ISSN No:-2456-2165

Promoting Social Economic Sustainability through Agriculture-Integrated Housing Design

(A Case Study in Khartoum, Sudan)

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Abstract:- This paper presents a case study of a housing design project aimed at promoting social and economic sustainability in Khartoum, Sudan. The project involved the construction of a residential complex consisting of individual houses, each with an agricultural yard. The integration of agriculture into the design of the housing complex was intended to increase food security, provide residents with a source of income, and promote sustainable practices and a sense of community. to achieve the objective of this research qualitative methods, include the wide survey of related literature and collect existing data about the soil structure of Khartoum city while quantitative methods include BIM architectural design using Revit software for both 2d and 3d design has been conducted This article describes the design and implementation of the project, as well as its impact on social and economic sustainability in the local community. The data collection was conducted by an observational study of the housing complex and surrounding area. The results suggest that the integration of agriculture into housing design positively impacts both social and economic sustainability and environmental aspects and provides insights for future housing development projects in similar contexts.

Keywords:- *Social economic sustainability, Food security, Agriculture household, Urban farming.*

I. INTRODUCTION

Climate change could have a variety of effects on the agriculture sector, ranging from direct impacts on crop production (e.g., differences in rainfall can Couse flooding or drought, cooler or warmer temperatures leading to changes in the growing period length) to changes in economies food costs, as well as infrastructure for supply chains. Climate change's proportional importance for food security varies by area. In southern Africa, for example, the climate is one of the most recognized sources of food insecurity since it operates as both an underlying, persistent issue and a short-term shock. Because of the inadequate capacity to deal with bumps minimize long-term pressures, coping methods that may be available in different parts of the country are unavailable or unsuitable in this region. However, other areas, such as other variables impacting food security, such as labor difficulties and the quantity and quality of groundwater for irrigation in sections of India's Indo-Gangetic Plain, rank higher than direct consequences of climate change [1].

According to the document that produced by FAO, United Nations to determine the food security state in the world the 2015 international hunger targets, about, 795 million people are undernourished globally a decrease of 167 million over the previous ten years and a decrease of 216 million from 1990 to 1992. In underdeveloped countries, the drop is more dramatic. despite significant population growth. In recent years, the development has witnessed slower and less inclusive economic growth like political instability in some developing counties, such as Central Africa and Western Asia [2].

Many components can significantly impact food security, such as global trade, socioeconomic and urbanization, technological development, and agricultural land use. Climate change is among the multiple factors that can provoke changes in the nature and occurrence of food safety hazards. These dangers can occur at any time throughout the food chain, from basic production to consumption, and climate change may, directly and indirectly, impact their occurrence [3].

The soil in Sudan Khartoum is very fertile. It is high in organic content and nutrients, and it holds a lot of water. This makes it ideal for growing a variety of crops, including sorghum, millet, cotton, and peanut, and because of the low income of most Sudanese people, the agriculture development must be supported in order to achieve economic sustainability Under where gardens contribute only 30% to the gardeners' subsistence needs but it is considered as a good income which provides too many needs increasing the agrobiodiversity of the gardens may help to strengthen the role of UPA in Khartoum and also achieving the food security for the owners (farmer) and thus increase small farmers' ability to confront changes of food prices and possible climate change impacts [4] Moreover, this project has the impact of a significant benefit on social sustainability by gathering in public parks and also on the environmental aspect to decrease carbon dioxide and proving fresh air and a healthy lifestyle.

A. Supporting Social Economic Sustainability Through Agriculture

In the twenty-first century, there is still misunderstanding and disinformation regarding the environment and the gravity of the environmental issues that exist. Economic expansion encourages the unsustainable use of non-renewable resources, necessitating actions to promote biodiversity, reduce carbon dioxide concentrations in the atmosphere, and prevent ocean acidification. Despite the fact that economic expansion has improved the living standards of billions of people, globalization is producing significant

environmental catastrophes, contributing to the depletion of nature and its natural resources [5].

Consumers' attitudes toward environmentally friendly activities and actions that take the environment into account in terms of eating habits, requirements, and interests have steadily changed as a result of environmental concerns. Efforts are also being undertaken to mitigate the harmful environmental impact of human activities.[6] It is critical to study and identify the stages of the food production process that produce environmental consequences for future decision-making and the deployment of measures for controlling and reducing them [7] To create sustainable development a reality and to make sure of hygienic-sanitary standards for meals, it is also necessary to establish measures aimed at limiting energy and water consumption, as well as training and monitoring those involved in the production process.

