Residential Density: 
Concept and Practice in Khartoum - Sudan

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Abstract
This paper reviews the development of town planning theory in regard to residential density concept, studies the various definitions of residential density and their use in planning purposes, and examines the measurements of residential density control.
It also outlines the effects of density on the urban form and on the behavior of residents.

1. Introduction
Residential density is an important factor in planning urban land use especially residential areas. The relationship between residential density and space is a complex one, because it involves in addition to the two dimensions: the length and the width, the third dimension: the height and the fourth dimension: the time measurements of density comprise different components related to population and dwellings. However they can be used as planning tools at the beginning of a project and can be used for assessing outcomes at the end. Moreover, there is a co-relation between the residential density and the choice of the suitable dwelling type.

2. The development of residential density concept in town planning
Bad conditions of life in the industrial towns at the end of the nineteenth century encouraged many philanthropists and reformers to form theories for solving social and planning problems of the poor.
One of those reformers was Ebenezer Howard (1902). In his book, Garden Cities of Tomorrow - John W. (1) reviewed Howards reforms and he contrasted the advantages of town and country: the varied social life possible in the town, the comparatively high
wages, and atmospheric pollution and savage in humanity, against the beauty of the countryside, its pure air and natural mode of life, its lack of social variety and poor wages. He found a solution in a town of a limited size (a garden city), which would combine the advantages of both town and country with the disadvantages of neither (see Fig. (1)). His Garden City had a population of about 30,000 in the city itself and about 2,000 people in the agricultural estate. There were 5,500 building lots; each family had its own house built on a plot of an average size of 20×130ft. The site of the Garden City was to be built near the center of 6000 acres agricultural land, the city covered an area of 1000 acres, and might be of circular form, 1,240 yards from center to circumference (see Figs. (2) and (3)). When the town reaches its maximum size, growth would take the form of further satellite towns each with its own green belt until the great Parent City is ringed by satellites.

Howard's ideas have been exemplified with great measure of success in Letchworth and Welwyn Garden cities and were basic to the post war new towns policy.

Howard's ideas have remained valid for more than half a century and they were legislated in the British town and country-planning Act 1932 which was the first act in Britain that gave public authorities a planning control over any land. The essential element in the Act was zoning both for use and for intensity, it assumed that higher residential density was unpleasant.

Howard's idea of the balanced town in which the amount of population and the opportunities for employment could be carefully equated, was the dominant concept of the Town and Country Planning Act 1947.

As Keeble (2) (1969) mentioned: "The 1932 Act and 1947 Act assumed that spaciousness was good in itself, but a good looked at from the point of view of proletarian welfare rather than the residential neighborhood unit, a concept of orderly development directed towards security, safety and convenience".
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![Fig (1) The Town - Country Magnet](image1)

![Fig (2) Garden City Diagrammatic Concept](image2)
The concept of residential neighborhood unit was first outlined by Clarence Perry in 1929(3). He described the concept as "A populated area which would require and support an elementary school with an enrollment of 1,000 - 1,200 pupils. This would mean a population of between 5,000 - 6,000 people. The district bounded by major thoroughfares, rather than intersected by them, and within a convenient walking distance of the elementary school building situated upon a common green park and playground - which would become the community center and focal point of neighborhood activity. It was designed to recognize the fundamental limitation concerning the size of the area, the number of people who can effectively participate in matters that affect them individually and as neighbors, and to meet needs of family life."

In the early 1950s a strong reaction set against spaciousness and higher residential densities got certain popularity. Planners prefer large building complexes as compared to individual dwellings, the division of residential area into neighborhoods was consciously and insistently abandoned and much higher residential densities were used, with the idea of producing a continuous urban mass in which all large open uses including secondary schools as well as public open space were thrust out to the edge of the town. After a while the subdivision of residential areas imposed itself and the neighborhood concept returned.

As an example of town planning concepts in the sixties, Keeble (2) (1969) designed a theoretical new town for 60,000 people a popular size for new town in Britain at that time. He assumed a featureless virgin site, and suggested land use allocations as follows:

- Housing sector represents 51.8% and its density is 25 acres per 1000 people.
- Industrial sector represents 14.5% and its density is 7 acres per 1000 people.
- Open space represents 14.5% and its density is 7 acres per 1000 people.
- Educational sector represents 6.2% and its density is 3 acres per 1000 people.
- Residential sector represents 13.0% and its density is 6.3 acres per 1000 people.

