

Climate and Socioeconomic Influence on House Design. 1. With Special Reference to the Hot-Dry Regions of Saudi Arabia and Sudan

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Abstract. This study is an attempt to analyse the influence of the expansion of the national economy of the Gulf States on traditional house design. Some urban centers representing different climatic types from Saudi Arabia and Sudan shall be selected as case studies. The study shall be conducted in two stages, the first one which is presented in this paper shall deal with examples representing the hot-dry climate. The second stage will deal with examples representing the hot-humid climate and shall be presented in the second paper. The climate of the selected case studies shall be analysed and its influence on traditional house design shall be discussed. A brief socioeconomic analysis for Saudi Arabia and Sudan will be conducted in an attempt to point out its influence on modern house design.

Introduction

The building industry is usually by far the biggest single enterprise in any country, and its decisions on planning, design and methods of construction often require accurate information on weather and climate. This applies particularly to the detailed design of buildings in order to provide an adequate indoor climate. Buildings must also be structurally sound and last for a reasonable period with these climatic conditions. Detailed information on the climate is, therefore, needed in a great variety of forms.

This study attempts to analyse socioeconomic influence in the design of houses in the main climatic regions of the Kingdom of Saudi Arabia and Sudan. The Kingdom of Saudi Arabia and Sudan were selected as case studies because of the similarities in the climatic conditions of their hot-dry and hot-humid regions and the significant differences in their socioeconomic structure. The study is carried out in two parts. The first part is presented in this paper and deals with the hot-dry regions, while the second part shall be presented in a separate paper and shall deal with the hot-humid regions.

The study begins with the climatic analysis of the selected locations representing the hot-dry climate, Riyadh, the capital of the Kingdom of Saudi Arabia and **Khar-**

toum, the capital of Sudan. The approach used in the analysis is based on the **Bioclimatic** Chart, the **Psychrometric** Chart and the Effective Temperature Isoleth Chart. The main climatic features of the selected locations are defined, also similarities and differences are pointed out. The analysis reveals that there are strong similarities during the hot periods and some minor differences during the cold periods. The summers of both locations are characterized by very high temperatures and very low relative humidity. During this season thermal comfort is experienced for short periods in the evening and for long periods at nights. The major difference was found to exist during the cold season. Khartoum has a short cold winter, while the winter of Riyadh is relatively colder and longer. Therefore, mechanical cooling and heating are required for both locations to provide adequate thermal environment. However, the socioeconomic analysis reveals that the means of mechanical cooling and heating, such as electrical energy and air-conditioning equipment, are rarely available and beyond the economic ability of the majority of the urban population of Sudan, while these means are abundantly available in the Kingdom of Saudi Arabia and they are within the economic ability of the majority of the urban population. Therefore, air-conditioning is widely used in the hot-dry region of the Kingdom of Saudi Arabia. Hence, the indigenous climatic solutions which are reflected by the traditional architecture of this region are overlooked by most designers and architects. The courtyard house built of thick mud walls, with small external windows is being replaced by European housing types such as the western villa style and blocks of apartments. In fact, the availability of cheap energy encouraged people living in the Kingdom of Saudi Arabia to spend most of their time indoors within a mechanically controlled environment. On the other hand, air-conditioning is rarely used in Sudan because of the high cost of electrical energy, the high cost of mechanical equipment and the low income of the majority of the urban population. Therefore, the traditional passive solutions for thermal comfort are still dominant. The courtyard house built of thick mud walls, small external openings and thatch roofs remains the typical housing pattern. The traditional pattern of space use which was developed to suit the climatic conditions **still exists**. People use the indoor space during the daytime of the hot season, when the outdoor air temperature and the solar radiation are considerably high. The open courtyard is used for living and sleeping at night under the cool clear skies. During the winter the problem is much easier due to the fact that the air temperature is not very cold and the duration is not very long. Generally, people depend on heavy clothing, use **woollen** blankets at night and spend most of the daytime under the sun in the open spaces.

Procedure

The procedure which is selected for the climatic analysis is based on the **Bioclimatic** Chart [1, pp. 314-319], which was later modified [2, pp. 33-37], and the Effective Temperature Isoleth Chart [3, pp. 27-28]. Briefly, the Bioclimatic Chart [4], which is shown in Fig. 1 is divided into four main zones as follows:

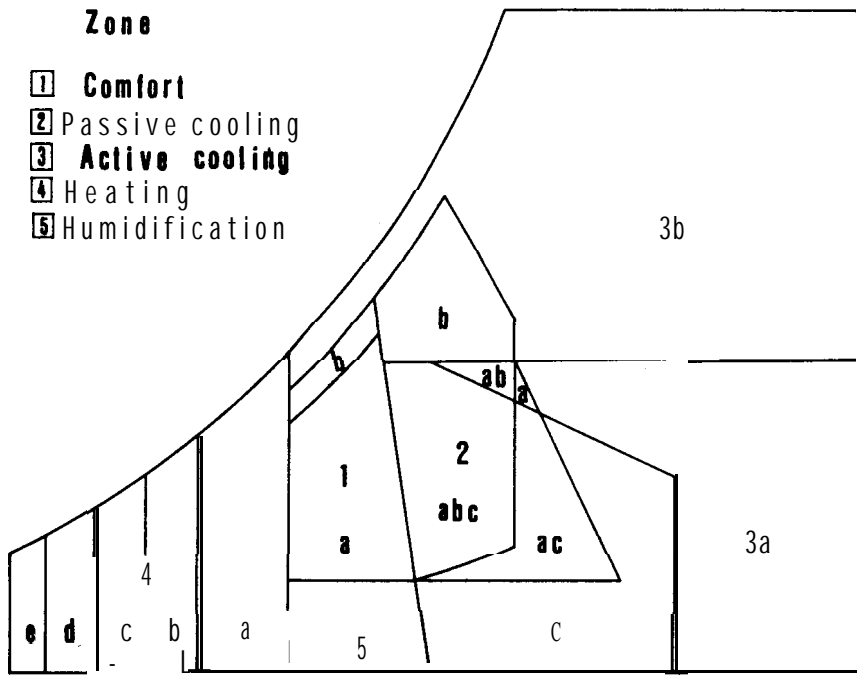


Fig. 1. Bioclimatic chart

The Comfort Zone

The comfort zone could be divided into two main parts. The first part which is indicated in Fig. 1 by 1a is the range where thermal comfort is experienced by sedentary subjects in the shade. The second part which is indicated in Fig. 1 by 1b is the range characterized by high relative humidity, which suggests a need for dehumidification and/or adequate ventilation.

