PAKISTAN GEOGRAPHICAL REVIEW

Volume 28 .. Number 1 & 2

1973

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Volume 28 | 1973 | Number 1 & 2

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Note : Maps by Zafar Hassan need a little job to be done.

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THE PROCESS OF URBANIZATION IN THE UPPER INDUS PLAINS

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URBANIZATION, SOME THEORETICAL IMPLICATIONS

URBANIZATION is defined variously as a particular phase-stage in human society and has drawn students and workers from almost every field of social sciences. Historians, sociologists and economists are more concerned with the impact of the process related to social and political behaviour of individuals or groups of people. While Town Planners and Architects have been confronted with finding a solution to the ever increasing physical demands of housing and recreation, it is for the geographers to deal with the phenomena as a cohesive phase-stage in human society. Urbanization is studied in geography as related to environmental control of habitat and differential patterns of human occupance of the earth's surface. It is not an exclusive realm of study, for geography has shared with other social sciences many common concepts and methods, but has contributed a distinctive set of view-points and a unique focus ; that which is primarily concerned with the organization of man's use of space and resources in the development and functioning of urban settlements.[1]

Considering urbanization as a process of change and a characteristic having high correlation with economic development of a region, studies have been undertaken with regard to spatial differences, and a prevalence of widely differing patterns have been noted by authorities.[2] Study of urbanization as a process of change in the form and structure of the habitat must take into account the differences in the level of economic base and technological infra-structure of the communities concerned. Hitherto more efforts have been devoted to the study of individual cities or urban agglomerations on the basis of which comparisons between different culture areas have been derived. This trend though measuring a highly representative form of urban growth, is deficient as far as degree of comparability among different areas is concerned. This weakness in current studies has been pointed out by many authorities.[3] Holzner has emphasized the role of urban geographer firstly for his contributions to the regional studies, secondly in interpreting the city as the expression of the surrounding cultural realm and thirdly, for comparative study on the regional variations of cities from one culture region to another.[4]

The points of population have multiplied in number and sizes in the developed and the developing countries alike. Rising standards and expectations have brought a rapid change in type and structure of houses, establishment of marketing and services, provision for recreation and transport in large parts of the world. Recognizing differentials in the pattern of urban growth, the study that follows looks into expansional aspects of urbanism in the Upper Indus Plains, a region which may first briefly be defined.

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The Upper Indus Plains, also known as the Punjab Plains, covering 182,840 square kilometers (70,600 sq. miles), comprise sixteen districts of the province of Punjab in Pakistan, leaving out three Potwar Upland districts namely Campbellpur, Rawalpindi and Jhelum. This distinct geographical region occupies the north-western portion of the South Asian Sub-continent, south of the Himalayas. Fig. 1 depicts the region and its administrative districts. The major river, the Indus, and four of its important tributaries, the Jhelum, Chenab, Ravi and Sutlej, traverse the Upper Indus Plains in a fanshape. Entering the Plains from the north, at intervals, each of these tributaries flows in a south-westerly direction and join together before their ultimate merger with the Indus, towards the south-western extremity.

Affected by a phase of Monsoon Climate, which however, becomes quite feeble here, rainfall over most of the region remains under 300 mm and is less than 90 mm over the extreme south-western parts. High dependence on available river water as a basic resource for sustained agricultural economy is thus too obvious.

Irrigation agriculture has been an age old tradition in the Indus Valley, but perennial irrigation developed since the 1880's provided avenues for new settlements to be established, as well as influenced the growth of earlier urban centres on an unprecedented scale. Another point to note is that industrialization (which had a late start) has accelerated urban growth, but the basic framework of urban centres is laid on agricultural expansion and the settlement plans indicate explicitly marketing and service functions as dominant features. This study takes into account economic development of the region as a whole and confines its investigations to the evolution of demographic size of urban centres. In addition, an attempt is made to identify a general urban system within the region. The study is growth oriented, identifies the forces of change and in the final analysis, emphasizes evolutionary trends of the current urban pattern.

Urban places and urbanization are widely considered, in a demographic sense, as agglomerations or attributes of a given size. However, in the consideration of city or an urban place, either as a dependent or an independent variable, much more than the demographic definition is necessarily involved[5]. This is where geographical studies of the process take over from the general social studies of human agglomerations and bring in morphology, structure, extent, locational interaction and spatial differentials.

For convenienec in quantification, a demographic criterion is best for definition of an urban settlement. For this reason, number of persons in a particular size class, usually +5,000 is taken ; although +20,000 and +100,000 figures have also been made a basis of study for various assumptions. Difficulties in international comparisons, however, arise as an urban place is defined variously in different national censuses.[6] Recognizing differences in national attitudes to urban criteria and keeping in view various forms and needs in which such data could be utilized, the U. N. Demographic Year Book appreciates a multidimensional approach to the setting up of arbitrary cutting points for differentiating 'urban' from 'rural'. As such statistics of urban population despite their shortcomings are useful for comparisons between countries or territories on a broad scale.[7] Whatever

criterion is adopted, the term 'urban' connotes a qualitative attribute of the locality, which differentiates it from a rural or non-urban locality.

In Pakistan Census Reports, it is the administrative, social, economic or demographic characteristics that determine the status of a locality as urban or rural.[8] While a demographic concept for urban definition has been followed here, other factors, especially those affecting the composition of large agglomerations and growth outside fixed boundaries, require due consideration. The system of making boundaries of towns and cities has produced some rigid skeletal outlines, due to historical causes or other arbitrary decisions. It does not take into consideration the economic and social changes that have taken place in later times. Rarely do the boundaries of the municipalities correspond to the actual built up areas ; we find that in the case of growing urban centres, many people though belonging to the same city have taken up their abode and established factories just outside the municipal limits to avoid certain taxes. Though urban in reality, this occupance is not reflected in urban population statistics.[9]

Before looking into actual figures of growth spread over the past decades, relation of economic development to urbanism may again be stressed. True, economic development in the Upper Indus Plains was in the field of agriculture alone, but even in Britain, large-scale industrialization and urbanization were preceded by the Agricultural Revolution of the 17th and 18th centuries. In the case of this region the resources and potentials do not offer any strong base for large-scale industrialization in the foreseeable future. Necessarily for such reasons, urbanization of a class and degree as witnessed in contemporary industrial regions of the world is very much out of question here.

