology emerges, companies are slow to adopt as this will lead to unforeseen risk, which cause building systems hard to be upgraded. Good sustainable

residence renovation information and examples are hardly available is another barrier, and without references, companies will hesitate to invest to sustainable renovation.

3.11 SIX PRIORITIES FOR THE RENOVATION OF HOUSING

(Advanced and Sustainable Housing Renovation: A guide for Designers and Planners; 2010)

The objective of the sustainable renovation process is to extend the life of an existing building, to give it a second life while limiting its impact on the environment. For this reason, the following priorities should be taken into account at each stage: design, construction and use of the building:

a) Increasing the comfort of life:
   - to increase the quality of outdoor areas
   - to increase the quality of indoor air
   - to increase the acoustical comfort

b) Limiting energy consumption:
   - to increase the thermal comfort
   - to reduce fossil energy consumption

c) Limiting drinking water consumption;

d) Increasing the water resources;

e) Limiting the production of waste;

f) Limiting consumption territory and resources

3.12 Analysis Criteria

Sustainable renovation is such a complex concept including many aspects that there is no analysis that can capture them all and there is no one case that can reveal and take care of all sustainable issues. In this part, based on two highlights in the aim of thesis which are decrease environmental impact and increase the comfort of life, the author select five aspects from 7-dimensional model and develop parameters of these

selected dimensions, in order to formulate a checklist for discussing the case (Table 3.2). In the case study, the rest two dimensions, mind (mainly refers to policy) and economic (mainly refers to cost) are not highlighted, but still mentioned.

Table (3.2) a yardstick for Case Study
Source: (author)

		Minimize Environment Impact	**Maximize Comfort of Life**
TANGIBLE	**Environment**	▪ Water consumption and reuse ▪ Energy consumption ▪ Reduce waste production and pollution ▪ Low impact materials	▪ Increase air quality ▪ Outdoor space (biodiversity etc.)
	Technological	▪ Technical systems (Heating, Ventilation, Air-conditioning etc.) ▪ Renewable technologies (biomass, PV, Solar thermal, wind, Geothermal) ▪ Maintenance to keep building system in good condition	▪ Technical systems (Heating, Ventilation, Air-conditioning etc.) ▪ Maintenance to keep building system in good condition
	Architectural	▪ Better construction way ▪ Space, function (flexible layout etc.) ▪ Building envelope	▪ Better construction way ▪ Space, function (flexible layout etc.) ▪ Design for Deconstruction ▪ Architectural aesthetic

NON-TANGIBLE	**Cultural& Emotional**	▪ Reuse of old building	▪ Neighborhood relationship ▪ Historic value ▪ Keep resident's memory maximum ▪ Care about residents' feeling and demand for renovation
NON-TANGIBLE	**Social**	▪ Users' behavior ▪ Planning process ▪ No relocation of tenants	▪ Social equity (provision for disabled facilities) ▪ Outdoor space (public space for social interaction) ▪ Information data collection & popularization

In this yardstick, issues of environmental, technological and architectural aspects can be visualized and felt directly. The author defined them as tangible issues. Issues of cultural/emotional and social aspects cannot be visualized or evaluated by a clear standard. The author defined them as non-tangible issues. Architectural aesthetic, which is an architectural issue, belongs to both tangible and non-tangible field.

The following paragraphs explain the checklist points:

a) Environmental aspect

Main issues about decreasing environmental impact are reducing natural resource such as energy, water and land; reducing waste and pollution; and using low impact materials. To increase the comfort of life, the author will focus on the issues of increasing air quality and outdoor space, which means preserve the biodiversity of existing flora and fauna.

b) Technological aspect

The author will focus on analyzing the issues of technical system such as HVAC, lighting and acoustic system; efficient appliance like tap, valve,

shower and electrical installation; and renewable technologies. Technical systems also contribute to the comfort of life.

c) Architectural aspect

Better construction way and reasonable layout contribute to satisfying both needs of decreasing environmental impact and increasing comfort of life. For example, using prefabricate models during construction can decrease the noise and waste which negatively affects the environment and the life of residence surrounded. Flexible layout enables occupiers to use a space for different purpose which facilitates their life. It also extends the building's lifespan which can reduce waste by avoiding demolition. The shape, form and envelope of buildings help to reduce the impact on nature by careful considering of insulation, air tightness, thermal inertia, solar protection, window conception, etc. Good looking at interior and exterior helps to provide a comfort living environment.

d) Cultural (emotional) aspect & Social aspect

These two aspects are mainly about increasing comfort of life. We will focus on social equity by provision of disabled facilities, outdoor space which is good for social interaction, preserving historical values and keeping residents' memory maximum.

This yardstick shows possible issues related to these two needs of minimizing the environmental impact and maximizing the living comfort. Environmental, technological and architectural aspects are tangible aspects that can be directly seen and felt by people, while the cultural (emotional) and social aspects are non-tangible aspects that bring potential or future benefits that people cannot realize right now and feel them directly. The aesthetic issues in architectural aspect are non-tangible as well.

3.13 Conclusion

In this chapter the concept of Renovation has been discussed; starting with kinds of lifespan of building: linear and cyclic lifespan, then

definitions of renovation were introduced, types of renovation, the concept of sustainable renovation systematic thinking of sustainable renovation on residential buildings, the MAINTRTRA model, which is for localized infrastructure planning and sustainable urban development. The model has four kinds of capitals (mind - artifact – institution – nature) make up a network, the 7-dimensional model of sustainable renovation on residential buildings which generate a network for sustainable renovation. The model has a pentagonal roof, with each corner representing an aspect of (environmental, technological, architectural, social, and cultural (emotional), and all of them are under the heading of "mind" and closely related to "economic". Under this roof is sustainable renovated building, the six priorities which should be taken into account at each stage: design, construction and use of the building, and finally based on two highlights in the aim of thesis, a checklist for case study has been created.

In the following chapter, the yardstick will be used as a tool to analyze the selected case study.

Chapter IV
Presentation and Analysis
Of the Case Study

Chapter (IV)

Presentation & Analysis of the Case Study

4.1 Introduction

This chapter will investigate and analyze the case study, which is a residential building at Algamayer area- Omdurman- Khartoum State.

The review of the case study will include a description of the area in which the residential building and its neighborhood are located. This is in addition to provide a thorough description of the building structures as well as the finishing materials used therein and more other points. Analysis will be based on a yardstick which has been presented in chapter three.

- All photos were taken by the researcher

4.2 Motivation of the Case Study Selection

The objective is to assess the Sustainability of residential building, based on five factors:

1. The time period of building execution and operation (specific historical building)
2. Multi-family residential building which are found in a great number in Omdurman
3. Energy efficiency and resources effectiveness, which include the reduction of consumption of non-renewable resources and enhance the natural environment matching thesis's aim and the yardstick.
4. The use of recyclable materials as well as the use of Sustainable (local) traditional materials.
5. Building Renovations among years

The review of the case study comprises the following points:

- Site of the building.
- The date (year) of construction.

- The date (year) of operation.
- The size of the site.
- Description: general, architectural, and structural.
- Renovations over the years and extent of its sustainability.
- Demographic study of the building's residents: number and ages of residents.

The review of the case study will include maps, pictures, tables and sketches.

4.3 Proposed Areas

Historically Omdurman is one of the oldest areas in Khartoum state, so the researcher proposed some neighborhoods as case studies. They are:

- Wad Nubawi
- Bait Almal
- Algamayer
- Abu rouf

4.4 Case Study Selection Analysis

Case Study selection analysis is based on four factors, table (4.1) shows a comparison between proposed areas based on these four factors which are:

1. Re-planning
   - Whether the neighborhood has re-planning structure plan or not?
2. Local materials
   - Whether local materials are used in neighborhood houses construction or not?
3. Houses renovations
   - Whether neighborhood houses are renovated or not?
4. Recyclable materials
   - Whether recyclable materials are used in neighborhood houses construction or not?