Zone of Passive Cooling

These are the extension parts of the comfort zone in the hot climate and are indicated in Fig. 1 by 2a, 2b, and 2c. There are three strategies which could be used alone or in combination with each other to achieve comfortable conditions. These strategies are based on the use of thick walls or ventilation and/or evaporative cooling.

Zone of Active Cooling and Dehumidification

This zone could be divided into two parts. For the first part, which is indicated in Fig. 1 by 3a, heat must be removed from the air to achieve comfortable conditions. For the second part, which is indicated in Fig. 1 by 3b, both heat and humidity must

be removed from the air to achieve comfortable conditions. Mechanical cooling system or absorption air-conditioning system are required to achieve comfortable conditions.

Heating Zone

The heating zone which is characterized by low air temperature values, could be divided into five parts. The first part, which is indicated in Fig. 1 by 4a **requires relatively** little heat gain from active or passive solar heating to achieve comfortable conditions. For the other four parts indicated in Fig. 1 by **4b, 4c, 4d,** and 4e active heating is essential to achieve comfortable conditions.

The Psychrometric Charts of Riyadh and Khartoum are then computed using relevant climatic data. Then by superimposing the "Bioclimatic Chart" over the Psychrometric Charts of Riyadh and Khartoum some very useful findings are reached. The same climatic data represented in the two Psychrometric Charts is plotted in the Effective Temperature Isopleth Charts. The main advantage of the Effective Temperature Isopleth Chart is that it defines the time and duration of the different climatic divisions.

Climatic Conditions of Riyadh and Khartoum

Climate of Riyadh

Riyadh, the capital city of Saudi Arabia, is situated in Najd Plateau, Latitude **24° 42' N**, Longitude **46° 44' E**, Elevation 624 m., with a total population of over one million. Meteorological data for Riyadh [5] recorded for sixteen years (1966-1981) is analysed. During the period extending from June to September, the average minimum temperature ranges from 21.5 to **24.5°C**, the average mean temperature ranges from 32.5 to **35.0°C** and the average maximum temperature for the same period ranges from 42.0 to **45.0°C**. On the other hand, for the same period, i.e., June to September, the average maximum relative humidity ranges from 33.5 to **39.0%**, the average mean relative humidity ranges from 14.4 to 16.5% and the average minimum relative humidity ranges from 5.0 to 6.0%. Generally, in the hot-dry region of Saudi Arabia the maximum air temperature coincides with the minimum relative humidity and their combined effect is an extreme hot-dry air which is known as "**Samoom**". In fact the aridity of this climate is accompanied by several characteristics of great importance to the built environment. Direct solar radiation is intense, ranging from **813-929 w/m²** on the horizontal surface in addition to the reflected and diffused components.

Convection currents due to intensive heating of the air near the ground cause frequent dust and sandstorms especially in the afternoon. The low humidity and the absence of cloud result in a very wide temperature range. During the summer season, the direct solar radiation falling on the earth surface raises its temperature up to **70°C** at mid-day, while at night the heat loss due to the **longwave** radiation towards the cool blue sky reduces this surface temperature to about **15°C**. The ranges in air **tem-**

peratures are much smaller, but nevertheless a diurnal range of 20°C is not uncommon. Rainfall is very scarce and takes place during the cold winter, reaching its maximum level, which is 29.9 mm in December.

Climate of Khartoum

Khartoum, the capital city of Sudan, is composed of three towns; these are Khartoum, Khartoum North, and Omdurman situated around the confluence of the Blue Nile and the White Nile at latitude 15° 36'N and longitude 32° 31'E and an average altitude of 380m. Khartoum is situated in the margin of the Sahara Desert [6, pp. 26-46] and thus its climate is described as "tropical continental" type of climate. It is dominated by two temperature maxima when the sun is overhead both in May and October. There is a short rainy season from July to September. The total amount of rainfall is 164 mm, most of which is apparently lost through evaporation and transpiration because of excessive heating. Temperatures of 32 to 38°C are common throughout the year, with extremes of 47.7, and 6°C which are usually recorded in June and December respectively. High temperatures and little rainfall have produced a thin cover of vegetation which is even absent in most urban areas. The seasonal climatic variations are largely due to the apparent movement of the sun and the direction of the prevailing winds. During the winter season Khartoum experiences a cool, dry, cloudless refreshing weather with a mean daily temperature of 23.9°C in January, which is the coldest month of the year, with relatively low values of humidity and direct solar intensity ranging from 121 w/m^2 at 7:00 a.m. to 1067 w/m^2 at 12:00 noon. The summer season is characterized by intensive heating which usually takes place between 10.00 and 16.00 hours local time when the temperature of air in shaded areas is about 45°C. The direct solar intensity during the summer ranges from 335 w/m^2 at 7:00 a.m. to 1334 w/m^2 at 12:00 noon. The relative humidity at the beginning of the summer season is very low reaching 13% and 12% at 2:00 p.m. in March and April respectively. Sandstorms are frequently experienced during this season. The rainy season extends from the middle of July to the middle of September. 90% of the total annual rainfall of 164 mm falls in the three months of July, August and September with 45% falling during August. From the point of view of human thermal comfort, the rainy season is more favourable than the hot dry summer, this is due to the fact that the air temperature values are somewhat less than those experienced during the summer. The daily mean temperatures for July and August range from 30.4 to 31.8°C., while the short summer extends from October to the middle of November with a mean daily air temperature of over 32°C. In general the Khartoum climate is rather unpleasant throughout most of the year because of its high temperatures, low relative humidity and the occurrence of duststorms. However, the cool, dry, pleasant weather which is experienced during December and January is most refreshing.

