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Punjab: Structure of the aged population

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Abstract:
Aged population in Pakistan is continuously increasing, but aged population in Punjab is increasing higher than the national rate. This increase is higher in urban areas rather than in rural areas. In all categories Punjab exceeds from national level. Share of the aged population is high in rural areas, which give a clear indication that aged 60+ population number in Punjab is high, as well as old aged 75+ percentage is high.

Introduction
Punjab is Pakistan's second largest province having an area 205,334 km² (79,284 square miles), but it is the most populous province of Pakistan. According to 1998 census, the population of the Province is 73,621,290. The population density is 353 persons per square kilometer as compared to the national figure of 164. The province is a mainly a fertile region along the river valleys, which is main reason of highest population. The region contains the Cholistan deserts. The landscape is amongst the most heavily irrigated on earth and canals can be found throughout the province.

Methodology
For the study data has taken from the population census of Pakistan has been widely used for the analysis which has almost completely depended, on the population census as its exclusive and prime source of relevant information. The population census 1998 which is the latest in the sources of the population censuses was used for the analysis of the most recent characteristics deemed as elements of the existing pattern or situation. The data assembled from the pervious censuses from 1951 to 1998 was attempted to trace past trends and changes in the evolving patterns

Size of the Aged Population
According to the census 1998 the aged population in that year was 7.16 million out of total population 129.17 million. It was 5.54 percent of the total population of Pakistan. The proportion of the aged in the population of the provinces in 1998 is given in Table 1. The province of Punjab, which contained 57.00 percent population of Pakistan, had 63.82 percent of the total aged population. The other provinces had far smaller size of the aged population as indicated by the percentage of their aged population that is Sindh 19.59, NWFP 12.13, Balochistan 3.94 and Federal Capital Islamabad 0.51.

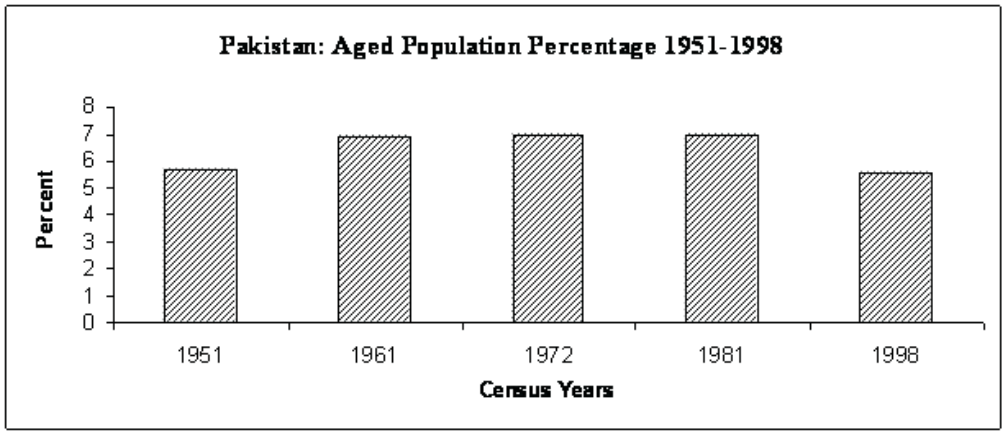
A remarkable feature of the size differences among the provinces is that the proportion of the aged in Punjab stands much above, its share in the total population of the country, whereas in rest of the provinces, it is lower than the share of their population in total population of Pakistan.

The size share of the aged in the Punjab is clearly owed to sizeable out-migration of the working age population.

Table1: Pakistan: Aged Population by Province, 1998

	Total Population	Total Share Percentage	Aged Population	Aged Share Percentage	Aged Proportion Percentage
Pakistan	**129,169,894**	**100.00**	**7,159,893**	**100.00**	**5.54**
Punjab	73,621,290	57.00	4,569,796	63.82	6.21
Sindh	30,439,893	23.57	1,402,597	19.59	4.61
NWFP	17,737,591	13.73	868,765	12.13	4.90
Balochistan	6,565,885	5.08	282,191	3.94	4.30
F. C. Islamabad	805,235	0.62	36,544	0.51	4.54

Based on Table 4 of Census Report of Pakistan, 1998



Change in Size of the Aged Population Since 1951

As part of the continuously growing population, the aged have recorded continuous increase since 1951. The size of the aged population as proportion of the total population has witnessed two distinct periods of change. Between 1951and 1981 the size increased gradually from 5.67 percent to 7.00 percent of the total population. The period of decline in size proportion occurred between 1981 and 1998 when its percentage was 5.54, showing considerable decrease in the proportion of the aged populations in 1998.

Size Changes in Rural and Urban Population Since 1951

Changes of size in the rural aged population indicate similar trend as the total aged population of Pakistan and that of the provinces, since two distinct periods of change are also indicated in respect of the rural aged. This implies the overall influence of the size of the rural aged in determination of the size of the total aged as well as its change from 1951 to 1998. This becomes very obvious when the rates of reduction in the sizes between 1981 and 1998 are compared.

A sharp decline in 1972 from the high size in 1961 was followed by static trend between 1981 and 1998. Between 1981 and 1998 the reduction in size followed the general trend as seen in

Table 2: **Punjab: Size Changes of the Aged Population**					
by Rural, Urban Categories 1951 – 1998					
(Percent of Total Population, Pakistan and Province)					
	1951	**1961**	**1972**	**1981**	**1998**
Total					
Pakistan	5.67	6.90	6.98	7.00	5.54
Punjab	5.90	7.21	7.59	7.80	6.21
Rural					
Pakistan	-	7.33	7.55	7.59	5.91
Punjab	-	7.61	8.12	8.42	6.65
Urban					
Pakistan	-	5.53	5.45	5.55	4.80
Punjab	-	5.74	5.94	6.18	5.23

Based on Table 4 of Census Reports of Pakistan

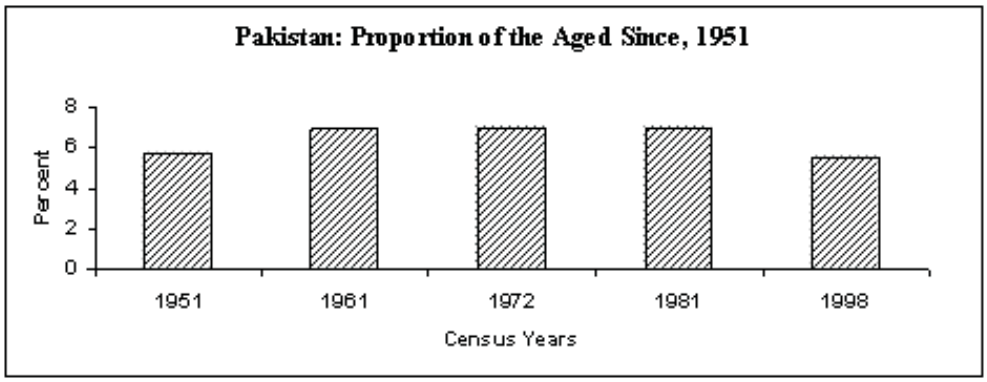


Fig 2

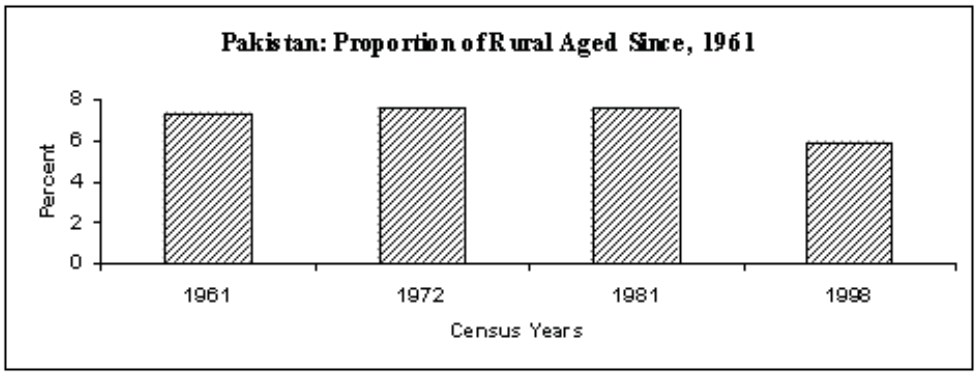


Fig 3

the total aged and Punjab aged population.

The size changes of the urban aged population are not as sharp as that of the rural aged and they also follow a slightly different trend. Between 1961 and 1981 either slight increase or

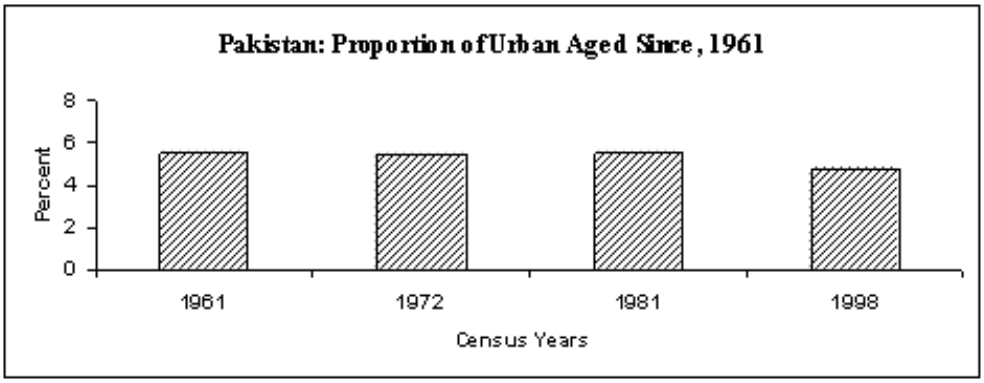


Fig 4

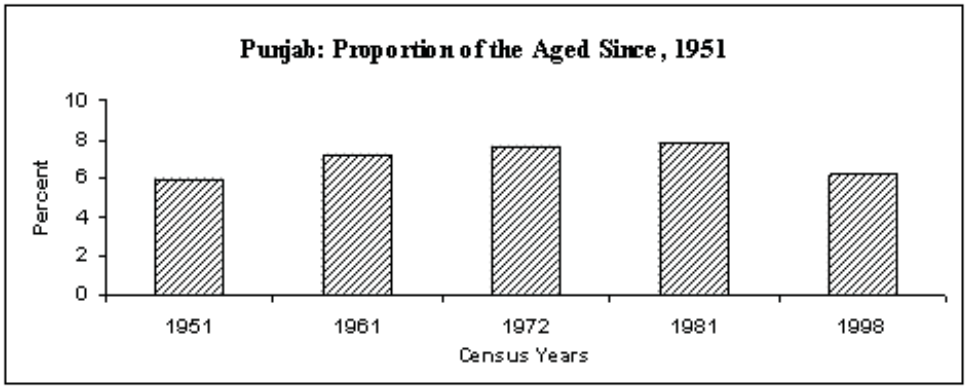


Fig 5

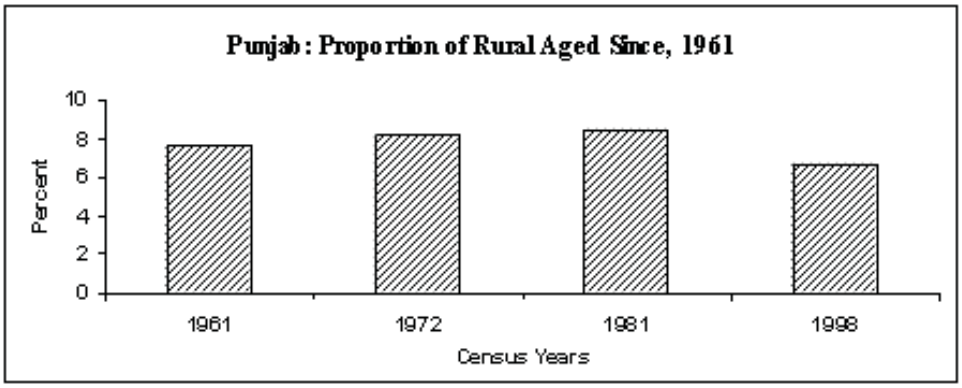


Fig 6

decrease in sizes was recorded. Punjab recorded slight increase, between 1981 and 1998 a slight decrease in size occurred. (Fig. 2. to 4)

Share Changes Since 1951

Aged Population share in Punjab has been changed since 1951. The share change depends on its total population and the aged population.

