





Urban Planning of Desert Human Settlements in Iraq

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ABSTRACT

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The research aims to demonstrate indicators of sustainable urban development in the desert city of Iraq and to present a sustainable urban model and policies for the city of Al-Nukhayb. The research relied on the descriptive, functional and analytical approaches, in addition to the field study, as 233 questionnaire forms were used and distributed to a random sample of the city's residents, i.e., 42% of the size of the studied community, with a confidence level of 95% and an error rate of 5%, during 15-25 May 2024. The research results showed that the per capita share of all urban land uses in the city of Al-Nukhayb is higher than the local planning standard, due to the small population of the city, which reached 2414 people in 2023 AD, and thus it is within the standards of small cities. The best alternative for sustainable urban development is the Desert Rose City with multiple uses, which is shaped like a rose in the desert, which helps it reduce electricity consumption, and depends on renewable energy that it will produce itself. The city also includes its own facility for recycling waste, similar to the sustainable city in the Al-Ruwayyah area in the Emirate of Dubai in the United Arab Emirates. The city also achieves functional efficiency for community services (health, education, entertainment) according to the survey standard and population number, with low functional efficiency for health and education services compared to other standards.

1. INTRODUCTION

Sustainable urban development is a vital and effective field that contributes fundamentally to meeting the needs of city residents, both now and in the future. Alternatives (models) will be developed using the Delphi comparison method, along with a set of sustainable policies for the city of Al-Nukhayb in Anbar Governorate, Iraq, with the aim of creating a sustainable urban environment that reduces the negative environmental impacts generated by cities and meets present and future needs.

1.1 Research problem

The city of Al-Nukhayb suffers from multiple urban development problems. These problems can be summarized in the following questions:

- 1) What is the reality of sustainable urban development in the city of Al-Nukhayb?
- 2) Is there a possibility of achieving sustainable urban development in the city of Al-Nukhayb?

1.2 Research hypothesis

H1: *There is a clear disparity in sustainable urban development indicators in the city of Al-Nukhayb.*

H2: *There is a possibility of achieving sustainable urban development in the city of Al-Nukhayb.*

1.3 Research objective

- 1) To identify sustainable urban development indicators in the city of Al-Nukhayb.
- 2) To present a sustainable urban model for the city of Al-Nukhayb.

2. LITERATURE REVIEW

Preparing desert cities according to the dimensions of sustainable development - the new city of Hassi Messaoud, Algeria, as a model [1].

The research aimed to shed light on the relationship between desert cities and sustainability. It concluded that the city represents a model that achieves integration between sustainable development and the desert environment, embodied through the urban structure and the attempt to invest in the natural environment without depletion or pollution, with a recommendation to invest in clean energy (wind and solar energy).

Tourism Development Strategy in Anbar Governorate [2]: This research addressed the importance of tourism in the desert governorate of Anbar in Iraq, identifying its natural resources and tourism infrastructure, and then presenting models of desert areas that were able to establish sustainable cities, such as the Desert Rose model in the city of Al-Ruwayyah in the

The reality and trends of urban growth of small cities in Al-Mahawil District [3]: This research sheds light on the repeated neglect of development programs and strategic plans for small cities with population sizes ranging between 5,000 and 20,000 people, which were represented by three regions (Nile, Project, Imam). The research also addressed the reasons for growth that are not subject to geographical controls, indicating that human, economic, demographic, historical and political factors play a role in the emergence of cities. The research also showed the future vision for urban growth and the need for land in the year 2025 AD, identifying the trends that stand in the way of urban expansion of the cities of the study area and determining the appropriate directions for their growth.