In fact, it is development of an economic base, in whatever sector it may occur, that leads to surplus production and ensuing trade and commerce ; creating markets for exchange and demand of goods and services. Through economic prosperity, a sizeable proportion of population is relieved from primary occupations and become engaged in secondary and tertiary occupations. The change in the case of agricultural growth is however, relatively slower than that which accompanies industrial growth, thus the process of urban and social change remains less perceptible for a time.

Considering the City, the State, and Economic Development, Keyfitz puts this very clearly.[10] In the early phase agricultural products are needed not only to support people in the cities while they add to local capital in the form of factory buildings, but also, through their export abroad, to finance the purchase of machinery. However, urbanism, itself a product of basic economic and technological development, tends in turn, once it comes into being, to affect every aspect of existence.[12]

Two points which have a bearing on the degree of urbanization in the Upper Indus Plains may be noted here. Firstly, economic gains both in public and private sectors brought by the opening up of the wastelands, were enormous and with each new scheme one notices a comparable shift in the degree of urbanism. Secondly, establishment of new towns in the Canal Colonies led to the planning of settlement morphology of a better quality then what existed before. In fact these Canal Colony settlements became

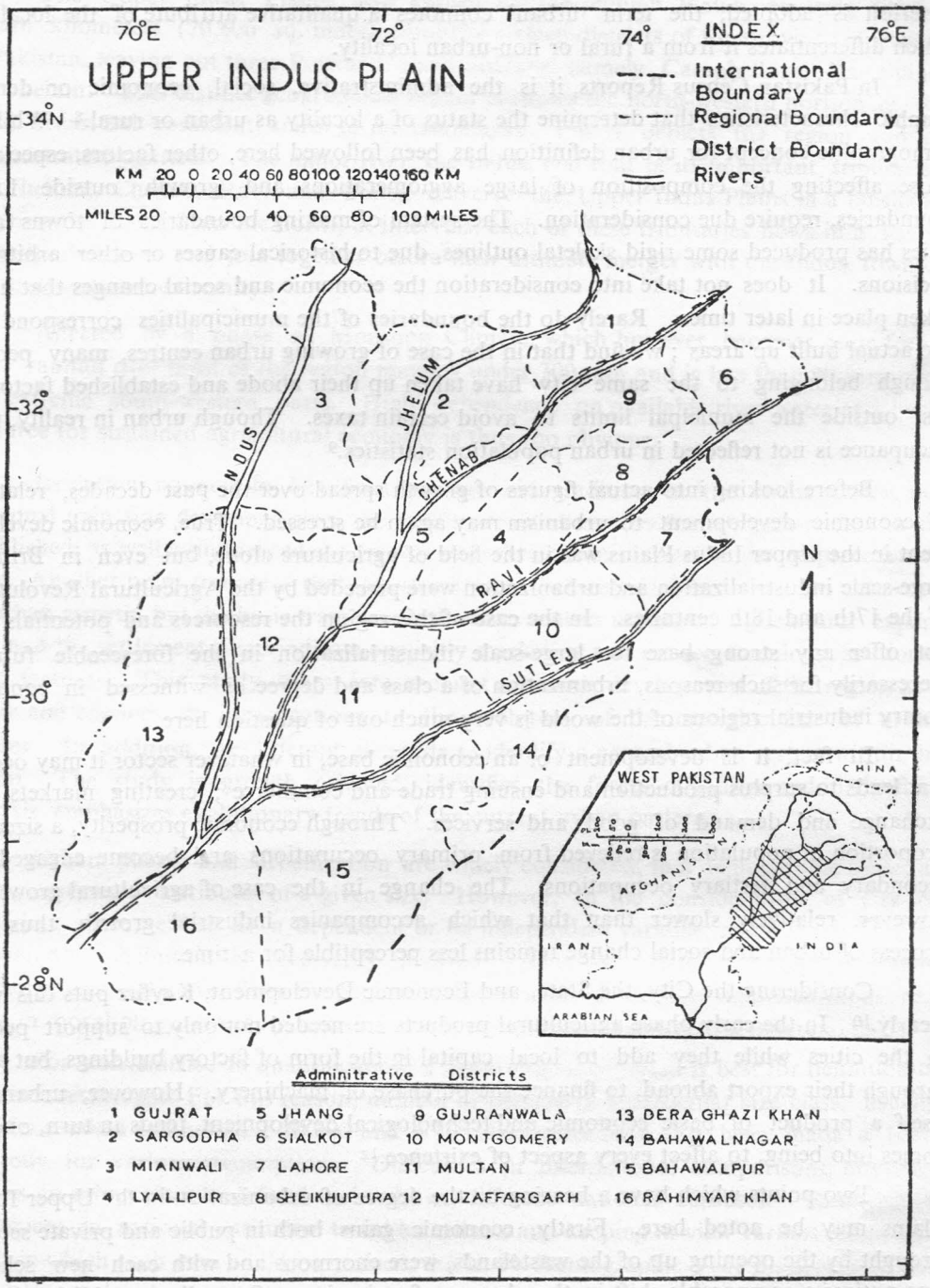

Fig. 1. The Upper Indus Plains—5 rivers and the 16 administrative districts of the region.

