

3-6 Criteria of Sustainability Indicators

3-6-1: The engineering dimension

1-Urban road network density index

The density of roads was relied on according to the number of the population, as it is more important and accurate, as the population is the main generator of movement and the exploitation of economic and social resources (Neamah, 2020).

According to the international standard for the density of roads for the population of 496 km per 100,000 inhabitants, which is close to the average urban road density for the population of Ramadi, which amounted to 491.03 km per 100,000 inhabitants, which is about 99%, which is a high percentage. This indicates that the area has a suitable road network. (Al-Anbaki, 2009)

$$\text{Road Density} = \frac{\text{Lengths of roads}}{\text{The total population of the area}}$$

2-Quantitative indicators to measure the efficiency of the urban road network

To analyze the network structure of any city, it must be transformed into a topological scheme. The urban road network consists of nodes and connections. The road is a line when there is a meeting point and the car is forced to stop, or when the line ends in a closed road, the nodes are formed because the links are lines of communication between points. In this way, nodes and connections are formed, and it is one of the quantitative geometric forms to determine the topology

of the region, which is known as the network theory that was used for the first time by the scientist W. More precisely, by developing quantitative indicators to measure the degree of interdependence (Ayed Taran, 2016). The degree of correlation can be found through:

e : Number of roads or links

v : Number of intersections or contract

~ Interconnection index for urban road network analysis

Calculate the value of beta according to the equation below

$$\beta = \frac{e}{v}$$

β : Beta Index (The degree of interdependence)

If the result is zero, then the network is nodes and there are no road lines, and the network is considered to be non-existent, and one or more indicates that there is a complete interconnection in the network (Diaa Qteishat, Ziad Makhamra, 2019)

~ Connectivity score indicator for urban road network analysis

Calculate the value of gamma according to the equation below

$$\gamma = \frac{e}{3(v - 2)}$$

When applying the indicator, if the result is zero and close to it, this indicates a weak or lack of connection to the network. If the result is equal to one, this indicates that the network has a high connection, and if it exceeds one, it indicates that the network has an integrated and developed interconnection (Aghrib, 2017)

~ Rotational degree indicator for urban road network analysis

According to the law below

$$\alpha = \frac{e - v + p}{2v - 5}$$

When the rotation index is applied, the scale value ranges between (0–1) zero indicates the presence of few or no circular roads or poor rotation and vice versa, meaning that the number one indicates the presence of circular roads or is characterized by a network with a strong turning ability. (Hamad Raafat Ghadiya, 2017)

~ ETA Network Spread Index

$$\eta = \frac{\textit{The total length of the network}}{e}$$

If the output is zero, this means that there is no spread in the network, and if the output is small, this indicates the length of one link or its length is short, and this means the convergence of the network. However, the network is low and underdeveloped (Aghrib, 2017) (Neamah, 2020)

3–Tiled and non–tiled area indicator

The table shows the percentages of paved and unpaved roads in the neighbourhoods of the city of Ramadi, based on the data of the Ramadi Municipality Directorate, which were obtained at the level of each sector earth.

4–Parking indicator

According to the design standards of parking lots, the permissible parking spaces are set at 5 square meters per person, one parking lot per family, and 1000 people

150 spaces, and the number of parking spaces varies by type. The use, whether administrative, educational, health or service, and in general for each of them. The user has a certain number of parking spaces (Specifications, 2010) Public Authority for Housing – Urban Housing Standards.

The parking index is calculated as a percentage to ensure that there are sufficient parking spaces that comply with the requirements of the building and the nature of use (<https://ar.businessemt.com/77-how-8066855-calculate-parking-rational-61171-How-to-calculate-the-parking-ratio-2021>).

$$\text{Per capita parking space} = \frac{150 * P}{1000} * 100$$

5- Hierarchy indicator

The urban road network is among the most qualitatively used subject networks for linear symbol basis. Important for city planners.

As the gradation of urban roads has become one of the most important basic principles adopted in drawing urban plans and the basic design of the city and road networks.

The suitability of the urban hierarchy of roads is a necessity in the construction and organization of the city, its general environment and the traffic requirements of the road .(Arwa,2018)

The hierarchy aims to organize the street network in a way that achieves flow, safety and security in the traffic. Therefore, it is a system for classifying the street

network in the city based on defining the general function of the road and its specifications .(Al-sahili, 2016)

wanted. Roads are classified according to variety, traffic, and purposes in several classifications for each country. The special system in this arrangement has its components, names and standards, so the first factor that must be determined is to determine the functional classification, the nature of the service that the road must provide. The basis for urban road classification varies from one country to another, but the most widespread classification is according to the width of the road and the traffic capacity.