Table (4.1) Proposed Areas comparison
Source (the researcher)

	re-planning		Local Materials		houses Renovation		recyclable materials	
	Yes	No	used	not used	Yes	No	used	not used
Wad Nubawi	√			√		√		√
Bait Almal	√			√		√		√
Algamayer		√	√		√		√	
Abu rouf	about (30%) of it		√			√	√	

Table (4.1) shows that Algamayer is the best option among the proposed areas, so the researcher picked it to be the case study

4.5 Criteria of case study selection

The choice of case study was considered for several factors. Firstly, this case covered dominated residential building type which is multi-family residential buildings which are found in a great number in Omdurman. This case also involved the specific historical buildings. Secondly, This case has a focus both on decreasing the environmental impact and increasing the living comfort, matching thesis's aim and the yardstick.

4.6 Structure of the case study

There are 4 parts for case analysis. The first part contains the background, including basic information before renovation. In the second part, a description and structuring of the collected material, and analysis of what efforts were made to reach the renovation goals. The description and

structuring was organized with focus on thesis's two highlights to minimize environmental impact and maximize comfort of life, and the five aspects, environment, architecture, technology, social, and culture/emotion in the yardstick presented in Chapter 3. In the description, data has been divided into two parts: tangible aspects including environmental, architectural, and technical issues; and non-tangible aspects including cultural/emotional, and social issues. The forth part focuses on the analysis of the efforts and effects, comparing the situation before and after renovation. In the last part, success factors, barriers and difficulties in the case will be analyzed.

4.7 Background

Algamayer area is located west of Elneel Street and to the north of Aburof and Kagabab neighborhoods and east to the eastern area of the Faculty of Education- Khartoum University and Elsherfia.

The origin of the name of Algamayer area is referred to Algameer, the area in which white lime was manufactured, which is used in house painting, where; at that time, the manufacturing of lime was performed on the shore of the Nile in the form of kilns to burn the lime, so the same has been known as bricks and lime kilns at Algamayer.

Algamayer area had been known for a long time, since its establishment before the Mahdia era. The inhabitants of the area fought the battle of Karari. Algamayer area has been the center and workshops of building materials, for instance, sand and concrete, which have been taken by donkeys to Khartoum in order to build the ministries.

The population of the area is about (10,000) persons and the area were included in the Omdurman map in 1954.

- The services have been introduced recently to the area, where, water supply has been provided in 1993.

- Electricity supply has been introduced in 1982, and land acquisition settlement has been performed in 1967, which has led to the physical re-planning of (7391) plots of land and was finished in the year 1975.
- The area has obtained seven kindergartens and five mosques, the Hamd Elneel mosque, in the first quarter, Elshiekh Eltayb mosque in the second quarter and Bakar mosque in Eldibaga quarter, in addition to tow religious nooks, one of which belongs to sheikh Ala Allah. For the people of the area are well known as religious. The area also has five bakeries.

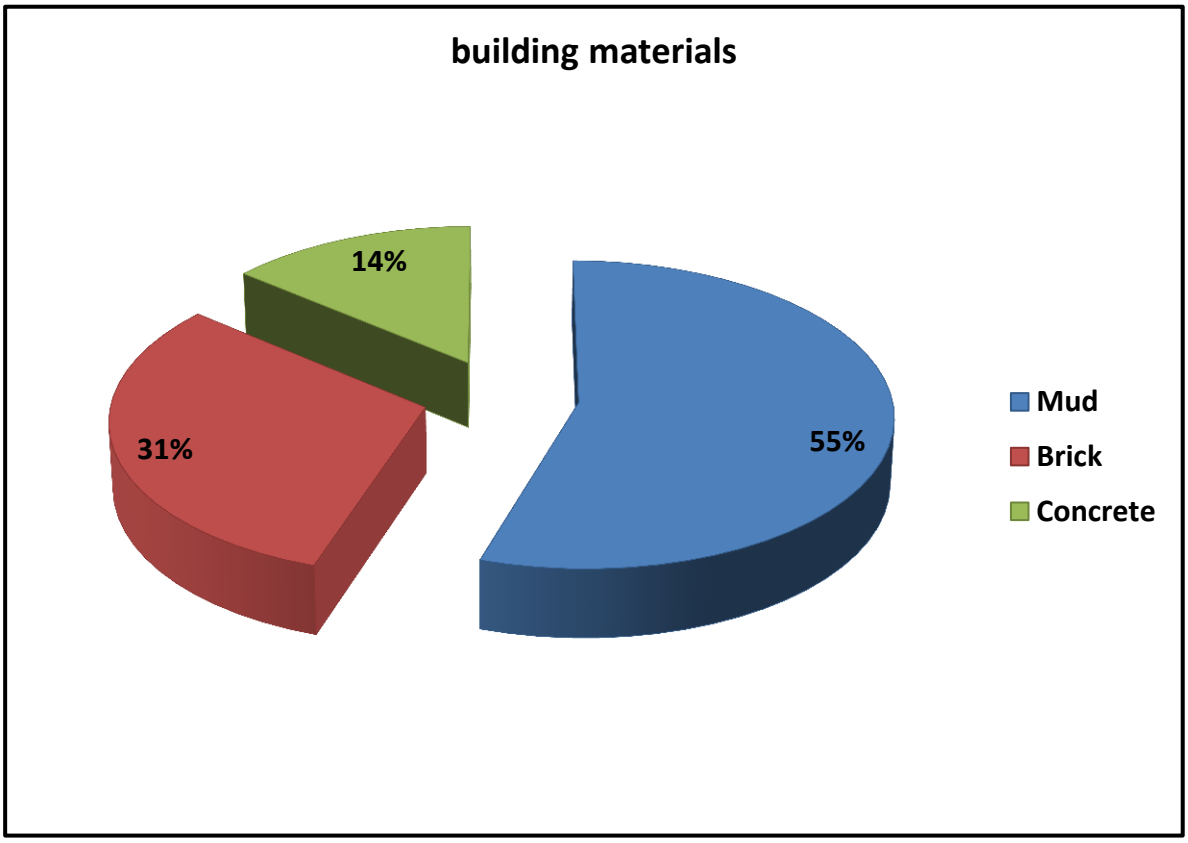


Chart (4.1) No. of floors

Source (unpublished report, Ministry of planning & urban development; 2016)

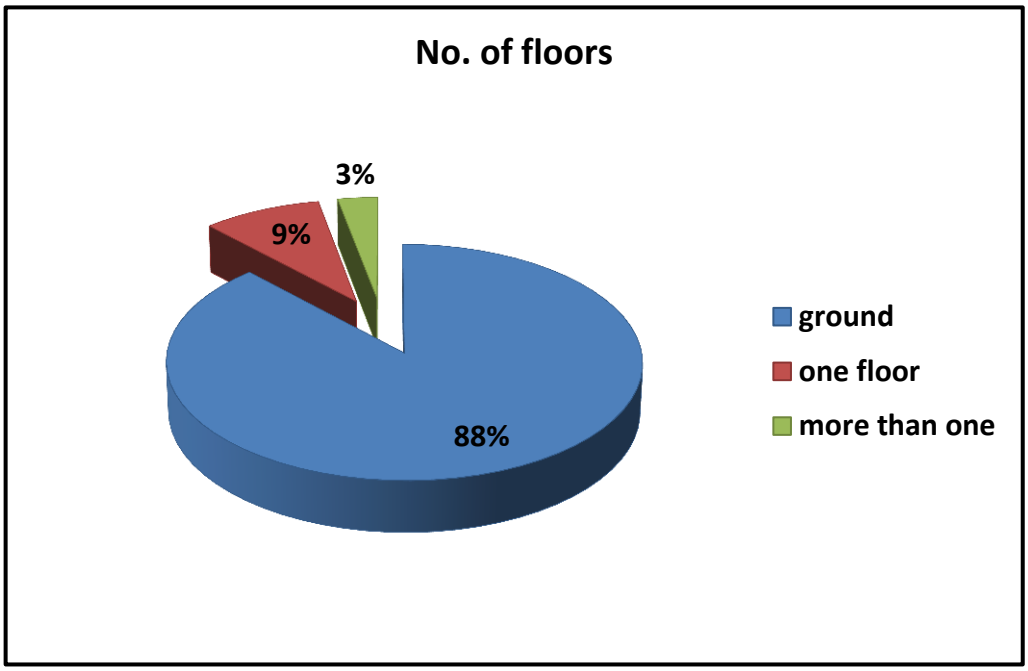


Chart (4.2) Building materials

Source (unpublished report, Ministry of planning & urban development; 2016)