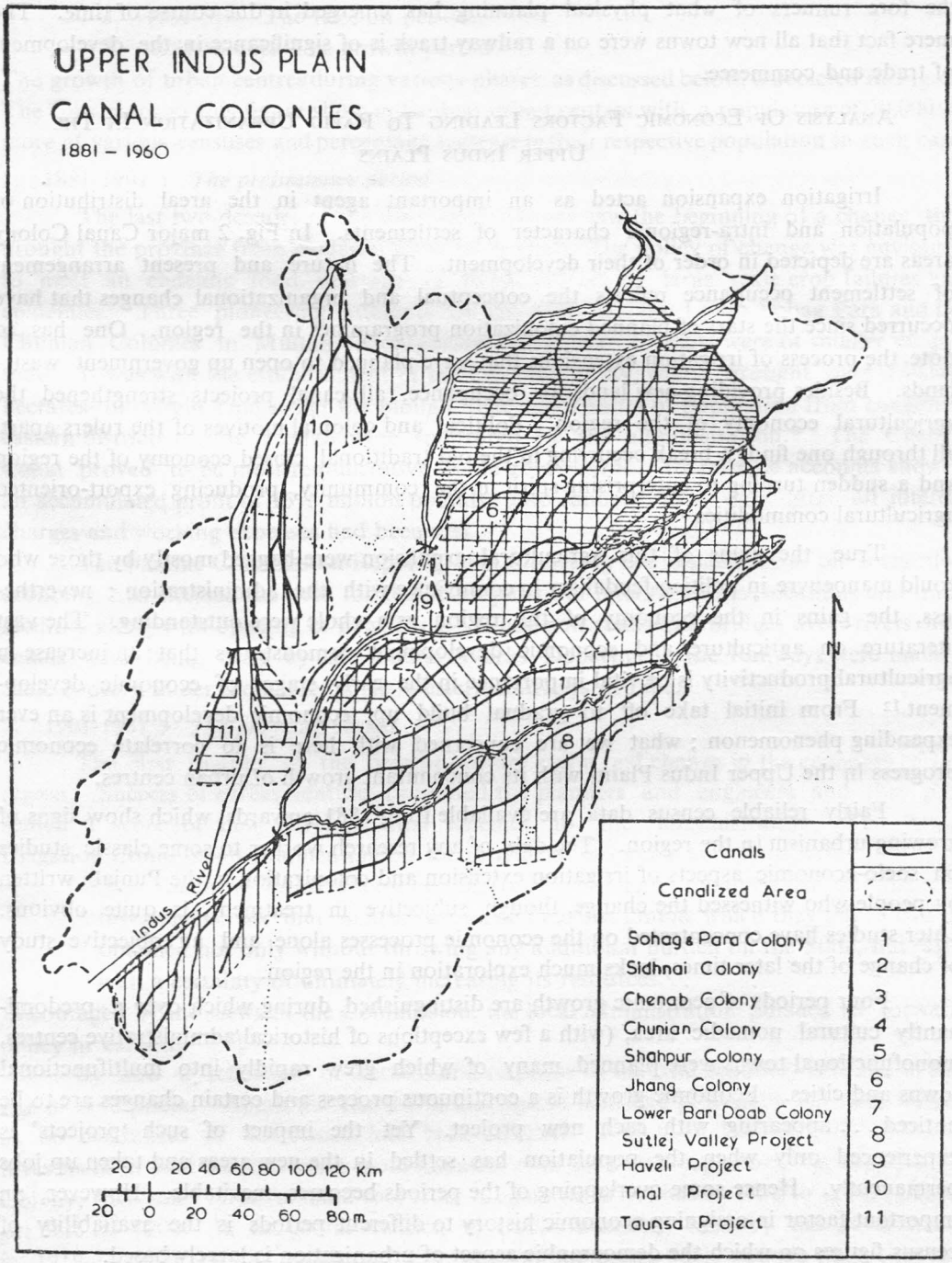

Fig. 2. The progressive opening up of interfluves for perennial irrigation has been responsible for agricultural productivity and growth of settlements in the region.

the fore runners of what physical planning has emerged in due course of time. The mere fact that all new towns were on a railway track is of significance in the development of trade and commerce.

Analysis Of Economic Factors Leading To Rapid Urbanization In The Upper Indus Plains

Irrigation expansion acted as an important agent in the areal distribution of population and intra-regional character of settlements. In Fig. 2 major Canal Colony areas are depicted in order of their development. The nature and present arrangement of settlement occupance reflects the conceptual and organizational changes that have occurred since the start of planned colonization programmes in the region. One has to note the process of irrigation extensions that were planned to open up government waste-lands. Besides providing new lands for occupance, all canal projects strengthened the agricultural economy of the region. Political and colonial motives of the rulers apart, all through one finds a break occurring in the old traditional, closed economy of the region and a sudden turning to enterprising spirit in the community, producing export-oriented agricultural commodities.

True, the gains of this agricultural expansion were bagged mostly by those who could manoeuvre in politico-feudalism in connivance with the administration ; nevertheless, the gains in the economy of the region as a whole were outstanding. The vast literature on agriculture and economic development demonstrates that an increase in agricultural productivity is of vital importance in the early stages of economic development.[12] From initial take off to gradual build up, economic development is an ever expanding phenomenon ; what we are concerned with here is to correlate economic progress in the Upper Indus Plains with its concomitant growth of urban centres.

Fairly reliable census data are available from 1881 onwards, which show signs of growing urbanism in the region. The debt of any research worker to some classic studies on socio-economic aspects of irrigation extension and colonization in the Punjab, written by people who witnessed the change, though subjective in treatment, is quite obvious. Later studies have concentrated on the economic processes alone and an objective study of change of the later times, lacks much exploration in the region.

Four periods of economic growth are distinguished, during which over a predominantly cultural nomadic area, (with a few exceptions of historical/administrative centres, monofunctional towns were planned, many of which grew rapidly into multifunctional towns and cities. Economic growth is a continuous process and certain changes are to be noticed . . . appearing with each new project. Yet the impact of such 'projects' is experienced only when the population has settled in the new areas and taken up jobs permanently. Hence some overlapping of the periods becomes inevitable. However, an important factor in assigning economic history to different periods is the availability of census figures on which the demographic aspect of urbanization is largely based.

1. 1881-1901 The preliminary period.
2. 1901-1931 The planning period.

3. 1931-51 The take off period.
4. 1951 to date The growth period.

The growth of urban centres during various phases, as discussed below, is depicted in Fig. 3. The four maps in this figure show individual urban centres with a population of 20,000 or more at various censuses and percentage increase in their respective population in each case.