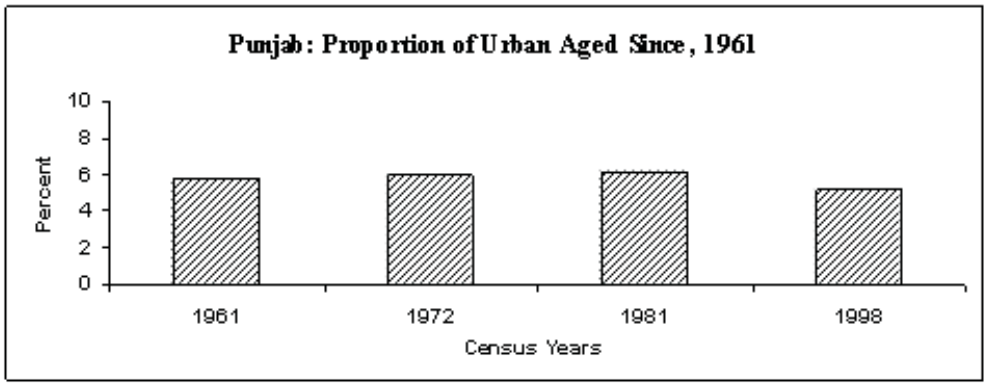


Fig 7

Table. 3

Punjab: Aged Population, Percentage Share by Urban Rural Categories, 1951-1998										
	1951		1961		1972		1981		1998	
	Total	Aged	Total	Aged	Total	Aged	Total	Aged	Total	Aged
Total										
Punjab	64.83	67.41	63.34	66.16	60.21	65.42	57.71	64.35	57.00	63.82
Rural										
Punjab			65.33	67.81	61.96	66.61	58.93	65.41	58.69	66.05
Urban										
Punjab			56.96	59.16	55.38	60.42	54.72	60.84	53.59	58.34

Based on Table 4 of Census Reports of Pakistan

Punjab had highest share of 63.82 percent in 1998. Similar situation prevailed in the past census years as well. Present share of Punjab's total population has recorded continuous decrease since 1951. Against this declining trend the decrease in the aged population share has been very slight except somewhat high increase in the percentage of the aged in 1961. It is clear that the differential between the share of the Punjab's population in total population of Pakistan and that of the Punjab's aged population is glaringly very high, suggesting a high degree of concentration of the aged in Punjab.

Share of the Aged in Rural Population

The share of the Punjab's population in the total rural population of Pakistan shows a declining trend since 1951. The share of the rural aged in the rural population shows an increasing trend with positive high differentials.

The trend of change in the share of both total rural population and rural aged population are only slightly static. The differential between the share of the total rural and rural aged

Table 4

Punjab: Pakistan: Differential between the Share in the Total Population and Share of the Aged Population										
	1951		**1961**		**1972**		**1981**		**1998**	
	Positive	Negative	Positive	Negative	Positive	Negative	Positive	Negative	Positive	Negative
Total										
Punjab	2.58		2.78		5.21		6.64		6.82	
Rural										
Punjab			2.48		4.65		6.48		7.35	
Urban										
Punjab				2.20		5.04		6.12		4.75

Based on Table 4 of Census Reports of Pakistan

population shows a negative trend.

Share of the Aged in Urban Population

In the Punjab the share of the urban aged has been higher than that of the total urban aged population of the province throughout the period 1951-1998. 1981 recorded the highest share 60.84 percent of the total urban aged population from which it declined to 58.34 percent in 1998.

The share of the urban aged in the total urban population of the Punjab has shown slight increase from 1961 to 1981 after which it declined in a small degree that is from 34.59 percent in 1981 to 34.55 percent in 1998. The share of the urban aged population has shown a slight decrease between 1961 to1981 and again a slight increase between 1981 and 1998. The year 1981 recorded the highest differential between the share of the total urban and the share of the urban aged population, the differential being 4.83.

Differentials between Share of the Aged Population and the Share of the total Population

Differentials are both positive and negative when the share of the aged in provincial population is higher than the share of the provincial population in the total population of the country. When the share of the provincial aged population is less than the share of the provincial population in total population of the country, the differential is negative.

A trend of continuous positive differentials indicates a higher rate of growth of the aged population compared with the rest of the population. Such a pattern of differentials will lead to gradual ageing of the population.

Rural Differentials

The positive differentials of the rural population in Punjab have shown high increase from one census to another. The differential recorded in 1998 rural population is even higher than the differential of the total population (rural urban population combined) indicating larger size of the rural aged population in Punjab.

Urban Differentials

Table 5: Punjab Population Growth and Growth of the Aged

Percentage Increase and Cumulative Increase Over 1951						
Census	All Ages	All Ages	Aged 60+	Aged 60+	All Ages	Aged 60+
Year	Percentage	Cumulative	Percentage	Cumulative	Intercensul	Intercensul
	Increase	Percentage	Increase	Percentage	Average	Average
		Increase		Increase	Annual	Annual
					Increase	Increase
Punjab						
1951						
1961	23.96		51.47		2.40	5.15
1972	47.02	70.98	54.76	106.23	4.27	4.98
1981	25.74	96.73	29.28	135.51	2.86	3.25
1998	55.67	152.40	23.85	159.36	3.27	1.40

Based on Table 4 of Census Reports of Pakistan

Differentials of the urban population in Punjab are positive in all the censuses. They show high increase from 1961 to 1981 and the decrease from 1981 to 1998. The implication of this trend is that the size of the urban aged segment decreased in 1998.

Growth of the Aged Population Since 1951

The trend of growth in the Punjab population is shown in the Table 5. In Punjab the aged population increase displayed two distinct trends: (1) the rate of increase of the aged population since 1951 is greater than the rate of increase of the total population, as indicated by the differences of their total cumulative growth, and (2) the rate of increase of the aged population has shown a downward trend in terms of average annual increase between the censuses which occurred also along with opposite trend of increase recorded by the total population.

Sex Composition of the Aged

The sex composition of the aged (Table 6, 7) is characterized by prevalent higher proportion of males in the national and Punjab population of the aged. The same pattern with higher masculinity occurs in both rural and urban areas. Considerable variation in the sex composition is found in the Punjab and also in rural and urban populations. These differences, which imply imbalance or gap in sex proportion, is indicated by the sex ratio as given in Table 6. Punjab has sex ratio 118.84 is less than the national figure, the national ratio is (119.26).

As for the differences of sex composition (as indicated by the sex ratios) between the rural and urban aged population, sex ratios of the urban aged are higher than those of the rural in the provinces of Punjab. The higher sex ratio among the elderly points out the higher survival rates of the males, which fact means as well a much higher life expectancy for the males. This stands in sharp contrast to many countries where female proportion and female life expectancy are remarkably higher than that of the male segments.

Sex Composition of the Aged Since 1951

For Pakistan as a whole changes in sex ratio between the year 1951 and 1998 recorded two

Table 6: **Punjab: Aged Population Sex Composition by Province Rural and Urban, 1998**

	Total Aged		**Rural Aged**		**Urban Aged**	
	Male	**Female**	**Male**	**Female**	**Male**	**Female**
Pakistan	54.39	45.61	54.32	45.68	54.58	45.42
Punjab	54.30	45.70	54.14	45.86	54.76	45.24

Based on Table 4 of Census Report of Pakistan, 1998

Table 7: **Punjab: Sex Ratio of the Aged Population by Rural and Urban, 1998**

(Males per Hundred Females)			
	Total Aged	Rural Aged	Urban Aged
Pakistan	119.26	118.89	120.18
Punjab	118.84	118.07	121.02

Based on Table 4 of Census Report of Pakistan, 1998

distinct trends; one, an increase in the sex ratio from 1951 (116.64) to an strikingly higher figure (136.94) in 1981, and two a downward trend from the high ratio of 1981 to a considerably low ratio in 1998 (119.26). The obvious implication of this trend is that the female mortality rates were in all probability much higher between 1951 and 1981 than they were in the period following 1981.

The national trend is closely followed by the province of Punjab. In the Punjab was recorded the highest masculinity in 1972.

Rural and Urban Aged Sex Composition Since 1951

Both the rural and urban sex ratios show the same trend as the national population of the aged. In Punjab the trend is different from the national trends as well as their own general trends. Both rural and urban population recorded increase in sex ratios in the period from 1961 to 1972. (Table 8, 9, Fig. 7 to 8).

Age Structure of the Aged

The difference of the sex proportion of the aged is also reflected in the age structure, which is presented in Table10, Fig. 8 to 9. Majority of the aged is found in the age group 60-64 for both male and female. A sharp decline of size in next age group, that is, 65-69 is significant in that the survival chances are greatly reduced for both sexes in this age group. The proportion of the old aged means age (75+) appears to be sizeable as in respect of both male and female it is comparable to almost similar size of the last two successive age groups.

Punjab age structure of the aged closely resembled the pattern exhibited by the national population.

