

**SUSTAINABLE -ECO -NEIGHBOURHOOD ASSESSMENT METHOD IN RESIDENTIAL  
NEIGHBOURHOOD IN GREATER KHARTOUM**

**By**

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## 1.ABSTRACT

This paper investigates the present situation of low to medium rise buildings for medium class professors, teachers and doctors in residential areas in Greater Khartoum such as the Ecological Neighbourhood, addressing questions like whether they are ecologically designed, how they can be evaluated and to what extent, the problems and issues in such evaluation and the solutions therefor.

To evaluate these Neighbourhoods, the researcher has to adopt a rating system; for this purpose, a comparison was made with LEED v3 for Neighbourhood development, which has been in vogue since 2009 and evaluates subjects using sustainable environmental parameters. This research studies three neighbourhoods in Greater Khartoum, which are Residential Villas, Arrak City and El Naser Apartments. This study devises a system known as SENAM, for evaluating the Eco Neighbourhood efficiency in a hot dry climate such as Greater Khartoum. SENAM evaluates nine main categories which are: Sustainable Site, Neighbourhood Design, Pattern and Construction, Waste Management system, Materials and Resources, Water Supply, Power Supply system, Environmental Plan process, Health and Safety and Emissions and Community Participation. The total points for the various categories is 113 and the system offers four main certifications: (35 - 44 pts) Pass, (45 – 59 pts.) Good, (60 - 75 pts) Very Good, (76-132) pts or more) Excellent.

The results would also be evaluated, analysed and discussed as per global parameters for sustained evaluation, such as LEED for Neighbourhood development.

The research finds that: Residential Villas score 38% (certified), Arrak City 29% (not certified) and El Naser Apartments 51% (silver). \*The analysis shows efficiency in Neighbourhood Design, Pattern and Construction (40%), and Waste Management System (40%).

The analysis shows inefficiency in designing, sustainable site (30%), Materials and Resources (20%), and services, such as Water Supply System (27%), Power Supply (20%), Emissions (33%) and Community Participation (27%).

The Researcher has applied the Suggested Sudanese Sustainable Rating Systems (SSRS) in the eco neighbourhoods in Greater Khartoum.

**Key words: The definition of ecological neighbourhood, Principle of Designing Ecological Neighbourhood, Sustainable Eco Neighbourhood Assessment Method, (SENAM) to evaluate the Ecological Neighbourhood.**

## 1. INTRODUCTION

-The importance of Sustainability has been recognized in 1992 at the United Nation Conference on Environment and Development, the "Earth Summit", held at in Rio de Janeiro, Brazil. The central aim was to identify the principles of action towards "sustainable development". Agenda 21 on "Promoting Sustainable Human Settlement Development" lays down that people should enjoy healthy sustainable neighborhoods to live in to meet with the global standards and to meet their own needs, with mixed use center, efficiency in water supply system, efficiency in power supply system, maximization of open spaces, green ecological buildings, and sustainable transportation system, waste management, etc. The researcher visited some of the new neighborhoods and compounds for residence in Grater Khartoum and noticed serious problems in the orientation of the buildings and on the services available in these neighborhoods, finding these solutions still far away from sustainable ones. This situation was compared to the one in global projects like AL Masdar city in Abu Dhabi, Bedzin Green project in UK and Siviano green project in USA.

This paper investigates the present situation of Ecological Neighbourhoods in Greater Khartoum, to assess whether they are sustainable ecological neighbourhoods and if so to what extent, the problems faced by them and possible solutions therefor. Accordingly, the researcher designed a rating system to evaluate three neighbourhoods in Grater Khartoum by comparing them to global systems.

## 2. Historical Background

### 2.1 LEED For neighbourhood development and others

LEED v3 for neighbourhood development came into vogue in 2009 and consists of five main categories, which are: smart location, neighbourhood design and pattern, green infrastructure and buildings, Innovation in design process and regional priority.

There are many Global green building councils around the world, some of which set up the Neighbourhood rating system like LEED for neighbourhood development. Similarly, QSAS for neighbourhood was started in 2010, while ESTEDAMA, which added the liveable community category including some points to evaluate the neighbourhood, also started in 2010.

LEED for neighbourhood development is applicable to many projects and it is easy to connect to United States green building council to manage your design, as the service is available through the internet.

However, LEED for neighbourhood development rating system does not include parameters like health, safety, emission category, community participation and environmental process as main categories and energy efficiency, water efficiency as waste management as separate categories. LEED announced LEED V4 for Neighbourhood development including more flexibility with strategies to fit the unique aspects of your project, performance based design, operation and design, smart grid and networking approach, material and resources, water and streamline documentation. (U.S.G.B.C, 2017)

Through this paper, the researcher will provide a sustainable assessment method suitable to a hot dry climate such as Greater Khartoum, in order to evaluate the Eco Neighbourhood in Greater Khartoum and this system will include all relevant parameters like energy efficiency, water efficiency, ecological building materials according to available natural resources and other parameters applicable to a hot, dry climate..

-The researcher expects to answer the research questions by applying this system to three case studies and evaluating the results. In addition, the system will evaluate this situation vis-a-vis sustainable environmental parameters and identify the problems and solutions therefor. This paper will also suggest a Sudanese Sustainable Rating System to evaluate ecological neighbourhood through the methodology of this research.

**Rieck, A.(2012)** discussed Masdar city in Abu Dhabi, and stated that the new green cities is about how we can control nature and highlighted such parameters for new green cities like: Energy Consumption, Energy storage, Transportation system, Waste Management, Mobility, Information Technology and Communications Technology.

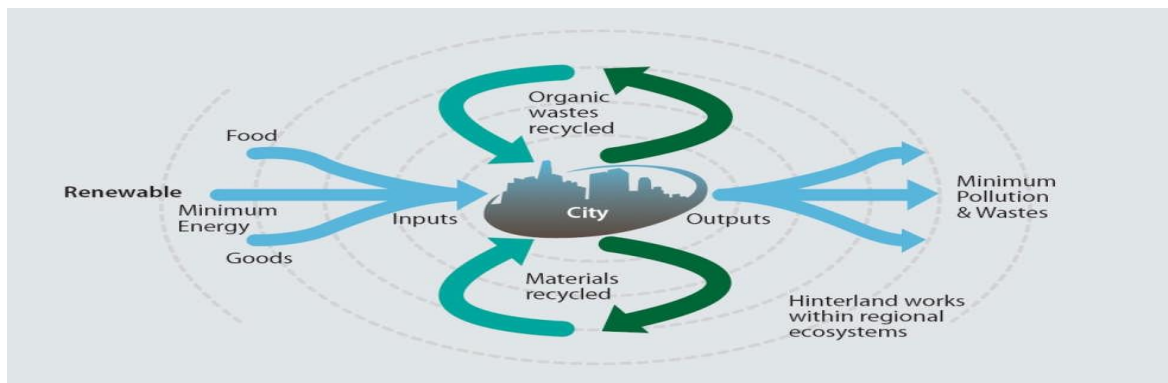
**Peled, G.(2008)** discussed the new Jerusalem eco housing project and some categories of eco neighborhood, viz., Energy Conservation, Waste Reduction, Water Conservation, Land Use, Transportation, Community Involvement, Health and Safety, Disaster Control, Wellbeing, Materials and Recycling, Urban Ecology and Footprint.