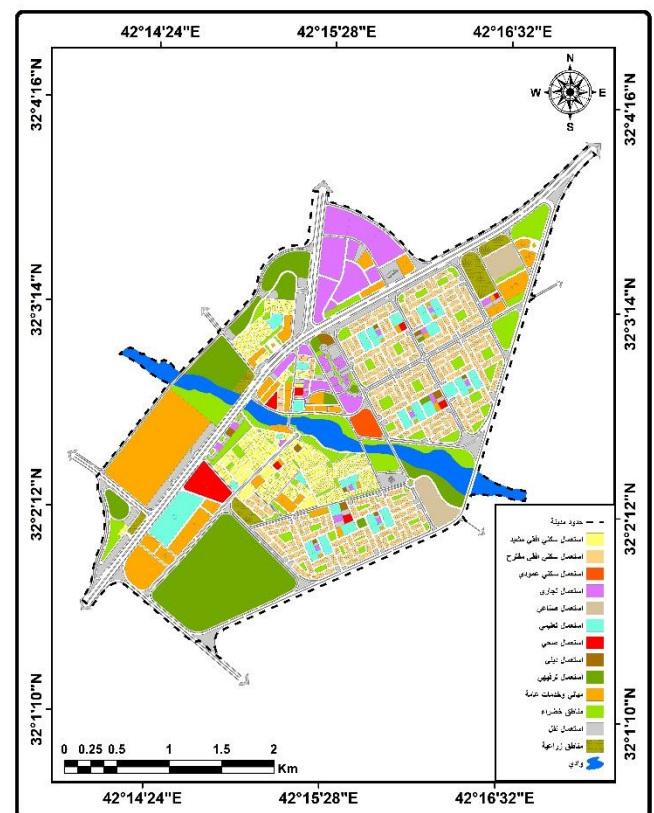
3. RESEARCH METHODOLOGY AND APPROACHES

$$n = \frac{N}{1 + N(e)^2}$$

e = error rate

The city of Al-Nukhayb is geographically located in the southwestern part of Iraq and south of Anbar Governorate. It is administratively affiliated with the Rutba District and is considered part of the Northern Badia. Astronomically, it is located between latitudes $32^{\circ}4'16''\text{N}$ to $32^{\circ}1'10''\text{N}$ and longitude $42^{\circ}16'32''\text{E}$ to $42^{\circ}14'24''\text{E}$, which are the borders

The city of Al-Nukhayb is considered a small city according to the Iraqi index, which defines it as a city with a population of 25,000 [9], while its 2023 population reached 2,414 [10]. The urban land use area is 1,098 hectares, as shown in Table 1 and Figure 2.



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Table 1. Land use area in Al-Nukhayb City in 2023 and per capita share (m²) by 2023, 2030 [12-14]

Required Area (m ²) for Urban Land Uses in Al-Nukhayb City by 2030	Per Capita Share (m ²) Criterion	Per Capita Share (m ²)	Ratio (%)	Area (ha)	Area (m ²)	Use
235,200	50	212.9	4.6%	51.4	514,033	Current Residential Use
-	-	-	8.8%	97.5	975,132	Proposed Residential Use
-	-	-	0.50%	5.5	54,551	Vertical Residential Use
37,632	8	69.2	1.5%	16.7	167,146	Industrial Use
143,001	30.4	88.4	11.8%	129.8	1,298,379	Recreational Use
5,315.6	1.13	3.8	1.1%	13.0	129,946	Healthcare Use
94,080	20	1,744	38.3%	421.1	4,211,000	Transportation Use
18,816	4	234.7	5.1%	56.7	566,698	Commercial Use
588	0.125	16.9	0.37%	4.1	40,800	Religious Use
10,349	2.20	176.3	3.8%	42.6	425,821	Educational Use
13,642	2.9	436.1	9.5%	105.3	1,052,909	Administrative Use
-	-	-	7.5%	83.4	834,092	Green Area
-	-	-	1.6%	17.8	178,150	Agricultural Areas
-	-	-	4.8%	53.1	531,209	Valley (Vacant Land)
470,400	100	853.94	100%	1,098	10,979,866	Total

The areas of each urban land use in the city of Al-Nukhayb for the year 2023 and their geographical distribution, in addition to the individual share and the standard of person share of each use, to show that the individual share of all uses exceeds the local planning standard mentioned in the same table. The urban land use in the city will be studied as follows:

First: Residential use: This use in the city of Al-Nukhayb occupied an area of 514,033 m² (51.4 ha), representing 4.6% of the total area. The city included 11 residential neighborhoods and 313 residential houses occupied by 557 families.

Second: Commercial use: The commercial use area in the city of Al-Nukhayb amounted to 566,698 m², equivalent to 56.7 hectares, representing 5.1% of the city's total area, comprising 16 commercial establishments, ranging from food and construction materials to other goods.

Third: Industrial use: The area in the city of Al-Nukhayb amounted to 167,146 m², equivalent to 16.7 hectares, representing 1.5% of the total urban land use area, comprising 18 industrial establishments, including auto and home appliance repair shops, one blacksmith shop, and one concrete block production plant.

Fourth: Land use for transportation purposes: It occupied an area of 4,211,000 m², equivalent to 421.1 hectares, constituting 38.3% of the city's total area.