Rural and Urban Age Structure of the Aged

The age structure of the aged by rural and urban categories is given in Table 11 Though the pattern of rural and urban aged closely conforms to that of the national structure, there are

Table. 8: **Pakistan: Aged Sex Ratio by Province, Rural and Urban Since, 1951**

Census Year	Pakistan	Punjab	Sindh	NWFP	Balochistan	F. C. Islamabad
1951	116.64	113.78	129.45	107.77	147.49	-
1961	133.38	137.28	124.38	127.37	136.43	-
1972	136.75	141.24	126.55	132.65	125.38	138.99
1981	136.94	139.46	130.18	137.51	127.79	143.55
1998	119.26	118.84	115.75	122.36	134.73	125.27

Based on Table 4 of Census Reports of Pakistan

Table. 9: **Punjab: Aged Sex Ratio by , Rural and Urban Since, 1951**

	1951	1961	1972	1981	1998
Total					
Pakistan	116.64	133.38	136.75	136.94	119.25
Punjab	113.78	137.28	141.24	139.46	118.84
Rural					
Pakistan	-	132.55	135.92	135.84	118.89
Punjab	-	135.75	140.11	138.76	118.07
Urban					
Pakistan		136.95	140.02	140.67	120.18
Punjab		144.99	146.15	141.99	121.02

Based on Table 4 of Census Reports of Pakistan

Table. 10: **Pakistan & Punjab: Aged Population Sex Composition by, Rural and Urban Since 1951**

	Total Aged		Rural Aged		Urban Aged	
Census Years	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
Pakistan						
1951	53.84	46.16	-	-	-	-
1961	57.15	42.85	57.00	43.00	57.80	42.20
1972	57.76	42.24	57.61	42.39	57.95	41.39
1981	57.80	42.20	57.60	42.40	58.45	41.55
1998	54.39	45.61	54.32	45.68	54.58	45.42
Punjab						
1951	53.22	46.78	-	-	-	-
1961	57.86	42.14	57.58	42.42	59.18	40.82
1972	58.55	41.45	58.35	41.65	59.37	40.63
1981	58.24	41.76	58.12	41.88	58.68	41.32
1998	54.30	45.70	54.14	45.86	54.76	45.24

Based on Table 4 of Census Reports of Pakistan

Age and Sex Structure of the Aged Population, 1998

Fig. 8

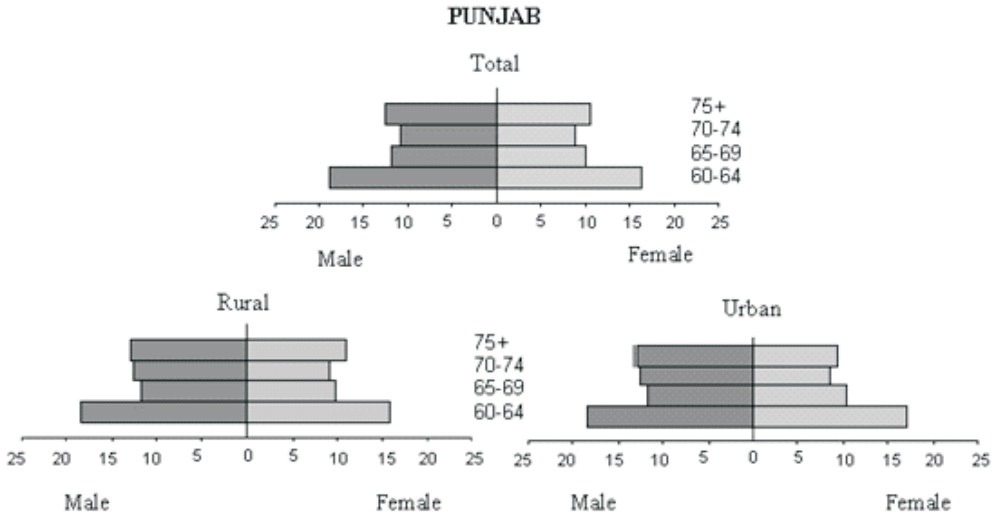


Fig. 9

some differences between rural and urban structure of the aged. The proportion of both male and female in the age group of 60-64 and 65-69 was higher in urban areas than those of the rural areas. Another significant difference between the age structure of rural and urban aged is in the size and proportion of the old aged (aged 75+) which was much higher than the size of the old aged of the urban aged population. It should be noted that Punjab which had highest number of the aged had smaller proportion of both male as well as female in the age group 60-64 than the corresponding size shown for Pakistan.

Table 11: Punjab: Age and Sex Structure of the Aged Population by Rural and Urban, 1998

	Male				Female			
	60-64	**65-69**	**70-74**	**75+**	**60-64**	**65-69**	**70-74**	**75+**
Total Aged								
Pakistan	19.80	11.87	10.86	11.86	17.02	9.83	8.83	9.94
Punjab	18.85	11.96	10.94	12.56	16.35	9.96	8.93	10.51
Rural Aged								
Pakistan	19.38	11.49	12.09	12.40	16.66	9.63	8.99	10.37
Punjab	18.41	11.70	12.61	12.97	16.00	9.84	9.03	10.93
Urban Aged								
Pakistan	20.87	12.83	10.35	10.53	17.84	10.35	8.35	8.88
Punjab	20.06	12.68	10.60	11.42	17.16	10.31	8.46	9.31

Based on Table 4 of Census Report of Pakistan, 1998

The proportion of old aged age group (75+) was the highest in Punjab for both rural and urban aged population. Pakistan contrastingly had a much bigger proportion of both male and female than similar age group under both rural and urban categories. The size of the next age group, that is, 65-69 of both male and female is considerably reduced, showing a much lesser survival rate than that recorded for Pakistan or the rest of the provincial rural population of the aged.

In the rural aged populations the size of the age group 60-64 was slightly smaller than the size of the total aged population. The next age group, that is, 65-69 was also smaller than the size of the similar age group in the total aged population. It is striking to note that in the higher age group 70-74 and 75+ the respective size is quite higher or larger than those of the total aged population. The size of the old aged group far exceeds the respective size of the last two groups, showing the significance of the old aged population under the rural category

In the urban category, the age group 60-64 both male and female had a slightly larger size than the similar age group in the national aged population. The decline in the proportion in the next age group 65-69 was also the same as that in case of the national aged. The proportion of the old aged in the urban population for both male and female was lower in the national aged in the same age group, but the proportion of the old aged in both male and female was quite lower than that of the rural aged.

In Punjab the proportion of the age group 60-64 was comparable to that of the national urban aged, but the proportion of the urban old aged both male and female, was significantly higher.

Conclusion

The aged have recorded continuous increase in numbers since 1951, but their proportion in the total population declined from 7.00 percent in 1981 to 5.54 percent in 1998. Changes in the size of the rural aged population are similar to those of the country's total aged population.

Changes of share of the provincial aged population as recorded by the censuses (1951, 1961, 1972, 1981, and 1998) showed much variation. Punjab registered a continuous

gradual decrease in its share of the aged since 1951; from 67.41 in 1951 to 63.82 percent in 1998.

In the rural population, the share of the rural aged has shown an increasing trend for Pakistan and also the province of Punjab.

In Punjab the share of the aged in the urban population of the province has been larger than that of the total urban population of the province during the entire the entire period from 1951 to 1998.

In Punjab the rate of increase of the aged population since 1951 is greater than that of the total population. The rate of increase of the total aged population has shown a downward trend in terms of annual average increase between the censuses (1951-1998) which occurred along with the opposite trend of increase recorded by the total population.

The sex composition of the aged is characterized by prevalence of higher proportions of males in both national and province populations. The same pattern with high masculinity marks the rural and urban areas. Considerable variations in the sex composition occurred in the Punjab and also in their rural and urban populations. Punjab had sex ratios less than their national figure (119.20).

The age structure of the aged population showed majority in the age group 60-64 for both males and females. There was a sharp decline in size of the next age group 65-69. The proportion of the old aged (75+) appeared to be sizeable in respect of both males and females, and was comparable to almost similar size of the two precedent age groups. The Punjab age structure of the aged population closely resembles the pattern exhibited by the national aged population.

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Population Growth and Land use Pattern of Karachi City

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Abstract

Karachi started its growth as a walled city in 1729 with a population of 1000 and an area of 0.12 sq. km. Its growth accelerated after 1947 when Pakistan came into existence. A large scale migration took place from India and other areas of Pakistan. As a result Karachi became the largest city of Pakistan in 1951. It retained this status in 1961, 1972,1981 and 1998 population Census. The land use arrangement of Karachi City reflects land use pattern of other large South Asian cities. The City centre is the core of business and commercial activities. Regional shopping centres have emerged in large numbers in different parts of the city. High class residential areas are located near to the city centre while low class residential areas are located in the periphery. Civil Lines and Cantonments reflect the colonial characteristic of the city.

Karachi emerged from a small fishing village, located at the present site of Karachi harbour around 270 years ago. This small village was known as Dirbo. Nearby was a deep pool of sweet water known as "Kalachi Jo Kun"Kun means deep ditch and Kalachi was the name of a fisherman (Lari,1996). It seems that Karachi is the distorted name of Kalachi. In 1729 A.D, a large number of people started to settle at Dirbo from a nearby port Kharak Bunder, located at the mouth of the Hub River. The port of Kharak Bunder was silted up, therefore the merchants selected Dirbo as a new port. This was the turning point when a fishing village turned into an embryo city. A mud wall was built around the settlement because of the threat of pirates (Khan 1969).

Population Growth and Areal Expansion

The history of population and areal growth of Karachi may be divided into the following periods.

Pre-British Period (1729-1839)
The British Period (1839- 1947)
Pakistan Period (After 1947)

Pre- British Period

Karachi started its growth as a walled city in 1729 with a population of 1000 and an area of 0.12 sq km (Khan,1967).In 1798, the population of Karachi increased to 10,000 (Baille,1975). The first official census was held in 1813 by Talpur Mir and according to this the population of Karachi was 13000 living in 3250 houses inside the wall (Baille,1975). Thus Karachi in the Pre-British period started to grow as a walled city with the attribute of a port. The city was compact and congested(Khan,1969).

The British Period

The British occupied Karachi in 1839 and it was annexed as a part of Sindh in British India in 1843 (Siddiqui,1996). Initially Hyderabad was chosen as the capital of Sindh but because of the hot climate it was shifted to Karachi. New residential and administrative buildings were constructed at a new site which was far way from the walled city.British named it Civil Lines. In 1847 Sindh was made part of Bombay and the capital was

shifted from Karachi to Bombay (Lari,1996).

The population of Karachi in 1839 at the time of British occupation was about 14000 (Baille,1975). In 1853, Karachi Municipality was established and a marked expansion and development of the town took place. The city was no more a fortified settlement. As more people came and settled in Karachi, the areas between the city and the Civil Lines were filled up. The population of Karachi in 1856 was 56879 (Baille,1975). The city which covered an area of 5 9.6 sq kms before the establishment of the Municipality became 114.2 sq kms a few years after its establishment (Gazetteer of Sind 1919).

In the beginning of twentieth century Karachi had emerged as the leading wheat exporting port of South Asia.As a result of its increasing commercial activity its population increased to 151901 in 1911 (Census, 1911).

In 1923, Karachi Municipality approved Miram's Development Plan for the planning and development of Karachi. Under that plan Bunder Road (M.A Jinnah Road) was extended up to the Central Prison (KDA,1974). In 1936, Sindh was separated from Bombay Presidency and Karachi was chosen as the capital of Sindh province. In 1941 the population of Karachi city increased to 386655 and its area expanded to 115 sq kms(Census,1941, fig 2.1).

Pakistan Period

Pakistan came into existence in 1947 and Karachi was made its capital. It retained its status as capital till 1960 when the capital of Pakistan was shifted to Islamabad (Hasan, 1999). Soon after the creation of Pakistan large scale migration from India took place. Between 1947 to 1950 about one million migrants came from different parts of India (Census,1951).Apart from this influx, a large number of people also migrated to Karachi from different parts of Pakistan (Khan,1967). As a result the population of Karachi increased rapidly(fig 2.2). In 1951 Karachi with a population of 1.6 million became the largest city of Pakistan (Census, 1951). Many new urban housing schemes were developed after the creation of Pakistan (fig 2.3). As a result the area of Karachi city expanded to 368 sq kms in 1961 (KDA, 1974) and population increased to 1912598 (Census,1961).

In 1971, separation of East Pakistan (now Bangladesh) took place.About 0.175 million people came from Bangladesh to Karachi (Census,1972). The population of Karachi increased to 3498614 in 1972(Census,1972) while the area expanded to 640 sq kms(KDA,1974).

The population and areal growth of Karachi city continued. Its population increased from 5153000 in 1981 to 9280000 in 1998 (Censuses, 1981, 1998). Its area extended from 800 sq kms to about 1800 sq kms during the same period(KDA,1990 , fig 2.1).

To sum up Karachi is not a very old city.It started to grow as a walled city in 1729 with the population of 1000 and area of 0.12 sq km. It became the largest city of Pakistan in 1951. Its population increased to 9.28 million in 1998 while its area has extended to 1800 sq kms.