Economic sustainability in agriculture focuses on the economic performance and viability of farming. In commercial economies, farms which are unable to generate sufficient profits, because of low farm product prices, reduced yield, higher cost of production, or whatever reason, are not self-sustaining. As a result, economic returns sufficient to effectively compensate farmers and hence continue operations are required for agricultural sustainability [8].

Sustainable agriculture combines sound husbandry's social, economic, and environmental components into a united package [9], A focus on one dimension at the expense of others may be risky. For example, agricultural production systems that maintain environmental quality but can neither produce an adequate food supply nor provide sufficient economic rewards to producers cannot be regarded as sustainable. Similarly, agricultural systems that maintain relatively high levels of production but employ increasing amounts of inputs to offset the yield-reducing impacts of environmental degradation would be viewed as less 2-2 The Potential for Increasing Agricultural Productivity and Agriculture's Role in Sustainability [10]-[11]-[12].

B. Agricultural Crops in Khartoum, Sudan

Soil is a human most significant and crucial natural resource, yet it cannot be renewed in the near future. It is the unorganized mineral on the topmost layer of the land that has been exposed to and exhibits the impacts of genetic and environmental influences. It is a medium through which organisms obtain nutrients for growth and development, which in turn acts as a way of meeting human requirements for food and clothes. [13] Green manure is a type of cover crop grown for plowing its whole mass into the soil as a fertilizer Before it begins to bloom, it incorporates minerals and organic matter into the soil, boosting fertility. It can be grown as a primary or secondary crop. Any type of plant is acceptable for green manure provided it produces substantial amounts of fresh biomass under the specified environmental and soil conditions and the planting seeds are reasonably priced. The collection of data from gardens involved a survey of all crops and their following classification into various use categories: fruits, vegetables, spices and condiments, cereals, and fodder.[14]. Non-crop plants were also classified into the use groups: weeds fence species, trees, and range plants. Khartoum's soil is classified as vertosol, which is known for its high clay content and good water-holding capacity. This soil type is suitable for growing a variety of crops that can thrive in a semi-arid environment.

The types of crops that can be grown in Khartoum's soil depend on factors such as climate, soil conditions, and water availability. However, with proficient management and planning, residents can utilize their agricultural yards to provide a source of food and income while contributing to a more sustainable community [15]-[16].

Some of the local agricultural crops (figure 1,2) that residents can consider growing in their agricultural yards in Khartoum include Sorghum: This drought-tolerant crop is well-suited to Khartoum's semi-arid climate and soil conditions. It is a main food crop in Sudan and may be used to make porridge, bread, and beer, among other things.

- Millet: Like sorghum, millet is a drought-tolerant crop that can be grown in Khartoum's soil conditions. It is also a staple food crop in Sudan and is used to make porridge and bread.
- Vegetables: Various vegetables can be grown in Khartoum's soil, including tomatoes, eggplants, okra, and green beans. These crops can provide a source of fresh produce for residents and can be sold in local markets for additional income.
- Fruits: Some fruits which can be grown in Khartoum's soil include watermelon, dates, and citrus fruits. These crops can also provide a source of revenue for residents through local sales.

According [17], Covers the composition of the crop composition in Khartoum's urban agricultural area for all modeled years, using the results of Khartoum State's 2007 agricultural survey (Ministry of Agriculture, 2007). Thompson in 2008 discovered that UA layouts in Khartoum's core are commercially focused, with an average size of 1-2.3 hectares. essentially Although older satellite images show some bigger fields and a few large-scale farms, the findings from the survey for Khartoum State offer the best approximation of the urban cropping pattern given the lack of data on farming operations within the city's boundaries [18],

During the summer and winter, the most frequent crops, vegetables, spices, and fruits in the entire agricultural area. Taking into account the amount that was not provided as crop-specific data (such as 'other veggies') for each of these groupings. and estimating the crop water needs for each crop group in the farm yard. In any given year, the total of these group requirements for water matched the overall water consumption of the entire yard.