Fifth: Service use: It includes:

- i. **Religious use:** Its area reached 40,800 m², equivalent to 4.1 hectares, and a percentage of 0.37% of the total area. This area was occupied by only one mosque (Al-Ihsan Mosque).
- ii. **Land uses for infrastructure services and public buildings,** which occupied an area of 1,052,909 m², equivalent to 105.3 hectares, and a percentage of 9.5% of the total land use area. Which included a number of governmental institutions, the number of which reached 13 institutions, and the most important infrastructure services such as potable water services represented by the Nukhayb Water Division, which has two stations for desalination and purification of groundwater, Station No. (1) and Station No. (2), which supply the city with a rate of 1280 m³/day of potable water [15]. It was noted during the field study that there are a number of residents who own private wells inside their residential homes to compensate for the shortage of water during the period of its interruption. Electricity services: As the city's national

electricity supply has been completely depleted, the state has resorted to supplying the city with two government-run generators with a production capacity of 1000 kVA [16], supplying the city with 9 hours of electricity in the summer, divided between 12 pm–6 pm and 6 pm–12 am. Operation in the winter only occurs at night for 6 hours from 6 pm–12 am. The city is also equipped with an electrical wiring network that reaches all residential buildings. As for sewage services, they are completely devoid of a network.

Sixth: Community services, which include:

- i. **Health land uses:** The area of health land uses in the city of Al-Nukhayb amounted to 129,946 m², equivalent to 19 hectares, representing 1.1% of the total area, represented by the Al-Nukhayb Health Center, which included a medical staff of 4 individuals compared to 3 health professionals. In addition to one private sector medical clinic in the same neighborhood with only one medical assistant working [17]. When compared with the Iraqi planning standards, it becomes clear that the city has enough health center in it according to the local surveying standard that determined the need of the residential neighborhood with a population of 10,000 people for one health center with an area of no less than 5,000 m² [18]. As for the other standards, they vary, as shown in Table 2.
- ii. **Educational land uses:** Its area reached 425821 m², equivalent to 42.6 hectares, at a rate of 3.8% of the total area. It included three schools, in which 1085 students study, as shown in Table 3. When comparing the reality with the local planning standards, it appears that the city is sufficient in the number of schools according to the surveying standard that specified one primary school for every 2,500 people with an area of 5,000-6,000 m², and one secondary school for every 5000 people [19], while there is a discrepancy in the other local standards, as shown in Table 4.
- iii. **Recreational land uses:** Recreational and green land uses in the city of Al-Nukhayb occupied an area of 2,132,471 m², 213.2 hectares, equivalent to 11.8% of the total land use area. This area represented the green strips on the sides of the roads and some internal gardens that need sustainable care. The city lacks all the local recreational services mentioned in Table 5, which require a certain population to establish them.

Table 2. Iraqi standards for health services [20]

Indicator	Population	Indicator
Negative (1-)	Per 1000 people	One doctor
(+1) Positive	Per 2000 people	One dentist
Positive	Per 2000 people	One pharmacist
Negative (2-)	400-500 people	Health Careers One
(-6) Negative	Per 200 people	One bed
Negative (1-)	For every 3 health professions	One doctor
Positive	For every 5-6 beds	One doctor
(+1) Excessive	For every 3 beds	Health Careers One
Positive		

Table 3. Educational services in the city of Al-Nukhayb [21]

T	School Name	The Site	Year of Establishment	Number of Students	Number of Teaching Staff	The People Are a Number	School Time	School Autonomy
1	Al-Moatasem Mixed Elementary School	Old Al-Nukhayb neighborhood - inside the neighborhood	1962	586	9	10	A.M	Original
2	M mixed Nukhayb	Old Al-Nukhayb neighborhood- Main Street	2008	308	4	8	A.M	Original
3	On the martyr Ornes Al-Hathal mixed	Old Al-Nukhayb neighborhood - Main Street	2023	191	4	8	P.M.	Guest with M / Al-Nukhayb Mixed

Table 4. Local planning standards for educational services [22]

Educational Stage	Standard Name	Planning Standard	Indicator
Primary education	School / Student	360-300	-266
	Student / Teacher	25-20	-40
	Student / Class	30-25	-29
	Student / School	540	M mixed Nukhayb (+191)
Secondary education (middle and preparatory)			On the martyr Ornes Al-Hathal mixed (259+)
	Student / Teacher	25-18	M mixed Nukhayb (-2)
			On the martyr Ornes Al-Hathal mixed (-1)
	Student / Section	30-25	M mixed Nukhayb (-9)
			On the martyr Ornes Al-Hathal mixed (1+)

Table 5. Local planning standards for recreational services [23]