Generalized Land Use Pattern

Like other cities of the world city centre, residential, commercial, industrial, education and health, administrative and recreation are important land use in Karachi(fig 2.4). Existence of cantonments and civil lines represent British colonial legacy common in South Asian cities like Calcutta, Lahore etc.

The City Centre

Table 2.1: Land Use of Karachi, 2000

Land Use	Area (sq. kms)	Percentage of total Area
Residential	480	26.66
City Centre	6.4	0.35
Commercial	14.0	0.77
Industrial	75.0	4.16
Educational/Health	15.0	0.83
Administrative	3.0	0.16
Civil Lines	2.0	0.11
Port	8.6	0.47
Railway	6.2	0.34
Roads/Streets	65.0	3.61
Utilities	5.4	0.3
Recreation	28.0	1.55
Notified Vacant	247	13.72
Vacant Undeveloped	410	22.77
Cantonment	180	10.0
Others	252	14.00
Total	1800	100

The city centre is the commercial and financial heart of the city. The total area of the city centre of Karachi is 6.408 sq kms (table 2.1). Business and finance are the dominant land use in the city centre followed by wholesale and retail. I.I Chundrigar Road (Macleod Road) and Shahra-e-Faisal are dominated by business, trade and finance establishments.M.A Jinnah Road (Bunder Road) and Sadder are the centres of wholesale and retail uses. The presence of non-city centre uses particularly residential in significant proportion is also an important feature of land use in the city centre of Karachi.

Residential Land Use

The arrangement of residential land use in Karachi is different from the Western cities. High class residential areas are located close to the city centre while low class residential areas are generally located in the peripheral areas of the city. The middle class residential areas are located between the two.

Source: Master Plan Department, Karachi Development Authority

Presence of a large number of squatter settlements in Karachi makes the residential land use arrangement more complex. These squatter settlements are locally known as Katchi Abadis inhabited by low income people. The squatter settlements are generally located at the peripheries but a few settlements are located within the high class and middle class residential areas like Punjab colony,Akhtar colony etc.Similarly Lines Area and Sultanabad are located close to the city centre. The residential areas occupy about 480 sq kms area of the city (table 2.1).

Commercial Land Use

The commercial land uses excluding the city centre occupy 14 sq kms of the city (table 2.1). Commercial activities in Karachi were once concentrated in the city centre. But with the growth of population and areal expansion of Karachi city centre has lost its accessible character for retail shoppers.As a result a large number of regional shopping centres have developed in the city like Tariq Road Shopping Centre, Hyderi Market, Liaqatabad Market etc.

Karachi has developed a clear hierarchy of shopping areas: the super regional shopping centres, the regional shopping centres, the community shopping centres, the neighbourhood shopping centres etc.

Industrial Land Use

The general pattern of industrial land use in Karachi is that industrial areas are located far away from the high class residential areas and close to the low class residential areas. The industrial land use in Karachi occupies 75 sq kms area which accounts for 4 percent of the total area. Industries are located in 12 scattered areas of the city. Most of them are located on the outskirts of the city(fig 2.4).

Educational and Health

Educational and health land uses occupy 15 sq kms area which accounts for 0.83 percent of total land uses.The educational and health land uses are scattered in the city. The educational institutions and hospitals which were developed in the British Period are due to the growth of the city centre located now either within the city centre or adjacent to the city centre.

Administrative

Administrative land uses in Karachi occupy about 3 sq kms (table 2.1). Sindh Secretriate, Sindh Assembly Building, High Court and offices of the city administration are important administrative land use in the city. All major administrative land uses are located adjacent to the city centre a legacy of British administration. After the creation of Pakistan new administrative buildings were constructed in the newly developed areas of the city. The most important is Civic Centre which is the head office of city administration.

The Civil Lines

The Civil lines is an important land use developed in the British colonial cities. Residences and offices of high class government officials exist in this area. In Karachi it was developed in 1843 when British selected Karachi as a capital of Sindh (Lari,1996). Then it was located a few miles away from the walled city.With the growth of the city now it is located adjacent to the city centre .

After the creation of Pakistan when Karachi was its capital civil lines became the administrative core of the country.Civil lines is still a distinct land use because of its function.The State Guest House and Chief Minister House are the main land use of the Civil Lines.

Cantonments

Cantonments are military land use. In Karachi first cantonment land use was military barracks of British troops known as Napier Barracks developed in 1839 far away from the walled city. Drig Cantonment,Malir Cantonment, Mauripur Cantonment and Manora

Cantonment are other military land uses developed in the British Period.Cantonments occupy a large portion of the city. The total area of cantonments is about 180 sq kms which is 10 percent of the total area of the city. Originally cantonments were developed out side the city in the British period. With the growth of Karachi city all cantonments are now located within the city affecting the growth of other land use.

Recreational

Parks, play grounds and beaches are main recreational land use which accounts for 28.0 sq kms area of the city. Safari Park,Qaid-e-Azam mausoleum, Allaudin Park and beaches of Clifton and Hawksbay are important recreational land uses in the city.

Vacant

Vacant lands in the city are of two categories, notified vacant and vacant undeveloped.Such housing schemes which were announced by government, cooperative societies, private builders etc and their area was demarcated but still vacant are classified as notified vacant land use (KDA, 1990). It occupies 203 sq kms area which accounts for 11.2 percent of the total area of the city (table 2.1). Halkani Housing Scheme, Hawksbay Scheme, Shah Latif Town, Taisar Town of K.D.A and a large number of cooperative housing societies are included. All such lands are located at the peripheries of the city. Vacant undevloped include hilly ranges,marshy coastal area and river valleys (KDA,1990). It occupies 410 sq kms area accounts for 22.7 percent of total area.

Conclusion

Karachi is the largest city of Pakistan. It emerged from a small fishing village in the early 18th century. It started to grow as a walled city. It gained status of the largest city of Pakistan in 1951 and has retained this status till now. The City has complex pattern of land use. City centre is the heart of commercial activities. Business thoroughfares and regional shopping centres are other main commercial land use. Residential, educational, industrial and recreational land use are other main land use. Presence of a large number of squatter settlements reflect the characteristic of the cities of Less Developed Countries. Civil Lines and Cantonments reflect the colonial history of the city.

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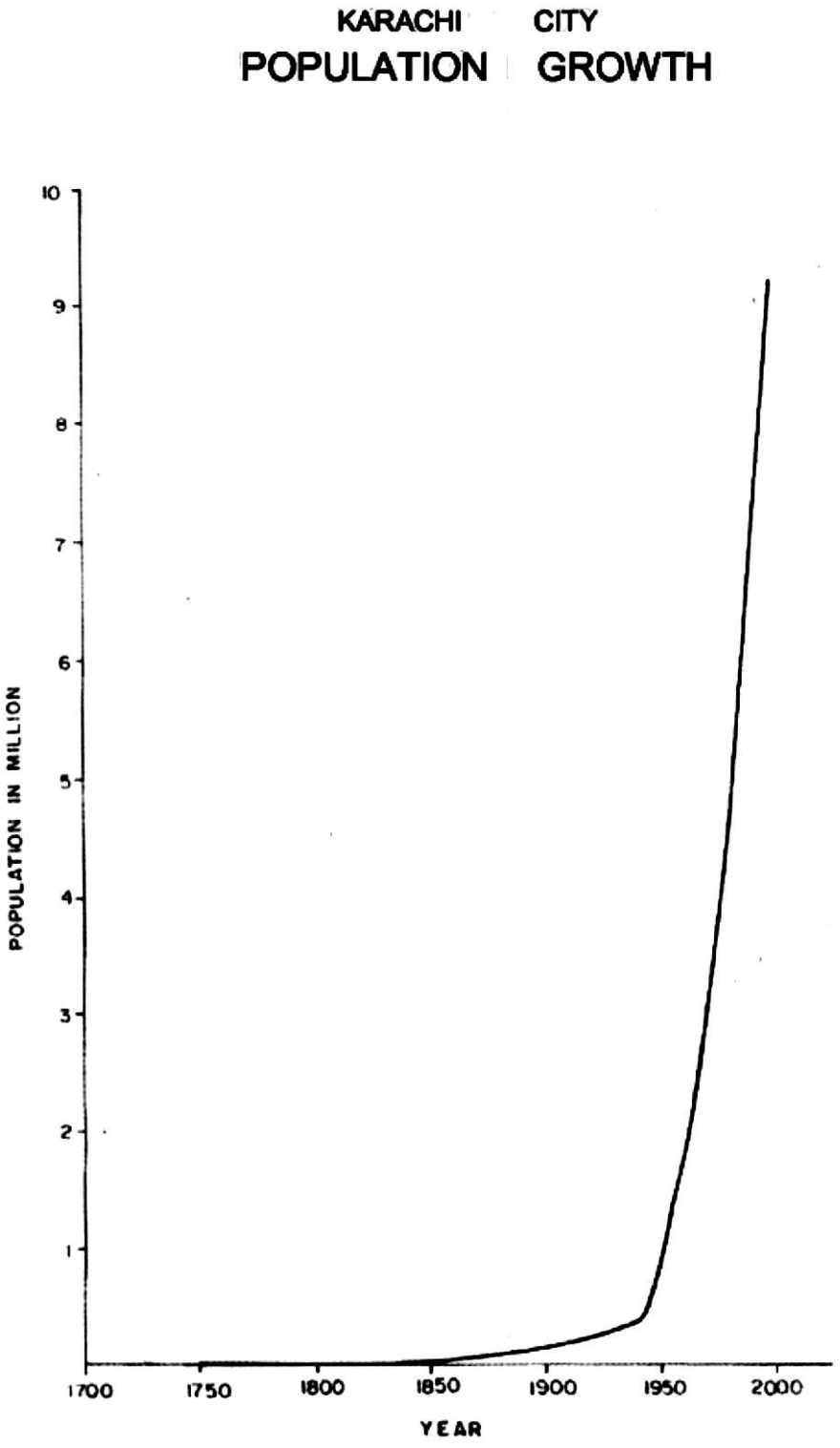
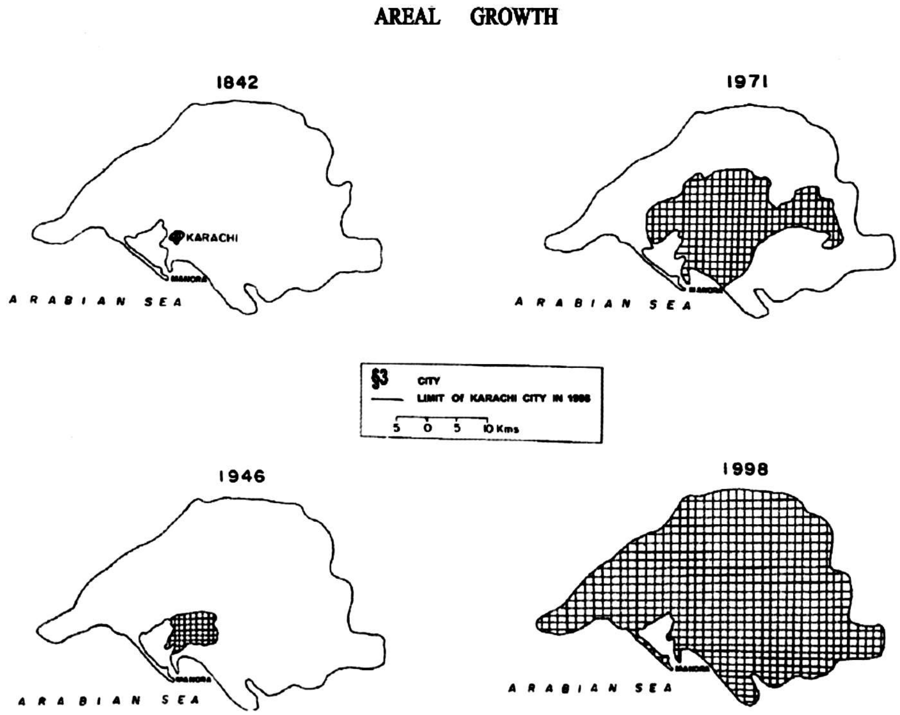
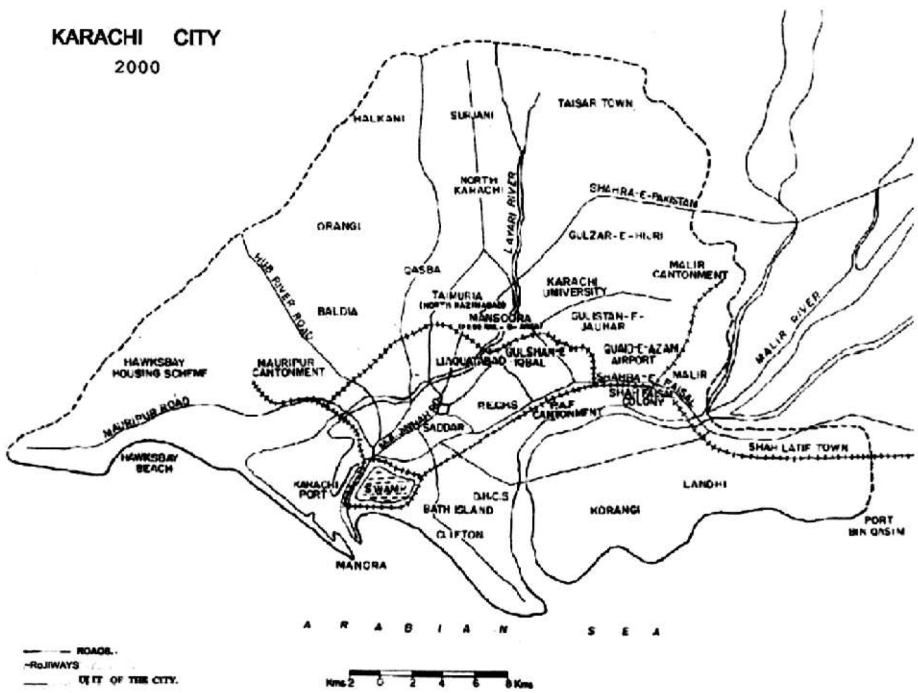
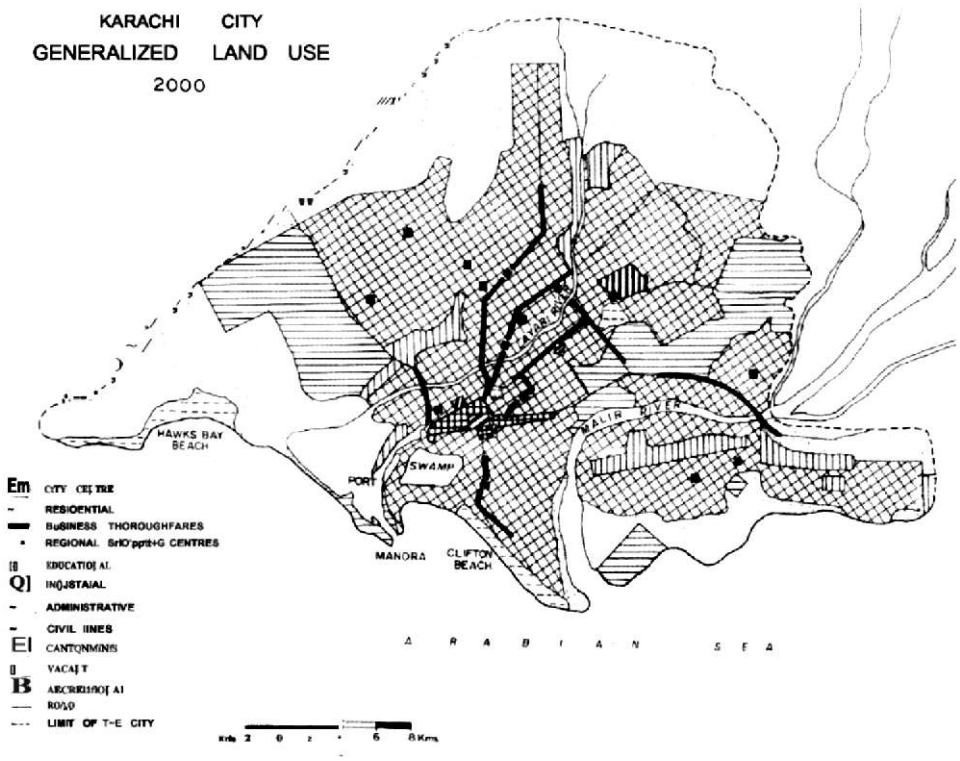