To account for probable water losses during transport to the farm and water supply, reduce the total crop water require by an established estimate of agricultural yard Water Use Efficiency [18]. This estimate of 0.56 makes no distinction between seasons. The average yearly rainfall in

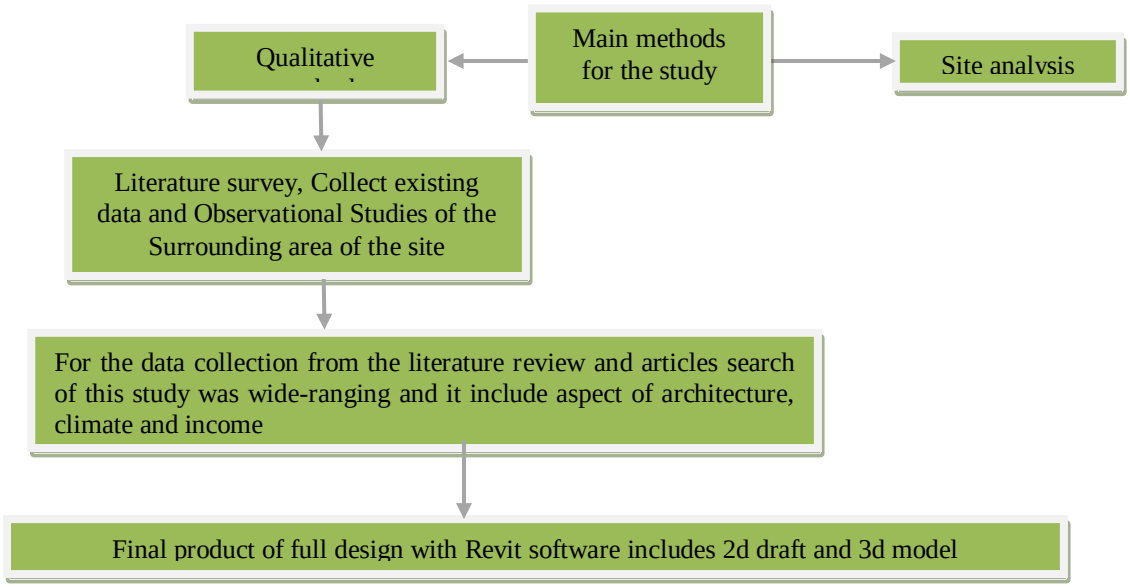
ISSN No:-2456-2165

Khartoum is 164 mm [19] and it is largely limited to the months of July, August, and September. [20] While evaporated water is at its greatest. Between March and October fall and winter;[21] there is rarely any precipitation. contribution to achieving agricultural water requirements is therefore minimal.

Based on Khartoum State's crop inventory, The city's modeled monthly need for water is maximum in November and December, on the other hand, its irrigation water needs are minimum in May and June when summer crops are newly planted and the area under growing is reduced to roughly 81% of the winter cropping area in response to extreme weather and low Nile water levels. Because cropping practices were assumed to remain consistent over all simulated years, [22] and the irrigation system was considered to remain the same, was probably similar overall years. However, when the conclusions from 1958 are compared with the other findings, the general water consumption has increased by an average of 4.8 million m3 year1. Between 1972 and now, Khartoum's crop-irrigation water consumption increased by 50%, or 3.9 million m3 year1, rising from 241 to 365 million m3 year [23].

Fig. 1: Corn -Source: United Nations (2016)

Fig. 2: Cotton -Source: USAID. gov-Sudan (2017)



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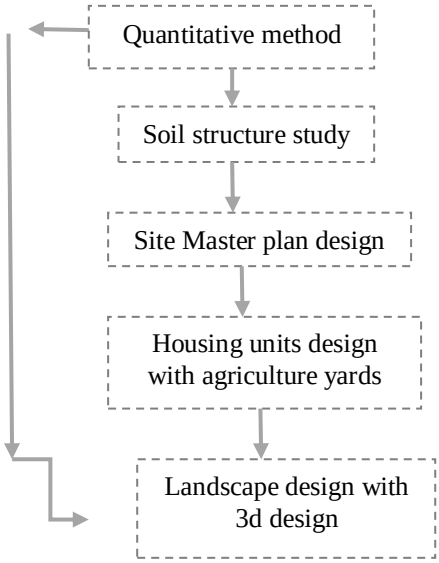
II. MATERIALS AND METHODS

To achieve the objective of this research both qualitative and quantitative methods have been conducted (table 1), the qualitative approach was through a wide survey of literature reviews, collecting data through Observational Studies of the surrounding area of the study area, while the quantitative approach involved two dimensions design with the model set up, recommend a unit and master plan design flows with model and views using Revit software to get the results and future recommendations.