T	Type of Entertainment Service	Type of Entertainment Service	Standard	Area (m ²)
1	Public parks	Public parks	1/ 10,000 people	10,000
2	Parks	Parks	1/ 10,000 people	15,000
3	Public libraries	Public libraries	1/ 50,000 people	15,000
4	Youth centers	Youth centers	1/ 20,000 people	15,000
5	Sports clubs	Sports clubs	1/ 50,000 people	15,000
6	Sports fields	Sports fields	1/ 25,000 people	50,000 -40,000
7	Sports arenas	Sports arenas	1/ 12,000 people	6,000-5,000
8	Sports halls	Sports halls	1/ 25,000 people	25,000
9	Leisure hotels	Leisure hotels	1/ 50,000 people	30,000
10	Entertainment restaurant	Entertainment restaurant	1/ 12,000 people	3,600
11	Cafes	Cafes	1/ 4,500 people	-
12	Games cities	Games cities	1/ 40,000 people	20,000
13	Museums	Museums	1/ 40,000 people	10,000
14	Swimming pools	Swimming pools	1/ 50,000 people	15,000
15	Wedding halls	Wedding halls	1/ 45,000 people	4,500

As for the future need for urban land, it is necessary to determine it in order to create sustainable urban development that guarantees the needs of future generations. To estimate the expected population of the city of Al-Nukhayb, the year 2030 AD was chosen as the target year in line with the Sustainable Development Goals (2030 SDGS), and according to the population projection equation, the population will reach 4704

people [24], and according to the data in Table 5, urban land uses will be able to contain this population.

4.2 Applying the Delphi method to achieve sustainable urban development in the city of Al-Nukhayb

This method has been used in some geographical studies,

particularly those on future trends, concerned with organizing space through the modern approach to geographical research, which is concerned with the geography of development, which is interested in studying space, economic activities, and the potential and obstacles to future development. It was possible to use the Delphi method, which is one of the most important means of prediction and forecasting, by selecting the best alternative determined by the researcher or experts [25].

The basic idea of this method is to prioritize group opinion over personal opinion. By presenting several preliminary alternatives for sustainable urban development in the city of Al-Nukhayb, experts compare them according to the intentional sampling method and the first (inductive) and second (weighted) rounds, as shown in Table 6.

Table 6. Some information about the respondents (experts) participating in the first and second rounds of the questionnaire

T	Gender	Academic Rank	General and Minor Specializations	Number of Years of Experience
1	Male	Professor Doctor	Geography of Planning and Regional Development	42
2	Male	Professor Doctor	Geography of Cities	22
3	Male	Professor Doctor	Geography of Services	19
4	Male	Assistant Doctor	Civil Engineering	10
5	Male	Assistant Doctor	Architecture	33

Source: Based on the results of the questionnaire, Appendix 1

4.2.1 Proposed alternatives for sustainable urban development in the City of Al-Nukhayb

The first alternative: Desert Rose City

A sustainable, multi-use city shaped like a desert rose, which helps reduce electricity consumption and relies on self-generated renewable energy. The city also includes its own waste recycling facility, similar to the Sustainable City in the Al Ruwayyah area of Dubai in the United Arab Emirates [26].

The second alternative: Water City

The concept of the Water City is based on treating wastewater using an advanced treatment system and then reusing it to irrigate crops, contributing to environmental sustainability and ensuring the provision of clean water to citizens. This alternative achieved environmental sustainability when implemented in Stockholm [27].

The third alternative: Smart Sustainable City

An innovative city that relies on information and communications technology and other means to improve the efficiency of urban services, enhance quality of life, and enhance competitiveness, while ensuring the provision of the economic, social, and environmental needs of present and future generations [28].

The fourth alternative: The Productive City

It is the city that adopts environmental improvement and

restores the relationship with the natural environment system, on which it depends to obtain the materials necessary for the continuity of the lives of its residents, and maintains mutual relations and interests with the surrounding unused lands by improving and increasing the production of the ecosystem in service of the city [29]. That is, transforming the city into a center of production rather than consumption, in addition to developing urban projects and infrastructure to increase and improve the level of self-sufficiency of the city in food, water and energy, and exploiting the semi-urban areas surrounding cities to achieve this, while increasing urban flexibility [30]:

4.2.2 Questionnaire method

The study employs two types of questionnaires, which are commonly used in the Delphi method [31].

- i. **The open questionnaire:** In this type, a set of questions was presented to the expert and he was asked to freely express his opinion. In this stage, the researcher presented four proposed alternatives for sustainable urban development in the city of Al-Nukhayb. These were then sent to the experts, along with a summary of each city. The experts expressed their opinions on the alternatives. Based on this, three alternatives were selected for the city of Al-Nukhayb, after the fourth alternative was excluded for the sake of competition. The best alternative was selected in the second round (the restricted questionnaire stage).