The total density is 48.3 acre per 1000 people.

He divided the residential area into 12 neighborhoods each has 5000 persons. Neighborhood's area varies from 124.5 acre to 250.5 acre. He concentrated housing around
the town center because of accessibility and placed all open uses towards the edge.

3. Definitions of residential densities
Density in ordinary language means the number of objects e.g., houses, rooms, persons etc. per unit space. Residential density can be expressed in different ways to serve different purposes in urban planning as mentioned by Keeble (2) (no one method of measuring and controlling residential density, which is wholly satisfactory for all purposes, has yet been devised)

However, houses per acre refers to the density of residential buildings and expressed in habitable rooms per acre, it may imply over or under intensity of development and depends upon the actual form of development whether it is a horizontal or a vertical one.

Persons per acre refer to the gross population density over the whole area of the town or net population density over the whole area.

Occupancy rate is defined as a rough measurement of adequacy of accommodation available and expressed as number of persons per habitable room. It changes frequently with the family cycle due to events such as marriage, birth or under utilization of residential areas.

The British standards of the above residential density measurements are as follows:

For occupancy rates:
Up to 1.0 occupancy rate is regarded as comfortable.
Up to 1.3 occupancy rate is regarded as crowded.
Up to 2.0 occupancy rate is regarded as overcrowded.

For habitable rooms:

<table>
<thead>
<tr>
<th>No. of rooms in the house</th>
<th>No. of permitted persons to use it for sleep</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>7.5</td>
</tr>
<tr>
<td>5</td>
<td>10</td>
</tr>
</tbody>
</table>

With an addition of two persons in respect of each room in excess of five.

For habitable floor space:

<table>
<thead>
<tr>
<th>Floor area of a room (sq. ft.)</th>
<th>No. of person permitted to use it</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;110</td>
<td>2.0</td>
</tr>
<tr>
<td>90–110</td>
<td>1.5</td>
</tr>
<tr>
<td>70–90</td>
<td>1.0</td>
</tr>
<tr>
<td>50–70</td>
<td>0.5</td>
</tr>
<tr>
<td>Under 50</td>
<td>Nil</td>
</tr>
</tbody>
</table>

It is clear that habitable floor space has more direct relation to number of persons who occupy it than habitable rooms per acre, because it doesn't specify the area of the bedroom whether it is large or small.

The Australian Model Code for Residential Development (AMCORD)(4) defines residential density measurements as:

Urban Residential Density (the district)
The ratio of the number of dwellings to the area of land they occupy including all the regional uses such as open spaces, large scale commercial uses and transport.
Gross Residential Density (the place)
The ratio of the number of dwellings to the area of land they occupy including internal public streets, open spaces, local community services and local employment areas.

Net Residential Density (the built form)
The ratio of the number of dwellings to the area of land they occupy including internal public streets and half the width of the adjoining access roads.

Site Density (the lots)
The ratio of the number of dwellings to the area of land they occupy.

However, detailed information about density is very important for planning and design purposes, as there is a great need to specify the scale of work to choose the right measurement of density. Below is the table (1) showing different density scales and how they could be used in planning:

<table>
<thead>
<tr>
<th>Scale</th>
<th>Measure</th>
<th>What it describes</th>
<th>What it can be used for</th>
</tr>
</thead>
<tbody>
<tr>
<td>lot</td>
<td>Site</td>
<td>-Intensity of built form on site only.</td>
<td>-Comparative tool (single houses – lot size, apartment – height)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-The intensity of built form in street context.</td>
<td>-Evaluating options for street design and built form typology.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-The relationship between net residential density, development standards and typology.</td>
<td>-Understanding the impacts of development standards.</td>
</tr>
<tr>
<td>street</td>
<td>net</td>
<td>-The intensity of built form in street context.</td>
<td></td>
</tr>
<tr>
<td>Neighborhood</td>
<td>gross</td>
<td>Neighborhood intensity.</td>
<td>-Meeting the planning targets at the local level for neighborhood intensity.</td>
</tr>
<tr>
<td>neighborhood</td>
<td></td>
<td>-The daily lived experience of a place.</td>
<td>-Estimating local population density (e.g. for public transport).</td>
</tr>
<tr>
<td>Urban</td>
<td>urban</td>
<td>-The overall picture of a place including impacts of regional open spaces and uses.</td>
<td>-Providing a big picture planning tool (e.g. Estimating population density for regional services).</td>
</tr>
</tbody>
</table>
4. Density and urban form:
The fabric and the texture of a city depends on the population density, and as mentioned before the numbers of persons per acre has a direct relation with number of dwellings per acre and hence determine the urban development and access (streets) for people and vehicles.