A. Khartoum, Sudan as Study Area

Sudan is located in north-eastern Africa (figure 3), bounded to the north by Egypt, to the east by Ethiopia, to the south by-South Sudan, and to the west by Chad according to Central Intelligence Agency, 2021. Sudan has a varied climate that ranges from dry in the north and southern tropical, and it is rich in natural resources, for example, natural gas, crude oil, and minerals such as both iron and gold metal, Khartoum is Sudan's capital city, located the confluence of the Blue and White Niles. It is the country's political, cultural, and economic hub, with a population of around 5 million people (Central Bureau of Statistics, 2008). Khartoum is located in a scorching desert environment. with Temperatures fluctuating between 27°C (81°F) in January to 41°C (106°F) in June (World Weather, 2021).

Table 1: The process of the methodology of this study (drawn by the author



In dry weather, Internal heat gain design solutions make it easier to obtain thermal comfort for buildings; internal heat gain contributes roughly 0.2% (5 h) to enhance thermal comfort. Without any design techniques, Khartoum's rainy season has the least thermal convenience. Compared to the other months, thermal comfort criteria only met 0.9% of the years' time (33 hours).

Sudan's structure of the soil is intricate, with a wide range of soil types found throughout the nation. Sudan's soils, in general, have low organic matter structure, poor nutrient levels, and high alkalinity, which might restrict their viability for cultivation. [24], Nevertheless, with proper supervision and irrigation, many parts of Sudan are suitable for agriculture., especially in the country's central and western regions [25]. Agriculture is an essential part of the Sudanese economy, which accounts for over 30% of the country's GDP and employs more than 80% of the workforce (World Bank, 2021). Sorghum, cotton, millet, wheat, sesame, and other fruits and vegetables are the most widely grown crops in Sudan [26]. However, despite its importance, Sudan's agricultural industry confronts a number of obstacles, including limited access to modern inputs and equipment, inadequate infrastructure, and the consequences of climate change [27].

Fig. 3: Sudan Map - Source: BBC (2023)

ISSN No:-2456-2165

B. Site location

The suggested site lies in north Khartoum (figure 4,5), the site is surrounded by mostly Residential areas with low rise Buildings, and most of all surrounding land is Agricultural land because of the Soil structure and its proximity to Al emerged Beach to facilitate the irrigation Process,

Coordinates: Longitude: 15.730466, Latitude: 32.560301
Topography: Flat with no obvious contour lines.
Accessibility: the site is attached to the main road
Site Area: 12.500 square meters
Orientation: north-south

Fig. 4: site location (google map)

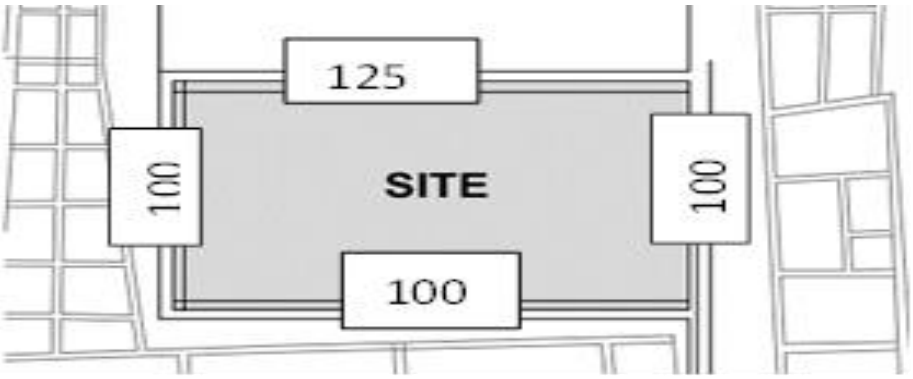
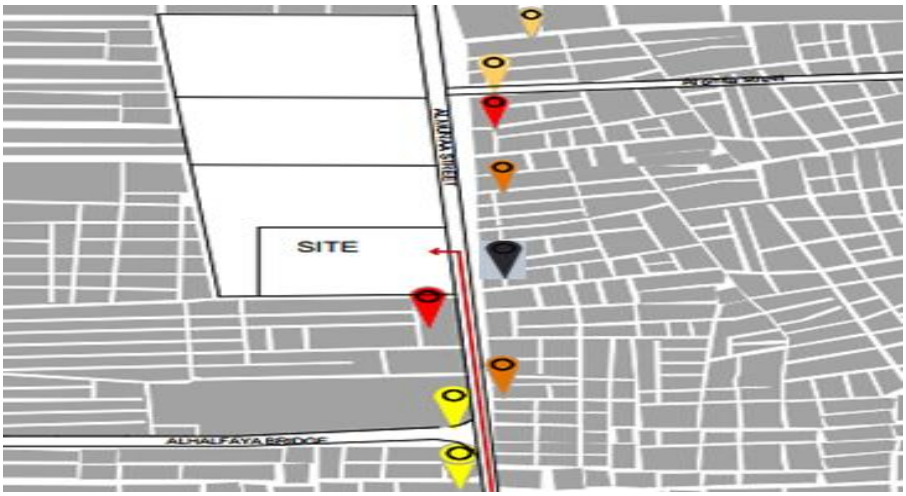