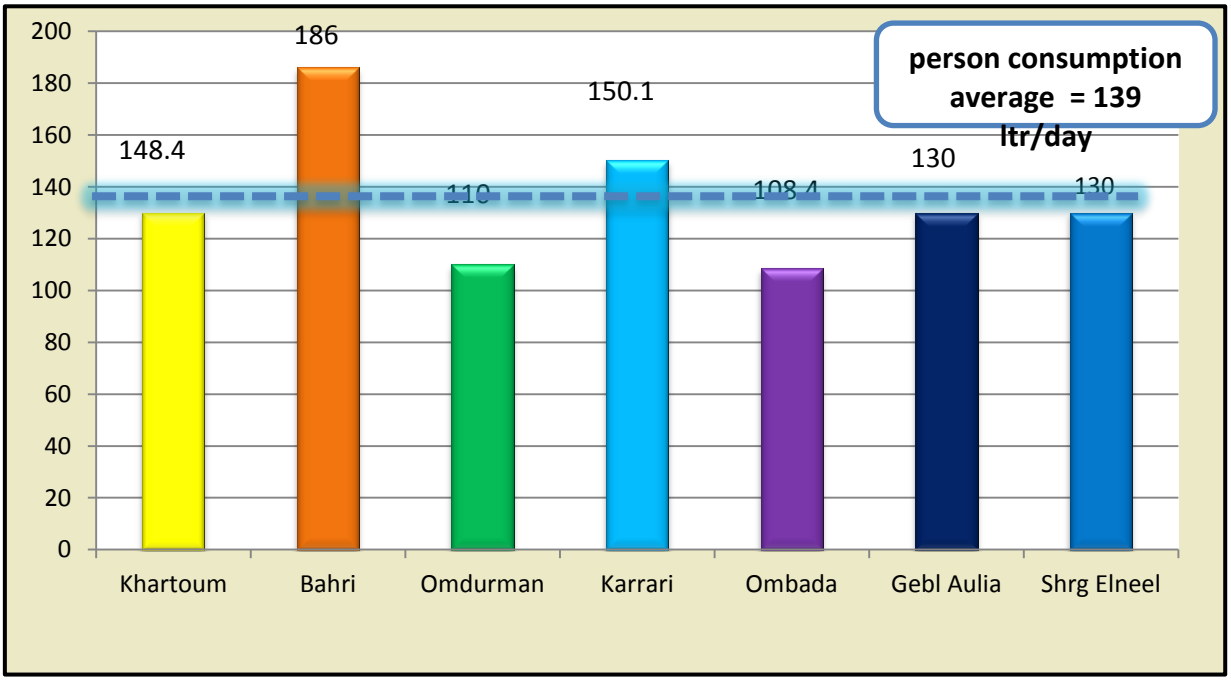


Chart (4.3) Water Consumption

Source (unpublished report, Ministry of planning & urban development; 2016)

4.8 Criteria of Case Site Selection

- Renovations history
- Users
- Date of operation
- Materials (Local, Environmentally friendly,…etc)

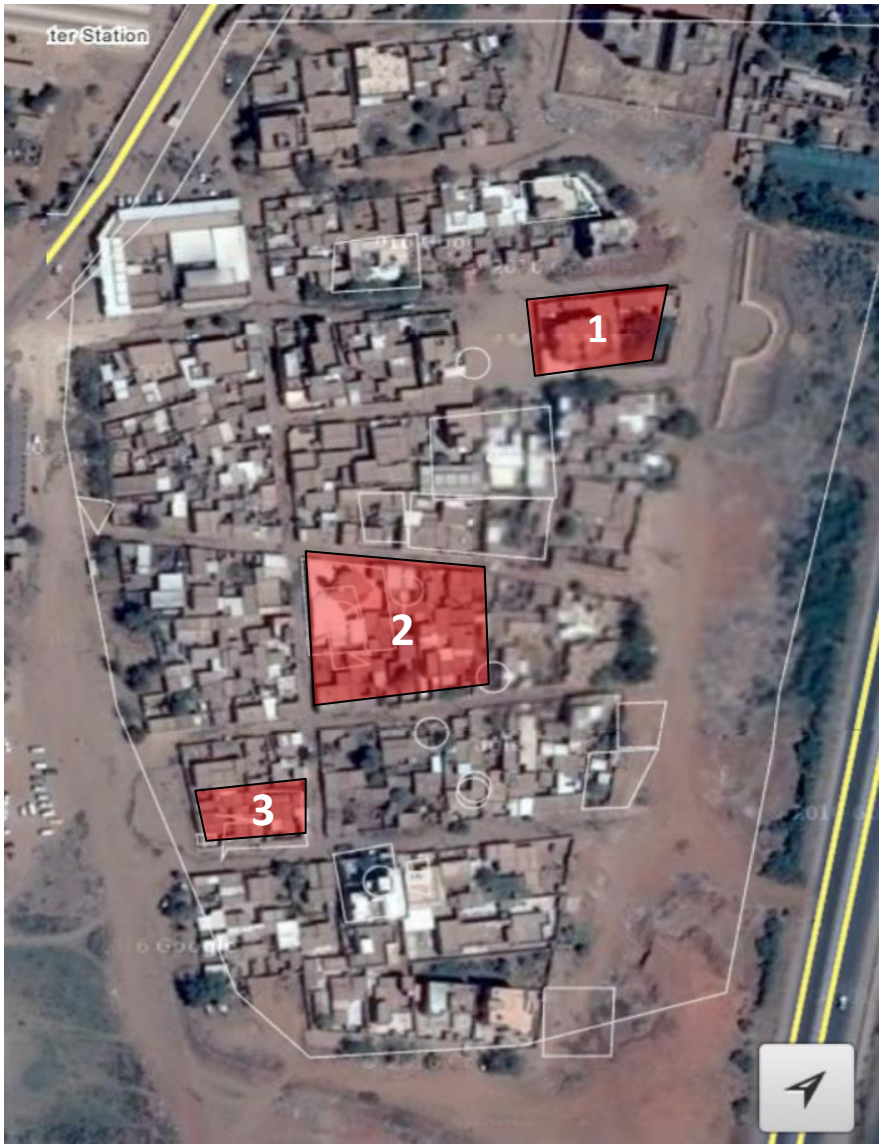


Figure (4.1) Proposed Case Study Sites
Source: (Google maps; 2016, Author)

4.9 Proposed Case Sites Analysis

Case Sites analysis is based on four factors, table (4.2) shows a comparison between proposed sites based on these four factors which are:

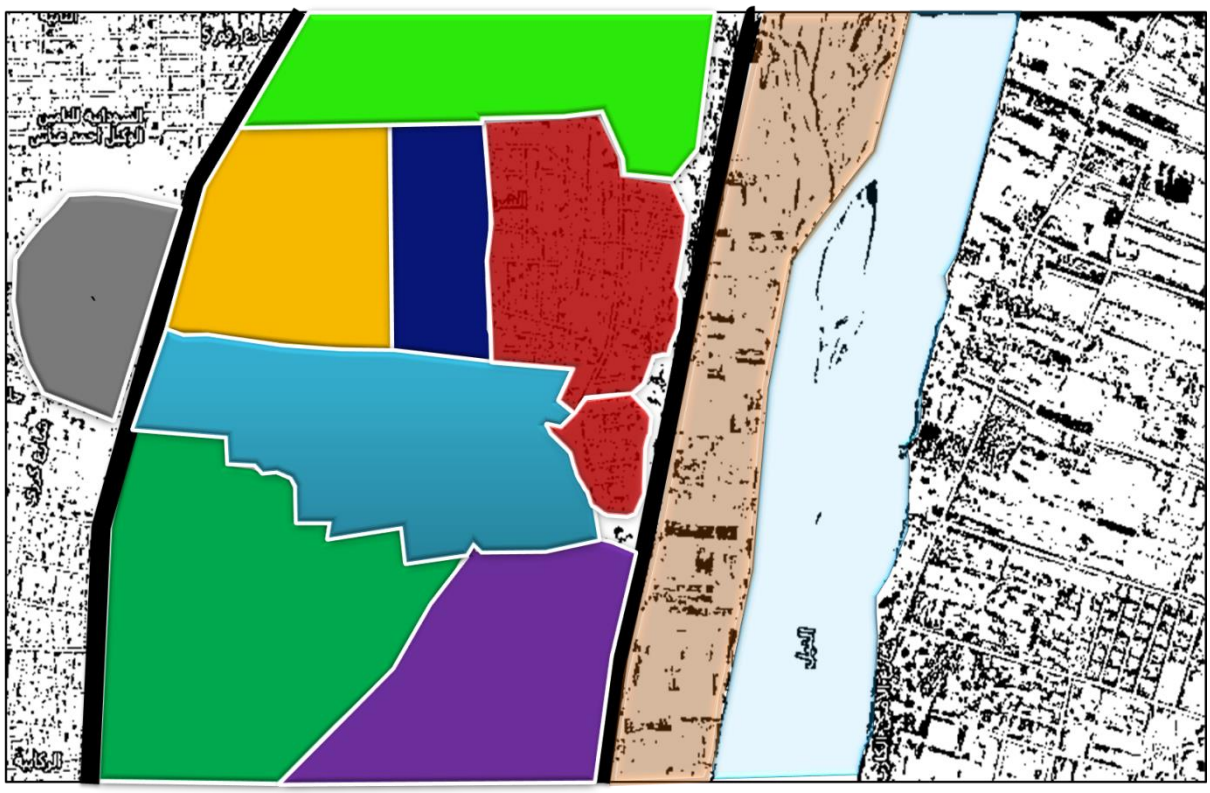
1. Renovation or Demolition
2. Local materials
3. Date of operation
4. recyclable materials

Table (4.2) Proposed Case Sites comparison
Source (the researcher)

	Renovation (R) or Demolition (D)		Local Materials		Date of operation	recyclable materials	
	(R)	(D)	used	not used	-	used	not used
1	√			√	1939		√
2	√		√		1925		√
3		√	√		1958	√	

- Site no. (2) was selected because it is the most one matched with the criteria of selection
- Case site is located at Aldabageen quarter, where, it deemed to be the oldest quarter in Algamayer area, since its establishment in 1901.
- Aldabageen quarter was established when the workers of the tanneries moved to dwell inside the tanneries. To maintain the health of the workers they have been required either to transfer their dwellings to another place or remove the tanneries, the option was to remove and transfer the tanneries, so the quarter has maintained the name of Eldibaga quarter.

Owner: Gubara Saeed.
Date of construction: 1923, (according to the testimony of the current residents).
Date of operation: 1925.



Legend

- AlGamayer
- Wad Nubawi
- University of Khartoum
- Elkabajab
- Abu Rouf
- Elsherfia
- Ahmed sherfy Cemetery
- Althawrat

Figure (4.2) Algamayer & its Neighborhood
Source: (Google maps; 2016, Author)

Figure (4.3) A Google image of Eldibaga quarter, Algamayer
Source (Google maps; 2016, Author)

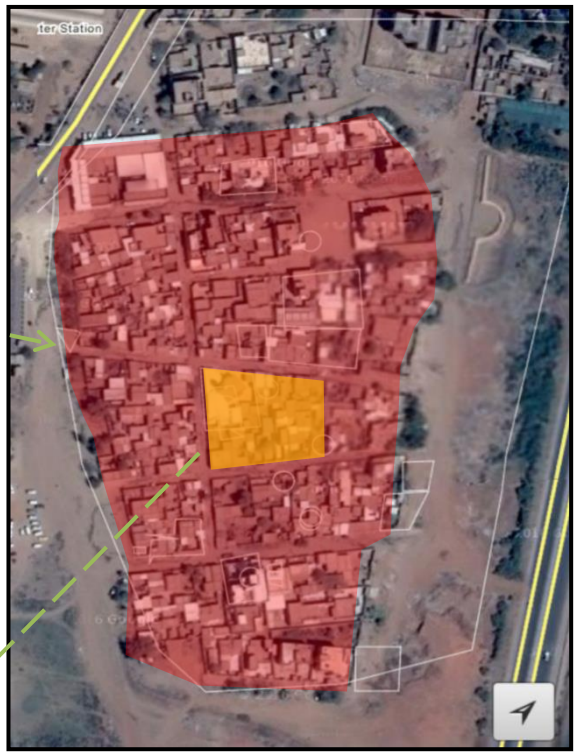


Figure (4.4) A Google image of Eldibaga quarter
Source (Google maps; 2016, Author)

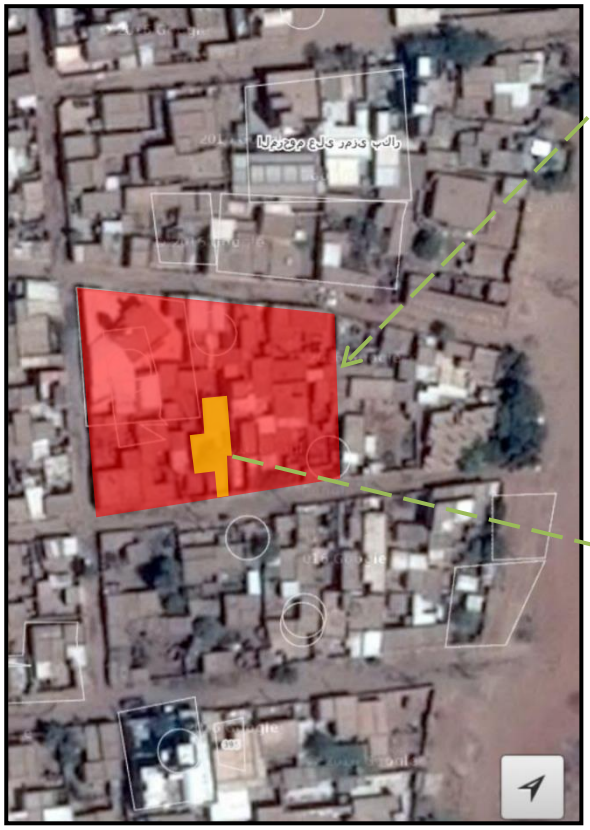


Figure (4.5) A Google image of Gubara Saeed's House (Case Study Site)
Source (Google maps; 2016, Author)

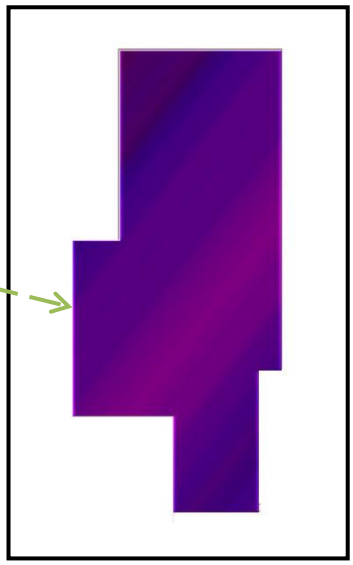


Figure (4.6) Sample's Site Plan
Source (Author)

4.10 Neighborhood Features

- Almost all buildings are made of mud, and there is some new buildings made of steel & concrete
- Most buildings use the natural ventilation and there is few air conditions in some buildings
- Eldibaga quarter is a typical traditional Sudanese quarter , which contains just about eight large families and most of them are cousins which create a strong social relationships between residents
- There is one place for garbage collection next to Eldibaga Fort
- The most obvious feature of residents life style that they sleep early about (9:00) pm after Elishaa prayer, which lead to energy consumption
- Sewage system is divided into two types: traditional Toilets with a separate well for each and what traditionally called “Masas” which is like septic tank in many ways
- There residents use grey water which comes from water taps on the front yard to reduce heat during day