- ii. **Restricted Questionnaire (Weighted Questionnaire):** This is a questionnaire presented by the researcher in the second round based on an analysis of the results of the first (open) questionnaire. The researcher also draws on the theoretical framework of the study, the researcher's opinion, and previous studies to design the questionnaire and establish criteria for this round. The expert is then asked to respond to the questionnaire items on a binary scale (agree, disagree) or on a graduated scale with multiple points to assign a relative weight to the importance of the criterion, for example, acceptable - average - good - very good - excellent. It is preferable to assign numbers to these items on the questionnaire sheet. After the questionnaire forms were collected, they were manually entered into a goal matrix table containing 15 criteria aimed at evaluating the effectiveness of the proposed alternatives. Each criterion was assigned five weighted scores, each assigned a number of points, as follows: (weak = one point, average = two points, good = three points, very good = four points, excellent = five points). This facilitates the process of entering them into the computer. The responses are then collected and evaluated to arrive at the best alternative (Appendix 1, Table 7).

After analyzing the questionnaire forms, the results appeared in the points shown in Table 8 and Figure 3. By analyzing the data from the same table using the Delphi method to compare alternatives, it became clear that the best alternative for sustainable urban development in the city of Al-Nukhayb is the first alternative, represented by the "Desert Rose City." This was followed by the third alternative, "The Productive City," while the weakest alternative was the second alternative, "The Water City".

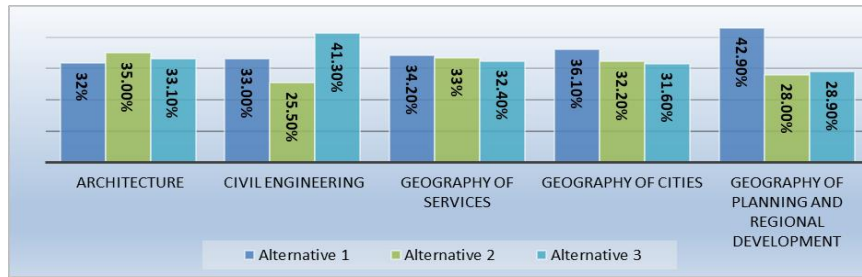


Figure 3. Evaluation of the alternatives presented for the city of Al-Nukhayb by experts according to the weighting method
Source: Based on Table 8

Table 7. The criteria set for the alternatives presented for the city of Al-Nukhayb and the degree of each criterion according to experts

T	Standard	Alternative 1	Alternative 2	Alternative 3	Total
1	Protects the environment from pollution	19	17	12	48
2	Achieves a sustainable economic foundation	15	15	20	50
3	Achieves social justice	12	12	11	35
4	Achieves sustainable investment in natural and human potential	19	18	20	57
5	Achieves urban attraction	19	13	15	47
6	Achieves regional reciprocity	18	10	22	50
7	Relieves population pressure in major cities	15	10	14	39
8	Reduces unemployment and provides job opportunities	15	10	19	44
9	Provides a healthy and comfortable environment for residents	15	18	13	46
10	Uses sustainable building materials	16	12	14	42
11	Achieves urban agriculture	18	19	17	54
12	Provides infrastructure and superstructure services	17	15	15	47
13	Waste management and recycling	15	16	16	47
14	Achieves sustainable transportation	17	11	16	44
15	Achieves optimal water management	17	42	18	59
Total		247	220	242	709

Source: Based on the results of the questionnaire and Appendix 2

Table 8. Evaluation of the alternatives presented for the city of Al-Nukhayb by experts according to the weighting method

Alternative	Geography of Planning and Regional Development		Geography of Cities		Geography of Services		Civil Engineering		Architecture		The Total	
	n	%	n	%	n	%	n	%	n	%	n	%
A1	46	42.9	64	36.1	39	34.2	44	33	49	31.8	242	35.3
A2	30	28	57	32.2	38	33.3	34	25.5	54	35	213	31
A3	31	28.9	56	31.6	37	32.4	55	41.3	51	33.1	230	33.5
Size of the proportions		100		100		100		100		100		100

Note: number of points (n); percentage (%); Alternative (A).

Source: Based on the results of the questionnaire, Appendix 2

4.3 Sustainable urban development policies for the city of Al-Nukhayb

4.3.1 The housing sector

Sustainable urban development aims to provide adequate housing for various segments of society. From this perspective, to meet the housing needs of future generations in 2030, the city of Al-Nukhayb will require 784 housing units [32]. Housing sector development is not limited to providing housing units alone, but rather encompasses a set of requirements to create a sustainable city. These include the use of sustainable local building materials, such as natural stone and clay, to reduce energy consumption on air conditioning units. This includes adopting sustainable urban design for housing units, providing infrastructure, superstructure, and

public services that serve the home and its occupants, and ensuring easy access from the home to service areas.