Fig. 5: Site dimensions (drawn by author)

C. Surrounded services of the site



(A)

(B)

Fig. 6: Site surroundings (drawn by author)

D. Distance of facilities from the site

Table 2: facilities from the site (by author)

Facility Name	Distance from the site (km)	Time by car(minutes)
Alrayhan hospital	1.8 km	4 min
Primary school	3.2 km	9 min
Alzakiab power station	1.0 km	3 min
Alezergab beach	4.3km	9 min
Ceaser restaurant	1.9 km	5 min
Alzakiyab playground	0.15 km	1 min
mosque	4.9 km	4 min

The site was selected especially for the distance to the Nile 2.6 km which provides the water supply directly (figure 7)

Fig. 7: Site distance to river Nile (google Maps)

III. RESULTS

A. Recommended site master plan (figure 9,10) instead of the original Sudanese neighborhood (Figure 8)

Fig. 8: Original Sudanese neighborhood -SOURCE: (Michael Runkle, Sudan / Almay Photo)

ISSN No:-2456-2165

Recommended master plan as a productive nationhood with green public areas

Fig. 9: master plan (drawn by author)

- The cluster includes 25 housing units each unit with a separate Agriculture yard to achieve the economic sustainability goal
- Creating a commercial market facing the main road and beside the bus station
- Designing interior roads 6 meters wide and parking zone
- Plot oriented north-south for best natural ventilation and airflow
- Providing a central green area and park for socializing to achieve the social sustainability goal.

Fig. 10: master plan (drawn by author)

Table 3: General information about Cluster design (by author):

Number of houses =25 houses	The number of users = 110 people. (Average of 5 users per 1 unit)
Number of open spaces =2 public green areas	Number of guest parking = 12

B. Housing units' design (figure 11)

This design approach combines residential living with agricultural elements, allowing homeowners to have a functional and productive outdoor space. the agricultural yard is easily accessible and seamlessly integrated into the overall design. Cluster zoning take have a cross ventilation and a strong connection to the Natural environment within the Open spaces and designing back yard for agricultural space to Improve income and achieve Self-sufficiency. Recommended ground floor plan (figure 12) and first-floor plan (figure 13) and building section (figure 14)

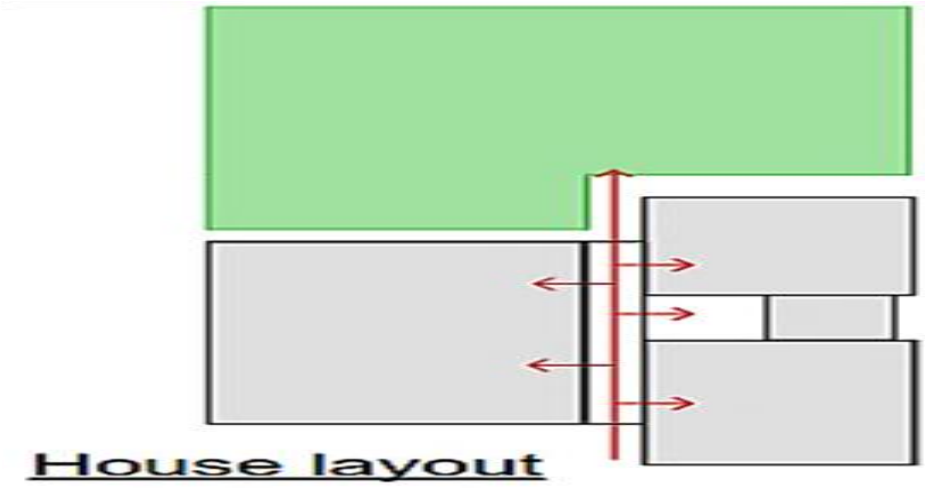


Fig. 11: house layout (Drawn by author)