It is also important to mention that residential density is not always a reliable measure of built form intensity and a higher residential density does not always mean higher buildings. A given housing type can yield different net residential densities depending on site coverage, dwelling size and street layout. As the dwelling type has a considerable effect upon density and neighborhood layout, Keeble (1969) made an example of a density of 60 habitable rooms per acre with different dwelling types. It would be congested if development were in form of 20 small bungalows to the acre, perfectly acceptable if it would be in the form of 12 houses, each 5 habitable rooms to the acre, and extremely spacious (even though lacking individual outdoor space), if it would be in the form of a five storey block of flats, four flats to each storey and three rooms in each flat – to the acre). Grosby (1969)(5) also presented a nice picture of clusters of highly concentrated buildings, separated by open recreational land, linked by rapid transit railways, restricted motorways or monorails, necessary area within the cluster is given up to car movement and parking with links to the peripheral motorways. The overall density of the area will be low especially when providing employment, along with shops, schools, and other services. There would be less necessity to travel large distances to work, living and working locally increase social involvement and save on transport.

5. Behavioral effects of density
Research on the effect of high density in high rise buildings on human attracted interest of some scholars, Stokols (1976)(6) stated that “density is not correlated with psychological and behavioral maladies. Any instance of spatial limitation involves potential inconveniences such as the restriction of movement, the preclusion of privacy or exposure to stimuli overload”.

It is clear that high densities affect human behavior and overcrowding is associated with social problems such as violence, crime, unemployment, etc. Regeczi (2002) (7) mentioned that experiments done by researchers suggested that when people are confronted with a large number of strangers in everyday life, they tend to withdraw and take less interest in the community in order to protect themselves from overload. Urban withdrawal and anomie resulting from density explain higher urban crime rates. There is an optimal relationship between crowding and withdrawal, the optimal point is 1.18 persons per room.

Behavioral and cultural traditions affect perception of density, detrimental effects of population density may be offset by cultural traditions, and cultural norms affect the
perception and adjustment of interpersonal distance. However, as stated by Herbert and Thomas (1990)(6) “population density to some extent is a measurable, objective state, but overcrowding is an experiential condition relevant to a particular time and space”.

6. Control of density
The control of density in a specific neighborhood is connected with two different items:
- The dwellings and their distribution within the neighborhood.
- The people and their distribution within dwellings.

The dwellings are classified in regard to the type of dwelling, the amount and kind of accommodation in it and the amount and kind of outdoor space associated with it (i.e. plot size).

Keeble (1969)(2) classified residential accommodations into:

Houses: they have ground floor accommodations, individual outdoor space and don't have other dwellings above or below and on either side. They may be divided into detached, semi-detached and terrace houses.

Flats: they haven't ground floor accommodations (unless they are on ground floor) or outdoor space. They may have dwellings above and on side. Flats may be divided into low blocks without lifts, high blocks with lifts.

The people, forming different households, are ranging in regard to their socio-economic and cultural characteristics e.g. number and age of people, their income level and their living habits.

The control of density serves two different purposes:
1. Provision of privacy, absence of congestion on streets, freedom from noise, etc. for residents. This is related to building bulk and garden space.
2. Provision of services such as shops, schools, open spaces, etc., which depends upon the number of people per acre.

It is clear that the fulfillment of the first purpose requires a relatively low density, which provides better standards of privacy and spaciousness, while the second purpose requires a relatively high density to support provision of all services within close limits.

Crosby (1969)(5) argued that a low density e.g. 25 persons per acre, is unable to support within a walking distance any of the requirements of a civilized life: shopping, restaurants, cinema, etc. In densities up to 100 persons per acre the vehicle is a necessity hence access to communal activities requires a car. While increase in density means that a smaller area of housing can support communal facilities, he gave an example of a one mile square of 250 persons per acre which would contain over 40000 persons, the furthest is 7½ minutes walk from a quite substantial center, at this density the use of a car is an option.
It might be a good idea if control of density is exercised by specifying a permitted number of dwellings per unit area and a permitted amount of habitual floor space per unit area and thus a clear picture of the type of development which results from them can be drawn. However, dwellings per hectare in the most appropriate measure for controlling the gross or net yield of existing or future housing that should be used in conjunction with other planning standards and with plot ratio in particular when controlling development form.