1. 1881-1901 : *The preliminary period*

The last two decades of the nineteenth century saw the beginning of a change that brought the province from medieval times to modern. The policy of change was envisaged to meet an endemic food shortage in India caused by large scale crop failures and epidemics. Three pioneering attempts of the Sidhnai, the Lower Sohag Para and the Chunian Colonies in Multan, Montgomery and Lahore districts were of smaller magnitude. It was with the establishment of the Chenab Colony, which brought over 250,000 hectares of virgin land under the plough, that major shifts of population from congested eastern districts of the Punjab were sponsored by the administration.* The Chenab Canal proved to be most remunerative to the government. Its revenue accounts showed an accumulated profit of 16.5 million pounds upto January 1924 only, after all interest charges and working expenses had been met.

The Famine Commission Report (1880) foreseeing the importance of an integrated economy, had stressed the need for the development of internal communications and trade facilities along with opening of new lands. While new roads and bridges over rivers and canals were being built by the Public Works Department, the Railways were made a State concern under the name North Western Railways in 1886.

2. 1901-1931 : *The planning period*

The first quarter of the present century saw a real change in the economy of the region. Success of earlier ventures promoted the planners and engineers and they presented a score of new developmental schemes to the administration. The Royal Irrigation Commission commenting on the provincial proposals and plans wrote :[13]

> " . . . Such works are almost certain to prove highly remunerative as financial investments, so that indirect protection against famine which they afford can be obtained not only without throwing any additional burden on the State, but also with a certainty of ultimately increasing its resources."

Encouraged by the views of the Commission, the local administration pursued its forward policy in earnest.

By now a reflection of success and response in the land economy is found in the rise of land prices. About the year 1870, unirrigated land had practically no sale value, as no clearances of wastelands had been effected. With the colonization that ensued, investment in land became much more lucrative even for urban capitalists. In the Chenab Colony, the sale value of land rose from roughly three pounds in 1892 to seven pounds per acre by 1900. In Sargodha district, in public auctions, held by the government in 1919-20, each of the residential sites was sold for nearly 6,000 pounds while sites for shops fetched up to 34,000 pounds for a plot of one acre.[14]

*Especially districts of Gurdaspur, Amritsar and Jullunder.

The intensity of agricultural land use, which eventually developed in the region, brought sufficiently large surplus of stable food and led the farmers to concentrate on commercial crops like cotton and sugarcane. In Darling's words : "the cultivator now began to look to the market.[15] Agricultural prosperity necessitated the emergence of specialist artisans and other non-agricultural workers, which form an essential element of urban communities. Much of the expansion of land distance trade in wheat and cotton depended on the intermediary efforts of traders and commission agents. The sophisticated methods of handling financial transactions encouraged further extension of business. Scheduled Banks and Credit Societies sprang up in many towns of the region. In Montgomery Colony alone, 113 new cooperative societies were established by 1920.[16]

It was in the last decade of this period that first signs of manufacturing and factory industry appear to have taken concrete shape in the region. The Provincial Department of Industries was established in 1919 ; previously affairs of industry and labour had also been a concern of the Agriculture Department. Foundry works, oil milling and weaving were established in selected towns ; while cotton packing and ginning factories brought a first change in the functions of many smaller towns.

Before 1920 the region had largely depended on animal power both for its soil produce and crafts. Small thermal electric generation plants, providing supply for lighting had appeared in some towns but Jogindernagar Hydroelectric Station (11,000 kw capacity) was the first major source of power in the British Punjab. Thence onward, the provincial government assigned a high degree of priority to the schemes related to hydro-electricity, for domestic as well as industrial usage. But it took long to realise such goals.

3. 1931-1951 : *The take off period*

This period saw great increase not only in the size and frequency of urban localities, but a real change in the functions of many towns. The Sutlej Valley Project, comprising four barrages which irrigates lands on both sides of the river, brought first perennial irrigation to the districts of Bahawalngar, Bahawalpur and Rahimyar Khan. The Haveli Project though smaller in extent, provided additional waters to the earlier established Sidhnai Colony.

As noted earlier, the agricultural economy had already acquired stability and now the region was looking to entrepreneurial leadership in trade and industry. Whereas export of agricultural raw material to other provinces in India and abroad flourished, lack of minerals and industrial fuel remained major handicaps for the growth of industry. With the increase in acreage of sugarcane in the irrigated areas, efforts were directed to capturing the home market from imports. It was considered that if a great sugar industry sprang up both agriculture and industry would benefit.[17]

Growing income of the communities led to greater demand for sophisticated consumer goods for which selective manufacturing concerns multiplied in all medium and large towns. The establishment of manufacturing (mainly to substitute imports of goods of everyday use) brought some concentration in the towns which encouraged it doubly ; as venues of a good market and also as sources of semi-skilled labour. A government

sponsored Metal Works Shop at Sialkot, led to the initiation of Sports Goods and Surgical Instruments industry in that city. Iron foundries, shoe factories and big flour mills sprang up in and around Lahore while some textile factories began to appear in Multan and Lyallpur. Although it is hard to find any substantial industrial growth by the close of this period, agricultural prosperity of the province had, however, produced a high propensity in the levels of consumption. The rise in socio-economic status of the community in general had created a base for industrial activity to commence. Explanations of the entrepreneurial spirit, which led to a sudden outburst of industrial development in the region after independence (*i.e.*, the next period) are to be found in the stage of economy that by then had been achieved in the region.

The mass immigration of Muslims from across the border was absorbed in the Colony areas of the Province.* A larger proportion of these new comers settled and took up urban jobs. The contribution of *Muhajirs* to the city life in the country or the region demands a separate study. Admittedly there was out migration too. Economic conditions became unsettled for a time and wide ranging adjustments were to come in later years. However, immediate effects of the migrants' arrival on the economy, resources and urban extensions is obvious.