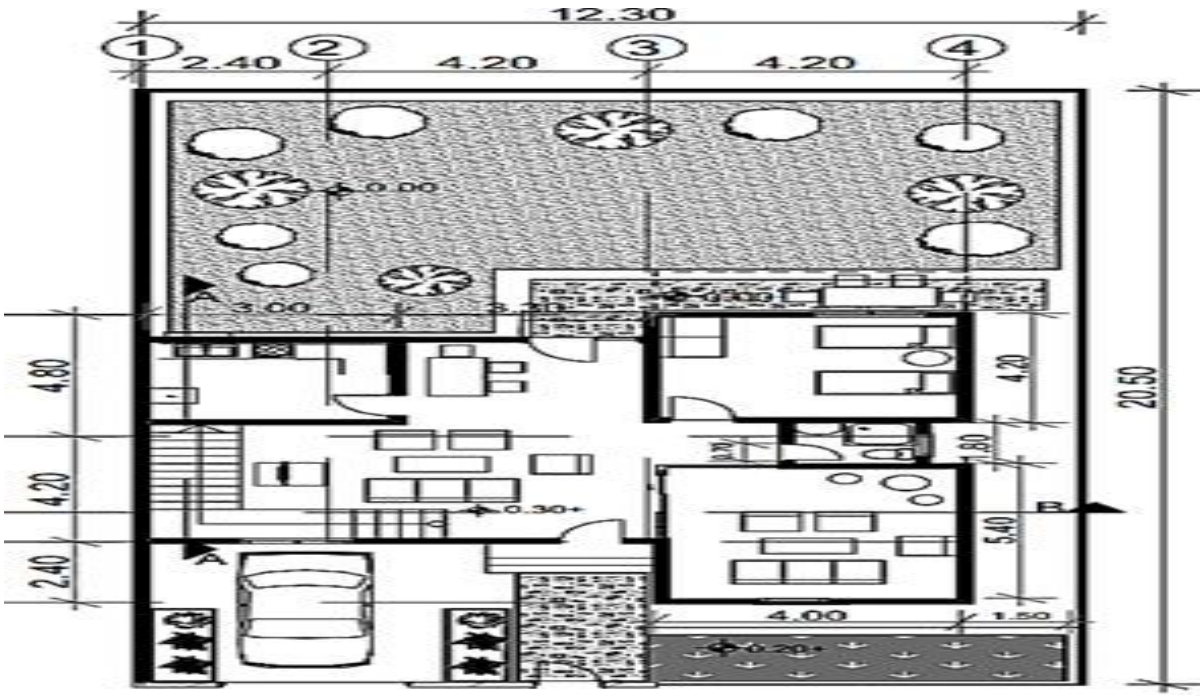


Fig. 12: Ground floor plan (drawn by author)

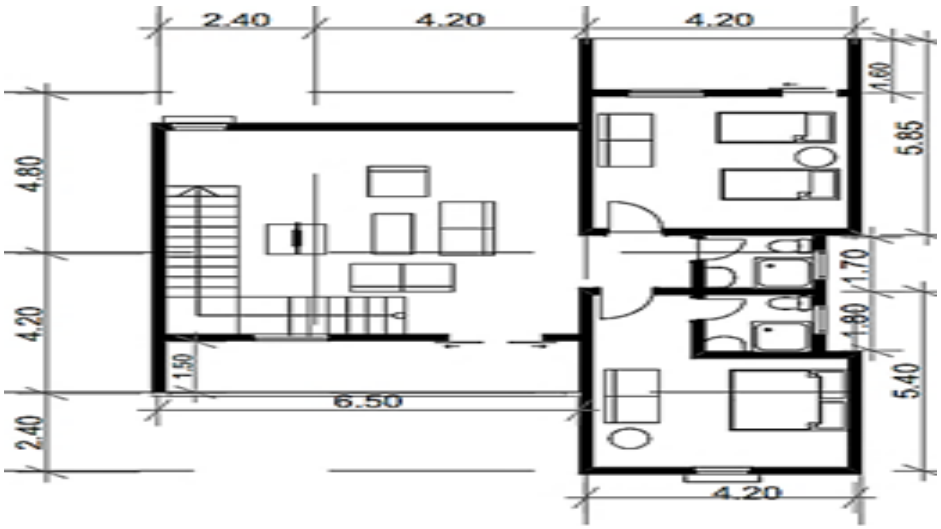


Fig. 13: first-floor plan (drawn by author)