**Alderson, A. (2005)** highlighted important categories for Eco- Village in Scotland, UK, like Energy, Telecommunications, Water and Sewage, Location, Solid Waste, Transportation, Ecological Environment, Design and Building, Economy and Social Issues and Education.

**Riis, C. (2014)** discussed in her paper about Green Strategies in Copenhagen, designated as the European Green Capital in 2014. The concept takes into account the urban life scale before building scale, strategic urban development on a large scale, urban development and site specific plans in the medium scale and in the small scale, considers other ideas and projects, as for example Green pathway, Green roof and Green backyards.

## **2.2 DEFINITION OF ECOLOGICAL NEIGHBOURHOOD**

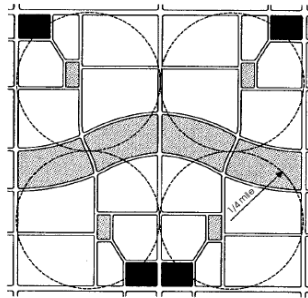
United State Green Building Council defines Neighborhood Development thus: *“integrates the principles of smart growth, urbanism and green building into the first national system for neighborhood design”*. **U.S.G.B.C (2012)**. It provides the balance between the income and food, renewable energy, goods, materials and the outcome of organic waste recycling, materials recycling, minimize pollution and waste and emissions. See Fig. 1.



**FIGURE 1:** Circular metabolism: Cities reduce consumption and pollution, recycle and maximize renewables, **Source:** Ben Hamadou, R. (2012).

### 2.3 THEORY OF TRADITIONAL NEIGHBOURHOOD

- **Walking distance:** The traditional neighbourhoods' typology comprises a compact residential area with a variety of housing types and services like small shops, libraries and mosques and churches. The ideal size of a neighbourhood falls within the 1/4-mile measurement (400m.), which is the distance the typical adult can walk from centre to edge in approximately five minutes.
- **Mixed use center:** The second theory of the traditional neighbourhood says it should provide for mixed use, areas of concentrated activity – living, working, learning, playing, eating, and shopping, designed to accommodate pedestrians and transit use in addition to auto travel. See Figure 2.
- **Neighbourhood centres** are mixed-use activity points scaled to serve a trade area with a radius of less than three miles. Larger neighbourhood centres typically include a full-service supermarket or grocery store and serve no less than six neighbourhoods, with parking, Malls, etc.



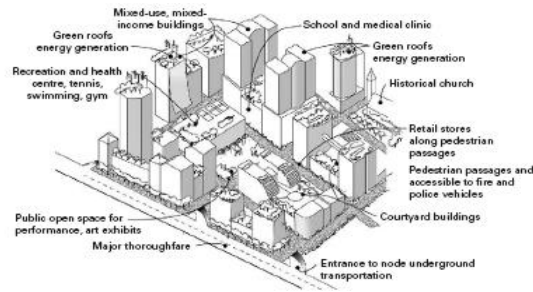
**FIGURE 2:** Traditional neighbourhood combination diagram: (*Drawing: Courtesy: Duany Plater-Zyberk And Company.* **Source:** Walters, D. and Luise Brown, L. (2004))

- **Study of the Master Plan:** The Master Plan should focus on a three-dimensional urban form, instead of two-dimensional plan diagrams that indicate land use only., which is the key message of the book *Three dimensions are better than two* by Walter (2004). Three-dimensional infrastructure of form and space allows long-term flexibility of use and operation. These issues include the impacts of changes in technology, social structures, economics, uses, architectural styles and development practices.

## 2.4 THEORY OF SUSTAINABLE NEIGHBOURHOOD

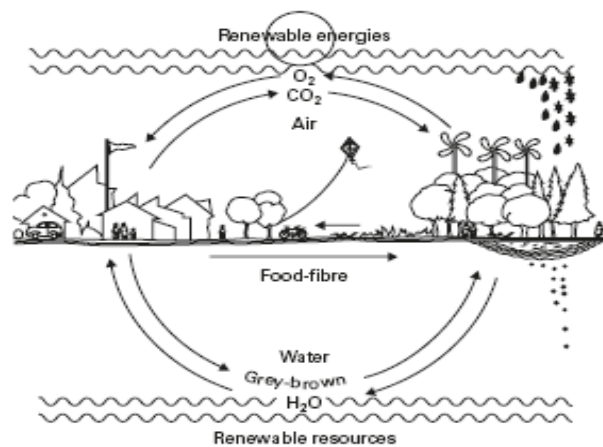
- **UN HABITAT (2009)** stated the environmentally sustainable urbanization requirements reduce greenhouse emissions, minimized and compact cities and use renewable resources.

Figure (3) shows a conceptual idea of mixed uses in a self-contained walkable neighbourhood node, Jenks, M. and Dempsey, N. (2005) stated that social, economic, and environmental justice depends heavily on mass transportation to incorporate a percentage of low-to-moderate-income families into every neighbourhood node.



**FIGURE 3: A conceptual idea of the mixed uses in a self-contained walkable neighbourhood node.** SOURCE: (Jenks, M. and Dempsey, N. (2005))

People are critically needed. Fire-fighters, police, health care workers, labourers, and food suppliers must live in close proximity, in order to provide immediate help. It should be a self-contained community that provides for schools, health care, police, fire protection, postal services, banking, open spaces for playgrounds and parks within walking distance.



**FIGURE 4: Sustainable cells of urbanization,** SOURCE: Jenks, M. and Dempsey, N. (2005)

- Sustainable cell is provided a balance between human activity in human–environmental systems (HVAC\_Heating Ventilating and Air-Conditioning) waste with the surrounding environment as well as human health with environmental systems of air, water, food, fibre (land), and energy for the community are modelled and measured to establish indicators for sustainability. See Figure (4). Jenks, M. and Dempsey, N. (2005) and Sassi, P. (2006).



## 2.5 Focus on Khartoum Conditions

### Khartoum location

Abu Sin and Davis, (1991) wrote that Khartoum state straddles the confluence of the Blue and White Nile that covers some 28,000 square kilometers and covers about 2.17% of the total area of Sudan. It lies at latitude 15° 36' north and longitude 32° 3 east, with an altitude of 380 meters above sea level. El Agraa, O.M. and Shaddad, M.Y. (1988) discussed the location of Khartoum too. Khartoum was first made the capital of the Turkish-Egyptian rule in the 1830s.

**Environmental factor:** Khartoum faces four climates:

Rainy season in the autumn, with precipitation ranging between 150 mm and 200 mm

In summer, the wind direction is South-South East and in winter, it is North and North –West.

The temperature: In summer, it ranges from 40°C to 50 °C, and in winter, between 10°C to 25°C.

Humidity ranges between 20% in summer to 40% in winter.

**Natural resources:** Khartoum is rich in solar energy, wind energy, biomass energy and geophysical energy, as well as hydroelectric energy.

**Political factor:** Sudan has subscribed to several international Agreements, starting with Agenda 21 in 1992, the Kyoto protocol, the United Nations Framework Convention on Climate Change (UNFCCC) and has a working relationship with UN- HABITAT, UNEP, UNDP and NGOs, to establish sustainable projects in SUDAN.

**Social factors:** Earlier studies showed that Khartoum population is increasing and may have doubled in the last 20 years, to the level of 5,500, 000 according to the last census. Reasons for the increase include increasing migration towards Khartoum city, which affects services such as education, health, transportation, the quality of housing and waste management in Khartoum.