Climatic Analysis

The Psychrometric Chart for Riyadh, shown in Fig. 2, is computed using climatic data provided by the Ministry of Defense and Aviation [5]. The chart reflects that

the climate of Riyadh covers the four zones defined by the Bioclimatic Chart shown in Fig. 1. The Riyadh climate ranges from the very cold zone indicated in the **Bioclimatic** Chart Fig. 1 by **4a, 4b, 4c, 4d**, and 4e to the very hot zone indicated by **3a**. This implies that, to achieve comfortable conditions in Riyadh, heating is required during the cold period, while cooling is required during the hot period.

Similarly, the Psychrometric Chart for Khartoum, shown in Fig. 3, is computed using climatic data recorded in Sudan Notes and Records [7]. The chart reflects that the climate of Khartoum extends from the end of the first upper part of the cold zone indicated in the Bioclimatic Chart Fig. 1 by 4a to the very hot zone indicated by 3a and 3b. This implies that, to achieve comfortable conditions in Khartoum, very little heating is required during the cold period while cooling is required during the hot period. It is clear that the relative humidity in Khartoum is generally higher than in Riyadh. This may be because of the influences of the Blue Nile and the White Nile,

Effective Temperature Isoleth Charts for Riyadh and Khartoum shown in Fig. 4 and Fig. 5 are computed from the same data represented in the two Psychrometric Charts shown in Fig. 2 and Fig. 3. The information given by the Effective Temperature Isoleth Charts is summarised in Fig. 6.

This indicates that comfortable conditions for Riyadh occur for about 43.7% of the total hours of the year, while for Khartoum comfortable conditions occur for 43% of the total hours of the year. The hot periods which require active and/or passive cooling for Riyadh are about 12.5% of the total hours of the year and about 18% for Khartoum. On the other hand, the hot periods for which active cooling is essential are about 7% of the total hours of the year for Riyadh and about 10.5% for Khartoum. The periods which require active and/or passive heating are 36.8% of the total hours of the year for Riyadh and 28.5% for Khartoum. For both locations cooling and heating are required but there are some variations in their magnitude and time duration. For Khartoum active cooling is essential for the period extending from May to September, from 12.00 noon to 16.00 p.m., reaching its maximum level in July from 10.00 p.m. to 18.00 p.m. For Riyadh active cooling is essential for the period extending from May to September, from 13.00 p.m. to 15.00 p.m., reaching its maximum level in July from 11.00 a.m. to 17.00 p.m. The most significant climatic variation between the two locations which can be concluded from both the **Psychrometric** Charts and the Effective Temperature Isoleth Charts, exists during the cold periods. Khartoum climate is characterized by a relatively short cold season which extends from December to February. Direct solar radiation during the day may help in achieving comfortable conditions together with heavy clothing and blankets at night. On the other hand, Riyadh is much colder during the winter which is relatively longer extending from November to March. Active heating is essential to achieve comfortable conditions during most of the cold period in Riyadh and would be desirable for the shorter cold season in Khartoum.

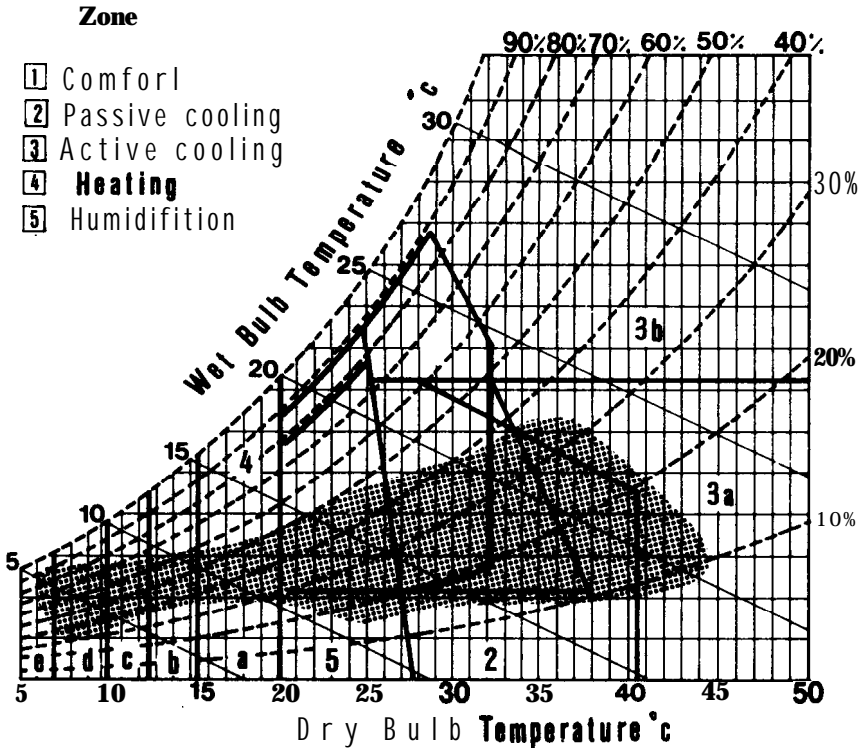


Fig. 2. Psychrometric chart; Riyadh

Socioeconomic Analysis

The economic growth has two distinct and interacting implications. These are economic development which results in economic changes, and social changes which influence people's attitudes, anticipations and behaviour. The influence of the economic growth on the pattern of living is best reflected by the Gulf States. Rapid changes in the economic base experienced by the Kingdom of Saudi Arabia [8, p. 71] moving from an economy based on agriculture, pasturing and Hajj taxes to one based on abundant oil revenues, has sparked numerous economic, social, political and cultural changes towards modernization. The modernization in the Kingdom of Saudi Arabia has been accompanied by many evident social changes; general **Europeanization**, a wide variety of consumer goods and services, increased personal mobility, some abandonment of traditional values, the modification of personal family relationships and regional occupational specifications. In contrast, the Sudanese economy faced a lot of difficulties which was clearly reflected by the deterioration of all the services and public utilities. According to the International Monetary Fund (IMF)