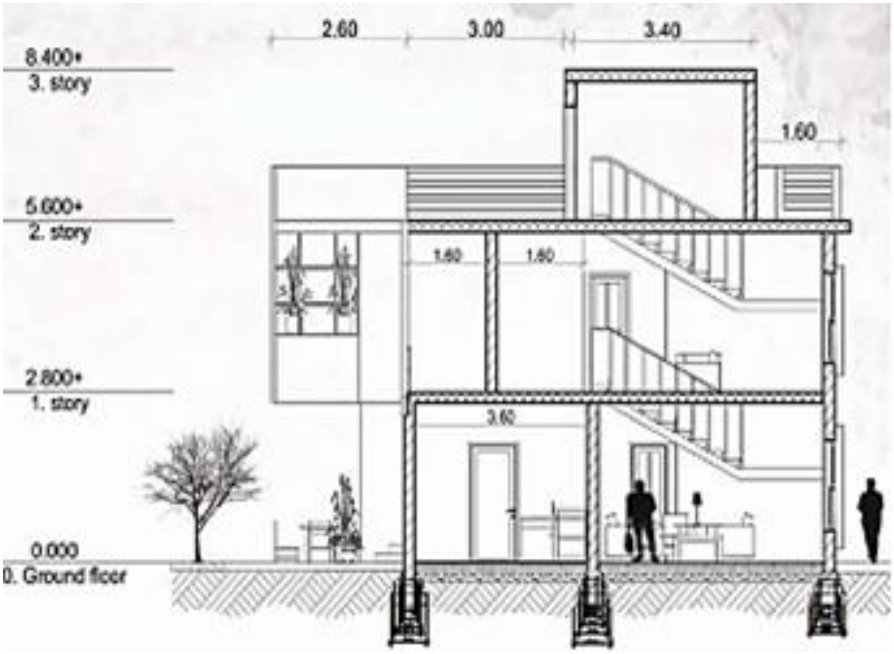


Fig. 14: Building section (drawn by author)

Table 4: General information about single-family building

s/n	Building information	description
1	Project	Agriculture households
2	Type	Single-family house
3	Number of rooms	3 bedrooms
4	Site area	295 m2
5	Built up area	100 m2
6	Agriculture area	100 m2
7	Number of floors	2 floors
8	Level above ground	1 meter
9	Walls types	Load bearing and partitions
10	Climate region	Hot-arid climate
11	Orientation	North-south
12	Orientation of openings	North -south-east-west
13	Window material	PVC
14	Door's materials	Wood
15	AC system	Spilt unit
16	Shading devices	Cantilevers and louver

C. 2D elevations of the single-family building:

The elevations (figure 15,16,17) are designed in a contemporary, minimalist style, incorporating wooden hand grills the balconies and cantilevered balconies as effective shading devices. The walls are finished with a combination of painting and plastering, while the outdoor areas feature metal doors for the garage.

Fig. 15: south elevation (drawn by author)

Fig. 16: north elevation (drawn by author)

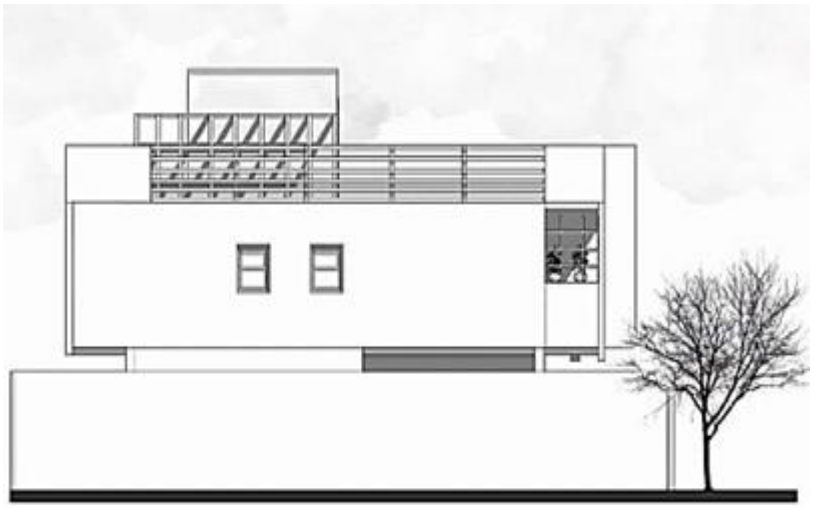


Fig. 17: East elevation (drawn by author)

D. (3D) Views for The Architectural Design:

3d modeling was created with Revit software to explain the idea of the project and to have a realistic simulation including the exterior, interior, and landscaping elements. (All figures presented are designed by the author) Moreover, 3D modeling aids in integrating the agricultural yard into the overall, 3D modeling aids in making informed design choices that maximize sustainability and minimize the environmental impact of the house and the agricultural yard. Overall, the design took a modern simple style and the exterior finishing of the wall's material is painting and plaster to minimize the cost