4. 1951 to date : *The growth period*

It is difficult to evaluate in summary form, economic growth of recent decades, concerning the prominent region of a developing country like Pakistan.[18] However, we can discern the economic forces which have a direct relation with urbanization by confining ourselves to what has been achieved in urban localities. Among many forces that have a bearing on current urban expansion three factors stand out conspicuously.

1. *The potentials and inheritance of the region.* Economic growth, entrepreneurship and manufacturing in the region had been set on a 'launching pad' in the decades immediately preceding independence. The potentials of a 'semi-industrial' system were just ripe and the region's inheritance was quite impressive by contemporary standards.

2. *The liability and assets of "Muhajirs" : Contribution to human resources and change in social aptitudes.* The vast number of *Muhajirs* though initially without much resources, contributed to the economic and social change as well as physical growth of the urban localities. No separate mention of their contribution is available as they were absorbed within the population as natural citizens of Pakistan. Only the 1951 census recorded the *Muhajirs* separately, and for all practical purposes there has been no distinction between the old and the new citizens.

Table 1 gives the number and percentage of *Muhajirs* settling in different class-sizes of urban centres within the Province and Table 2 details similar figures for some towns and cities as enumerated in 1951 census. In the former case proportion of *Muhajirs* in larger urban class sizes is between forty-five to fifty per cent, whereas in case of individual

*A total number of 5,281,200 *Muhajirs* settled in the Punjab by 1951 which formed 26% of the total population of the Province. Incidentally the bulk of these political immigrants came from the Eastern districts (Now East Punjab) which had previously sent settlers to the colony areas.

cities (second table) their percentage amounted to over sixty in case of Lyallpur, Sargodha and Jhang. The impact of movement and mobility within the population, skill of many a craftsman, and sudden addition to labour force and capital in the region are thus obvious.

TABLE 1—NUMBER OF MUHAJIRS IN THE URBAN CENTRES OF THE PUNJAB AS ENUMERATED IN THE CENSUS 1951

Class size of the Urban Centres	Total Population	*Muhajirs*	Percentage of *Muhajirs* in the Total Population
100,000	1,743,817	787,316	45%
25,000 to 100,000	661,977	327,692	49.5%
10,000 to 25,000	612,561	298,551	48.7%
5,000 to 10,000	408,551	158,272	38.7%

Source : *Census of Pakistan* 1951, Vol. I, Report and Tables, Table 2.

TABLE 2—PROPORTION OF MUHAJIRS IN SELECTED URBAN CENTRES OF THE UPPER INDUS PLAINS, CENSUS 1951

(IN THOUSANDS)

Urban Centre	Total Population	Number of *Muhajirs*	Percentage of *Muhajirs*
Lahore	849,000	366,000	43%
Multan	190,000	94,000	49%
Lyallpur	179,000	124,000	69%
Sialkot	168,000	54,000	32%
Gujranwala	121,000	61,000	52%
Sargodha	78,000	54,000	69%
Jhang	73,000	47,000	64%
Bahawalpur	42,000	17,000	40%

Source : *Census of Pakistan*, 1951, Vol. 5, Punjab and Bahawalpur State, Statement 5-B, p. 73.

3. *The Role of Specialized Agencies and Events :* Government policies and programmes of economic growth and physical expansion of the towns during the period have been many and varied. The role of specialized agencies like PIDC, WAPDA, IDBP, ADBP, ADC etc., is a subject of many studies on the economy of Pakistan. The Thal Development Authority has been concerned with the colonization of the most difficult tract (Sind Sagar Doab) in the region. The Indus Waters Treaty (1960) has brought in many a concept of water utilization through economic and technical collaboration on an international scale. While the Taunsa Barrage has provided irrigation to the trans-Indus district of Dera Ghazi Khan, construction of high storage Dams and Link Canals have their own bearings on the region's growth.