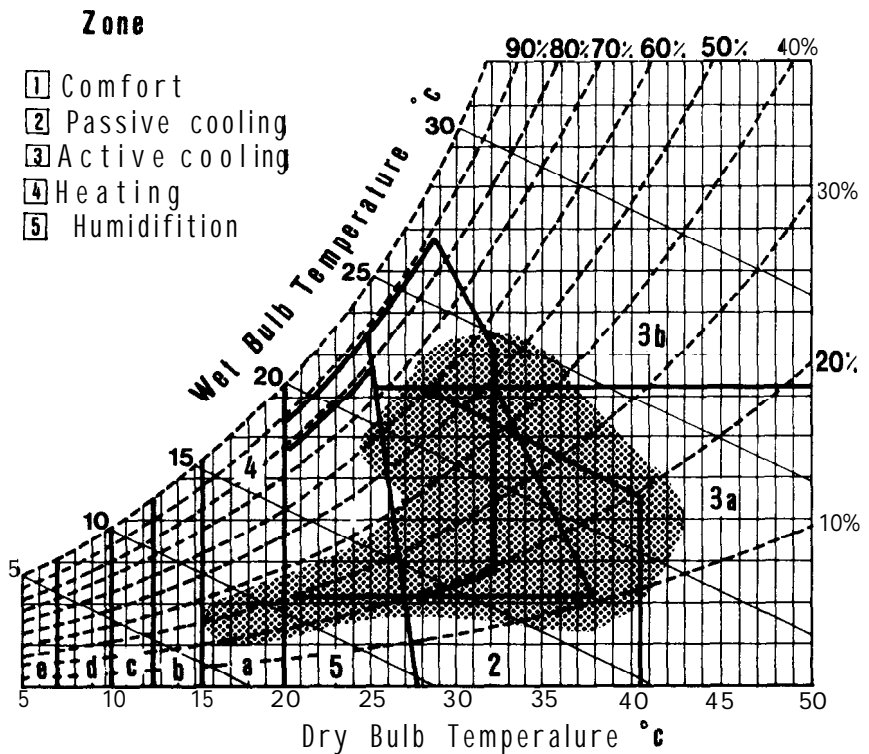


Fig. 3. Psychrometric chart; Khartoum

statistical report [9, p. 102-112], as shown in Table 1, the GDP per capita of the Kingdom of Saudi Arabia was 623.6 US Dollars in 1971 and it increased considerably in ten years to reach 15593.7 US Dollars in 1980. According to the same report and as shown in Table 2, the GDP per capita of Sudan was 143.0 US Dollars in 1971 and over the same ten years period it reached 436.0 US Dollars.

The expansion of the Saudi economy is reflected by the improvement of many services and facilities such as housing, industry, health, transportation, electricity, education... etc. Housing in the Kingdom of Saudi Arabia has improved considerably during the last twenty years to meet the housing needs of the Saudi population and the **labour** force recruited from abroad. This improvement is due to a number of factors such as the importation of huge quantities of building materials, the expansion in the Saudi building industry, the housing projects constructed by different ministries and organizations for their staff, the significant financial support provided by the Real Estate Development Fund., etc. The Real Estate Development Fund [10, p.23] provided 41,027 loans in 1975/76 at a total cost of 8,197,000,000 Saudi Riyals