To provide and design a sustainable neighbourhood in Khartoum, we should consider all this information, taking into account the traditional and sustainable principles of designing an ecological neighbourhood. This will be discussed while considering the methodology of this research.

## 3. THE METHODOLOGY

**3.1.** The researcher has undertaken a wide literature review, to identify the main principles of sustainable eco neighbourhood. Global standards leader **LEEDV3 for Neighbourhood and development** (Leader in Energy and Environmental Design) applied criteria like smart location, neighbourhood pattern and design, green infra structure and building, innovation in design and regional priority categories. On the other hand, The Environmental Assessment Method (**BREEAM, 2017**) applied categories like energy, health wellbeing, land use, pollutants, waste, ecology, innovation, materials and water, with different details and sub-issues.

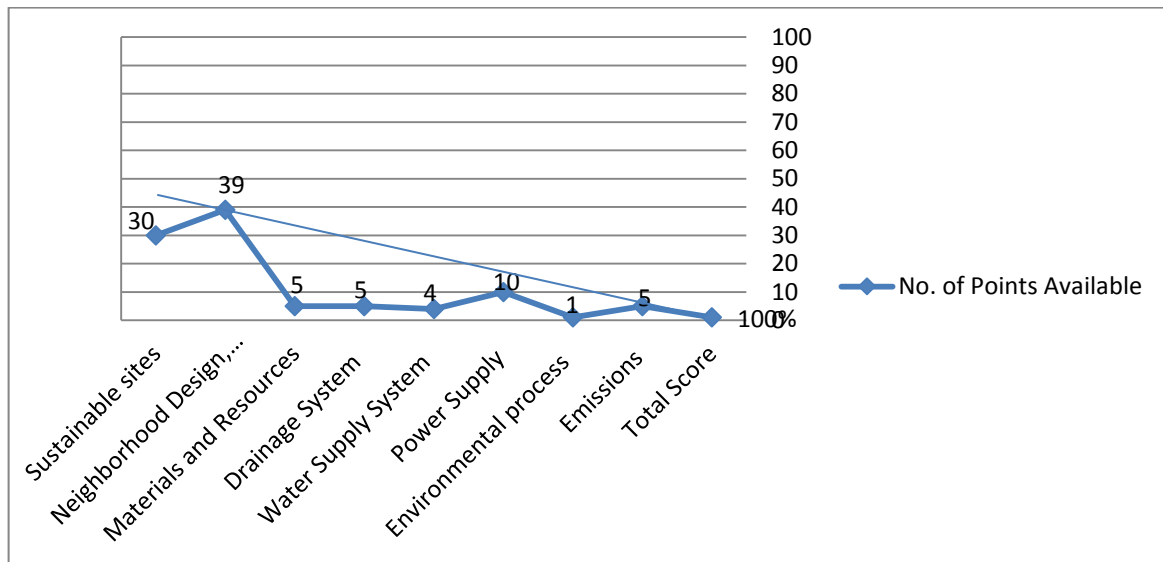
**3.2.** The researcher identified the main categories to be applied in a hot dry climate like Greater Khartoum. These are: Sustainable Site (30 points), Neighbourhood Design, pattern and construction (39 points), Materials and resources (5 points), waste management system (5 points), water supply system (5 points), power supply system (4 points), Environmental process (1 point), health, safety and emissions (5 points), with details and sub issues indicated in table 1 of the Appendix.

**3.3.** The researcher added additional categories like Environmental design process, health safety, emission and community participation. The community in Greater Khartoum needs to be educated about sustainable design, and involve itself in improving the environment. These additional categories were discussed by the researcher in a previously published scientific paper (**Abdelmoneim, H., 2016**).

**3.4.** Comparison between the research method of assessment (Sustainable Eco Neighbourhood Assessment Method, SENAM) and LEED for neighbourhood development

Figure (5) shows the difference between the research method of assessment (Sustainable Eco Neighbourhood Assessment Method, SENAM), which has nine main Categories, carrying weightage as follows: Sustainable Site (30 points), Neighbourhood Design, pattern and construction (39 points), Materials and resources (5 points), waste management system (5 points), water supply system (5 points), power supply system (4 points), Environmental process (1 point), health, safety and emissions (5 points) and community participation. Figure (4.6) shows LEED for Neighbourhood Development which contains five main categories, which are: Smart Site (27 points), Neighbourhood Design and pattern (44 points), Green Infrastructure (29 points), Innovation in design (6 points) and Regional priority (4 points).

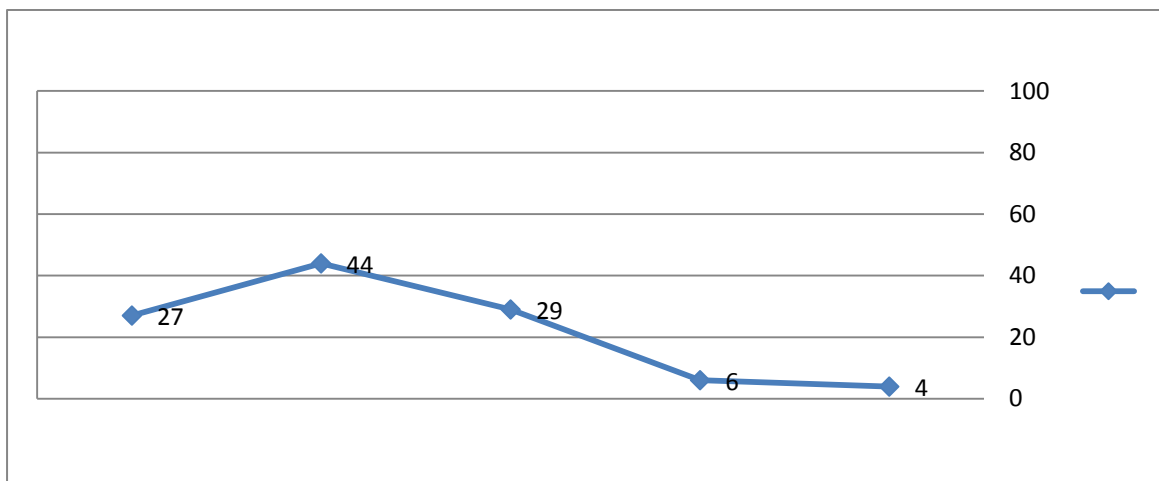
The researcher added Waste management, Material, Energy, Water and drainage system, Environmental Design Process and Community participation as new categories to the Sustainable Eco Neighbourhood, for a more comprehensive evaluation.