KARACHI CITY
POPULATION GROWTH
POPULATION IN MILLION
10
9
8
7
6
5
4
3
2
1
1700
1750
1800
1850
1900
1950
2000
YEAR


KARACHI
AREAL GROWTH
1842
1971
1946
1998
KARACHI
ARABIAN SEA
CITY
LIMIT OF KARACHI CITY IN 1998
5 0 5 10 Kms


KARACHI CITY
2000
HALKANI
SURJANI
TAISAR TOWN
NORTH KARACHI
LAYARI RIVER
SHAHRA-E-PAKISTAN
ORANGI
GULZAR-E-HIJRI
QASBA
MALIR CANTONMENT
KARACHI UNIVERSITY
BALDIA
HUB RIVER ROAD
GULISTAN-E-JAUHAR
HAWKSBAY HOUSING SCHEME
MAURIPUR CANTONMENT
QUAID-E-AZAM AIRPORT
MALIR
MALIR RIVER
MAURIPUR ROAD
SADDAR
SHAH LATIF TOWN
HAWKSBAY BEACH
KARACHI PORT
BATH ISLAND
KORANGI
LANDHI
PORT BIN QASIM
CLIFTON
MANORA
ARABIAN SEA
ROADS
RAILWAYS


KARACHI CITY
GENERALIZED LAND USE
2000
HAWKS BAY BEACH
PORT
SWAMP
MANORA
CLIFTON BEACH
MALIR RIVER
A R A B I A N S E A
RESIDENTIAL
BUSINESS THOROUGHFARES
ADMINISTRATIVE
CIVIL LINES
CANTONMENTS
VACANT
ROAD
LIMIT OF THE CITY

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A review of map reading techniques with special reference to topographical maps of Pakistan

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Abstract

Reading any piece of work demands knowledge of the language employed in writing or creating the piece. Similarly reading maps requires us to understand the language employed by the mapmakers in producing them. Maps are termed as the "geographer's shorthand" and a geographer should be able to transcribe and to interpret the whole of the notes comprised in such shorthand. Maps convey different types of information in several ways. Some of which are universally accepted conventions and others non-conventional. Geographers try to understand the language employed by these maps to get maximum information relevant to their studies. Map reading needs knowledge of the methods of representing relief and other natural features, conventional symbols, colors, scales, map projections, grid references and bearings etc. These are the alphabets of map reading and to understand the language of maps these are essential to know. The study in hand is an attempt to provide some basic information about maps and to create map-reading skills. It pinpoints some fundamental principles of map reading. Despite many deficiencies the study may prove helpful to understand the basic methodology of map reading in general and topographical map reading in particular.

Introduction

Since beginning people struggled to know and communicate information about things around them. For this purpose, they used signals, drawings, languages and so on. Such vehicles of thought and communication are the forms of knowledge representation. Mainly the following four such vehicles are currently used.

- The written language known as literacy.
- The spoken language known as articulacy.
- The use of numbers, symbols and magnitudes known as numeracy or mathematics.
- The use of graphic methods such as drawings, paintings, maps and diagrams known as graphicacy.

The fourth method is commonly used to express geographic knowledge. The graphic representation of the geographic setting is gives birth to map and art of map making is called cartography. This art is concerned with reducing the spatial characteristics of an area of the earth or all of it to make it observable. The same technique can be used to enlarge microscopic things to make them visible. Although it is not common to refer these enlarging activities as cartography but the resulting images are some times called maps. A map is the symbolic representation of the earth's features on a flat surface on reduced scale. On maps, natural and cultural landscapes are depicted graphically (Dury, 1960). These are regarded as basic tools of geographers, which they use for their geographical investigations. The oldest map known today is a small clay tablet dating back to 2800 BC. It represents the location of river Euphrates flowing through northern Mesopotamia in Iraq. This map is kept in the Semitic Museum of the Harvard University in USA (Leong, 2000). Greek Cartographer Claudius Ptolmey is probably the best known of all the ancient mapmakers. He lived in 150 AD and made 26 regional maps of Europe, Africa and Asia which formed a part of his eight volume book 'Geographia' and the 'Ptolemy Atlas'.

The term 'map' is used in many areas of science as a synonym for a model what it represents. A model, which enables one to perceive the structure of the phenomenon

represented. Maps are presently regarded as a form of scientific visualization, which aims at to analyze information about relationships graphically (Kraak & Ormeling, 1998).

Uses of the maps

It is difficult to get an overview of an area in any way other than by consulting a map. A map presents spatial information therefore it can be considered as a spatial information system that provides the answers to many questions regarding the area depicted. Such as;

1- The distances between areas and objects.
2- The positions of objects in respect of each other.
3- The sizes of areas.
4- Nature of distribution pattern of things.

The answers can be read directly from the map without using any other thing. Maps have been used for centuries to visualize spatial data. They help their users to better understand spatial relationships. From maps, information about distances, directions, sizes, patterns and density can be obtained easily. People belonging to all sectors of life use maps. These are essential for tourists, navigators, pilots, planners, climbers, engineers, teachers, geographers, leisure activities like trekking and cycling and so on.

Maps are used for;

- Orientation or navigation, i.e. road maps, topographic maps, navigation charts etc.
- Physical planning, i.e. future land use etc.
- Forecasts i.e. weather charts.
- Management or monitoring, i.e. roads, railways, canals, airports forests etc.
- Educational purposes i.e. school atlases, wall maps etc.
- Codification i.e. land ownership property maps etc.
- Military operations.

Generally geographers use maps;

- For information such as distribution pattern of phenomena.
- To know spatial relationships between various phenomena.
- For making statistical and descriptive analysis.
- For identifications of problems for study purposes.
- For the identification of the natural and human environments.

Classification of maps

The number of possible combinations of map scales, subject matter and objectives is astronomical. Therefore there is an almost unlimited variety of maps (Robinson, A.H., et al-1995). Following are some major classes of maps;

a) Classification of maps based on function

Based on function we can recognize three main categories of maps, which are as under;

I) General reference maps

The main objective of some maps is to show the locations of a variety of different features, such as water bodies, coastlines, roads, cities, agricultural areas etc. These are called general reference maps.