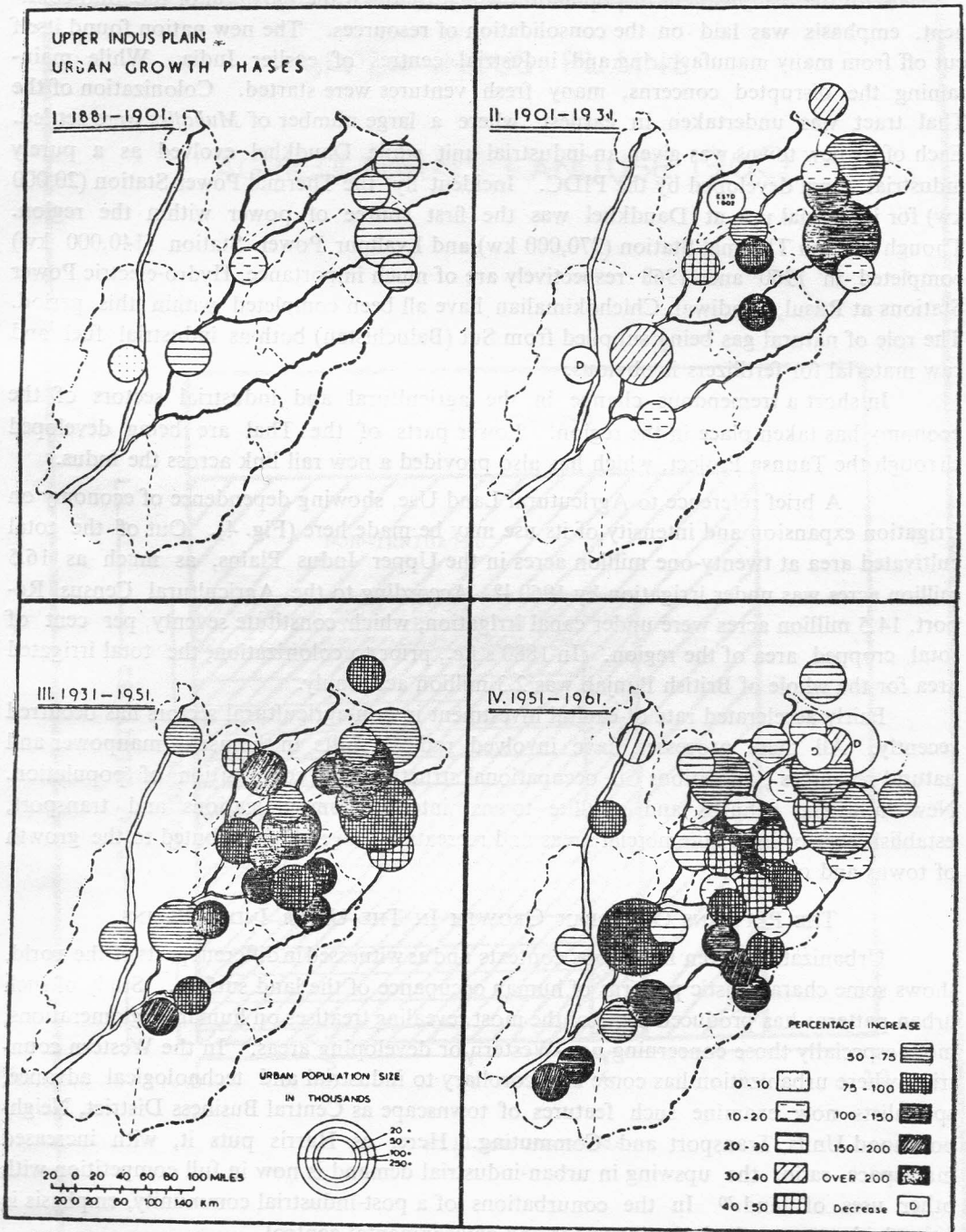

Fig. 3. Urban centres with a population of 20,000+ and the percentage increase in their population during the four growth periods identified in the study. (In 1881 there were just 6 urban centres having above 20,000 population and by 1961 their number increased to 37).

With the readjustment of population which followed the Partition of the Sub-continent, emphasis was laid on the consolidation of resources. The new nation found itself cut off from many manufacturing and industrial centres of earlier India. While maintaining the disrupted concerns, many fresh ventures were started. Colonization of the Thal tract was undertaken in earnest, where a large number of *Muhajirs* were settled. Each of its new towns was given an industrial unit while Daudkhel evolved as a purely industrial town developed by the PIDC. Incidentally, the Thermal Power Station (20,000 kw) for industrial use at Daudkhel was the first source of power within the region. Though Multan Thermal Station (270,000 kw) and Lyallpur Power Station (140,000 kw) completed in 1960 and 1968 respectively are of much importance, Hydro-electric Power Stations at Rasul, Shadiwal, Chichokimalian have all been completed within this period. The role of natural gas being supplied from Sui (Baluchistan) both as industrial fuel and raw material for fertilizers is obvious.

In short a tremendous change in the agricultural and industrial sectors of the economy has taken place in the region. Lower parts of the Thal are being developed through the Taunsa Project, which has also provided a new rail link across the Indus.

A brief reference to Agricutural Land Use, showing dependence of economy on irrigation expansion and intensity of its use may be made here (Fig. 4). Out of the total cultivated area at twenty-one million acres in the Upper Indus Plains, as much as 16.5 million acres was under irrigation by 1960.[19] According to the Agricultural Census Report, 14.5 million acres were under canal irrigation, which constitute seventy per cent of total cropped area of the region. In 1880's *i.e.*, prior to colonization, the total irrigated area for the whole of British Punjab was 2.3 million acres only.

Fairly accelerated rate of capital investment in non-agricultural sectors has occurred recently. All these processes have involved radical shifts in the use of manpower and natural resources ; alterations in occupational structures and composition of population. New industrial suburbs and satellite towns, internal communications and transport, establishment of local commercial areas and recreation, have all contributed to the growth of towns and cities.

The Patterns Of Urban Growth In The Upper Indus Plains

Urbanization taken in various contexts and as witnessed in different parts of the world, shows some characteristic patterns of human occupance of the land surface. Study of such urban patterns has produced some of the most revealing treatises on human agglomerations, more especially those concerning non-Western or developing areas. In the Western countries, where urbanization has come as a corollary to industrial and technological advance, specialists now examine such features of townscape as Central Business District, Neighbourhood Units, Transport and Commuting. Here, as Harris puts it, with increased man-space ratio, the upswing in urban-industrial demand is now in full competition with other uses of land.[20] In the conurbations of a post-industrial community, emphasis is being laid on an ecological adjustment and environmental control.

In the developing world, where urbanization is seen mostly as a symbol of modernization and change, notwithstanding the size of population and areas involved,