**Figure 5:** Sustainable Eco Neighbourhood Assessment Method, SENAM,

**Source:** Designed by the researcher

**Figure 6:** LEED-Neighbourhood Development, Source: LEED for Neighbourhood Development



**Figure 6:** LEED V3-Neighbourhood Development, Source: LEED for Neighbourhood Development

### 3.5. Summary of the Assessment System Applied on Eco Neighbourhood:

#### 3.5.1 Weightage, credits and percentage points:

**Table (1): Weightage, credits factors**

The Category	The average result	The Average Result by LEED ND, V3	The evaluation BY SENAM
<b>Sustainable site</b>	<b>30%</b>	<b>Not certified</b>	<b>weak</b>
<b>Neighborhood Design, pattern and Construction</b>	<b>40%</b>	<b>certified</b>	<b>pass</b>
<b>Materials and Resources</b>	<b>20%</b>	<b>Not certified</b>	<b>weak</b>
<b>Waste management system</b>	<b>40%</b>	<b>certified</b>	<b>pass</b>
<b>Water Supply System</b>	<b>27%</b>	<b>Not certified</b>	<b>weak</b>
<b>Power Supply</b>	<b>20%</b>	<b>Not certified</b>	<b>Weak</b>
<b>Environmental process</b>	<b>60%</b>	<b>good</b>	<b>good</b>
<b>Emissions</b>	<b>33%</b>	<b>Not certified</b>	<b>Weak</b>
<b>Community participation</b>	<b>27%</b>	<b>Not certified</b>	<b>weak</b>

Source: Designed by the researcher

### 3.5.2 The scale system

**Table 2: The scaling system**

The Mandatory	Mean	Points availability
Yes →	Means it's applicable	
	The most Positive impact	3
	More Positive impact	2
	Positive impact	1
No →	Means it's not applicable	0
	Negative impact	-1

Source: Designed by the researcher

### 3.5.3 The System Certifications

This system gives four main certifications:

- < 35                      **weak,**
- (35 - 44 pts)            **pass**
- (45 – 59)                **good,**
- (60 - 75 pts)            **very good**
- (76-111pts or more) **Excellent**

## 4. THE FIELD WORK

### 4.1 THE LOCATIONS

The research studies three Neighbourhoods in Khartoum, which are Residential villas, Arrak City and El Naser Apartments.

See the site location in Fig 8, Fig. 9 and Fig. 10 and Fig.11.

## 4.2 STANDARD OF SELECTION OF THE CASE STUDIES

New Neighbourhoods and new urban planning areas. See satellite images. They applied new approaches in design concepts and environmentally sustainable ecological design, which had just been adopted in the 1990s and which took into account the Eco Design principles and the main categories. They were built by famous Consultant companies. Looking for applying Sustainable Neighbourhood Cell. The researcher was looking for proper technical solutions in services. Water supply, waste management and drainage system. Energy System. Site security and health awareness. Building materials were recycled and eco-friendly building materials. Looking for applying the latest new technologies in the field of eco design. Outdoor environmental control. Diversity in house type. Ecological treatments



Figure 8: The Location of Residential villas near the River Nile, Khartoum City, Sudan

Source: Google image 2017



Figure 9: The second location is Araak Neighbourhood , Madani street , Khartoum City, Sudan. Source: Google image 2017



Figure 10 : The third location is Al Naser Neighbourhood , Africa street , Khartoum City, Sudan. Source: Google image 2017

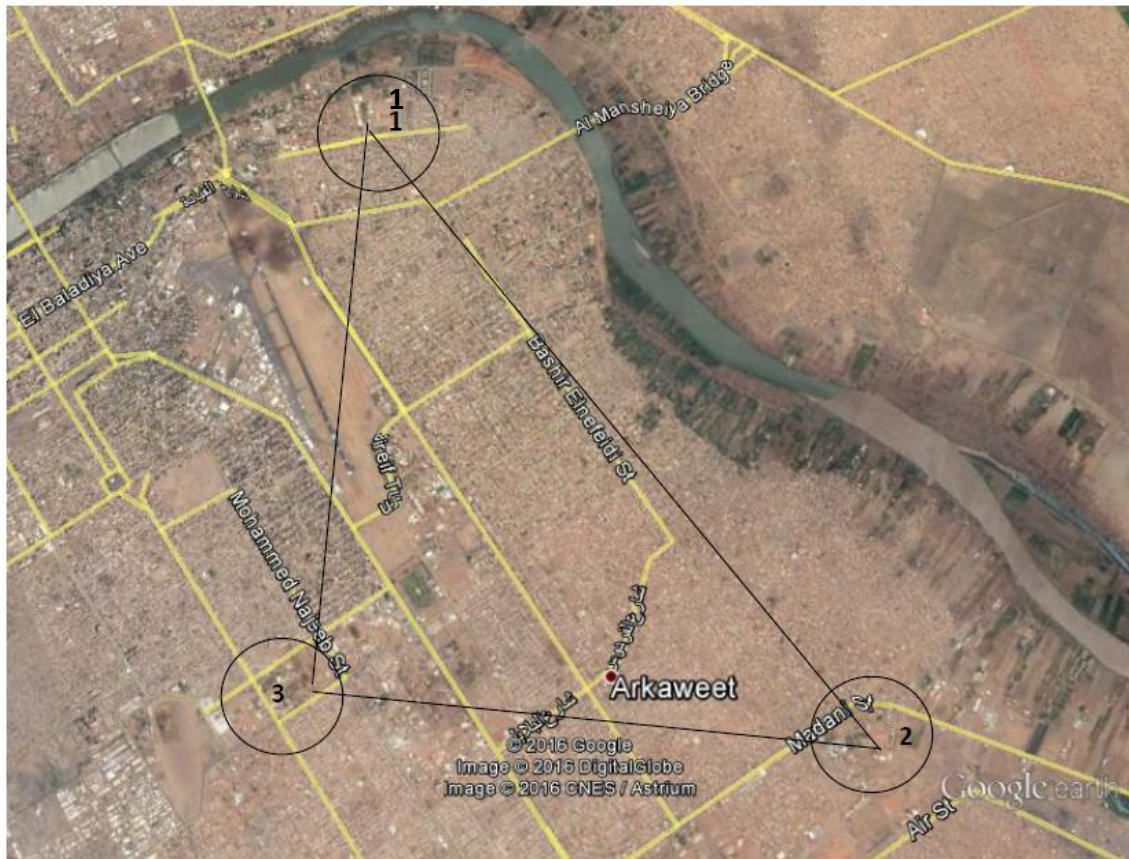


Figure 11: The three locations in perspective: Residential villas , Araak City and Al Naser Apartments, Source: Google image 2017.

Figure 11: The three locations in perspective: Residential villas , Araak City and Al Naser Apartments, Source: Google image 2017.

### **THE APPLICATION OF (SENAM) TO THE CASE STUDIES**

The researcher applied the Sustainable Eco Neighbourhood Assessment Method-SENAM to evaluate the three neighbourhood case studies.

### **3.4.5 UPDATES OF THE CASE STUDIES**

In June 2017, the researcher started to make updates to the case studies and as per his supervisors instructions, he visited all the cases, starting with the research studies in the three neighbourhoods in Greater Khartoum, viz., Residential villas, Araack City and Al Naser Apartments . She found that most of the sites had not changed and no sustainable solutions had been added by stockholde



#### **4. The Results:**

The summary of the results of three case studies on the level of eco neighbourhood is presented in Appendix -1, and the result of each case study on the level of eco neighbourhood presented is presented in the following Tables and Figures.

##### **Case Study-1, the Residential Villa Type-B**

**Table 3** shows the result of the analysis of case study of the Residential Villas neighbourhood and the results were as follows:

Sustainable Sites 23%, neighbourhood design, pattern and construction 38%, materials and resources 20%, waste management system 40%, water supply 40%, power supply 17% environmental process 60%, emissions and safety 60% the community participation 27%. Total result was **39%**.