4.3.2 The agricultural sector

To achieve sustainable urban development in the city of Al-Nukhayb, an urban agriculture policy can be implemented, employing modern agricultural methods, from preparation and seeding to harvesting and marketing. Fields for raising and fattening calves and sheep can be built, as well as poultry, with a focus on high-quality breeds, while providing government veterinary services. Establishing palm farms and focusing on strategic grain crops (wheat and barley) will also be important. This will also include investing in the seasonal agricultural resource of truffles, a source of income for many of the city's residents.

4.3.3 The industrial sector

For industrial development to be sustainable in the city of Al-Nukhayb, it is necessary to create industrial projects that serve as growth poles that work to stabilize and attract residents and develop the city urbanly and economically in a way that enhances the opportunities for sustainable growth of the city in accordance with the available promising development qualifications of labor, raw materials, capital, and available natural resources, especially in the construction industries and building materials, as gravel deposits and compost are present in the city, which are basic materials in the construction industries. And achieving agricultural-industrial economic integration, by establishing factories for leather and wool industries, a feed and grain grinding factory, and a factory for dairy, cheese and meat derivatives to provide livestock (Sheep and camels) in the city's region and its affiliated villages. Emphasis is placed on providing government support (financial, administrative, security, technical, marketing, and advisory).

4.3.4 The transportation sector

Transportation routes function like arteries in the human body, supplying the city with the necessities of life. To develop the transportation sector sustainably, the implementation of a smart transportation system, which aims to develop technologies that enhance safety, reduce fuel consumption and emissions, cut financial costs, optimize time, and provide comfort for people, will achieve sustainability goals. This is in addition to focusing on transportation routes by furnishing, planting trees, and paving the city's side streets with environmentally friendly natural stones instead of asphalt, using solar-powered traffic signs and lighting, and establishing modern rest stops in the city of Al-Nukhayb for travelers crossing the Arar border crossing into the Kingdom of Saudi Arabia. Sustainable transportation using bicycles, animals, walking, and hybrid vehicles, which are less polluting than conventional cars, will be encouraged. A train station will be established in the city of Al-Nukhayb and linked to the Ramadi train station. Emphasizing the need to expedite the completion of the Nukhayb-Ramadi road, which is one of the vital roads linking Nukhayb to the city of Ramadi.

4.3.5 The commercial sector

Sustainable development in this commercial sector can be achieved by supporting the agricultural and industrial sectors to benefit from inputs and outputs through the transport of raw materials and final goods between production and consumption areas, thus stimulating commercial activity. Establishing a free trade zone with the Kingdom of Saudi Arabia and establishing small commercial complexes supported by the state, by investing in model market buildings currently under construction.

4.3.6 The community services sector

This includes:

- i. **Health Services:** The health services development policy seeks to provide a sufficient number of health centers and their medical staff, in terms of quality and quantity, in a manner commensurate with the population size. Therefore, by 2030, the city will be self-sufficient with its existing health center, according to the surveying standard. As for the number of doctors, it will need 5 doctors, 2 dentists, 2

pharmacists, 34 health professionals, and 67 beds (Table 9).

Table 9. Future needs for health and education services in the cities of Al-Muhammadi and Al-Nukhayb for the year 2030

Population in 2030	Health Services					
	Health Center	Doctor	Dentist	Pharmacist	Health Professions	Bed
4704	1	5	2	2	14	29
	Educational Services					
	Type of Educational Institution					
	Kindergarten		Elementary School		High School	
	1		5		2	

Source: Table 5 [33]

- ii. **Educational Services:** The educational services development policy aims to provide school buildings and teaching staff at an efficient level, as well as to locate school buildings in locations that ensure easy access and protect the safety of students. Therefore, by the year 2030 AD, the city will need one kindergarten, 2 elementary schools, and one secondary school (Table 9) to accommodate the increasing number of students and pupils in 2030 AD, and to provide laboratories, supplies, and modern teaching methods.
- iii. **Recreational Services:** The vast desert areas of the city of Al-Nukhayb must be invested in by holding desert recreational activities such as night camping to observe the sky and stars, a shooting range, horse and camel riding, and free-range hunting. Tourist trips can be organized there, given the presence of enthusiasts of these activities, as well as those seeking the comfort and tranquility available in the city's desert, away from the hustle and bustle of large cities.