Fig. 18: (3D) Views for The Architectural Design

IV. DISCUSSION

The specific application and effects of Agricultural Transformation Agendas differ and are often molded by each country's unique circumstances and goals. These agendas are frequently formed through collaboration among government institutions, development groups, private sector entities, and civil society organizations, with the goal of encouraging sustainable agricultural development and rural development. The ATA's The goal was to achieve security in terms of nutrition and food, generate employment, and convert the country into a key player in the international food markets, while also growing wealth for millions of farmers. Following this viewpoint, the policy objective was to restart the clock' by introducing a business-like approach to agriculture (led by firms) [28]

According to [29], The farming households modeling method is critical. The combination between consumption and production choice through farm income is particularly significant. It will typically be essential to account for the effect on the demand because modern household consumption changes follow the economic developments, as demonstrated by Senegal research, which can have major implications for a variety of outcomes, that study also emphasizes the benefits of shifting to general equilibrium analysis since it better captures varied production and consumption substitution options. However, more household-level research is required to increase knowledge of the decision-making process and broaden the basic model to include additional sorts of decisions, to achieve the goal of creating housing and feeding project through Integrated land-use options due to the growing population in order to lower environmental effects than is the norm for greenfield development. [30], Abandoning agricultural yards is the most important challenge the agricultural and rural aspects are faced with. These different cases in the last years have had several environmental social, and economic effects, and their management has been one of the important issues that policymakers and decision-makers are faced with. [31], The cultivar's productivity is an important factor in terms of the ultimate results attained. Attention must be devoted to the cultivation timing, with the goal of minimizing crop damage and applying appropriate farming practices. This study can be valuable for farms looking to optimize and turn their marginal space, which is now untouched or underutilized, into new regions of productivity. This feature has an opportunity to boost the local economy by reintroducing earlier abandoned agriculture. [32]-[33].

V. CONCLUSION

The project promotes social sustainability by fostering a strong sense of community, a strategic approach lies in the design of central public green areas for socializing, diverging from the prevailing pattern in Sudanese neighborhoods characterized by horizontal expansion and an unfortunate scarcity of green spaces. Moreover, developing a comprehensive system that effectively enhances the overall quality of life, and the city’s urban landscape offers tangible improvements and sustainable advancements, Supporting the low-income segments of society through establishing a productive housing complex, incorporating individual agricultural projects for each family. to achieve food self-sufficiency by enabling families to cultivate crops and subsequently sell them in the market, thereby augmenting their income levels, however, agriculture development and promotion of small farmers to establish this type of project will have a significant impact on the economic future of the country by increasing the market development and exporting the crops, moreover, Agricultural housing promotes Sustainable Land Use as one of the environmental sustainability aspects and mitigates climate change by enabling local food production, resource efficiency, waste reduction, ecosystem preservation, and community education., reduces carbon emissions from food transportation, and encourages sustainable practices for a more sustainable and climate-friendly living environment.

VI. LIMITATION AND FUTURE WORK FOR THIS RESEARCH

The widespread adoption and replication of the design concept may face obstacles due to funding and construction costs, which present significant challenges. Adequate infrastructure for the land is a crucial prerequisite for the successful implementation of agriculture-integrated housing design. Moreover, approval and acceptance of such designs are influenced by cultural norms, traditions, and social perceptions concerning agriculture and housing practices. Overcoming these cultural barriers requires proactive measures to ensure community engagement, acceptance, and participation. Additionally, existing regulations and policies related to housing, agriculture, and land use may lack support or adaptability for the implementation of agriculture-integrated housing design concepts, necessitating a careful evaluation and potential modification of these frameworks.

The successful execution of a project requires a comprehensive estimation process to determine the construction costs involved throughout the planning and implementation phases. In order to enhance the project's infrastructure, the implementation of intelligent water management and precipitation systems plays a crucial role. These systems contribute to efficient resource utilization and sustainable water practices. Furthermore, the architectural framework should integrate renewable energy sources to create an environmentally sustainable community. This approach not only aims to reduce electricity consumption but also promotes the conservation of power, aligning with the project's overall objectives. In addition, It is critical to examine the economic impact of agricultural households on the market and the country as a whole. This includes assessing the monetary returns achieved by farmers through the sale of their crops, as it has significant implications for the agricultural sector and the overall economy.

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