##### **Case study-2 (Arak City villa type-D)**

**Table 3** shows the result of the analysis of case study two on the level of neighbourhood.

Sustainable Sites 13%, neighbourhood design, pattern and construction 23%, materials and resources 20%, waste management system 40%, water supply 20%, power supply 25%, environmental process 50%, emissions and safety 20% Community participation 7%. The total result was **29%**.

##### **Case study-3 Al Naser Apartments**

**Table 6** shows the result of the analysis of case study three on the level of neighbourhood.

Sustainable Sites 53%, neighbourhood design, pattern and construction 60%, materials and resources 20%, waste management system 40%, water supply 20% power supply 17%, environmental process 70%, emissions and safety 20% the total Community Participation 27%.

Result was **51%**.

#### **4. The Results Shown in tables**

##### **4.1 The Result of the case studies on the Level of Neighbourhood**

**See Table 3 and table 8 and FIGUR 12 to 14**

### 5.1 THE RESULT OF EACH NEIGHBOURHOOD IN FIGURES

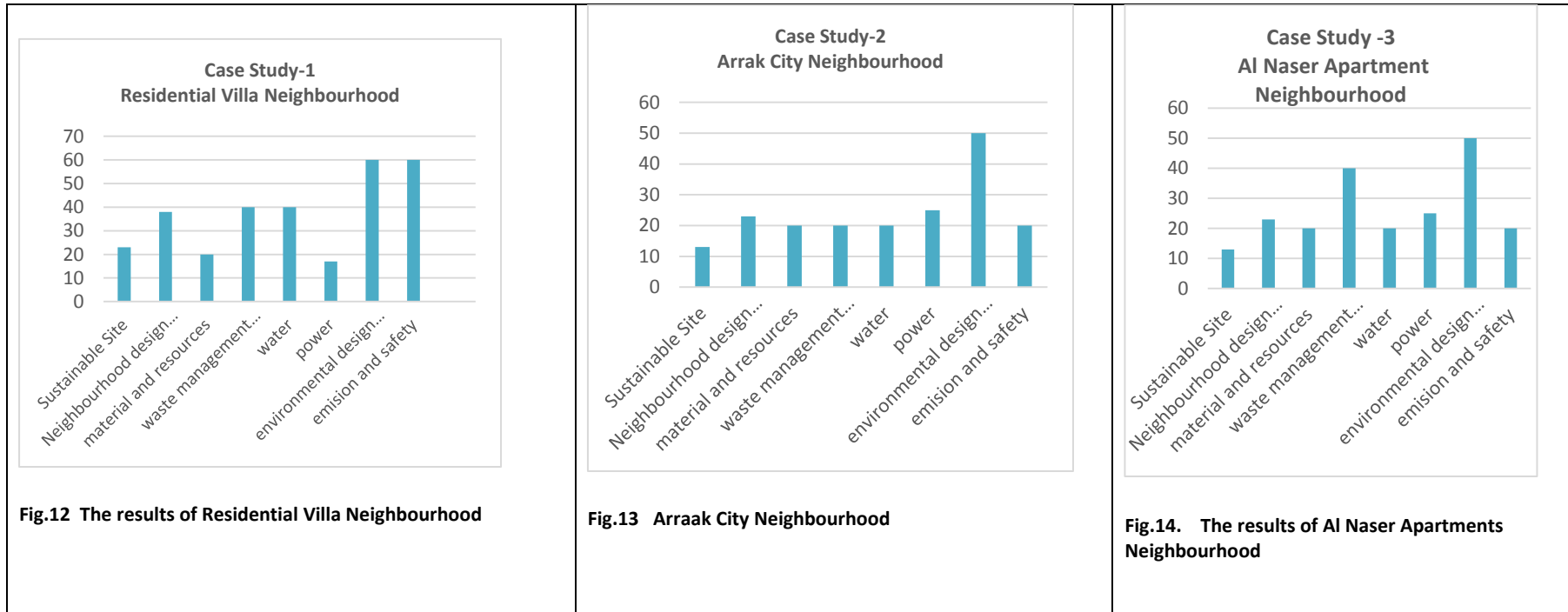


Fig.12 The results of Residential Villa Neighbourhood

Fig.13 Arrak City Neighbourhood

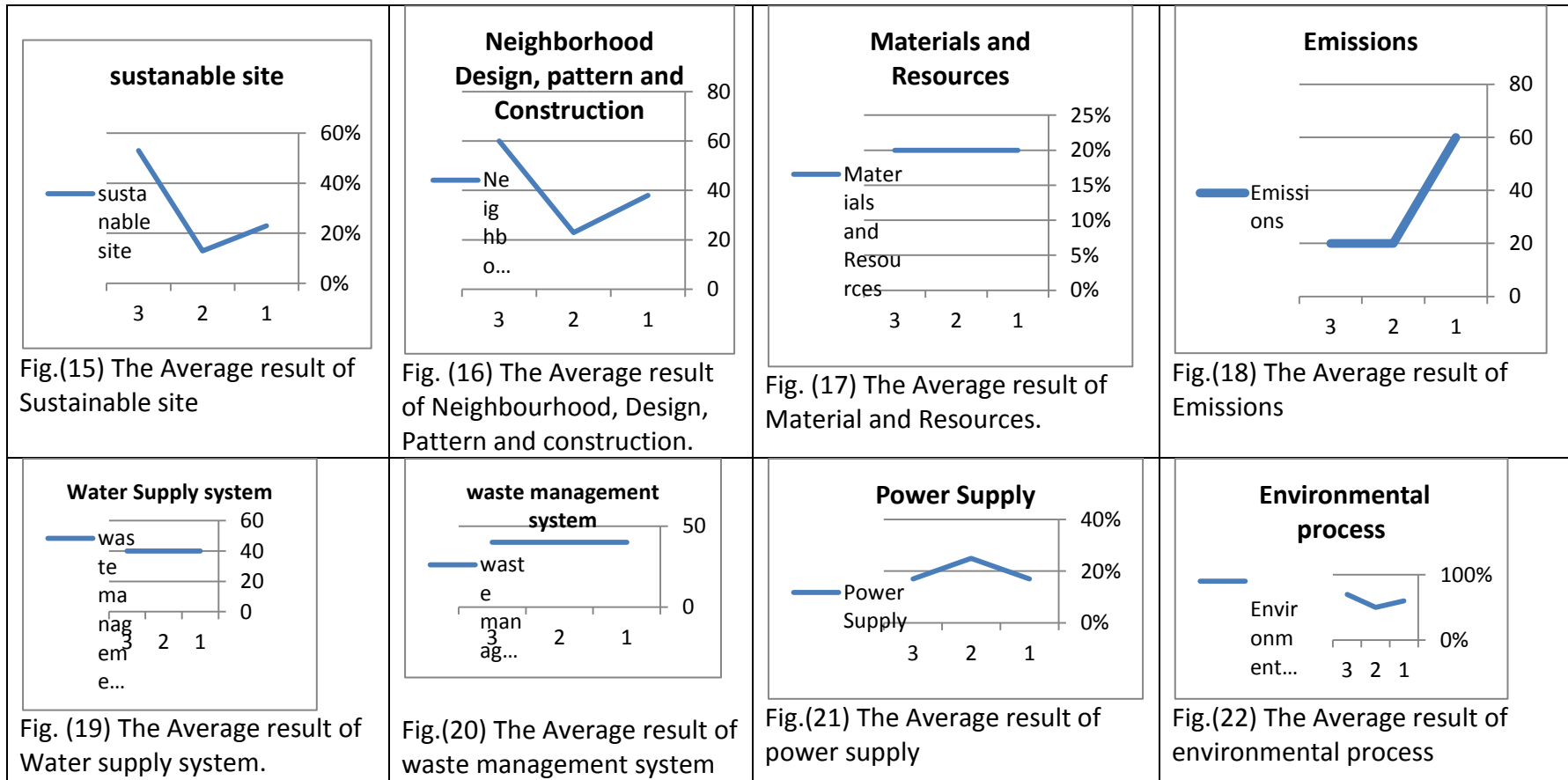
Fig.14. The results of Al Naser Apartments Neighbourhood