An analysis of the international practice (9) indicates that in general, the method for controlling density fall into two principle categories:

- Dwellings per hectare.
- Plot ratio (total amount of floor space over total site area).

Residential density codes are used to control residential development, in Western Australia(10) R-coding designate the number of dwellings that can be built within one hectare of land and the minimum size of each lot e.g: R 40 allows approximately 40 dwellings per hectare with each lot to be 220m².

It is misleading to judge the pleasantness of an area simply by the net density assigned to it in terms of habitual rooms per acre and of whether these dwellings would be all dispersed horizontally or would be wholly or partially stacked vertically.

The determination of the suitable densities for dwelling (houses or flats) should be governed by consideration of daylight, privacy, open space and so on. Those considerations for flats are more difficult and complex than for houses because variations in height and layout are much greater. Some of the controlling factors (2) in determining appropriate densities in areas developed with flats only are summarized as:-

- Spacing of blocks of flats to give day light,
- Avoid noise,
- Good access,
- Outdoor living space and semi-private gardens.

7. The Sudanese Practice

7.1 Gross residential densities:

As mentioned by Madibbo (11) United Nations had conducted a survey of housing conditions in Africa in 1960. The survey revealed that the gross residential densities in Sudan are: 15-35 persons per acre for first class residential areas and 60-65 persons per acre for third class areas. Densities in the majority of North African countries at that time were 300 persons per acre, while densities in most East and West African countries were 150-200 persons per acre. The Sudan was the lowest country in terms of such densities.

By the end of the sixties (12) the densities increased to: 24-36 persons per acre for first class residential areas and 60-80 persons per acre for third class ones. In the early nineties the situation is not changed as the average gross density stood at 115 persons per hectare, about (46 person per acre), compared with densities obtained in other large metropolitan
areas of the third world, this density is very low.

The low residential density in Sudan is one of the shortcomings of housing policies. The absence of adequate official dwelling standards (e.g. plot size and house type) had been the main reasons for the consumption of residential land. It increased the cost of services and aggravated the transportation problems.

Bearing this in mind, the Sudanese planning authorities in collaboration with foreign planning consultants had prepared development plans for Metropolis Khartoum e.g.

- Doxiadis Master Plan (1960 – 1980) (12)
- McFit Master Plan (1975 – 1990) (13) and
- Doxiadis Structure Plan (1990 – 2000) (14)

7.2 Review of the main aspects concerning residential density in the development plans:


The programme introduced for the first time in Sudan the concept of creation of integrated human communities as a basic principle of planning. The community should include residences, places for work, recreational facilities and all other services, and must be planned in a way to satisfy all the economic, social, political, technical, cultural and aesthetic needs of the inhabitants. They termed it unity of purpose. The urban communities are defined by the social functions they served according to their size (see Figs. 4 and 5) and they are classified into a capital city, A town, a district and a neighborhood as shown below:

Community class VII: is a large metropolis or capital city. It consists of more than one township.

Community class VI: is an average town which consists of several communities' class V

Community class V: is a small town or district in a larger one. Its population ranges from 30,000 to 100,000 persons. It consists of a number of neighborhoods class IV and has a major civic and business center.

Community class IV: is a basic urban residential neighborhood for 1,000- 1,600 families or 3500-8000 persons. It contains all needed functions, has a main market and a shopping center, civic, cultural, recreational center and intermediate or secondary school, public park and small stadium. It is made up of 2-4 communities' class III.

Community class III: consists of 300-400 families; the connecting element is the elementary school and local shopping center. It is composed of 4 communities' class II

Community class II: contains 75-100 families belonging to the same income group. The connecting element is the playground or kindergarten or a small square. It is composed of 3-4 communities class I.
Community Class I: is the smallest urban community and made up of 20-25 families of the same income group. The connecting element is the street or a small square.