Figure (4.7) House Sample

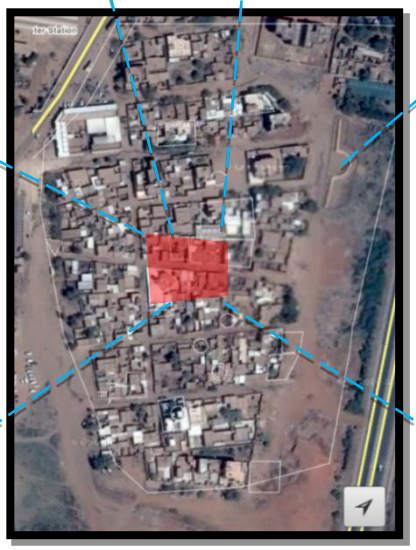
Western Neighborhood

Western Neighborhood

Eldibaga Fort

N

Bakar's Mosque



Case Study house, Eldibaga quarter

Eastern Neighborhood

Eastern Neighborhood

Figure (4.8) Neighborhood Features

Figure (4.9) Garbage Collection Area

Figure (4.10) Water front

4.11 General description:

- The total area of the building is about (1450 square meter).
- Residents: five families (the building is a bequest used as a residence for five brothers and sisters).
- Area of sample's house: 148 m^2.
- The building consists of two rooms, the area of which is (3X3), (3x4) respectively, and a hall and a kitchen and water cycle. This is in addition to the front area.

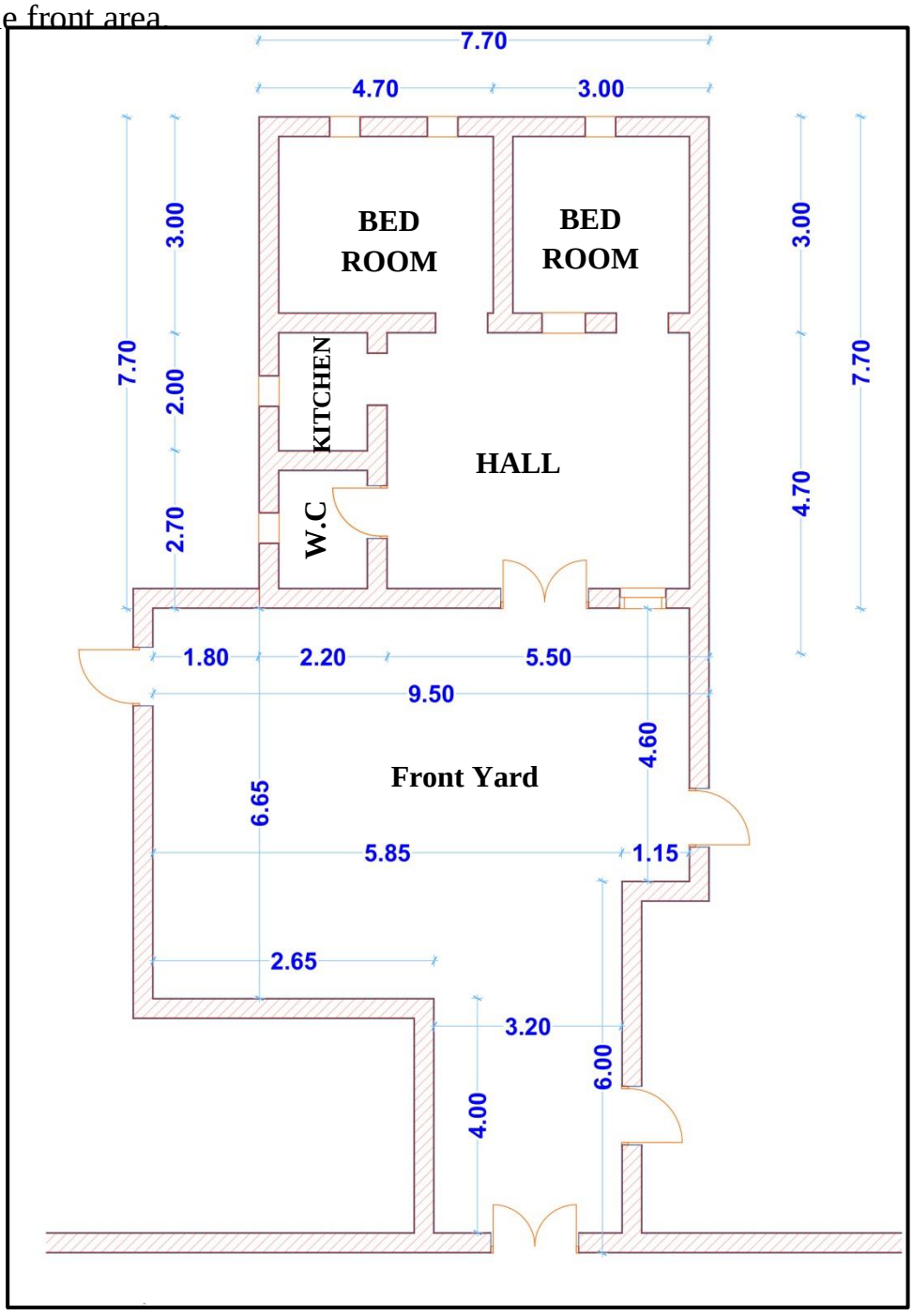


Figure (4.11) Sample's ground floor plan

Source (Author)

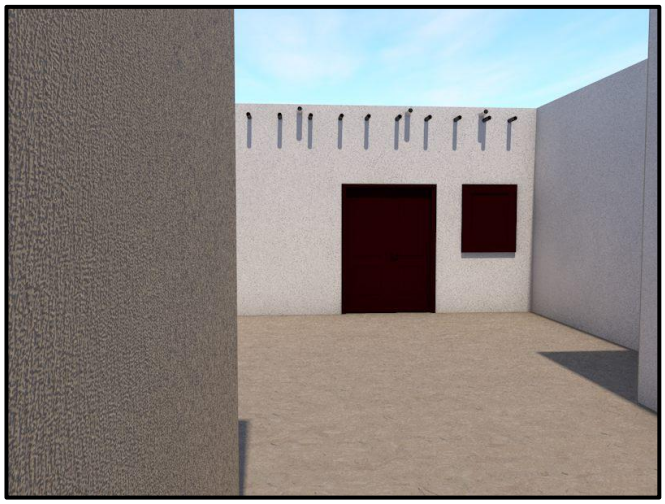


Figure (4.12) External perspectives

Shows Sample house components and the relation between the blocks

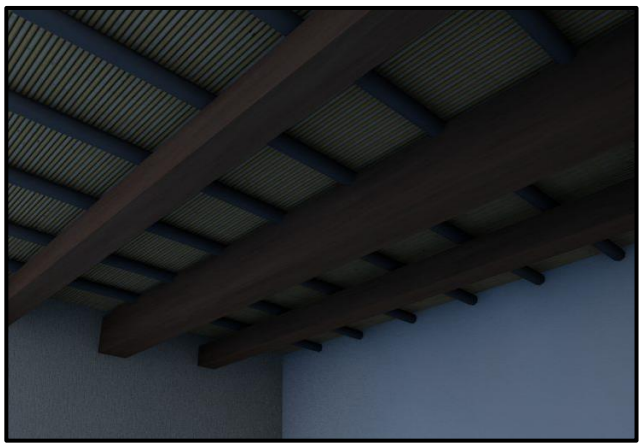


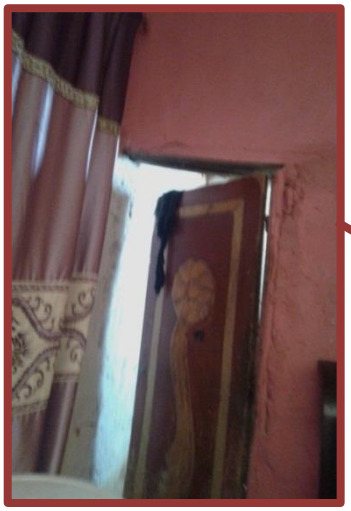
Figure (4.13) Internal perspectives

Shows Sample openings and roof

Southern bed room

Northern bed room

N



Toilet

Hall

Entrance corridor

Front Yard

(South)