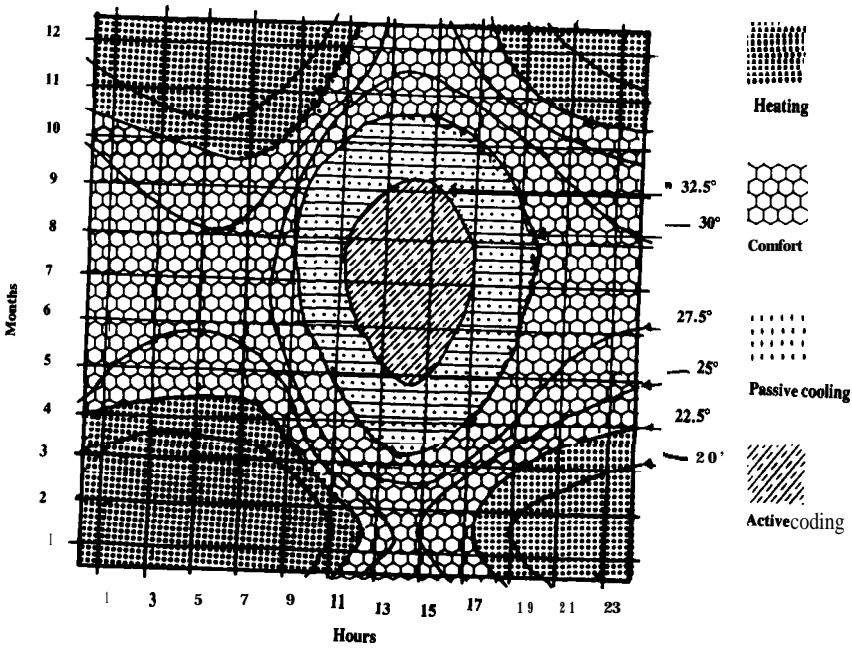


Fig. 4. Isopleth chart; Riyadh

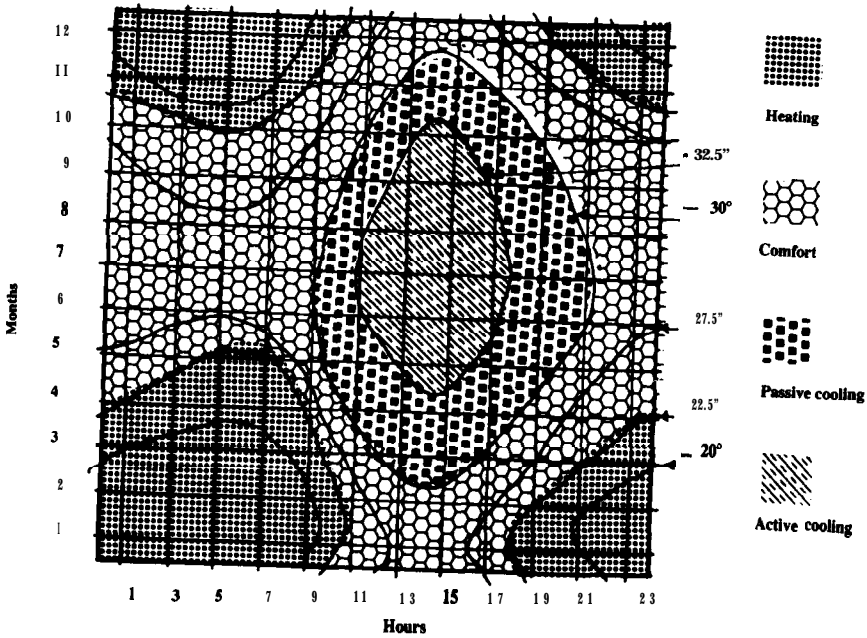


Fig. 5. Isopleth chart; Khartoum

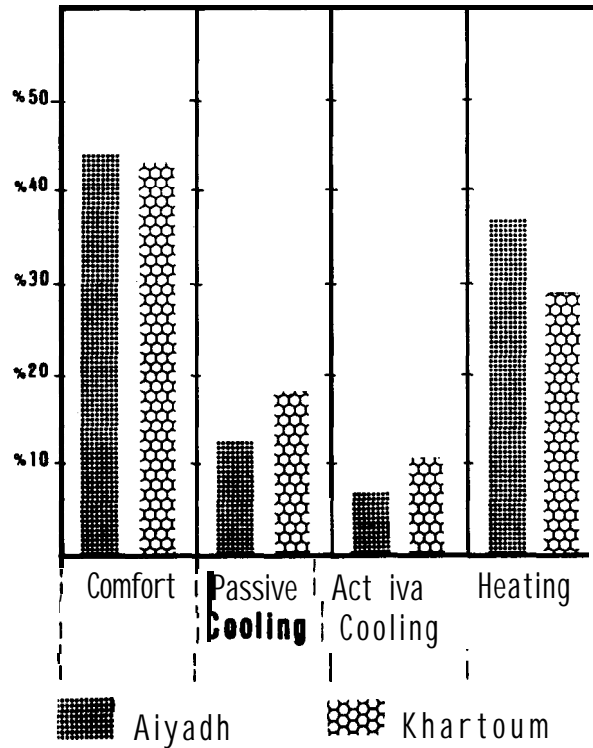


Fig. 6. Climatic divisions.

(2,322,096,300 US Dollars). As shown in Table 3 the financial support by the Real Estate Development Fund continued over the years and it reached 42,430 loans in 1982/83 at a total cost of 7,617,000,000 Saudi Riyals (2,179,399,100 US Dollars). In contrast, the housing sector in Sudan experienced a significant deterioration. The increase in population, the migration from rural areas to urban centres and the influx of refugees from neighbouring countries made the housing situation even worse. This is clearly reflected by the growth of squatters in and around Khartoum. The government failed to provide the substantial financial support required to solve the housing problems. As a result, most houses are built by self-help and/or private owner limited savings. In most cases these houses lack the essential services such as electricity, water supply and drainage system. According to a statistical report [11, pp. 206-207] the Estate Bank of Sudan offered its maximum financial support in 1976/77 to build 1211 housing unit at a total cost of 2,456,000 Pounds Sudanese (7,052,659 US Dollars). The number of loans and the amount of money varied over the years, as shown in Table 3.

Table 1. The main features of the Saudi economy

Year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
Gross domestic product (Million Riyals)	17399	22921	28577	40552	99316	139601	164527	205056	223747	248412	385807	520589	524718	415230	381592
Population (Million)	6.20	6.38	6.57	6.76	6.97	7.25	7.62	8.01	8.42	8.82	9.23	9.63	10.00	10.42	10.80
Imports (Million US Dollars)	710	818	1136	1972	2859	4214	86946	14656	20350	24455	30165	35269	40644	39197	33690
Exchangerate S.R./\$US	4.500	4.150	4.150	3.550	3.530	3.530	3.530	3.530	3.315	3.365	3.325	3.415	3.435	3.495	3.575
GDP per capita (SR.)	2806.3	3592.6	4300.9	5998.8	14249.1	119255.3	21591.5	25600.0	26573.1	28164.6	38548.0	54059.1	52471.8	39849.3	35332.6
GDP per capita (\$ US)	623.6	865.7	1036.4	1689.8	4013.8	5454.8	6116.6	7303.9	8016.1	8369.9	11593.7	15829.9	15275.6	11401.8	9883.2

Table 2. The main features of Sudanese economy

Year	1970	1971	1972	1973	1974	197.5	1976	1977	1978	1979	1980	1981	1982	1983	1984
Grossdomesticproduct (Million Sud. Pounds)	701.5	752.1	752.1	890.8	1246.2	1510.8	1848.0	2339.7	282.7	3253.8	4072.1	4792.7	6217.9	.	.
Population (Million)	14.09	14.14	14.81	14.96	15.34	15.73	16.13	16.95	17.56	18.13	18.68	19.24	19.80	20.36	20.95
Imports (Million US Dollars)	287.5	331.5	338.6	436.1	710.8	103.5	980.4	1081.2	1194.3	1109.2	1576.4	1504.8	1282.4	1354.4	.
Exchange rate \$ US/SUD. Pounds	2.8176	2.8176	2.8176	2.8176	2.8176	2.8176	2.8176	2.8176	2.5000	2.000	2.000	1.1100	.7692	.7692	.7692
GDPpercapita (Sud. Pounds)	49.8	52.1	50.8	59.5	81.2	%O	114.6	138.0	164.2	179.5	218.0	249.1	314.0	.	.
GDPper capita (\$ US)	143.0	149.6	145.8	171.0	233.3	275.8	329.0	396.4	410.4	358.9	436.0	276.5	241.6	.	.