The programme found that the relationship between houses, rooms and persons at that time was as shown in Table (2):

Table (2) Relationship Between Houses, Rooms and Persons(12)

<table>
<thead>
<tr>
<th></th>
<th>Khartoum</th>
<th>Omdurman</th>
<th>North</th>
<th>Khartoum</th>
<th>Omdurman</th>
<th>North</th>
<th>Average of the three towns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Persons per family</td>
<td>4.4</td>
<td>7.1</td>
<td>5.7</td>
<td>5.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rooms per house</td>
<td>3.3</td>
<td>3.9</td>
<td>3.2</td>
<td>3.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Families per house</td>
<td>1.6</td>
<td>1.3</td>
<td>1.5</td>
<td>1.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Persons per room</td>
<td>2.1</td>
<td>2.3</td>
<td>2.6</td>
<td>2.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Persons per house</td>
<td>6.9</td>
<td>8.9</td>
<td>8.5</td>
<td>8.1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The programme proposed allocations for the different land uses. It was noticeable that in the proposed land allocations, residential areas had the highest percentage (64.4% - 42.7%) in the three towns as shown in details in table (3).

Table (3) Proposed land areas allocations (12)

<table>
<thead>
<tr>
<th>Zone</th>
<th>Residential</th>
<th>Industrial</th>
<th>Commercial</th>
<th>Major open space</th>
<th>Railway</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage</td>
<td>59.6</td>
<td>8.7</td>
<td>20.1</td>
<td>10.2</td>
<td>1.4</td>
<td>100</td>
</tr>
<tr>
<td>Area in hectare</td>
<td>5000</td>
<td>730</td>
<td>1700</td>
<td>800</td>
<td>180</td>
<td>1460</td>
</tr>
<tr>
<td>Percentage</td>
<td>64.4</td>
<td>13.3</td>
<td>12.3</td>
<td>9.0</td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>Area in hectare</td>
<td>5000</td>
<td>600</td>
<td>600</td>
<td>400</td>
<td></td>
<td>4200</td>
</tr>
<tr>
<td>Percentage</td>
<td>42.7</td>
<td>44.6</td>
<td>7.2</td>
<td>3.4</td>
<td>2.1</td>
<td>100</td>
</tr>
<tr>
<td>Area in hectare</td>
<td>3000</td>
<td>2100</td>
<td>340</td>
<td>180</td>
<td>100</td>
<td>4700</td>
</tr>
<tr>
<td>Total Area in hectare</td>
<td>9000</td>
<td>3430</td>
<td>2840</td>
<td>1420</td>
<td>210</td>
<td>17000</td>
</tr>
</tbody>
</table>

Type of residential unit
The programme noticed that the two basic types of private residence were the single detached house and the flat.

Flats were not popular at that time because of many reasons: the climate, the great desire for privacy, the large size of families, traditional tendencies and lack of community services especially sewerage.

Therefore it proposed plot sizes according to space requirements for single detached houses without conducting further research on other suitable dwelling types such as semi-detached houses or row houses.
The proposed plot sizes ranged from 252m² to 760m² as shown in details in table (4).

Table (4): Proposed Plot Sizes and Residential Units (12)

<table>
<thead>
<tr>
<th></th>
<th>Khorram</th>
<th>Chinwara</th>
<th>North</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min. plot size (m²)</td>
<td>252.00</td>
<td>252.00</td>
<td>252.00</td>
</tr>
<tr>
<td>Max. plot size (m²)</td>
<td>760.00</td>
<td>760.00</td>
<td>760.00</td>
</tr>
<tr>
<td>Average plot area (m²)</td>
<td>405.70</td>
<td>429.10</td>
<td>393.00</td>
</tr>
<tr>
<td>Total residential area (hectares)</td>
<td>2,424.90</td>
<td>1,433.40</td>
<td>944.50</td>
</tr>
<tr>
<td>Average Family size (persons)</td>
<td>6</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>No. of population (persons)</td>
<td>359,000</td>
<td>267,000</td>
<td>167,000</td>
</tr>
<tr>
<td>Residential unit (units)</td>
<td>59,800</td>
<td>33,400</td>
<td>23,976</td>
</tr>
</tbody>
</table>

The programme recommended plot sizes and net population densities for the three residential classes (see table (5)).

Table (5): Recommended Plot size (12)

<table>
<thead>
<tr>
<th>Class</th>
<th>Plot size (m²)</th>
<th>Net population density</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st class areas</td>
<td>Plot of 500</td>
<td>80 persons per hectare</td>
</tr>
<tr>
<td>2nd class areas</td>
<td>Plot of 400</td>
<td>95 persons per hectare</td>
</tr>
<tr>
<td>3rd class areas</td>
<td>Plot of 200</td>
<td>190 persons per hectare</td>
</tr>
</tbody>
</table>
The plan classified residential areas into first, second and third class according to income levels and didn't propose different density zones for residential areas according to the spatial pattern of the whole town i.e. high densities near the center and low densities in the peripheries.