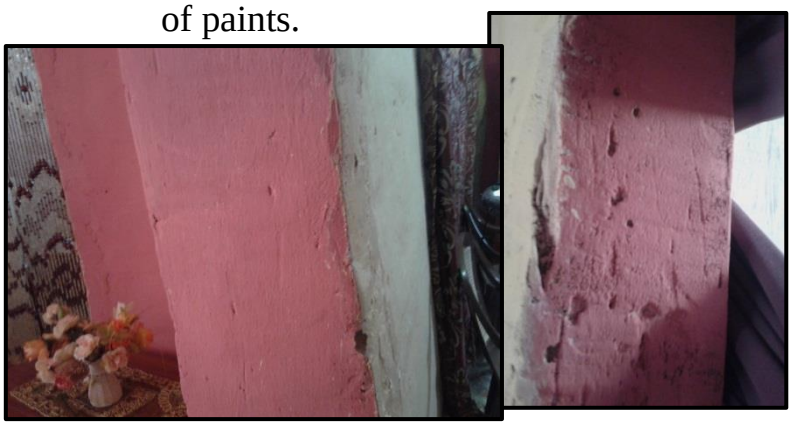
Ground floor plan

Front door (eastern elevation)

Figure (4.14) sample's house views

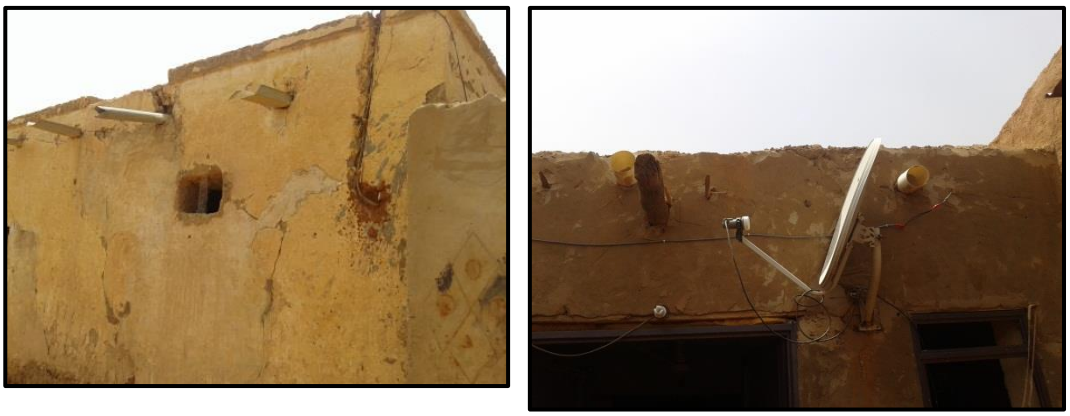
4.12 Construction description

- **Foundations:** Strip foundations: in the form of three building blocks with depth amounts to (0.60) m.
- **Walls:** Mud walls, in the form of mud courses with (0.30)m as the width, covered with a layer of wire and screw, in addition to a layer of cement plaster, with white lime as finishing, covered with a layer of paints.



Walls' width is about (60 cm)

Internal walls finishing using plaster and painting



External walls finishing using plaster and a layer of white lime wash

Figure (4.15) Sample house's Walls

- **Ceiling:** Traditional ceiling, which consists of main log of timber with iron pipes and wooden sticks, which are known as (rusasat) covered by a layer of tiny grass sticks known as mat, which in turn covered by another layer of twisted palm leaves, which is well known as (Elbirish). This is in addition to a thin bed of mud known as (Elnyal) and finally there is a layer of garbage material (similar to that of the modern cement mixture, but instead of crushed bricks, the main component of the garbage material is animals' dung).

Timber

(The main roof supporter)

Decorative roof of the bed room

Decorative roofs fixing using stews and steel plate

Rusasat

Wooden branches which hold the mat

Steel pipes are put over the timber

Figure (4.16) Sample house's Roofs

- **Floor:** Bedrooms are finished with concrete tile, the dimensions of which are (0.15x0.15) m and cement tile with crushed ceramic tile, hall is covered with mold mixed with gravel, and front yard's floor is finished with sand

Cement tiles with crushed ceramic (Bedroom)

(0.15x0.15) m Cement tiles (Bedroom)

Hall's floor which is finished with Mud mixed with gravel

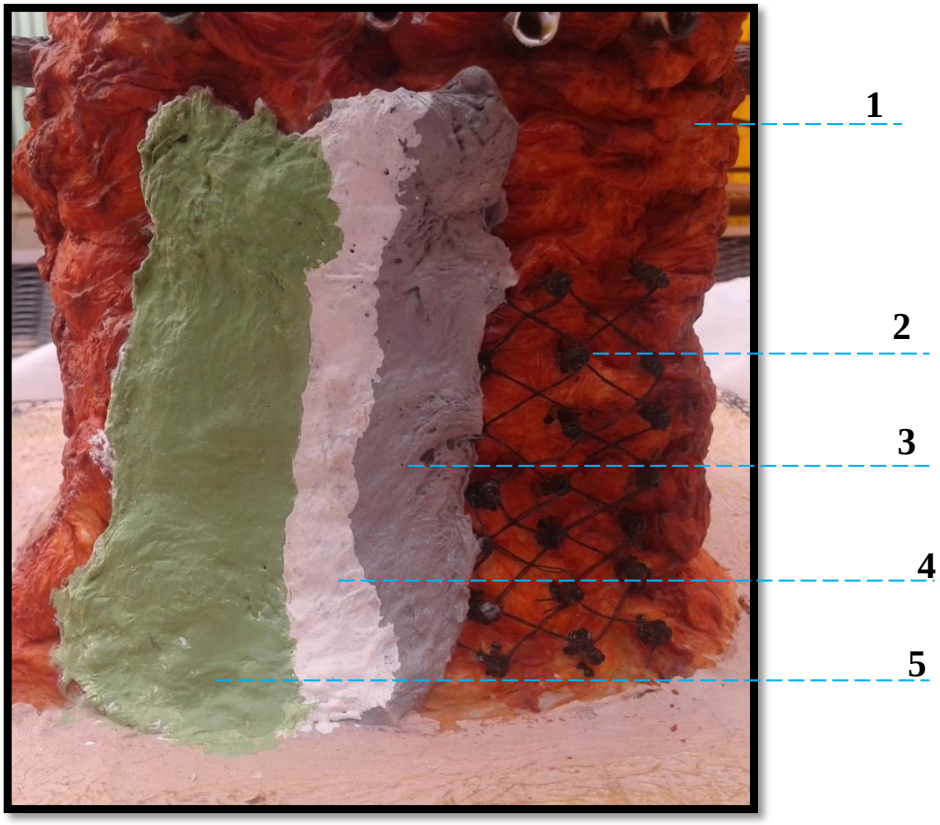
Front yard floor which finished with loose Sand

Figure (4.17) Floor's finishing

4.13 Renovation History of the Building

4.13.1 Walls

- Upon the construction of the building in the early 1920s of the last century, the walls were made only of mud courses with (0.30 m) as the width.
- In the early 1950s, the layer of the wire and screw as well as the plaster layer were constructed.
- In the mid-1960s, the layer of the white lime was added