Large-scale general reference maps of land areas are called topographic maps. They are usually made by government agencies (i.e. The Survey of Pakistan department in our country) and are issued in series of individual sheets. Maps of much larger scale are required for site locations and other engineering purposes. Great attention is paid to their accuracy in terms of positional relation ships among the features mapped.

ii) Thematic maps or special purpose maps

These maps concentrate on the distribution of a single attribute or the relationship among several. They include maps of precipitation, temperature, population, atmospheric pressure etc.

Maps showing soils, rocks or population density etc. can be classified as general reference maps if the purpose is to show the locations of these features. On the other hand maps of the same features may be called thematic maps if they focus attention on the structure of the distribution. If the objective of map is to show location it is called general reference map but if the purpose is to show the structure or pattern of distribution the same map can be called as thematic map.

iii) Charts

Maps especially designed to serve the needs of navigators, nautical and aeronautical are called charts. One major difference between maps and charts is that maps are looked at while charts are to be worked on. On charts, navigators plot their courses, determine positions, mark bearings and so on. Navigators also use general reference maps. The marine equivalent of the topographic map is the bathymetric map.

Nautical charts include;

- Sailing charts for navigation in open waters.
- General charts for visual and radar navigation offshore using landmarks.
- Coastal charts for near-shore navigation.
- Harbor charts for use in harbors and small-craft charts.

Their scales vary depending upon the detail necessary. Aeronautical charts are of two types those for visual flying and those for instrument navigation. Aeronautical charts for visuals flying are similar to general reference maps showing such features as cities, roads, railroads, airports etc. Charts for instrumental navigation include radio facility route charts, high-altitude charts, terminal arrival charts etc.

b) Classification of maps based on subject matter

It is some times useful to group maps on the basis of their subject matter. On this basis several important categories may be recognized. Two important categories are;

i) Cadastral maps

These maps show the property relationships. These are used to express the geographic relationships among land parcels i.e. property maps etc.

ii) Plans or large scale maps

These are in fact plans used for planning and development purposes, i.e. building maps etc.

In short, there is no limit to the number of classes of maps that can be created by grouping them according to their dominant subject matter. Thus there are following types of maps;

- Cadastral Maps & Plans
- Topographic Maps
- Atlas Maps
- Orographical or Relief Maps
- Bathymetric Maps
- Bathy-orographical Maps
- Geological Maps
- Weather Charts
- Climatic Maps

- Vegetation Maps
- Historical Maps
- Distribution Maps
- Soil Maps
- Political Maps
- Communication Maps or Route Maps
- Navigation Charts
- Linguistic Maps
- Population Maps
- Economic and Statistical Maps
- Ethnographic Maps and so on without end.

4- Some major characteristics of maps

All the geographical maps are concerned with following two elements of reality;

1- Locations: These are the positions in two-dimensional space, such as places with the co-ordinates, x & y.

2- Attributes: These are qualities or magnitudes of phenomenon in places, like rainfall, temperature, population, vegetation etc.

From these two basic elements, many relationships can be established. Following are some examples;

- Relationships among locations when no attributes are involved, such as the distances or bearings between origins and destinations needed for navigation.
- Relationships among various attributes at one location, such as temperature, precipitation, evaporation, vegetation type etc.
- Relationships among the locations of the attributes of a given distribution, such as variations of temperature or precipitation amount from place to place.
- Relationships among the locations of combined variables of given distributions, such as the relation of per capita income to educational level, as they differ from place to place.

Furthermore, all the geographical maps are reductions. The maps are smaller than the regions they represent. Every map has a defined dimensional relationship between reality and the map. This relationship / ratio is called scale.

All the maps involve geometrical transformations. For example, it is common to transform a spherical surface (shape of the earth) to a surface, which is easier to work with computer screen or a flat map sheet. Such a systematic transformation with the help of coordinate system is called map projection.

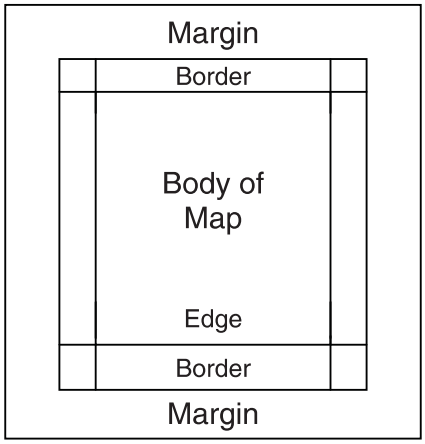
All the maps are abstractions of reality. The real world is so complex that it cannot be represented in reduced form with all its aspects and characteristics. So the maps represent only the chosen information.

All the geographic maps use signs/ symbols to represent the elements of reality. All map symbols used to represent data consist of various kinds of marks, such as lines, dots, colors, tones, patterns and so on. While using a map, user must constantly compare the symbols with those in legend.

5- How to study of topographic maps of Pakistan?

A topographic map of Pakistan is in fact a graphic representation of a portion of land area on a much reduced scale. It has lines, words, symbols and colors to depict the various natural and cultural features. It has a great advantage over descriptions because it can be seen at a glance. For this reason, no verbal description of an area can be as effective as a topographic map. The cartographers /map makers of the Survey of Pakistan department prepare topographic maps by using the information gathered from field surveys and assisted by

Fig 1: Layout of Topographic map



aerial photographs taken by special air-crafts. A lot of hard work is done before these maps can be prepared.

Total number of topographic maps of Pakistan, produced on scale 1/50.000 is 1491. Out of these only 700 are available for common uses while remaining are restricted (classified). Topographic maps of the areas starting from international border up to 50 miles inward are classified. One dot () having zero dimension, occupies the area equal to 7.5 meters on these maps.

These maps are highly helpful to analyze the geographic structure of the areas and morphometric analysis. By noting density, dispersion and patterns of the objects, a detailed analysis of natural as well as cultural landscapes can be made. Objects can very accurately be located by using 4-figure and 6-figure grid references. Their distance from each other can be calculated with the help of scale given at the lower margin of the map and direction by finding bearings.

A reader or user can easily understand the information given in the topographic maps by using following methodology.

Divide the map into three distinct parts (fig 1);

I) Margin

ii) Border and

iii) Body, and then gather information from each part according to the following guidelines.

i) Marginal information

Topographic maps have margins within which several kinds of information are provided and every map-reader should first look at and understand such information. Information in the margins normally includes the following;

- **Central heading** includes the name of the province to which topographic map is concerned.
- **District heading** includes the name of the district/ districts to which the map belongs.
- **Topographic map/Sheet No.** is usually given on the right hand upper corner of the margin.
- **Season's heading** tells the year in which the area represented on the map was surveyed.
- **Restricted /classified,** this word is written just above the season's heading only on

those sheets, which belong to sensitive areas and are not available for common use.

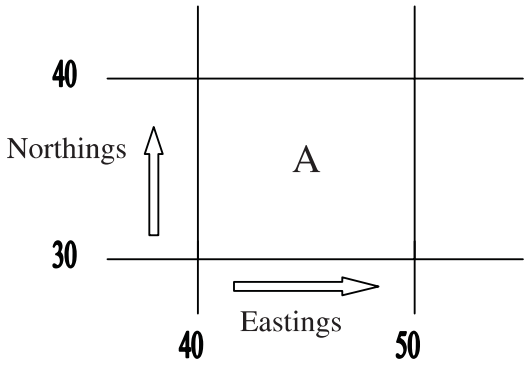
- **Upper margin edition note** tells the edition number of the map.
- **Convergence note** indicates the angular difference in terms of degrees between grid north and true north.
- **Magnetic note** expresses magnetic declination.
- **Rate of magnetic declination** indicates the annual rate of change in magnetic declination.
- **Printing note** tells the name and address of the place where maps are prepared. Topographic maps of Pakistan are printed at the Survey of Pakistan offices, Rawalpindi.
- **Right hand side symbol table (RHST)** contains symbols used to represent various features on the map and given usually at the right hand side bottom of the map.
- **Left hand side symbol table (LHST)** also contains symbols used to represent different objects on the map and given usually at the left-hand side bottom of the map.
- **Registration note** gives the registration number of the map.
- **Copyright note** tells the name of agency, institution or person who reserved the copy right of the map. The Surveyor General of Pakistan, Government of Pakistan, reserves copyright of the topographic maps of Pakistan.
- **Price note** contains the price of the map.
- **Administrative index** indicates the administrative units / districts represented in the map.
- **Lower margin edition note** expresses the years of various editions of the map.
- **Reference box** carries the reference to the map such as scale, sheet number, edition etc.
- **Index to sheet** in which the numbers of the sheets of neighboring areas are mentioned. This index helps in finding the sheets that represent areas adjacent to the area shown on the map in hand.
- **Surveyor General's imprint** the authority under the direction of which map is published.
- **Scale legend** given at the foot of the map and represents scales in various forms.
- **Contour interval** given at the bottom, if any.
- **Central foot notes** also given at the bottom if any.
- **Grid reference** for the purpose of topographic survey and mapping, Pakistan has been divided into two grids, northern grid or grid-1 and southern grid or grid 2. Grid references are usually given in meters.
- **Grid box** is given at the bottom of the map.
- **Conversion scales & tables** are usually given on the right and left hand side margins of the map which helps in the inter conversion of measuring units.

ii) Border Information

Topographic maps of Pakistan usually contain following border information.

- **Absolute location** in the form of latitudinal and longitudinal extent of the area is given at the corners of border on the map.
- **Grid values** are given in some unit of distance measurement (meters etc.) in the border space of the map sheet.
- **Names and distances** of the prominent places of the adjacent areas not covered by the map but are linked by the penetration lines and roads shown on the map are also written in the border space of the map.

Fig 2: Grid Location of the Object



iii) Body Information

Body of a topographic map includes much information. Some major of them are as follows;

Location of the objects

There are two methods of locating the objects on a map;

- By longitudes and latitudes.
- By grid references.

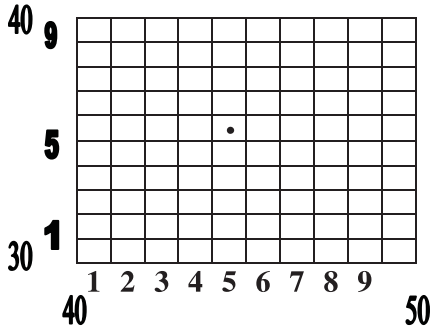
There are so many topographic features on topographic maps that some form of quick reference is needed to pinpoint the accurate location of any one feature. For this purpose grid references are used. If we look at a topographic map, there are two sets of lines running across it which are known as grid lines. The vertical lines with numerical numbers increasing from west to east are called 'eastings' and horizontal lines with numerical numbers increasing from south to north are known as 'northings'(Leong,1998). The point at which an easting intersects with a northing gives the location of the required object on the map (fig 2).

There are two types of grid references; the 4-figure grid reference, which gives a general location, and the 6-figure grid reference, which gives a more precise location. The reading of grid reference always starts with the 'easting' followed by the 'northing'. Thus, the 4-figure grid reference of 'A' in fig 2 is 4030. Although, for general purposes the 4-figure grid reference is commonly used, but for a more precise location the 6-figure grid reference is always preferred. It pinpoints the exact location within the square formed by the 4-figure grid lines. This involves the subdivision of big square into 10 imaginary vertical as well as horizontal lines. Each resulting tiny square represents 1/100 of the original big square. Now, with the help of these tiny squares the location of the objects can be expressed in terms of 6-figure grid reference. In fig-3, the 6-figure grid reference of the object is 404305.