7.2.2 The Regional Plan of Khartoum and Master Plan for the Three Towns (1975-1990) MEFIT S.P.A Consulting Engineers (13).

MEFIT plan in its long- term goal recommended higher levels of residential densities for the new and the existing residential areas. The aim was to reduce the area required for the new urban expansion and by that meant to reduce the cost of the infrastructures necessary for the new services.

It stated two approaches to increase gross residential density:
1. Regarding areas of public use.
2. Regarding private dwellings.

The aim regarding dwellings was to achieve the minimum plot size with special concern to the fundamental social requirement that each dwelling must include an open-air yard.

MEFIT plan proposed different building typologies in new areas regarding dwelling type and size. The plan analyzed the relationship between houses, rooms, and persons in the three towns as shown in table (6).

<table>
<thead>
<tr>
<th></th>
<th>Khartoum</th>
<th>Omdurman</th>
<th>North</th>
<th>Average of all areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Persons per family</td>
<td>4.4</td>
<td>7.1</td>
<td>5.7</td>
<td>5.6</td>
</tr>
<tr>
<td>Rooms per house</td>
<td>3.3</td>
<td>3.9</td>
<td>3.2</td>
<td>3.5</td>
</tr>
<tr>
<td>Families per house</td>
<td>1.6</td>
<td>1.3</td>
<td>1.5</td>
<td>1.4</td>
</tr>
<tr>
<td>Persons per room</td>
<td>2.1</td>
<td>2.3</td>
<td>2.6</td>
<td>2.3</td>
</tr>
<tr>
<td>Persons per house</td>
<td>6.9</td>
<td>8.9</td>
<td>8.5</td>
<td>8.1</td>
</tr>
</tbody>
</table>

In areas which have already been developed, the plan stated that intervention was more difficult, a major increase of density would happened if it would be possible to divided single plots into two, but this was impossible. Therefore the plan had located the total increase in residential density to the new areas as follows:
- 50 persons per hectare in residential zone in proximity to already developed areas
- and 100 persons per hectare for the others.

MEFIT plan focused on major land uses such as residential, industrial, commercial and open space at the macro level of the capital region, and paid little attention for residential areas at the micro level of communities and neighborhoods.

The plan accepted the existing residential classification system with recommendation to reduce plot sizes in new residential areas.
Doxiadis Associates and Abdel Moneim Mustafa (14)

The Structure plan introduced for the second time the concept of organizing the metropolitan area into a number of self-contained residential communities (districts). This time the concept is more elaborate than that of 1958, a district should be constituted by a continuous sector of the metropolitan area, which should be sufficiently large to be in a position to offer all necessary services to its inhabitants; it is something like cities within the city (see Fig. (6)).

A district is subdivided into a number of large neighborhoods, which offer a complete range of lower level of services for their respective catchment population. It is divided into a number of 15-20 neighborhoods of some 10,000-15,000 persons.

These neighborhoods are constituted of a number of 5-8 local communities of 250-300 houses. The district will become a largely self-contained unit of an optimum size of some 250,000-300,000 persons that offers basic community services as well as local employment opportunities. Such opportunities should be created through the promotion of small scale informal sector enterprises especially in the low income communities.

Fig. (6) Population Distribution by District

The Structure plan expected Khartoum to have 18 districts or sub-municipalities in the year 2000, an approximate number of 350-500 neighborhoods and approximately 2600 local neighborhoods.

The Structure plan stated that the overall population density of Khartoum metropolitan area at that time was rather low -about 53 persons per hectare. The low population density was due to the large open areas within the metropolitan boundaries (such as airport, large tracts of agricultural lands, military areas, green belt, river courses, etc) as well as large tracts of undeveloped land at various locations within the city. There was a great difference between the gross residential density -115 persons per hectare- and the net residential density -220 persons per hectare.

The Structure plan suggested that the density should be increased by 30%. The desirable
density has to take into consideration particular characteristics of each district such as:
- The present level of density.
- Availability of vacant land.
- Income levels.