The index of road areas and length of roads was taken according to their classification distributed over the neighbourhoods of the study area

6- Traffic volume indicator

Table No. () shows the traffic volume data for the city of Ramadi due to the epidemiological conditions that the world is going through, so it was relied on previous sources that were calculated for working days and holidays through a field survey within monitoring stations within a city for the year 2018 and on the equations for future prediction of traffic volume, which were applied as follows:

- 1- Traffic volume data for the year 2018 for 12 hours has been converted to the inflated irrigated volume as it is less than 24 hours to equal the daily traffic volume**
- 2- To convert the traffic volume to the equivalent daily irrigated volume, it must be taken into account the generated, developed and attracted traffic volume as in the following equation**

$$AADT_F = AADT_P (1 + (5 - 25\%) + (10 - 20\%) + (5 - 20\%))$$

3- To obtain the future daily traffic volume, the design age and the rate of increase must be chosen, and it is always estimated at 5% in normal cases, as in the following equation

$$AADT_{dy} = (AADT_F) * (1 + G_f)^n$$

n: Design age from 2019-2021

4- The future irrigated volume for the year 2021 is extracted through the above equations

3-6-2: the social dimension

1- pedestrian sidewalks indicator

Pedestrians are one of the most important means of transportation. Therefore, the pedestrian movement must be studied and given priority in dividing the traffic network. There is no doubt that the study of pedestrian movement is important in transport planning studies as it is considered an integral component of automated transport, as walking is the important means of movement in city centres and therefore must be provided with The spaces necessary for pedestrian movement and separating them from the movement of vehicles within the city, avoiding traffic accidents, and ensuring the elements of health, safety and safety for pedestrians. (Abboud, 2009)

Therefore, there are special standards for the design of sidewalks, the most important of which is the hierarchy of the pavement from the main road sidewalks

to the local road sidewalks and down to the residential neighbourhoods so that it fits the human scale and encourages walking and gives a feeling of safety for pedestrians and vehicle drivers(Kuki, Sarmadnya, g., M., 2012)

2– Public transport index

Reliance was made on previous studies, which were applied to the GIS program, in addition to the field survey and daily observations in the city of Ramadi. It was found that the areas served by public transportation are represented in two lanes. The first is the Ramadi–Sofia line. The number of vehicles serving the area is 24, with a capacity of 11 passengers, and the second is a centre line. Ramadi – Tamim The number of vehicles serving the region is 12 with a capacity of 11 passengers. (Nisreen, 2020) The percentage of the area serving public transportation was found to be 664,66 hectares, which is a weak percentage compared to the area of the city of Ramadi

3– Road Accidents Index

Table No. () shows the number of traffic accidents within the city of Ramadi (the boundaries of the study area), which were documented by the Anbar Traffic Town Directorate for the year 2020–2021

3–6–3: the environmental dimension

1– Green Spaces Index

Each city has its criteria for green spaces due to the different nature and topography of the land, that is, there are no special determinants. There are general

formulas and criteria for green spaces according to planning criteria. In the 1970s, the United Nations Environment and the European Union set a standard for green spaces and set the minimum and maximum at (12–16) square metres, and established Simmons' plan that green space should not be less than 10% of the city area (Boanaca, 2010). In the nineties, the United Nations Environment Program set standards that specify the minimum green spaces that range between (12–18) square meters, per capita according to the equation below (Badlaway, 2017), and for the Iraqi planning standards it was (6–7%) Of the land uses and the per capita share thereof (7) square meters. (AHMED, 2020) In another source, the average per capita share of green spaces in Iraqi cities ranges between (0.5–2) within neighbourhoods, according to estimates by the Parks and Gardens Unit in the municipalities of Iraq (Dr Bashar Thanoun Al-Shakraji and Muhammad Thanoun Al-Sharabi, 2012).

$$T = G/P$$

Where T: per capita green space (m² / person)

G: Green areas

P: population

2– Pollution index

According to national standards, the pollution level should range from (0.5–5) parts per million (Abraham, 2019), while we found that the pollution level ranges between (0.3–3) parts per million, but it is not reliable due to different parameters, which is

an expected result. Streets, road spaces, and a large number of events increase the rate of air pollution. The table (3-23) below shows the pollution concentrations that were taken from the Environment Department, Anbar Branch, and since the areas of neighbourhoods roads are not equal, so it was calculated using the equation below. (Air Pollution, Prof Dr Monim H Al-Jiboori,2015)

$$\text{Pollution concentration} = \text{Measured pollution concentration (instantaneous)} * \text{Area}$$

3- Noise indicator

According to international standards, the sound intensity s (Abraham, 2019) should be about (30 – 35) dB, while we found that the intensity level ranges from (60–70) dB, which is higher than usual due to the increase in the number of streets and road spaces, this leads to the emergence of the highest level of noise

-6-4: The economic dimension

1- Land value index

The unit of the land area is fixed and does not move, meaning it is not transferable, but its value is variable and variable due to the influence of several factors, the most important and best of which are according to the prevailing pattern of use in the region, and it is the main driver of the value of the land (Al-

Kinani, 2008). Data on land plots prices were obtained from the Property Division / Municipality Directorate Gray as shown in the table below

2–Vehicle ownership index

Most of the city’s residents at present tend to own more than one vehicle, as is evident in Table No.(3–28) of the increase in vehicle ownership during the years 2017, 2018 and 2020, according to data from the General Traffic Directorate, Anbar branch

The vehicle ownership criterion can be calculated to see the increase or decrease in the ownership index as follows

Vehicles/per 1000 people = Number of vehicles in general/Population for age group (18 and over)

$$= 71014 / 107010 = 0.6636$$

Vehicle ownership = 664 vehicles per 1000 people

Assuming that each family consists of five members, each family owns more than one vehicle, and this is evidence of an increase in the vehicle ownership index

3–Mobility Price Index

Transport prices differ from one city to another, meaning there are no fixed standards, but they depend on several factors, the most important of which is the distance and proximity to the city centre. Through fieldwork, transport prices were reached according to the distance travelled and distance from the city