4.3.7 Infrastructure services

Infrastructure services include:

- i. **Potable Water:** The city will require 1,693,440 liters/capita/day (Table 10). This should not be overlooked due to the qualitative characteristics of potable water. Policies should be adopted to conserve and sustain water for future generations by: recycling graywater and using it to irrigate crops instead of potable water; rationalizing consumption in all daily uses; raising citizens' awareness of the importance of water and the need to conserve it quantitatively and qualitatively; and extending a water pipeline from Ramadi District to Al-Nukhayb City, which lacks any surface water source.
- ii. **Sanitation Services:** The sanitation services development policy aims to include the city with a sewage network (drainage of heavy and rainwater) with treatment plants for this water, which can then be reused for washing streets, irrigating crops, or injecting it into the ground, and eliminating septic tanks that have negative environmental impacts. The amount of water that will be released in the year 2030

AD will be 658560 liters/day in the city of Al-Nukhayb (Table 10).

Table 10. Future projections for drinking water and wastewater in the city of Al-Nukhayb in 2030

Population in 2030	Water Quantity (Liters/Capita/Day) Based on a Standard of 360 Liters/Capita/Day [34]
	1693440
4704	The amount of water discharged in liters/day according to the standard 140 liters/person/day [35]
	658560

- iii. Electricity Services: According to the standard 3.5 kilowatt-hours per capita/year [36], it was shown that the city will need 16,464 kilowatt-hours per capita/year in 2030. To sustain and develop the electricity services sector, it is possible to rely on clean, sustainable energy (solar and wind energy), especially with the availability of sufficient solar radiation hours to be used for electricity production at a rate of 9.3 hours. Wind energy speeds are suitable for electricity production during the spring and summer seasons, ranging between 5.1^{-4} m/s [37].
- iv. Waste Disposal: Waste disposal is extremely important given the impact of waste on the environment, the general appearance of the city, and the economy, and its continuous and increasing generation with the city's population growth. The city will produce 1,646 tons/day in 2030, according to the standard 350 grams/capita/day. To organize the disposal of these quantities and invest them in a sustainable manner, a recycling policy must be adopted, and waste must be sorted by placing three containers: one for organic waste, one for plastic waste, and one for paper waste.

5. CONCLUSIONS AND PROPOSALS

5.1 Conclusions

1. The per capita share of all urban land uses is higher than the local planning standard, ensuring no pressure on uses within the city.
2. The city achieves functional efficiency for community services (health, education, and entertainment) according to the spatial standard and population size, with variations in functional efficiency relative to other criteria.
3. The best alternative for sustainable urban development chosen by experts is the Desert Rose City.
4. The availability of natural factors to achieve urban sustainability in the field of electricity production or the use of building materials such as natural stone, mud brick, and others.
5. Attention should be paid to infrastructure and superstructure services in the city to create a sustainable urban city.
6. Raise awareness among citizens and students in schools and kindergartens about the importance of sustainability in general and urban sustainability in particular.
7. Establish economic projects that improve the living conditions of residents, contributing to their stability in the city and serving as growth poles that attract projects and labor, contributing to its sustainable growth.

5.2 Proposals

1. Implementing the sustainable urban model developed using the Delphi method (Desert Rose City).
2. The necessity of working to implement the proposed policies for sustainable urban development, represented by (the development policy for the housing, agricultural, industrial, transportation, commercial, community services, and infrastructure sectors). If properly invested, they will contribute effectively to the city's growth by stabilizing and attracting residents and development projects.
3. Increasing the efficiency of health services provided to the city's residents, while emphasizing the need for medical and health personnel to be present at the health center.
4. The city currently needs one primary school to relieve the pressure on the Al-Nukhayb Mixed Primary School and to provide the city's schools with more teaching staff, commensurate with the number of students, according to local standards.
5. Investing in the natural and human resources of the cities of Al-Muhammadi and Al-Nukhayb to achieve sustainable urban development.
6. Expand and focus on green spaces within the city and on its outskirts, given their importance in providing recreation, their role in environmental protection, and their role as the lungs through which cities breathe.
7. Develop small cities and direct investments toward them by adopting well-thought-out development policies, which will alleviate the population pressure in large and medium-sized cities.
8. Emphasize the rapid completion of the Ramadi-Nukhayb road to connect the city to the governorate center, breaking its isolation, thus helping to increase regional connectivity.

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APPENDIX

Appendix 1

M/Question

Dear Expert.....

Given your expertise and academic integrity, you have been selected among a group of five experts with diverse scientific specializations to apply the Delphi method (expert opinion) to select the best alternative for sustainable urban development for the cities of Al-Muhammadi and Al-Nukhaib. This is for your doctoral thesis entitled: (Sustainable Urban Development of Small Cities (Al-Muhammadi and Al-Nukhaib) in Anbar Governorate), submitted by doctoral student Yazan Yassin Jabbar, and supervised by Prof. Dr. Amjad Rahim Muhammad. Please note that the questionnaire will consist of two rounds: the first round is inductive, and the second round is weighted. We kindly ask for your approval and to express your scholarly opinion regarding the selection of the best alternative, or to amend or add other alternatives as you deem appropriate.