**Average Results:**

**Table (3): THE AVERAGE RESULTS OF MAIN CATEGORIES**

Case Studies	Sustainable Site	Neighbourhood Design, Pattern and construction	Material	Water Supply System	Waste Management	Power Supply System	Health Safety And emission	Environmental Design Process	Community Participation
Residential Villa	23	38	20	40	40	17	60	60	27
Araak City	13	23	20	20	20	25	20	50	27
Al Naser Apartments'	53	60	20	20	40	17	20	70	27
<b>Average result</b>	<b>30</b>	<b>40</b>	<b>20</b>	<b>27</b>	<b>33</b>	<b>20</b>	<b>33.3</b>	<b>60</b>	<b>27</b>

**THE AVERAGE RESULTS OF MAIN CATEGORIES IN FIGURES**



## 6. DISCUSSION OF THE RESULTS

The discussion has two parts.

### Part one: The discussion the results for each neighbourhood

The research has identified nine main categories of Eco Neighbourhood, which are: sustainable site, neighbourhood design and pattern, materials and resources, drainage system, water supply system, power supply, emissions and safety procedure, environmental design process and community participation, as explained in the Method. The researcher proposes environmentally sustainable tools for Eco Neighbourhood, suitable for hot dry climates. The results were analyzed with SENAM

**Table 4: The system of evaluation**

The Certification by SSRS	
<35	Weak
(35 - 44 pts)	Pass.
(45 - 59)	Good.
(60 - 75 pts)	very good
(76-111pts) or > more	Excellent

### Case Study-1, the Residential Villa Type-B

Table 3 shows the result of the analysis of case study one on the level of neighbourhood, with the weightage scores as per SENAM being as follows:

Sustainable Sites 23%, neighbourhood design, pattern and construction 38%, materials and resources 20% , waste management system 40%, water supply 40%, power supply 17%, environmental process 60%, emissions and safety 60% the community participation 27%.

Total result was 39%. This result is a “pass”.

The evaluation showed efficiency in designing a sustainable site, indoor environmental quality and outdoor thermal control, inefficiency in building form, materials, resources and services, such as drainage and water supply systems, power supply and emissions.

### **Case study-2 (Arak City villa type-D)**

*The Total Credit for the building was 35 % for villa type D*

The evaluation showed efficiency in designing a sustainable site, indoor environmental quality, inefficiency in building form, materials and resources, and outdoor thermal control and services, such as drainage and water supply systems, power supply and emissions.

**The total result for the neighbourhood was 29%, meaning weak result.**

### **Case study-3 Al Naser Apartment, one Building**

*The Total Credit was 46 % for one apartment building type*

The evaluation showed efficiency in designing a sustainable site, indoor environmental quality, inefficiency in building form, materials and resources and services such as drainage and water supply systems, power supply and emissions. The score indicates “Good”.

**Result was 51% for the neighbourhood.**

This result is good.

## **Part two: discussion of the average result among the three neighbourhoods**

### **6.2 DISCUSSION OF THE AVERAGE RESULT**

**Table (5) The certification system of SENAM and LEED V3 for Evaluating Eco Neighbourhood**

### 6.2.1 Sustainable site

**Table 5:** The certification system of SENAM and LEED V3 for Evaluating Eco Neighbourhood

The Category	The average result	The Average Result by LEED ND, V3	The evaluation BY SENAM
<b>Sustainable site</b>	<b>30%</b>	<b>Not certified</b>	<b>weak</b>
<b>Neighborhood Design, pattern and Construction</b>	<b>40%</b>	<b>certified</b>	<b>pass</b>
<b>Materials and Resources</b>	<b>20%</b>	<b>Not certified</b>	<b>weak</b>
<b>Waste management system</b>	<b>40%</b>	<b>certified</b>	<b>pass</b>
<b>Water Supply System</b>	<b>27%</b>	<b>Not certified</b>	<b>weak</b>
<b>Power Supply</b>	<b>20%</b>	<b>Not certified</b>	<b>Weak</b>
<b>Environmental process</b>	<b>60%</b>	<b>good</b>	<b>good</b>
<b>Emissions</b>	<b>33%</b>	<b>Not certified</b>	<b>Weak</b>
<b>Community participation</b>	<b>27%</b>	<b>Not certified</b>	<b>weak</b>

The result of sustainable site is 30 % in the scale mentioned above, indicating the result of evaluation as “passing”. It can be noticed from Figure (13) that Al Naser Apartment has a good neighbourhood design and a U-shaped pattern, with the building and site orientation being certified as good. However, the neighbourhood failed in providing the other solutions like local food production, diversity in housing type, neighbourhood mix used Centre.

### **6.2.2 Neighbourhood, Design Pattern and Construction**

The result of neighbourhood design and pattern is 40 % in the scale mentioned and is evaluated as good. It can be seen from Figure 14 that Al Naser Apartment has a good neighbourhood design with a U shaped pattern and a good building design.

### **6.2.3 The Materials**

The score relating to the material is 20%, and indicates a “weak” valuation. It is noticed from Figure 15 that Arack City Residential villas utilised eco building material in construction, like recycled building materials, eco cement, eco building materials, earth stabilised bricks, etc.

### **6.2.4 The water supply**

The result of the water supply is 27%, signifying a “weak” value. We notice from Figure 17 that Residential Villas present a good solution in providing local water treatment station plant with highly efficiency. On the other hand, the other two sites provide poor solutions, with water being provided from the National Grid, which does not meet WHO standards for potable water. We need to increase the efficiency in water treatment, and we need to provide each neighborhood a local water treatment plant, and adopt such solutions as rain water harvesting, recycling of grey water for irrigation, etc.

### **6.2.5 The Waste Management**

The result of the waste management is 40, which indicates “pass”. It is noticed from Figure 17 that all the case studies followed the same solution in drainage system which consists of a well and septic tank. This is the best practice solution at present in Greater Khartoum. Other solutions as biological treatment and surface run off are not found.

### **6.2.6 Power Supply**

The result of the power supply is 20%, which is “weak”. It was found that Residential villas and Arack City used electrical generation room and underground cable, to avoid environmental hazards resulting from use of high tension cables. Other solutions like solar energy or wind energy are not found.



### 6.2.7 Emissions

The average result is 33.3%, “weak”. Compared to the result by LEED V3 for Neighborhoods Development, this result rates as “not certified”. It can be noticed from Figure (16) that Residential villa provides good solutions in the buildings in controlling the gaseous emissions, through the provision of fire alarm system, smoke detectors, low green gas emissions and solid waste management. Such solutions are good in designing Eco Neighborhood. Araak City as well as Al Naser Apartments also provide exhaust fans in Kitchen and Bathrooms.