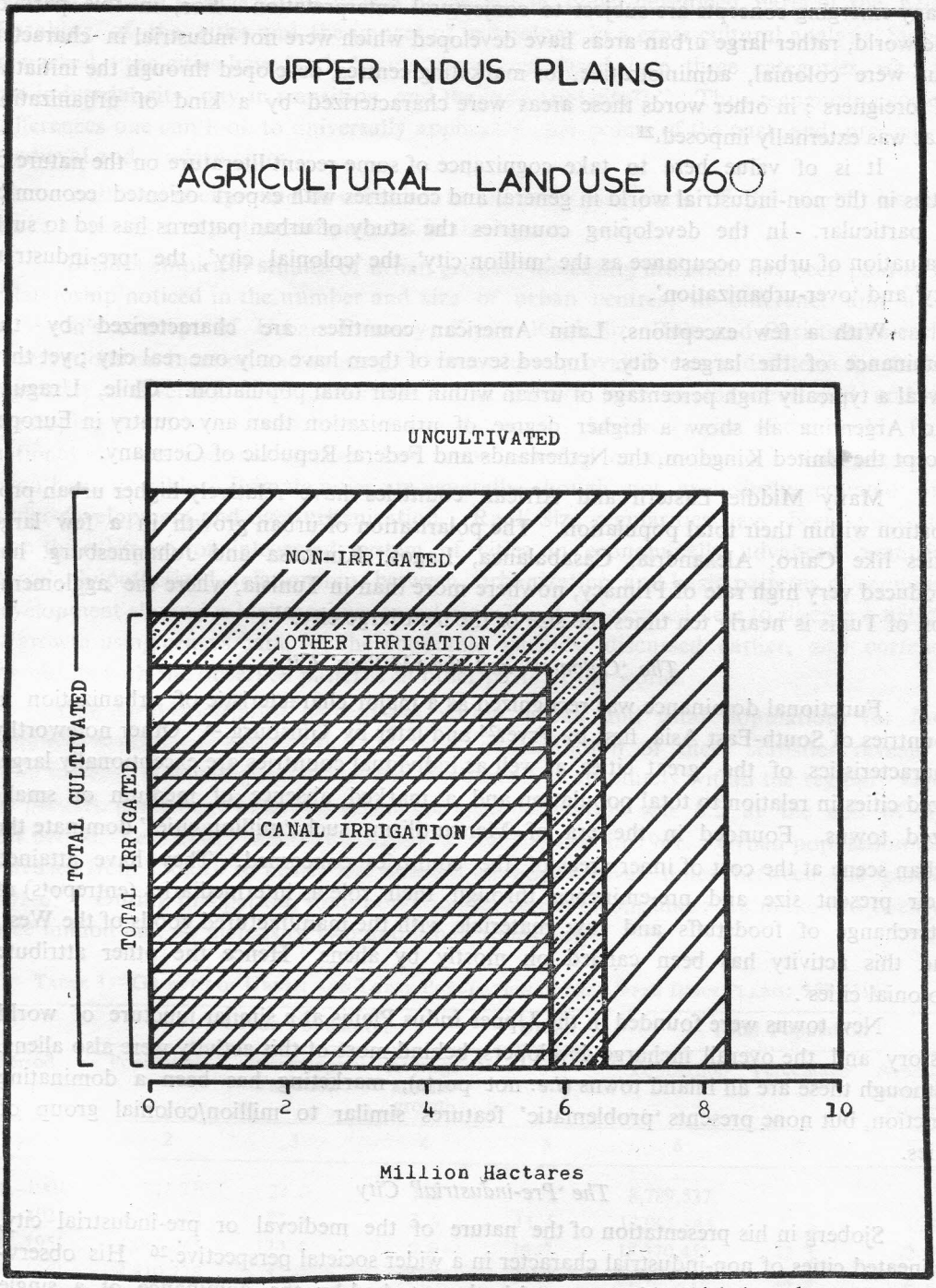

Fig. 4. Agricultural Land Use in the Upper Indus Plains depicting high dependence on canal irrigation.

many emerging concepts are subject to conjectural interpretation. For, in this part of the world, rather large urban areas have developed which were not industrial in character, but were colonial, administrative, or marketing centres, developed through the initiative of foreigners ; in other words these areas were characterized by a kind of urbanization that was externally imposed.[21]

It is of value here to take cognizance of some recent literature on the nature of cities in the non-industrial world in general and countries with export oriented economics in particular. In the developing countries the study of urban patterns has led to such evaluation of urban occupance as the 'million city', the 'colonial city', the 'pre-industrial city' and 'over-urbanization'.

With a few exceptions, Latin American countries are characterized by the dominance of the largest city. Indeed several of them have only one real city ; yet they reveal a typically high percentage of urban within their total population. Chile, Uraguay and Argentina all show a higher degree of urbanization than any country in Europe, except the United Kingdom, the Netherlands and Federal Republic of Germany.

Many Middle Eastern and African countries have relatively higher urban proportion within their total population. The polarisation of urban growth in a few large cities like Cairo, Alexandria, Casabalanca, Lagos, Kinshasa and Johannesburg, has produced very high rate of Primacy, nowhere more than in Tunisia, where the agglomeration of Tunis is nearly ten times the size of the next large city.[23]

The 'Colonial' and the 'Million' City

Functional dominance was recognized as a major characteristic of urbanization in countries of South-East Asia, first by Fryer[24] and later by Ginsburg.[25] Other noteworthy characteristics of the 'great cities' as well as individual countries are exceptionally large-sized cities in relation to total population and a marked absence of medium or small-sized towns. Founded in the era of Mercantilism, such 'million cities' dominate the urban scene at the cost of inner areas of the countries concerned. They have attained their present size and pre-eminence through their role as intermediaries (entrepots) of interchange of foodstuffs and raw materials with the manufactured goods of the West, and this activity has been carried on mostly by aliens. Hence the other attribute 'colonial cities'.

New towns were founded in the Upper Indus Plains at a similar juncture of world history and the overall incharge developers, behind most of this activity were also aliens. Although these are all inland towns (*i.e.* not ports), marketing has been a dominating function, but none presents 'problematic' features similar to million/colonial group of cities.

The 'Pre-industrial' City

Sjoberg in his presentation of the nature of the medieval or pre-industrial city, delineated cities of non-industrial character in a wider societal perspective.[26] His observation that the pre-industrial city was, and is characterised by the dominance of a single function or very few functions, may not be held universally true. However, his theoretical

characterization reflects visual aspects of city life in 'under-developed' parts of the world. Speaking of the cities and the impact of technology in a cross-cultural analysis, Sjoberg remarked, "the cities have lately been compartmentalized into three categories *viz.*, the pre-industrial city, city in transition and the industrial city[27]." Thus recognizing societal differences one can look to universally applicable view-points of the past and present, or medieval and modern cities.

With this background of urbanism in the developing parts of the world, we now make a specific study of urban patterns in the region.

Besides empirical studies of urban growth, increasing attention has been paid to the relationship noticed in the number and size of urban centres, in differenct unit areas. Jefferson's concept of Urban Primacy, Zipf's Rank-Size Rule and Christaller's earlier observations on location and spacing of towns, have provided tests and criteria for finding regularity or diversity, in the patterns of urban growth both in the developed and the developing countries. Availability of varied data, for the greater part of the world, from national and international agencies, has made drawing of comparisons and testing of hypotheses possible. Primate cities are generally, though not exclusively, equated with under-development and over-urbanization. Rank-Size regularities have been associated with the existence of integrated system of cities in economically advanced countries. Berry's hypothesized relationship between urbanization and basic patterns of economic development showed a high positive correlation.[28] It is intended here to discern a pattern of growth using census data, for the economic pariods, discussed earlier, and correlate the results with the observed patterns in other parts of the world.