Table 3. Electrical energy consumption and housing loans in the Kingdom of Saudi Arabia and Sudan.

Years	Saudi Arab&		Sudan			Total amount (Thousands Sud. Pounds)
	Elect. energy prod. mega WH	Number of loans	Total amount (Million Saudi Rlyals)	Elect. energy prod. mega WH	Number of loans	
1975/76	4.270.146	41.027	8.197	628.000	-	
1976/77	6.388.999	56.346	13.536	683.000	1.211	2.456
1977/78	7.262.996	4.598	0.955	738.000	78	131
1978/79	9.713.334	41.288	8.690	863.000	1.263	2.598
1979/80	15470.085	39.828	8.185	935.000	512	2.233
1980/81	18.908.838	34.312	6.956	979.000	403	1.646
1981/82	25.061.449	37.360	9.438	1.010.000	-	
1982/83	31.014.329	42.430	7.617			

Electrical energy consumed in buildings and the number of air-conditioning equipments in the two countries may reflect the extent of mechanical control of the indoor climate. A summary of the statistical data of electrical energy consumption in Sudan [11, p. 132] and in the Kingdom of Saudi Arabia [12, p. 315] is given in Table 3. As shown in the table, the production of electricity in Sudan in 1975/76 was 628,000 MWH, while in the Kingdom of Saudi Arabia it was 4,270,146 MWH. Over a six years period i.e., in 1981/82 the production of electricity in Sudan reached 1,010,000 MWH while in the Kingdom of Saudi Arabia it reached 25,061,444 MWH. No accurate data is given for electricity consumption for air-conditioning in the two countries. But nevertheless there are some rough estimates which are reasonably reliable for the sake of comparison. According to a statistical report [12, p. 131], 40% of the electrical energy produced in Sudan is consumed in buildings. As for the Kingdom of Saudi Arabia it is reported [13] that about 66% of the total energy generated is consumed by residential and commercial buildings. The analysis of the data available shows that 65% of this electrical energy is consumed in air-conditioning of buildings. Therefore the electrical energy consumed in buildings is estimated as 404,000 MWH in Sudan and 16,540,553 MWH in the Kingdom of Saudi Arabia.

Regarding the availability of air-conditioning equipment, the statistical data reflects the big difference between the two countries. According to a report [14, pp. 336-339] in 1984 there are eleven factories in the Kingdom of Saudi Arabia producing air-conditioning equipment. The total production of these eleven factories in 1984 was estimated as 469,550 air-conditioning and air-cooling units and 28,300 units for central air-conditioning. However, it seems that the local production does not satisfy the demand and hence extra equipment is imported from abroad. The General Department of Statistics reported [15, p. 137] that during the second half of 1985 the Kingdom of Saudi Arabia imported 17909, 8981, 1163, 177562 and 585 air-condition-

ing units from USA, France, U.K., Japan and West Germany respectively. On the other hand according to the statistical report [12, pp. 104-125], there are no factories producing air-conditioning equipments in Sudan. However, according to personal observations, there is a small workshop for the assembly of air-coolers. This workshop imports most of the essential parts from abroad. The output of this workshop is so small that it is not recorded anywhere. According to the statistical data given in an annual report [16, pp. 128-129] of the Bank of Sudan, the total number of air-conditioning units imported from abroad was 709, 341, 631, 871 and 775 units during the years 1977, 1978, 1979, 1980 and 1981 respectively.

From the above analysis, it is clear that the means for controlling the indoor environment are within easy access to the majority of the urban population in the Kingdom of Saudi Arabia. This encouraged people to spend most of their time within a mechanically controlled environment. As a result, the traditional passive solutions which were developed over the years to suit the hot-dry climate were overlooked by most designers and architects. Consequently, the traditional courtyard house, Fig. 7 and Fig. 8 was replaced by a western villa type, see Fig. 9 and Fig. 10. The villa is characterized by relatively thin external walls from reinforced concrete, large glazed openings to the outside facing different directions and exposed open spaces which