Distance between objects and places

When we state a distance between two places, we are in fact stating the absolute or geographic distance. The distance between two places or objects on a map is measured by using scale given at the bottom margin. Scale is the ratio of a given distance on map to the corresponding actual distance on the ground. On the topographic maps of Pakistan having scale 1/50,000, two centimeters represent the actual distance of one kilometer. On such maps if two objects are located at a distance of 5cm from each other then the actual distance between them on ground is 2.5km.

Fig 3: 6-figure grid location of the object



Direction

From key compass direction, north (N) that is always given on topographic maps, we can estimate all the other cardinal points, south, east and west. Between all these cardinal points are four sub-cardinal points, NE, SE, NW and SW. Between these sub-cardinal points are eight other subsidiary points, NNE, ENE, ESE, SSE, SSW, WSW, WNW and NNW (Dink, 1962). On topographic maps, required location is always given from the observer's point of view. For example, the object A on map is located on the west of object B etc.

Bearings

Position of the objects with relation to each other can also be determined by using bearings. The bearing of an object is its direction from the observer and is the angle at the observer between the meridian through the observer and the line joining the observer to the object. Bearing can be expressed in two ways;

- By quadrantal method in which the figures never exceed 89degrees. For example N 40 degrees E or S 30 degrees W
- By whole circle method in which bearings are measured clock wise from the north Point 0degree to 359degrees.

Bearings are either true, magnetic or grid and can be measured simply with the help of protractor on map.

Scheme of colors

Following colors are used to represent various features on topographic maps.

- **Brown color** is used for relief features such as mountains, hills, sand dunes and plateaus, which are represented with the help of contours etc.
- **Blue color** is used for water bodies like rivers, lakes, springs, ponds, canals, water distributaries etc.
- **Green color** is used to depict forests and other kinds of flora.
- **Yellow color** is used for cultivated area (agriculture).
- **Red color** is used for settlements, roads, paths and buildings.
- **Black color** is used for lettering and to represent railway lines, dry streams, boundaries, telegraph lines, graveyards etc.
- **Purple color** is used for grid network.
- **Gray color** is some times used for sandy desert.
- **Blank areas** with out any color indicate barren lands.

Fig 4: 1: 1 million map

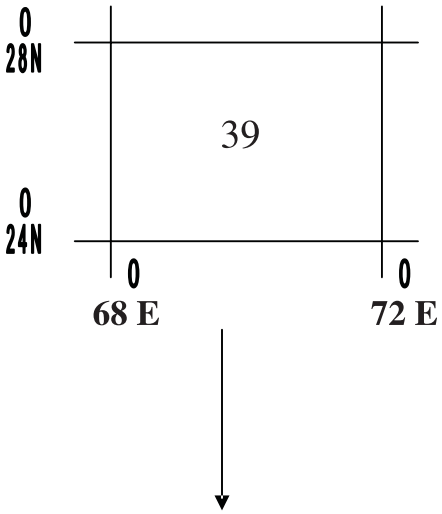


Fig 5: 1 inch to 4 miles map

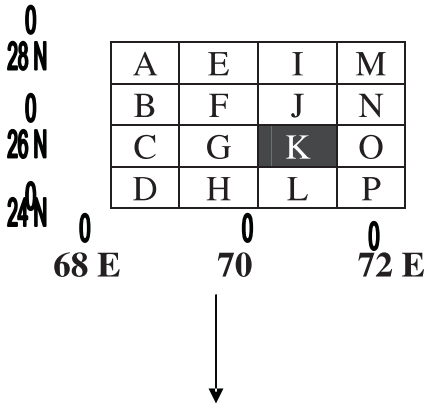
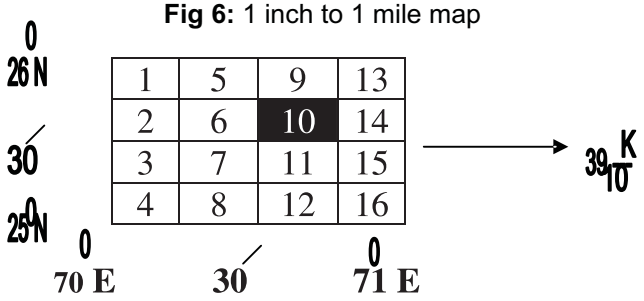


Fig 6: 1 inch to 1 mile map



Numbering the topographical maps

For the purpose of numbering the topographic sheets, maps of the continents are made on one to one million scales. These maps are divided into parts (sheets) each having a specific number, covers an area equal to four degrees of longitude as well as four degree of latitude

(fig 4). Then each sheet is produced on scale one inch to four miles and divided into 16 equal parts each covering an area of one degree of longitude and one degree of latitude. Each part is allotted an alphabetic name i.e. A, B, C… etc. (fig 5). Now the each of these parts is produced on scale one inch to one mile (1:50,000) and further subdivided into 16 equal parts covering an area equal to one-fourth of a degree of longitude as well as of latitude. Each part is given a specific numbering (fig 6). Each sheet is then numbered with reference to primary, secondary and tertiary sheets i.e. 39K/10.

Physical landscape

Physical landscape refers to the natural features of the earth's surface shown on topographic maps such as relief features, drainage, flora etc.

- **Relief features:** The degree of unevenness of land surface is called relief. The major relief features are mountains, hills, plateaus, cliffs, valleys and plains. On topographic map contours, hachures, hill-shading, bench marks, spot heights and trignometrical stations are used to represent such relief features and their elevation from sea level (Bygott & Money ,1969). Because relief involves height so none of these methods is completely satisfactory. To bring out the best results, some times a combination of several methods is used.

  Of all the methods used to show relief, contouring is probably the best one and widely used. Contours are the lines that join the places of equal height from sea level. Their pattern and density depict the shape, height and gradient of the area. Inter- visibility of the points shown on map can also be determined by section drawing using contours. Steep slopes have closely spaced contours with large contour interval whereas gentle slopes have widely spaced contours with small contour interval. The pattern of contours represents the type of feature such as hill, plateau, col, saddle, undulating ground, ridge, cliff, spur, escarpment, valley, convex and concave slopes etc.

  On topographic maps specific heights of the areas are indicated by specific symbols used by the surveyors. These are spot heights, taken at random heights, trignometrical stations usually taken at hilltops and mountains peaks, and bench marks which are measured heights usually shown along roads.

  Hachuring is another method to represent relief on maps. In this method hairy lines are drawn parallel to the direction of the slope. On steeper slops these lines are closely spaced and on gentle slopes are widely spaced. These are difficult to draw and interpret. Some times hill shading method is also used in which hill slopes are shaded dark and valleys or plains are shaded lighter. Both these methods give only a general impression of the landscapes and do not represent the actual height of the area.

- **Drainage pattern:** Drainage pattern of any area is the layout geometry or shape of its streams, springs and glaciers. Streams flowing through different landforms, rocks and geological settings develop different drainage patterns such as trellised or rectangular, dendritic or tree-like, radial or spoke-like, centripetal or inland and parallel etc. These drainage patterns are very well depicted on topographic maps and are very much helpful in understanding various aspects of the areas. For example, trellised drainage pattern is the indication of alternate layers of resistant and less resistant rocks; dendrite drainage pattern indicates homogeneous rocks with only one kind of rock structure where erosion takes place uniformly; radial drainage pattern refers to structural dome, volcanic cone or conical hill; parallel drainage pattern is found on newly uplifted area; and centripetal drainage pattern is common in inland basins and deserts where streams from different directions flow towards the center of a depression.

- **Drainage density:** Stream density can be calculated from topographic maps. It refers to the number of streams per unit area. It is highest in clay and impermeable rocks and lowest in sand and permeable rocks. High density also indicates highly uneven mountainous areas and fine textured rocks.
- **Flora:** Cover of green vegetation forms an important component of natural landscape. On topographic maps various kinds of natural vegetation such as forest, deciduous trees, coniferous, marshes, mangroves, bushes, shrubs and grasses are depicted with the help of specific symbols of green color.

Cultural landscape

Cultural landscape refers to the man made features of the earth's surface shown on topographic maps such as various kinds of land uses, settlements, agriculture, irrigation and communication systems etc.

- **Land use:** Topographic maps provide general impression of various kinds of land use such as cultivated and uncultivated area, area under forests, grass lands, parks, gardens, roads, airports, different types of buildings, water reservoirs, canals etc.

- **Settlements:** These are the places where people live, work, interact with others and organize their various activities. Settlements reflect human relationship with environment. On topographic maps settlements are shown with the help of specific symbols in red color. Maps also depict the site and situation of settlements and their various patterns. A map-reader can very easily observe that whether the settlements are dispersed, linear, nucleated, planned, irregular, ring type, small hamlets, villages, towns or cities. Names of the settlements are given on the maps.

- **Agriculture:** This activity occupies most of the accessible areas and is the dominating feature of plains. On topographic maps all the farmlands are depicted by yellow color and non-agricultural barren lands are usually left without any color. These lands consist on mostly the deserts with shifting sand dunes and scattered scrub type vegetation or highly uneven mountainous and rugged regions. Orchards and various crops are shown by specific symbols.

- **Irrigation system:** Irrigation means artificial watering of fields. Irrigation system consists on dams, barrages, head works, canals, tube-wells, distributaries and karezes etc. All these components of irrigation system are depicted on topographic maps with the help of specific symbols and blue color. Such as canals and small water distributaries are represented by line symbols in blue color.

- **Communication system:** This system consists on airports, ports, railway lines, roads, paths, cuts, transmission lines etc. All these are represented on maps with the help of symbols in specific colors. For example, roads, paths and cuts are represented by line symbols of red color, railway and transmission lines by line symbols of black color.

- **Boundaries:** International, provincial, districts and other boundaries on topographic maps are represented by different line symbols of black and red colors.

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Planning a Least Cost Gas Pipeline Route A GIS & SDSS Integration Approach

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Abstract
Optimal route planning in mountainous areas is a challenging issue which requires scientific approaches and multiple criteria to be satisfied. Research identifies and evaluate the various criteria inevitable for route planning and presents a model of an automate route planning system using least cost approach. Linear features such as roads, railway, streams, and rivers have been considered as major obstacles in the course of pipeline. Rank weighted method has been used to assign the weights to hurdles according to prioritization. GIS analysis incorporates the cost weighted distance function based upon cost weighted distance and cost weighted direction rasters which are further integrated with shortest path function. Topographic diversifications in mountainous areas require critical evaluation between elevation and slope data consequently slope data has been more emphasized to facilitate the heavy vehicle movement carrying construction material to the site. Study area includes the typical mountainous terrain of Hattar, Haripur District, and Murree, Rawalpindi District, as the source and destination for pipeline route planning respectively. Result of the research is in the form of a prototype development for optimal route planning.

1. Introduction
Natural resources are the key factors in the development of a country. Pakistan is rich with a large number of metallic and non metallic minerals. Natural gas is one of the most important resources which is not only a good substitute of coal and petroleum but is also providing a sound base for the development of industries as well as contributing towards the higher standards of life for its people.