With appreciation...

Expert Name..... General and Specific Specialization..... Academic Degree..... Place of Work....

Number of Years of Experience

Proposed Alternatives for Sustainable Urban Development in the City of Al-Nukhayb

Alternative 1: Desert Rose City: A sustainable, multi-use city shaped like a desert rose, which helps reduce electricity consumption and relies on self-generated renewable energy. The city also includes its own waste recycling facility, similar to the Sustainable City in the Ruwayyah area of Dubai, United Arab Emirates.

Alternative 2: Water City: The concept of the Water City is based on treating wastewater using an advanced treatment system and then reusing it to irrigate crops, contributing to environmental sustainability and ensuring the provision of clean water to citizens. This alternative achieved environmental sustainability when implemented in Stockholm.

Alternative 3: Sustainable Smart City: An innovative city that relies on information and communications technology

and other means to improve the efficiency of urban services, enhance quality of life, and enhance competitiveness, while ensuring the provision of the economic, social, and environmental needs of present and future generations.

Alternative 4: The Productive City: A city that embraces environmental improvement and reconnects with the natural ecosystem, upon which it relies for the materials necessary for the sustainability of its residents. It also maintains mutual relations and interests with the surrounding unused lands by improving and increasing the productivity of the ecosystem in service of the city. This includes transforming the city into a center of production, not consumption, in addition to developing urban projects and infrastructure to increase and enhance the city's level of self-sufficiency in food, water, and energy. This is achieved by utilizing the peri-urban areas surrounding cities to achieve this, while increasing vegetative resilience.

Expert Opinion: Other proposed alternatives that can be mentioned:

Appendix 2

M/Second Round Expert Questionnaire

Thesis Title: (Sustainable Urban Development of Small Cities (Al-Mohammadi and Al-Nukhaib) in Anbar Governorate)

Dear Expert Dr.....

After the researcher considered your esteemed opinions in the first (inductive) round of the questionnaire, one of the alternatives presented was removed, leaving three alternatives for each city. Please evaluate each alternative separately according to the tables attached to each alternative, so that we can select the best alternative as the objective of our study and formulate a sustainable urban development policy for the cities in the study area (Al-Mohammadi and Al-Nukhaib) in Anbar Governorate. Thank you for your cooperation.

Supervised by PhD Student Yazan Yassin Jabbar
Prof. Dr. Amjad Rahim Muhammad

Dear Expert

Please respond by placing a check mark (✓) in the appropriate place for each criterion.

Alternative One: Desert Rose City: A sustainable, multi-use city shaped like a desert rose, which helps reduce electricity consumption and relies on self-generated renewable energy. The city also includes its own waste recycling facility, similar to the Sustainable City in Al Ruwayyah, Dubai, United Arab Emirates.

Alternative Two: Water City: The Water City's concept is based on treating wastewater using an advanced treatment system and then reusing it to irrigate crops, contributing to environmental sustainability and ensuring the provision of clean water to citizens. This alternative has already achieved environmental sustainability when implemented in Stockholm.

Alternative Three: Sustainable Smart City: An innovative city that relies on information and communications technology and other means to improve the efficiency of urban services, enhance quality of life, and enhance competitiveness, while ensuring the economic, social, and environmental needs of present and future generations are met. The Fourth Alternative: The Productive City: A city that embraces environmental improvement and reconnects

with the natural ecosystem, upon which it relies for the materials necessary for the sustainability of its residents. It also maintains mutual relations and interests with the surrounding unused lands by improving and increasing the productivity of the ecosystem in service of the city. This means transforming the city into a center of production, not

consumption, in addition to developing urban projects and infrastructure to increase and enhance the city's self-sufficiency in food, water, and energy. This is achieved by exploiting the peri-urban areas surrounding cities to achieve this goal, while increasing vegetative resilience.

T	Standard	Alternative 1	Alternative 2	Alternative 3	Total
1	Protects the environment from pollution				
2	Achieves a sustainable economic foundation				
3	Achieves social justice				
4	Achieves sustainable investment in natural and human potential				
5	Achieves urban attraction				
6	Achieves regional reciprocity				
7	Relieves population pressure in major cities				
8	Reduces unemployment and provides job opportunities				
9	Provides a healthy and comfortable environment for residents				
10	Uses sustainable building materials				
11	Achieves urban agriculture				
12	Provides infrastructure and superstructure services				
13	Waste management and recycling				
14	Achieves sustainable transportation				
15	Achieves optimal water management				
Total	Total				

Note: Evaluation weights: (Weak = 1), (Average = 2), (Good = 3), (Very Good = 4), (Excellent = 5).