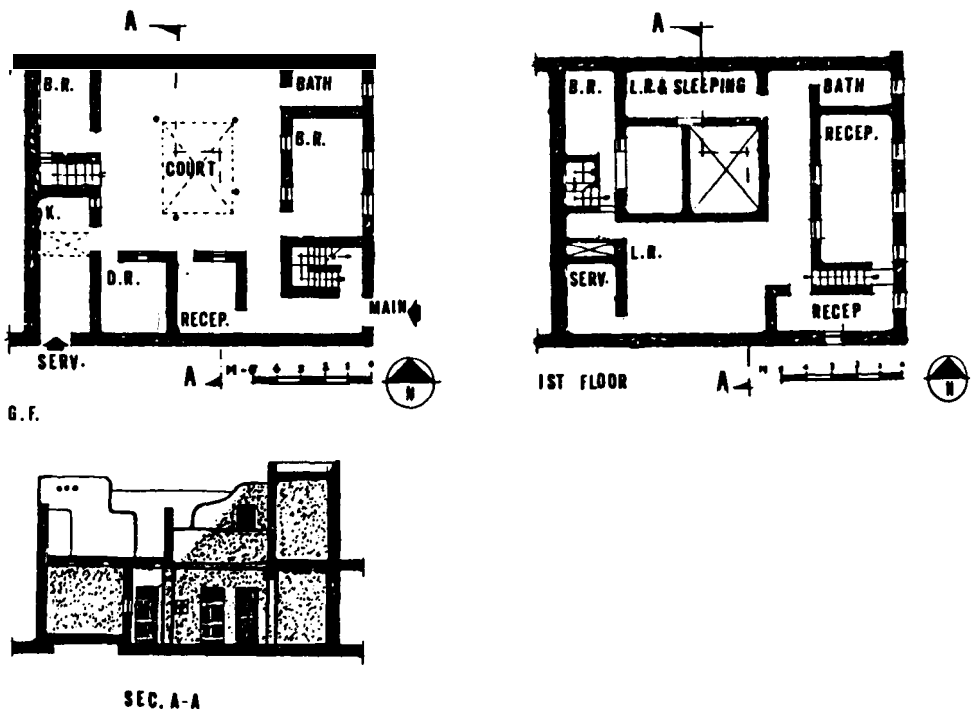


Fig. 7. A traditional courtyard house; Riyadh

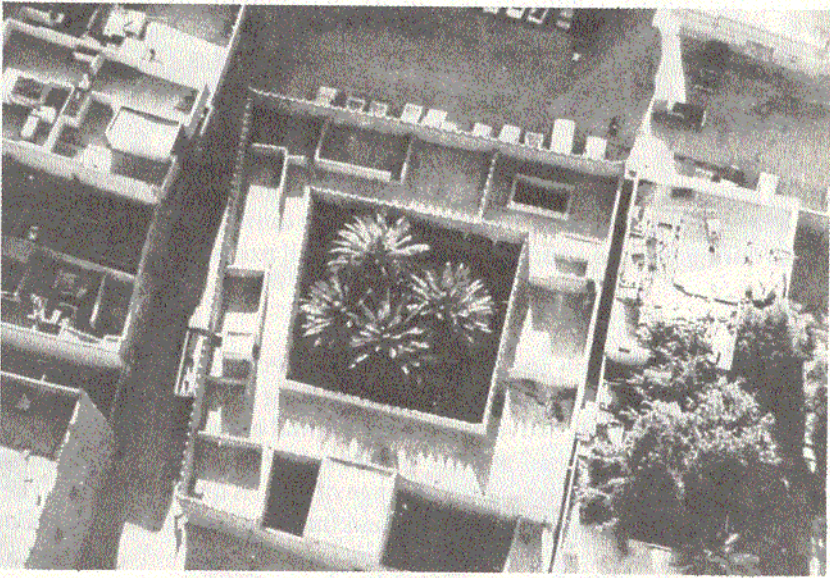


Fig. 8. A traditional house; Riyadh.

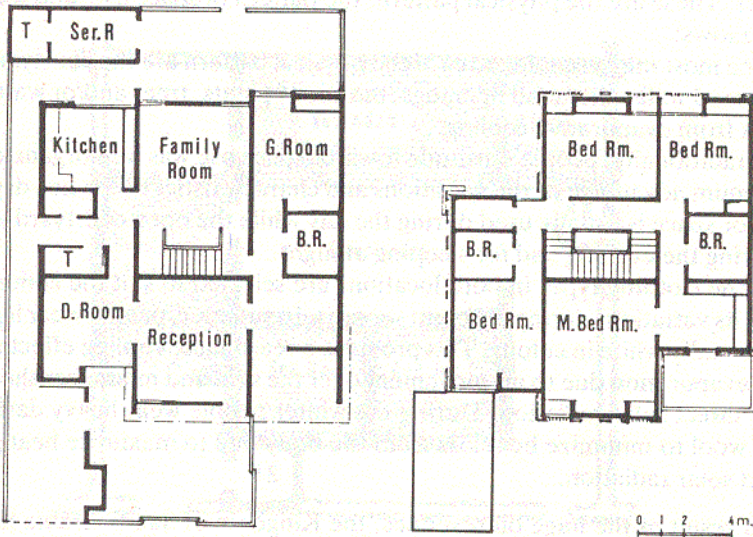


Fig. 9. A contemporary villa; Riyadh

neither suit the climatic conditions nor the social requirements of a Moslem society, As for Sudan, since there are no significant changes in the economic situation there are hardly any changes in the pattern of living. Because of the fact that the majority of the population could not afford the high cost of air-conditioning, most houses still depend on their natural thermal performance. As shown in Fig. 11 the courtyard house built of thick mud walls, with small openings and thatch roofs remains the dominant feature of urban centres in the hot-dry regions of Sudan. The traditional pattern of space use, that is the use of indoor space during the daytime and the open courtyard during the late afternoon and at night still exists.

Conclusions

The climates of Riyadh and Khartoum are characterized by very high temperatures and very low relative humidity during the long summer seasons. To achieve adequate thermal comfort, active cooling is essential especially during daytime due to the high temperature values and the intense solar radiation. At night the air temperature falls considerably and a diurnal range of 20°C is quite common. The winter of Riyadh is somewhat cooler and longer than that of Khartoum. Active Cooling is essential in Riyadh and desirable in Khartoum.

Over the years a number of indigenous traditional passive alternatives were developed to suit the hot-dry climate. Some of these alternatives were successfully implemented in **Riyadh** and Khartoum and they could be classified into three main categories. These are the physical pattern, the pattern of space use, and the clothing type as follows:

i- The most important features of the physical pattern are the courtyard design, the thick mud walls, the small openings, the use of plants, trees and/or water surface to benefit from evaporative cooling.

ii- Traditionally, people's attitude towards space use was well organized to take the maximum advantage of the variations and characteristics of the hot-dry climate. The indoor space is usually used during the day while the open courtyard is used for living during the evening and for sleeping at night.

iii- The clothing types in both locations are selected to suit the climatic conditions and its variations during different seasons. In summer, people wear light roomy clothing usually white in **colour**. This provides a reasonable cooling effect as a result of sweat evaporation due to air movement over the skin and minimizes the heat gain from the direct solar radiation. During the winter people wear heavy dark clothing made of wool to minimize heat loss from the body and to maximize heat gain from the direct solar radiation.