### 6.2.8 Environmental Design Process

The environmental design process is 60% and is evaluated as good. It is noticed from Figure (20) that Al Naser Apartments presented a good solution in environmental design. We should apply the environmental design process from the initial stages at all levels:

1-pre building phase

2-building phase

3-post building phase

Refer to chapter six, Figure 6.7

### 6.2.9 Community Participation

By comparing the average result 27 with the scale, this result rates as **weak**. **Comparing the result by LEED V3 for Neighbourhood Development this result rates as not certified**. It could be noticed from Figure 21 that Al Naser Apartments, residential villas, Arak City, Provide the same level in community participation which includes investors and consultants and the government. We should engage all levels and partners who include architects, planners, engineers; suppliers and contractors, agents in order achieve sustainable development.

## 7. CONCLUSION

**Residential villas            39% Pass .**

**Arrak City                      29% Weak .**

**El Naser Apartments        59% Good .**

The research obtained different evaluations, of which El Naser apartments emerges as a good example on an ecological neighbourhood, with neighbourhood centre offering most of the services like sustainable site, care about safety procedures, a range of rising buildings with different solutions and variety in areas; these buildings have good ventilation and good

orientation and provide economic value as well. Arak city failed because they didn't adhere to building orientation codes, nor did they provide a complete range of services for everyday activities in the neighbourhood centre. The Residential Villas emerges weak in the results because there are 12 villas having inappropriate ventilation and orientation, along with a problem in the on-site drainage system. On the other hand, Residential Villa provides high safety, health, emission, telecommunication and services. Araak city offers good solutions for building design and services.

## **RECOMMENDATIONS**

1. This study recommends managing the sustainable site, waste disposal system, water supply system, power supply and emissions, applying the principles of sustainable eco neighbourhood assessment, to evaluate such neighbourhoods in a hot, dry climate.
2. Management of the power supply system, with adoption of renewable resources such as solar energy and wind energy, is recommended for managing the power shortage, vis-à-vis the National Grid.
3. The research recommends use of local building materials and recycling technologies in building construction.
4. The water supply system should be augmented and made more efficient through adoption of WHO standards in water treatment to meet WHO Standards.
5. For the drainage system, the research recommends adoption of solutions like biological treatment, recycling of grey water to be used for irrigation and application of drainage net.
6. The research recommends adopting such solutions as shaft and filters in the kitchen, fire alarm system, smoke detectors, etc. and the use of clean energy to minimize CO<sub>2</sub> emissions
7. Finally, we should apply an environmental design process right from the initial stage of the design.
8. The research recommends applying the principles of eco- neighbourhood to such areas in hot, dry climates (See the applied sheet).

### **i. Sustainable Site**

#### **Smart Location, Control systems**

Enhanced parking control, Reduced Automobile Dependence, Bicycle Network, walkable Streets, Pollution control in construction activities, noise prevention, controlling natural water feature, avoidance of Floodplains.

#### **Improvement of outdoor thermal environment**

- Heat Island effect, Enhancement of landscaping on site, Public Transport Access, Maximization of Open space,
- Universal Accessibility,
- Community Outreach and Involvement,
- Ecological Awareness.

## **ii. Neighborhood Design, Pattern and Construction**

### **Design**

Certified Green Buildings, Neighbourhood strategies, Affordable Rental Housing, Building Reuse and Adaptive Reuse, sustainable Historic Buildings, Minimization of Site Disturbance through Site Design, Site Orientation, Local Food Production.

### **Construction**

Construction Management, Minimization of Site Disturbance during Construction.

### **Neighborhood Pattern**

Diversity of Housing Types, Access to Active Public Spaces

### **Street Network**

Reduce car parking, walking streets, Cycle parking, Transportation Demand Management

### **Ecological footprint**

Local Food Production, independent food stores, Reduce food waste, Eco-scape (ecological-landscape)

## **iii. Materials and Resources**

Recycled Content for Infrastructure, Eco Building Materials used for construction, Eco Concrete, eco recycled building materials, enhancement of proper technologies in building materials industries.

## **iv. Waste management system**

Ecological sanitation, Surface run off, Recycling of grey water, on- site Sewage Treatment: Septic Tank System, Solid waste classification and recycling.

## **v. Water supply system:**

Efficient water supply system, conservation of rainwater, recycling of grey water, conservation of water consumption.

## **Vi Power supply**

From the National Grid, Site electrical Station, Underground cable, generation of Solar energy, Solar energy heating system, solar energy cooling system, solar boiling, solar cooking, wind energy, availability of outdoor solar lighting, efficiency of Infrastructure Energy.

**vii Environmental plan Process**

Enhance environmental design process.

**viii Safety and Emissions Systems:**

Land, fire alarm system, security, smoke detectors, Low greenhouse emissions, solid waste management, waste recycling.

**IX. Community Participation**

In applying eco neighbourhood principles, we should involve: the Government sector, Investors, Developers, Agents, Project Managers, Architects, Planners, Contractors, Suppliers, Owners and Users, to make sustainable development a broad-based, people-based initiative.

**X. The Environmentally Sustainable checklist and the certified:**

From the case studies and the analyses, the researcher has arrived at the results of this research and come out with measures suitable for Sudanese environment and its prevailing conditions.

**< 35 weak:**

**(35 - 44 pts) pass.**

**(45 – 59) pts (Best Practice) (good).**

**(60 - 75 pts) (Very good). (76-111pts and more) (Excellent)**

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## **Appendices**



## On The Level Of Eco Neighbourhood Case Study-1 The Residential villas and villa type-B

**38%=PASS**

**Site Location:**

The compound located in east Khartoum centre in Garden City area, on the west bank of the Blue Nile river, 2.5 km North-east of Khartoum International Air Port  
To select the site, the challenge was to comply with the following conditions:  
Near Khartoum Air port  
To be built in a quiet area  
To prevent the noise as far as possible  
To be near the republication Palace

**Hotel Service Classification:** 5 Stars.

**Infrastructure:**  
40 Separated Villas Each Villa consists of  
One suite.  
5 Rooms.  
Main lobby.  
Family lobby.  
Kitchen.  
Roof.

Presidential Restaurant.  
Presidential Hall.  
Conference Room.  
Health Club.  
Swimming Pool.  
Tennis court.  
Party area.  
Gardens.  
TV Stations: 40 Channels.  
Business Centre.  
Wireless Internet Access.