Pipelines are the most efficient, cost effective and environment friendly means of fluid transport and reduce the highway congestion, pollution and spill. [1] Careful planning of the pipeline route can save on cost, time and operating expenses to ensure longer operational life and help prevent environmental fallouts. Proper planning and management are considered essential means of guiding and accelerating the development of an industry. It can mobilize and utilize the available resources in the best interest of the company and eliminate business fluctuations. [2]

Development of a shortest possible route through traditional methods has never been a problem while dealing in an open plain area. However, if the area between the source and destination is comprised of undulating land, the shortest possible route is difficult to plan due to the following reasons:

a. The Preliminary survey for the route selection takes longer time in mountainous areas than in plains i.e. approximately 2 km per day which eventually leads towards the expansion of the project time and cost.
b. While surveying in undulating mountainous areas it appears to be difficult to develop shortest /straight line route to minimize the cost thus a longer route has to be followed.
c. It is also crucial to identify the pipeline route along with a low gradient slope for the heavy vehicles to carry the construction material to the site, the dumping of the construction material and for the camping sites.
d. Besides all these natural constraints, Man as a major decision maker / stakeholder plays the most important role and influences the decision making. This decision

	Height (meters)	x coordinates	y coordinates
Hattar (Source)	4861	72°51'14.38"	33°50'54.43"
Murree (Destination)	2269	73°24'38.12"	33°54'4.45"

making generates conflicts if there are more than one stakeholder involved and thus consensus building of a variety of stakeholders takes even longer.

All these limitations, at one side, take longer time for route planning while increase the cost of the project on the other.

Due to these hurdles in the way of planning, most of the mountainous areas are still deprived of this basic facility of life and can not cope with the pace of development in other areas.

Considering this situation, a prototype has been developed with main objectives:

a. To plan a least cost gas pipeline route using GIS techniques (the term cost involves two things: the time consumed for planning a route and the expenses of crossing physical and man made hurdle).
b. To highlight the role of integration of SDSS with GIS techniques in the planning process to facilitate a single as well as a large number of stakeholders in generating a mutually accepted single route.
c. To avoid the geographical (steep slope, rivers, streams) and man-made (road, railway, canal) features encountered by the pipeline as much as possible as the crossing of these hurdles increase the cost of construction.
d. To identify the route along such a gradient which is feasible for heavy vehicles to carry construction material to the site.

This study incorporates source and destination as Hattar and Murree. Table 1 shows the approximate extent and the height variation from source to the destination of the route.

TABLE 1. The extent of the route and the height variation from source to destination.

A large variety of hurdle are encountered by the pipeline on its route from source to destination but only five have been involved in the research namely railway line, roads, streams, rivers and the steep slope.

2. The Input Datasets

To map the physical hurdles like rivers, streams and man made hurdles like roads and railway line, the toposheets at the scale 1:50000, prepared by Survey of Pakistan have been used. The SRTM (Shuttle Radar Topography Mission) 3 arc-second (90m) height data has been used to generate slope raster at the angle of 12° which is a moveable slope for the heavy vehicles in the mountainous areas to carry the construction material to the site.

3. Methodology

A detailed study of the realm of GIS analysis was made to develop a Least Cost Path. The input datasets, required by the system, were identified. ArcGIS 8.1 by ESRI was used to generate this Cost Raster. Fig 1

Following steps were performed to generate the Cost Raster:

a. Georeferencing of the scanned images
b. Digitization of the vector layers (road, railway, stream, river)
c. Database Development
d. Rasterization of vector layers
e. Generation of Cost Weighted Raster

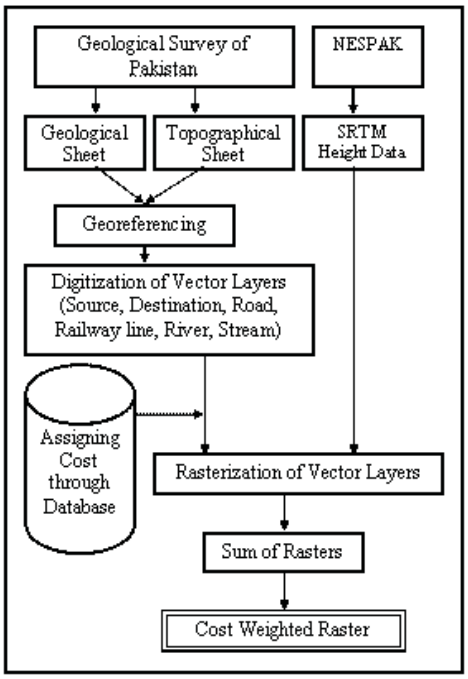

Fig 1. The methodology for the generation of the cost raster.

As the tools provided in Spatial Analyst, an extension of ArcGIS, are primarily intended for use on thematic raster data therefore the use of database is on limited scale. The database is required only for the cost/weight assignment on the vector layers which were to be converted to raster layers, later. These weighted costs values served as the pixel values for the raster layers of road, railway line and water bodies.

GIS analytical techniques support the spatial decision support system and thus provide an opportunity of producing a variety of decisions depending upon the goal and objectives of a variety of stakeholder. Table 2 shows the ranking of the weights assigned to each hurdle in the route of pipeline by the stakeholder.

In this study, the experts of SNGPL (Sui Northern Gas Pipeline Ltd.) were involved as the decision maker for determining the weight to each criteria/hurdles being involved in the study. The values of cost are basically the ratio existing between the expenditure of crossing these hurdles during pipeline construction. These ratios have been arranged in a ranking style. These very weighted ranks have been taken as the cost values of the pixels when the vector layers are converted to raster.

This table 2 provides with the simple weights arranged in a ranking style, assigned by a single stakeholder to generate a path which fulfills all the objectives of the concerned single stakeholder. The integration of SDSS with the GIS techniques opens the door of another opportunity where the values of consensually assigned weights can be arranged in the same manner as the simplest input to generate such a path that will depict the objectives of all the stakeholders involved.

It is also noteworthy here that by the method of assigning weights automatically replaces the step of reclassification: a step provided by the route planning automated systems where it is compulsory to reclassify all the criteria layers into same number of classes so that such a Cost raster is generated where the Shortest Path Function run.

Once every hurdle has been digitized, assigned weighted cost through database and

Table 2. The cost of crossing the features set by the stakeholder.

Features to Cross	Cost of Crossing the Feature based upon Rank Weighting Method
Road	1
Railway	2
Stream	3
River	4

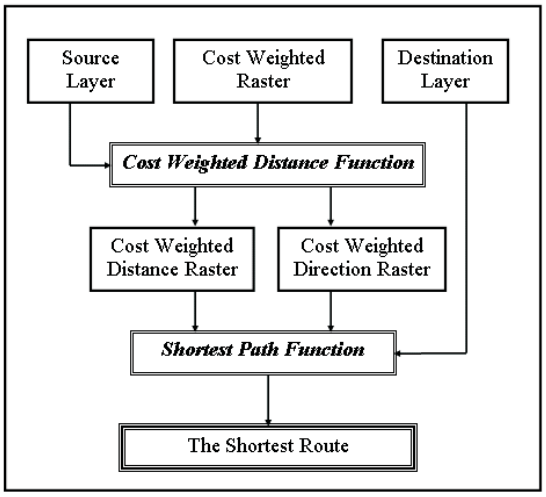

Fig 2. The methodology for the generation of the least cost path.

converted to raster, they all were merged along with the Slope Raster into a single layer called Cost Raster or Cost Weighted Raster.
In this example the weights have been assigned on the basis of cost of construction by the stakeholder, the cost raster, therefore, identifies the cost of traveling through

every cell i.e. the lower the value, the lower the cost. Each cell may be seen as a node linked to its eight neighboring cells. The cell value of each node represents the cost of traversing this particular cell. This cost-of-passage surface is a grid where the values associated with the cells are used as weights to calculate least cost paths. These weights may represent the resistance, friction or difficulty in crossing the cell and are expressed in terms of cost. Starting from a given destination cell, it is then possible to spread outward and calculate for each surrounding cell, the accumulated cost of traveling from any surrounding cell to the destination cell. From this accumulated surface it is then possible to delineate the shortest or least-cost path to the destination cell from any surrounding cell. [3]
After the generation of the Cost Weighted Raster, the Source and Destination layers are used as the input datasets for the development of Least Cost Path. At this stage, two sub functions are performed namely Cost Weighted Distance Function and the Shortest Path Function. Fig. 2
The Cost Weighted Distance Function uses the Cost Weighted Raster and the Source Layer and generates two rasters i.e. the Cost Weighted Distance Raster and the Cost Weighted

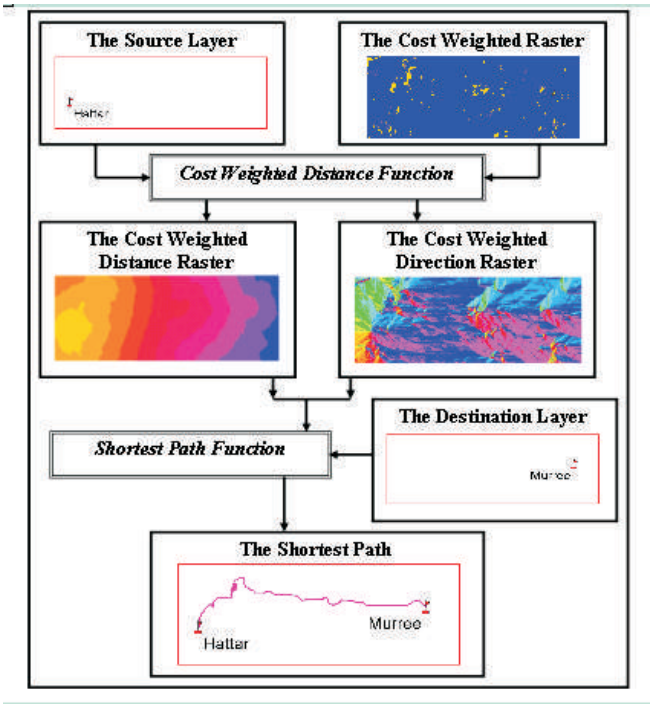

Fig 3. The rasters generated to produce the least cost path.

Direction Raster. Fig 3
The Cost Weighted Distance Raster calculates the least accumulated cost of getting from each cell to the source while the Cost Weighted Direction Raster identifies the cells with the least cost and determines directions of the route from any cell to the source.
The second Shortest Path Function takes the resulted Distance and Direction Raster Layers as inputs with the Destination Layer and calculates the Shortest Path between the Source and Destination.

4. Conclusions

GIS provides a large number and a variety of analytical functions that are capable of replacing manual and traditional methods of route planning. It is a powerful tool to integrate thematic layers in an automated environment to compute possible shortest route with associated costs which eventually can reduce the cost and time of project execution and hence the operating expenses. The integration of GIS and the spatial decision support system provides a baseline for complex kind of decision making where a variant nature of criteria and stakeholders can be catered successfully.
This research identifies an automated system to plan a Least Cost/shortest route for gas pipeline. The same methodology, however, can be applied for the planning of water, sewerage pipeline as well as highways with a little modification of the criteria involved.
The generation of paths using this approach can be applied for comparing the existing routes developed with the help of manual and tridional methods e.g. Ahvaz-Marun oil pipeline in south west of IRAN was chosen for
development of the prototype. The Ahvaz-Marun pipeline was about 34-km and carries

Ethan gas from Marun Petrochemical Company (MPC) to Ahvaz. The length and cost associated with existing pipeline that made by traditional approaches were compared those of the least cost pathway through GIS best path analysis. The existing pipeline path is 34-km long, and the least cost pathway is 35- km long. Although longer in length, the least cost pathway is 29% cheaper than the existing pipeline path.[4]

The use of satellite images for mapping the current physical and man made hurdles, more accurate elevation data and addition of other factors like population distribution pattern, soil type, forest cover etc. will help to make the planning process more efficient. In short the use of this kind of cost and time effective and efficient system in the planning of national and international projects will certainly lead toward the faster and cheaper economic growth of the country.

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