As a result of the huge oil revenues, the Kingdom of Saudi Arabia has experienced significant economic, social and cultural changes towards modernization. The sudden increase in the national income and the per capita income together with the availability of cheap electrical energy and a variety of air-conditioning equipment

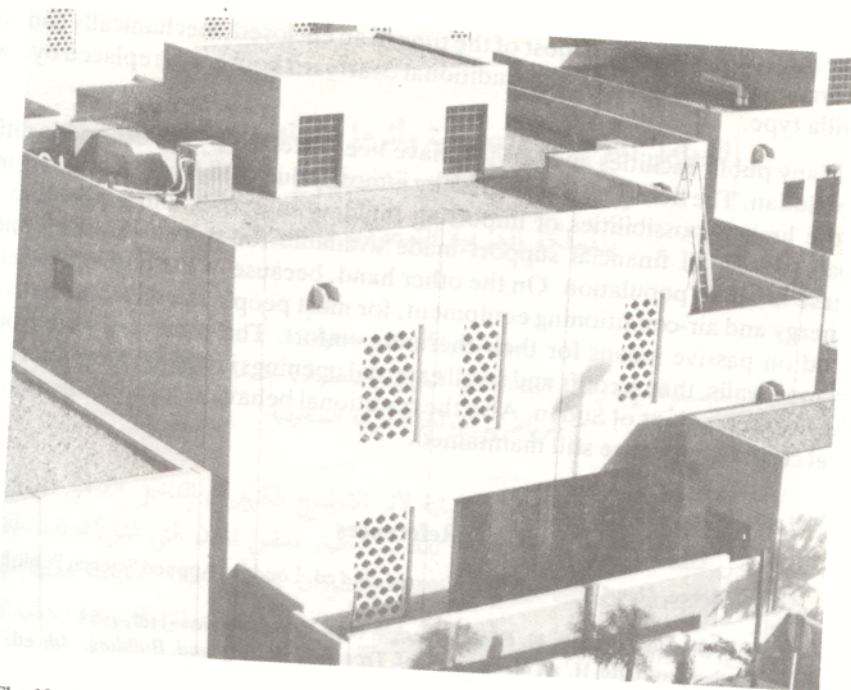


Fig. 10. A contemporary villa; Riyadh

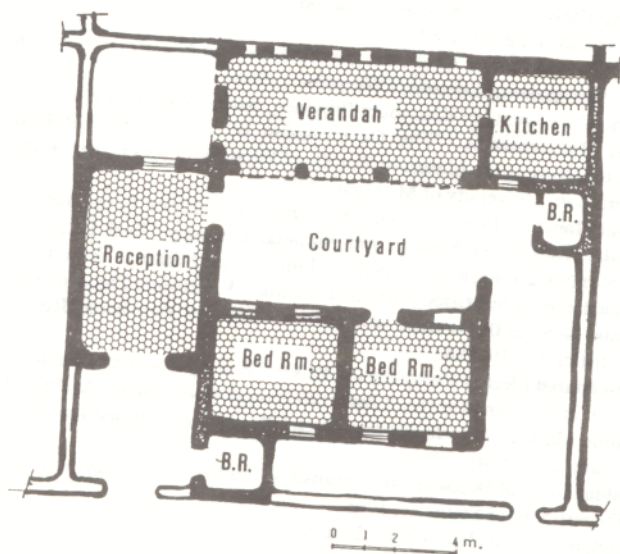


Fig. 11. A courtyard house; Khartoum

encouraged people to spend most of the time in an enclosed, mechanically controlled environment. Consequently, the traditional courtyard house was replaced by a western villa type.

Many public facilities and services have been affected by the economic difficulties of Sudan. The deterioration in housing is mostly due to the lack of building industry, the limited possibilities of importing building materials and equipment from abroad, the small financial support made available for private housing and the increase in urban population. On the other hand, because of the high cost of electrical energy and air-conditioning equipment, for most people the only alternative is to depend on passive means for their thermal comfort. The courtyard house built of thick mud walls, thatch roofs and small external openings is still the dominant feature in the hot-dry regions of Sudan. Also the traditional behaviour of space use and traditional clothing types are still maintained.

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العوامل المناخية والاقتصادية وأثرها على تصميم المساكن ١ - دراسة خاصة بالمناطق ذات المناخ الحار الجاف بالمملكة العربية السعودية والسودان

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ملخص البحث . تعتبر هذه الدراسة محاولة تحليلية لأثر الارتفاع الكبير في الدخل القومي لدول الخليج العربي وانعكاس ذلك على تصميم المساكن . لقد تم اختيار بعض المدن التي تمثل مختلف التقسيمات والظروف المناخية الأساسية بالمملكة العربية السعودية والسودان كعينة لإجراء الدراسة عليها . وتسهيلا للبحث والاطلاع فقد تمت تجزئته على مرحلتين . المرحلة الأولى وهي التي تتعلق بالدراسة الحالية للمناطق ذات المناخ الحار الجاف كجزء أول . أما المرحلة الثانية والتي سوف يتم عرضها في وقت لاحق إن شاء الله تتعلق بالمناطق ذات المناخ الحار الرطب .

وتتلخص محتويات الدراسة المقدمة في المرحلة الأولى على تحليل المناخ الطبيعي للمناطق التي تم اختيارها ودراسة أثر المناخ على تصميم المساكن القديمة، ويعقب ذلك تحليل مختصر للنواحي الاقتصادية والاجتماعية للمملكة العربية السعودية والسودان ومحاولة إبراز أثرها على تصميم المساكن الحديثة .