**The landscaping:**

The site is provided with a large number of different types of vegetations and plants: some are flowers and small are plants; others are large trees . the architect used the trees to classify the site used area and to give the site some privacy

**The public space:**

This is the area in the middle and it includes the administration, restaurant services, the conference hall, the



PI.(4.2.121) South Elevation



PI.(4.2.122) North elevation



PI.(4.2.123) Fumes chaff











PI.(4.2.124) sensors



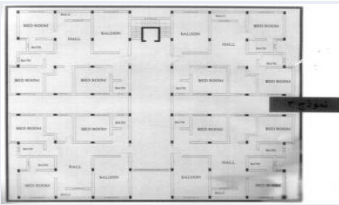

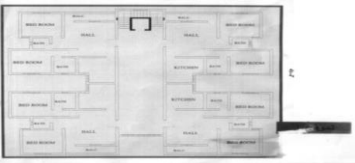

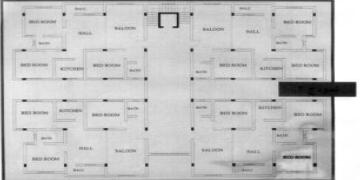



**Case Study-2**  
**The Araak City**  
**and villa**  
**type-D**

29%=WEAK

<p><b>The Location</b></p> <p>The city is distinctively located in south east khartoum, within the suburbs of capital, off the junction of Sixty Street and Wad Medani Road (main highway linking Khartoum and the major cities). The centre of Khartoum is easily accessible with the airport only 4km away Araak City is made up of five residential districts spanning an area over 200,000m2 with 510 villas and 420 apartments of different styles and sizes. An area of 15,000m2 is allocated as a park that</p>  <p>Pl.(4.2.125) site location</p>  <p>Pl(4.2.129): Type –D location in Araak</p>	<p><b>Services</b></p> <p>Araak City is clearly identified by its green areas, well-furnished roads and ready infrastructure. It has been constructed in a manner to ensure that the services foster a healthy lifestyle with families in mind. They include state-of-the-art leisure facilities, a shopping area and children’s playground. Araak City’s modern utilities include:</p> <ul style="list-style-type: none"> <li>Independent Water Network</li> <li>Independent Electrical Network</li> <li>Telephone Network</li> <li>Irrigation Network</li> <li>Sewage System (well+septic tank)</li> <li>Private Parks</li> <li>Well-lit asphalt roads</li> <li>Planted pavements</li> <li>Sidewalks</li> <li>Araak club</li> </ul>  <p>Pl.(4.2.126): Araak city</p>  <p>Pl.(4.2.130): The Main Elevation,</p>	<p><b>Specifications:</b></p> <p>The villa plans were carefully designed to provide a functional, yet comfortable home catering to the needs of each member of your family. Different villa layouts and different villa sizes ensure that you’ll find your perfect home. Only the highest quality materials were used in the construction and finishing of the villas to guarantee, only the finest standards. Some of the many unique characteristics and beautiful finishing touches of the villas:</p> <ul style="list-style-type: none"> <li>Highest Quality Marble floors for all halls, kitchens, staircases.</li> <li>Security Front Doors with beautiful wooden architraves</li> </ul>  <p>Pl.(4.2.127): The outdoor garden</p>  <p>Pl.(4.2.131): Villa Type-D Ground Floor Plan</p>	<ul style="list-style-type: none"> <li>Elegant Cornices line the interior walls.</li> <li>Complete fully fitted Kitchen with cooker and refrigerator.</li> <li>Split Unit Air Conditioners in all Halls and Bedrooms.</li> <li>Fully Fitted Bathrooms installed with Water Heaters.</li> <li>Private Front Yard or Back Garden.</li> <li>Separate Housekeeper Living Quarters.</li> <li>Parking Garage.</li> </ul>  <p>Pl.(4.2.128): villa type B</p>  <p>Pl.(4.2.132): Villa Type-D First Floor Plan</p>
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Case Study-3 The Al Naser Apartments complex			51%=GOOD
<p><b>The site Location:</b> Elnasr Apartments complex are located west Afra Commercial Center, south 61 street , north, east Sudatel club east national park in Khartoum city. It's about five kilometer from city centre, two kilometer from Khartoum International Airport. It contain 28 buildings, and five different types, Type one 120m2, type two 145m2, type three 168m2 and the duplex 240 m<sup>2</sup>.</p>	<p><b>Areas:</b> Site area=72000m2 Total Build up area =18500m2 Open spaces(parking area + green areas)=53500m2 Open spaces=42% Build up area ratio=25% Number of buildings=35 buildings Number of flats about 1000 flats</p>	<p><b>Services</b> Apartments Parking area Green areas Super markets Girls Primary school Boys primary school Mosque Kindergarten Clinic</p> <p><b>Negative points:</b> There is no fire escape staircase .for each building There is no shoot for waste in each buildings Less green areas Less plantation There is no grey water treatment and recycling for plantation</p>	<p>There is no natural resources power supply system The re is only semi private and public open space , the company should add a private green terrace to each flats The re is no fire alarm system for each floor The super market should be at the centre of the site.</p> <p><b>Positive points:</b> Site security Complete services Good parking area The good evaluation of this site in comparison by other two sites The good cross ventilation and orientations for all types The re is a main electrical station inside the site A good u -shape cluster it and provides a privacy to each zone</p>
	 <p><b>Lower Floor</b> 1- BEDROOM BEDROOM - 4.50x4.00 m 2- BALCONY - 3.00x1.40 m 3- CORRIDOR - 4.00x2.00 m 4- LOBBY - 2.00x1.10 m 5- KITCHEN - 4.00x4.00 m 6- BATHROOM - 2.50x2.00 m 7- STAIRS - 3.50x1.25 m 8- BALCONY - 3.00x1.40 m</p>		 <p>1- MASTER BEDROOM - 4.50x4.00 m 2- BEDROOM - 4.00x3.00 m 3- BALCONY - 3.00x1.40 m 4- HALL - 6.00x4.00 m 5- LOBBY - 3.00x1.50 m 6- KITCHEN - 4.00x2.00 m 7- LOBBY - 2.50x1.50 m 8- BATHROOM - 2.50x2.00 m 9- BATHROOM - 2.00x2.00 m 10- BATHROOM - 2.50x2.00 m 11- BATHROOM - 2.00x2.00 m 12- BALCONY - 1.80x4.00 m</p>
<p><b>Pl.(4.2.133): Elnasr Apartments Site Plan</b></p>	<p><b>Pl.(4.2.134): The ground floor plan of type-4(Duplex), 240m<sup>2</sup></b></p>	<p><b>Pl.(4.2.135): The plan of type-3, 168m<sup>2</sup></b></p>	<p><b>Pl.(4.2.136): The plan of type-3, 168m<sup>2</sup></b></p>
	 <p>1- MASTER BEDROOM - 4.00x4.00 m 2- BEDROOM - 4.00x3.00 m 3- BALCONY - 3.00x1.40 m 4- HALL - 6.00x4.00 m 5- LOBBY - 2.00x1.10 m 6- KITCHEN - 4.00x4.00 m 7- BATHROOM - 2.50x2.00 m 8- BATHROOM - 2.00x2.00 m 9- BALCONY - 3.00x1.40 m</p>		 <p>1- MASTER BEDROOM - 4.00x4.00 m 2- BEDROOM - 4.00x3.00 m 3- BALCONY - 3.00x1.40 m 4- HALL - 6.00x4.00 m 5- LOBBY - 2.00x1.10 m 6- KITCHEN - 4.00x4.00 m 7- BATHROOM - 2.50x2.00 m 8- BATHROOM - 2.00x2.00 m 9- BALCONY - 3.00x1.40 m</p>
<p><b>Pl.(4.2.137): The plan of type-1, 120m<sup>2</sup></b></p>	<p><b>Pl.(4.2.138): The plan of type-1, 120m<sup>2</sup></b></p>	<p><b>Pl.(4.2.139): The plan of type-2, 144m<sup>2</sup></b></p>	<p><b>Pl.(4.2.140): The plan of type-2, 144m<sup>2</sup></b></p>