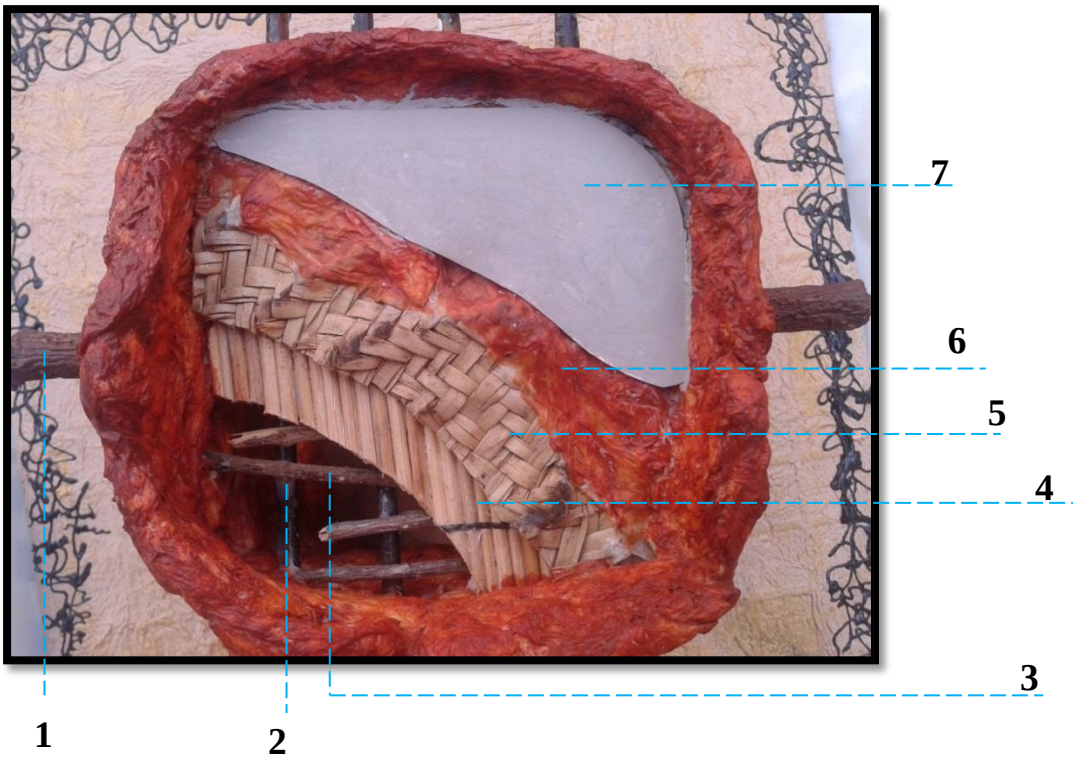
1	**mud courses**	**4**	**white lime**
2	**wire & screw**	**5**	**paint**
3	**plaster**		

Figure (4.18) wall layers of Sample house

Source (Author)

4.13.2 Ceiling

- In the early 1920s of the last century, when the roof was first constructed, it has been consisting of main log of timber and wooden rod and mat covered with a layer of twisted palm leaves.
- In the early 1960s, the tree branches were replaced with iron pipes.
- In the early 1970s, a layer of mud known as Alnyal was constructed over the layer of twisted palm leaves.
- In the mid-1970s, the layer of organic garbage traditionally called "Zibala" was added, which took the present form of the building and the same is renewed every (5-7) years.



1	**Timber**	**5**	**mat (Albirish)**
2	**steel pipes**	**6**	**Alnyal (mud)**
3	**wooden rod**	**7**	**Animal Dung (Zibala)**
4	**palm leaves**		

Figure (4.19) Roof layers of Sample house
Source (Author)

4.13.3 Floor Finish

- Upon the construction of the building, all spaces had a muddy ground.
- In the mid-eighties, a quantity of sand mixed with gravel was bonded.
- In the early nineties a concrete tile, the dimensions of which are (15x15) cm, was constructed, in addition to the crushed ceramic tile in the bedrooms, which is, the currently existed ground.

4.14 Case Study Analysis based on the yardstick

4.14.1 Environment

Table (4.3) Tangible Issues - Environment
Source: The researcher

	Tangible Issues	
	Environment	
Aims	**Minimize Environment Impact**	▪ Water consumption and reuse ▪ Energy consumption ▪ Reduce waste production and pollution ▪ Low impact materials
	Maximize Comfort of Life	▪ Increase air quality ▪ Outdoor space (biodiversity etc.)

- **Water Consumption and reuse:**
  - Grey water coming from taps and shower drainage is used for cooling by spraying it over the front yard, which helps in lowering indoor and outdoor temperature as shown in figure (4.20):

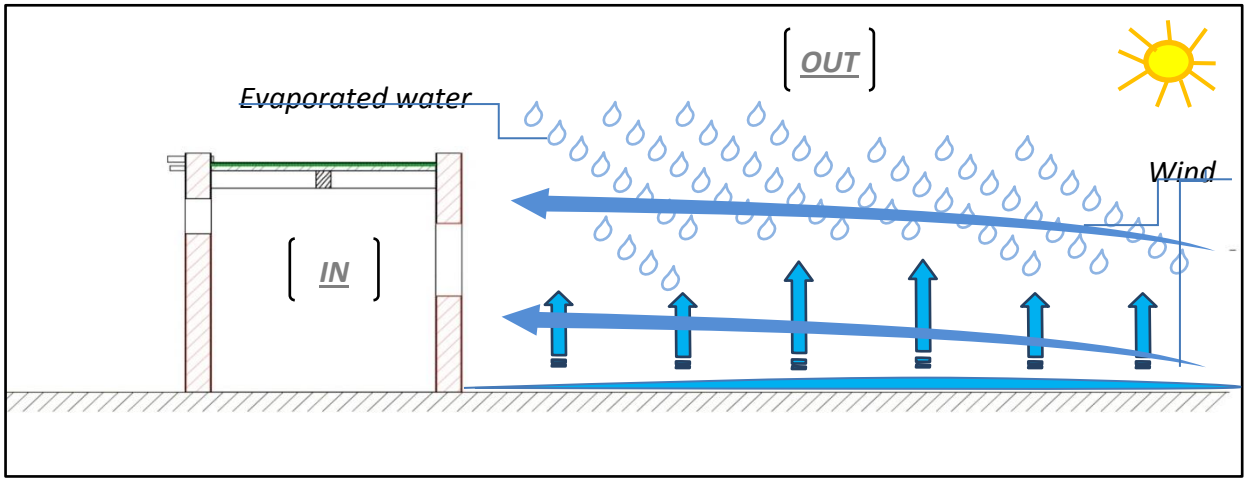


Figure (4.20) Water Consumption

Source: The researcher

- **Energy Consumption:**
  - Although there is an air conditioning unit, Sample's house uses such a low amount of energy. Energy consumption average is about (60-82) kw per month, which is really low when compared with a same size house in another block.
  - An obvious reason for low energy consumption is residents' life style which is based on an early sleeping about 9.00 p.m.
  - Even during a day spaces are well cooled by cross ventilation and the wind which is full of humidity.
- **Low impact materials:**
  - Local materials have been used in construction (mud, wood …etc.). by other words the building was built and renovated by materials come from the ground and from the surrounding area.
  - Mud for example is known of his low sunrays' reflection and low heat absorption

Figure (4.21) House built with mud layers

- **Increase indoor Air quality**

The quality of air in indoor spaces can be considerably improved, in a passive way, bearing in mind the following aspects (advanced and sustainable housing renovation, a guide for designers & planners; 2010):

- The choice of building materials
- The choice of the types of construction and details of indoor finishing
- The layout of the dwelling to favor natural ventilation
- The lifestyle of the occupants (cleansing products, maintenance of the house, etc.)