Also changes in the demographic indicators such as the expected drop in the average household size and family size, expected improvement in room occupancy ratios, etc. affect residential density. The sum total of these components, together with the characteristics of each district, would contribute to the establishment of the final desirable levels of density. The residential development profile at that time is shown in table (7):

### Table (7): Residential Development Profile—1990 (14)

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Income Groups</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>low</td>
<td>middle</td>
<td>High</td>
<td>Total</td>
</tr>
<tr>
<td>No. of Households</td>
<td>316,000</td>
<td>44,000</td>
<td>28,000</td>
<td>388,000</td>
</tr>
<tr>
<td>Average Household Size</td>
<td>8.9</td>
<td>7.5</td>
<td>6.8</td>
<td>7.5</td>
</tr>
<tr>
<td>% of Total Households</td>
<td>81.3</td>
<td>11.3</td>
<td>7.2</td>
<td>100</td>
</tr>
<tr>
<td>No. of Plot Acres</td>
<td>203,600</td>
<td>39,600</td>
<td>28,000</td>
<td>261,200</td>
</tr>
<tr>
<td>Average Plot Size (in yd²)</td>
<td>350</td>
<td>400</td>
<td>600</td>
<td>400</td>
</tr>
<tr>
<td>Total Plot Acres</td>
<td>9,000</td>
<td>1,380</td>
<td>1,680</td>
<td>12,660</td>
</tr>
</tbody>
</table>

The Structure plan decreased the proposed plot sizes, and fortunately it reduced the gap between the plot sizes of low-income group (200m²) and the plot size of high-income group (300m²). It succeeded in considering other components which affect residential density such as demographic characteristics, so that it reduced the proposed average household sizes as shown in details in Table (8):

### Table (8): Proposed Plot Sizes (14)

<table>
<thead>
<tr>
<th>Type</th>
<th>Average plot size (yd²)</th>
<th>Average Household Size</th>
<th>Average Per household Furniture</th>
<th>Residential area %</th>
<th>Gross residential densities</th>
<th>Common facilities %</th>
<th>Roads and open Space %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low income</td>
<td>250</td>
<td>7.5</td>
<td>146</td>
<td>45</td>
<td>14</td>
<td>20</td>
<td>50</td>
</tr>
<tr>
<td>Middle income</td>
<td>250</td>
<td>6.5</td>
<td>126</td>
<td>45</td>
<td>15</td>
<td>20</td>
<td>35</td>
</tr>
<tr>
<td>High income</td>
<td>300</td>
<td>5.1</td>
<td>93</td>
<td>55</td>
<td>15</td>
<td>20</td>
<td>30</td>
</tr>
</tbody>
</table>

### 8. Conclusions

The previous review of the development of residential density concept in town planning...
shows that residential density controlling measurements has a dual role in town planning:

* Firstly, it can be used as a tool to fulfill certain planning objectives - that is the main and important role of residential density - in terms of habitable floor space per acre, occupancy rate and dwellings density. It enables planners and designers to design specific spatial layouts of buildings and streets, and to provide adequate services.

* Secondly, it is one of the important outcomes of the planning procedure; hence, it reflects how appropriately a town has been planned in terms of concept, zoning, spatial pattern and services.

The Sudanese practice revealed that controlling residential density had not been among the objectives of planning. However residential density had been a product of certain planning concepts and calculated after the formulation of development plans.

The experience of the three development plans: Dosides (1960-1980), MEFFIT (1975-1990) and Dosides (1990-2000) aggravated that situation, as they hadn't stated certain measurements for density control, the plans neglected the important role of dwellings and their distribution in the neighborhood i.e. the type of dwelling, amount and kind of accommodation in it and the amount and kind of outdoor space associated with it. They accepted existing conditions of dwelling types and dwelling layouts within neighborhoods.

Their role is limited to reduction of plot size. It is important that reduction in plot size should be used to reduce differentiation between residential classes, but the recommended plot sizes didn't satisfy that purpose.

Therefore, raising the existing low residential density in the Capital requires a thorough investigation and research on the two main aspects of density control:

- The dwellings and their distribution in neighborhoods
- The people and their distribution within dwellings.

Obviously each aspect affects and is affected by the other aspect. For example one component of the second aspect: the people and their cultural traits and attributes have a determining role on the preference for a special dwelling type (houses or flats) and so it determines the degree of residential density in certain areas.

References