- **Table (4.4) Indoor Air quality aspects in Sample house**

Source: The researcher

Indoor air quality Aspects	Sample house	Matched with aspects or not	
		√	X
building materials	Natural, local and traditional building materials	√	
types of construction and details of indoor finishing	Local finishing materials are used in both, like mud, wood and animals' dung	√	
natural ventilation	Natural cross ventilation for each space	√	
The lifestyle of the occupants	▪ Natural cleaning products ▪ Natural, local building materials are used in each maintenance process	√	

As shown on table (4.4) above Sample house's score is 4/4, so indoor air has a high quality

4.14.2 Appropriate Technology

Table (4.5) Tangible Issues – Appropriate Technology
Source: The researcher

	Tangible Issues	
	Technological	
Aims	**Minimize Environment Impact**	▪ Technical systems (Heating, Ventilation, Air-conditioning etc.) ▪ Renewable technologies (biomass, PV, Solar thermal, wind, Geothermal) ▪ Maintenance to keep building system in good condition
	Maximize Comfort of Life	▪ Technical systems (Heating, Ventilation, Air-conditioning etc.) ▪ Maintenance to keep building system in good condition

- Technological in general means using high tech and smart systems; the research used the term "Appropriate Technology" to refer to using simple, local techniques to achieve aims. Both cooling and ventilation are done in a high degree of efficiency by applying simple ideas: using Mud walls, openings' sizes and locations.
- Walls are built with mud in the form of layers of (0.30)m each width, covered with a layer of wire and screw, in addition to a layer of cement plaster, with white lime as finishing, covered with a layer of paints. Total width of walls is (0.36) m which helps in run rays delay which create cool internal spaces. Also roofs are made of several layers which delay sun rays from top.
- Sample house is maintained regularly, so it keeps in a good condition.

- Actually it is not just maintained, but renovated; to improve both its condition and thermal performance.

4.14.3 Cultural & Emotional

Table (4.6) Non-Tangible Issues - Cultural & Emotional
Source: The researcher

	Non-Tangible Issues	
	Cultural & Emotional	
Aims	**Minimize Environment Impact**	▪ Reuse of old buildings
	Maximize Comfort of Life	▪ Neighborhood relationship ▪ Historic value ▪ Keep resident's memory maximum ▪ Care about residents' feeling and demand for renovation

- About (90%) of Algamayer quarter's houses were built between 1910s and 1930s. Changes which had been made by the residents such a sustainable renovation in how they dealt with space. Material, …etc

Eastern View of Algamayer

Showing the difference between buildings in heights, types and finishing materials

Western View of Algamayer

Showing group of mud layers houses and the main mosque of Algamayer

Figure (4.22) Panoramic Views of Algamayer

Source: The researcher

- There is a strong relationship between residents as they do almost everything together. The older generations tell the younger ones stories and events happened in the past, so nothing will be forgotten tomorrow.
- In general the younger generation wants new designs and rebuild houses where the older one want to keep old and historic buildings, In Algamayer quarter they do both; as they keep the old buildings & traditional jobs but adding modern furniture, equipment and technological items.

White lime mixing with mud

Clay pottery

Figure (4.23) Traditional industries

Source: The researcher

4.14.4social:

Table (4.7) Non-Tangible Issues - Social
Source: The researcher

	Non-Tangible Issues	
	Social	
Aims	**Minimize Environment Impact**	▪ Users' behavior ▪ Planning process ▪ No relocation of tenants
	Maximize Comfort of Life	▪ Social equity (provision for disabled facilities) ▪ Outdoor space (public space for social interaction) ▪ Information data collection & popularization

- In Algamayer there is many public spaces such as the social, cultural club and the playground area

The new playground

Club's playground

Figure (4.24) Playgrounds

4.15 Conclusion

The previous chapters have led to one clear conclusion that transformation is a much more environmentally efficient way to achieve the same result than are demolition and rebuilding. This raises the questions if and to what extent and in what way this should influence the design of new buildings? It is easier to achieve sustainability if the new-built building designed for further renovation. Before renovation, the life of a new building is similar to an old building had experienced, from designing, construction to usage. Lessons can be learnt in all these stages during the life of a new building.

Improvements can be achieved by considering future demolition and disassembly of building elements at the designing stage of new buildings. Design for deconstruction or disassembly integrates waste prevention into the design process.

In the construction stage, a good management both on site and off site is essential to achieve the goal of less depletion of energy, natural and human resources, resulting in relatively low costs. Another consideration during construction is to minimize the impact on surroundings, both the nature and the neighborhood. Good managerial methods are also a point we – as an architect's - need to focus, which can increase productive in site, so that, time and cost can be saved to some extent.

For the case study in this thesis, data collection focused on both on the adoption of measures and what follows after measures have been done. This provides knowledge and experience for future projects. It is worthwhile to have this kind of data collection in new buildings in the usage stage. It would be useful to have more annual data on the measures and quality of energy measures taken in new buildings. A database can be set for future projects.

The conclusion of the study is often related to specific cases. The debate about the environmental impact of interventions in the existing housing stock is not finished yet.

Today, the long necessary lifespan of the existing stock combined with rising energy prices and environmental measures could boost innovations and improvements in the field of sustainable renovation. Hopefully this effort can contribute a little to the research in this field focus on sustainable renovation and provide knowledge and experience for similar projects in the future.

Chapter V
Conclusions & Recommendations

Chapter V

Conclusions & Recommendations

5.1 Introduction

This chapter summarizes the whole thesis, it begins with Sustainable renovation application in Sudan, Summary of conclusion, then general recommendations will be introduced to express the researcher's ideas and suggestions, and, finally recommendations for future studies will be suggested.

5.2 Sustainable Renovation application in Sudan

Sustainability is a global challenge, and in Sudan, recently, it is a hot topic and paid more attention as well. The current situation is Sudan has a large stock of existing residential buildings which are in poor condition that not satisfying the sustainable needs. At the same time, Sudan has a quite high rate of constructing new buildings, maybe one of the highest in the world. In this case, if we can renovate the exiting stock to meet the sustainable standards, and to design and construct the new buildings in a sustainable way, it will contribute a lot to the sustainable issue. Since Europe is more advanced in the field of Sustainable building, some good measures and methods can be learned and taken in the future sustainable renovation projects or sustainable building construction in Sudan. To borrow the sustainable building design ideas from European projects is one of the important motivations for me to do this thesis.

5.3 Summary of conclusions

i. Renovation is a much more environmentally efficient way to achieve the same result than demolitions and rebuilding are.
ii. It is easier to achieve sustainability, if the new-built building designed for further renovation.

iii. Before renovation, the life of a new building is similar to that the old building had experienced; from designing, construction to usage.

iv. Design for deconstruction or disassembly integrates waste prevention into the design process, as seen in the case study

v. In the construction stage, a good management both on site and off site is essential to achieve the goal of less depletion of energy, natural and human resources will be resulting in relatively low costs.

vi. It would be useful to have more annual data on the measures and quality of energy measures taken in new buildings.

vii. The long necessary lifespan of the existing stock combined with rising energy cost and environmental measures could boost innovations and improvements in the field of sustainable renovation.

5.4 Recommendations

After theoretical and practical study the research would introduce the following points as recommendations:

- Development today must not undermine the development and environment needs of present and future generations.
- Living comfort, energy saving and environmental protection are no contradiction, but the best way to increase living comfort, and finally secure the future.
- The new-built buildings must be designed for further renovation to ensure that sustainability will be achieved.
- Renewable materials, such as mud, are the priority selection as the construction material in the renovation project, due to the consideration of reducing impact to natural environment.
- Using prefabricated construction method, which can not only shorter construction period, but also reduce the negative influence to surrounding environment.

- Policies about residential buildings renovation must be stated by Sudan Engineering council, The Sudanese Institution for Architects, and other parties to encourage residence, architects and contractors to renovate instead of demolish.
- Adopting the European experience in sustainable renovation is not a negative matter, but in my opinion it is the best thing to do.

5.5 Recommendations for future studies

The debate about the environmental impact of interventions in the existing housing stock is not finished yet, so more studies about renovation should be done to push the cycle of sustainable renovation forward.

Future studies must focus on the following points:

i. Design research for renovation, starting from early design stages.
ii. Renovation and sustainable renovation is a recent topic, so they must be studied in more details.
iii. Research on the relationship between good management, increasing production in site, and saving time and cost.

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“There is a way back from the concrete jungle to a green world.
It requires both social and technical steps, both planning and invention”

Lewis Mumford