Comparable variation percentages within urban and total population, for four economic periods, are detailed in Table 3. A consideration of these statistics reveals a rapid increase in urban population both relatively and absolutely within the region. Over the periods, percentage of urban within the total population was 8.5 at the end of the first period, *i.e.*, 1901, whereas it rose to twenty-one in 1961. Urban population has increased from 750,020 to nearly five million, *i.e.* almost seven times between the period 1901-61. During this period, total poulation has grown from under 8.8 million to twenty-three million *i.e.*, an increas of two and a half times only.

TABLE 3.—GROWTH OF URBAN AND TOTAL POPULATION IN THE UPPER INDUS PLAINS: 1881-1961

Period	Urban Population			Urban percentage	Total Population		
	Population	Percentage Variation	Average annual growth		Population	Percentage	Average annual growth
1	2	3	4	5	6	7	8
1881–1901	747,859	24.0	1.2	8.5	8,789,537		
1901–1931	1,389,981	85.9	2.9	11.5	12,065,444	37.3	1.2
1931–1951	3,063,065	120.4	6.0	16.7	18,370,451	52.3	2.6
1951–1961	4,810,228	57.0	5.7	21.0	22,928,516	24.8	2.5

Source: *Census of India Reports* 1881-1931 and *Census of Pakistan Reports* 1951-1961.

TABLE 4(*a*).—GROWTH OF URBAN CENTRES IN THE UPPER INDUS PLAINS BY SIZE-CLASS AND PERCENTAGE OF URBAN POPULATION EACH SIZE CLASS

Class and Size	1881			1901			1931			1951			1961		
	No.	Population	Percentage	No.	Population	Percentage	No.	Population	Percentage	No.	Population	Percentage	No.	Population	Percentage
+1,000,000	—	—	—	—	—	—	—	—	—	—	—	—	1	1,296,477	26.9
+ 100,000	1	157,287	26.0	1	202,964	27.1	3	650,177	46.8	5	1,506,977	49.2	5	1,273,240	26.5
+ 50,000	1	68,674	11.4	2	145,350	19.4	1	58,716	4.2	4	265,136	8.7	6	456,981	9.5
+ 20,000	4	113,077	18.7	4	99,359	13.3	10	296,167	21.3	15	473,449	15.4	25	785,162	16.3
+ 10,000	7	104,911	17.4	7	112,433	15.0	11	145,195	10.5	34	464,241	15.2	37	513,455	10.7
+ 5,000	23	159,474	26.4	27	187,753	25.1	34	239,726	17.2	47	353,262	11.5	64	484,913	10.1
———	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
(—) 5,000*	31	106,433	15.0	14	50,310	6.3	18	7,224	4.6	26	97,074	3.0	21	75,360	1.5

Source : *Census of India Reports* 1881-1931 and *Census of Pakistan Repo ts* 1951-61.

*This category is not included in percentage calculation for total urban populatic n in Table 3.

Table 4(*a*) showing growth of urban centres by size classes and percentage of increase in each class reveals that medium-size urban centres have grown in larger proportions as compared to very small towns or a single large city. A summary statement, Table 4(*b*) showing number of urban centres in size-classes of +20,000 and above is as follows:

TABLE 4(*b*) *Increase in number of urban centres*, 1881—1961

Class-Size	1881	1961
1,000,000+	—	1
100,000+	1	5
50,000+	1	6
20,000+	4	25

Furthermore, whereas there were thirty-one towns in (—) 5,000 category with a combined population of over 106,000 in 1881, the census of 1961 recognized only twenty-one such small centres as urban, with a combined population of 75,360 only which was 1.5 per cent of the total population.

From historic records one learns that, at the time of British annexation of the Punjab, only Lahore and Multan were above 50,000; Sialkot and Dera Ghazi Khan above 20,000 in the region, and no town approached 100,000 in the whole of the Punjab.[29] Apart from Lahore, five other cities had more than 100,000 population by 1961 and two of these, Lyallpur (2nd in rank) and Sargodha are colony towns.

As for the rate of growth within the successive economic periods, the decades after 1931 show much accelerated growth. By this time, fifty years of agricultural expansion had provided a viable economic base, and the expanding economy led to the establishment of manufacturing and services in many towns and cities of the region. As the colony towns matured they surpassed the old centres both in number and size, and in respect of their new and better physical outlook. We have already noted the impact of *muhajirs*, coming from Eastern Punjab districts a sizeable majority of whom settled in colony towns permanently.

Rank-size distribution of urban centres

Zipf's Rank-Size Rule[30] states that, when all towns of a region are arranged in descending order by population, the size of the *r*th towns is $1/r$ the size of the largest town, according to series $1, 1/2, 1/3 \ldots\ldots 1/r$. Thus a regularity of hierarchy in towns is established, for a given self contained region. However, departures from this empirical deduction are many and varied, as a linear logarithmic distribution of towns by size is rarely found.[31] In broader terms, approximation to this rule is indicative of a contrast to the related concept of urban primacy.

Berry recognizes three categories of city-size distribution; log-normal, intermediate and primate.[32] Further, he draws three sub-categories for the intermediate type; those with more small cities than the primate, those with more medium-size cities and those

with more large cities. Fig. 5 drawn on a logarithmic scale, shows curves for urban centres for different periods of the study. It is found that city-size distribution in the Upper Indus Plains has been of sub-category one and two of the intermediate type, with fluctuations of the curves within medium-size range. The topography line shows that this distribution has progressed towards log-normal type in the decade 1951-61.

Positive relationship between city-size distributions and urbanization or economic development is not a universal measure; however, its evolutive appearance in the Upper Indus Plains demonstrates the importance of a large number of urban centres as against a single town becoming 'supereminent'. In the hierarchy of towns, number one city is

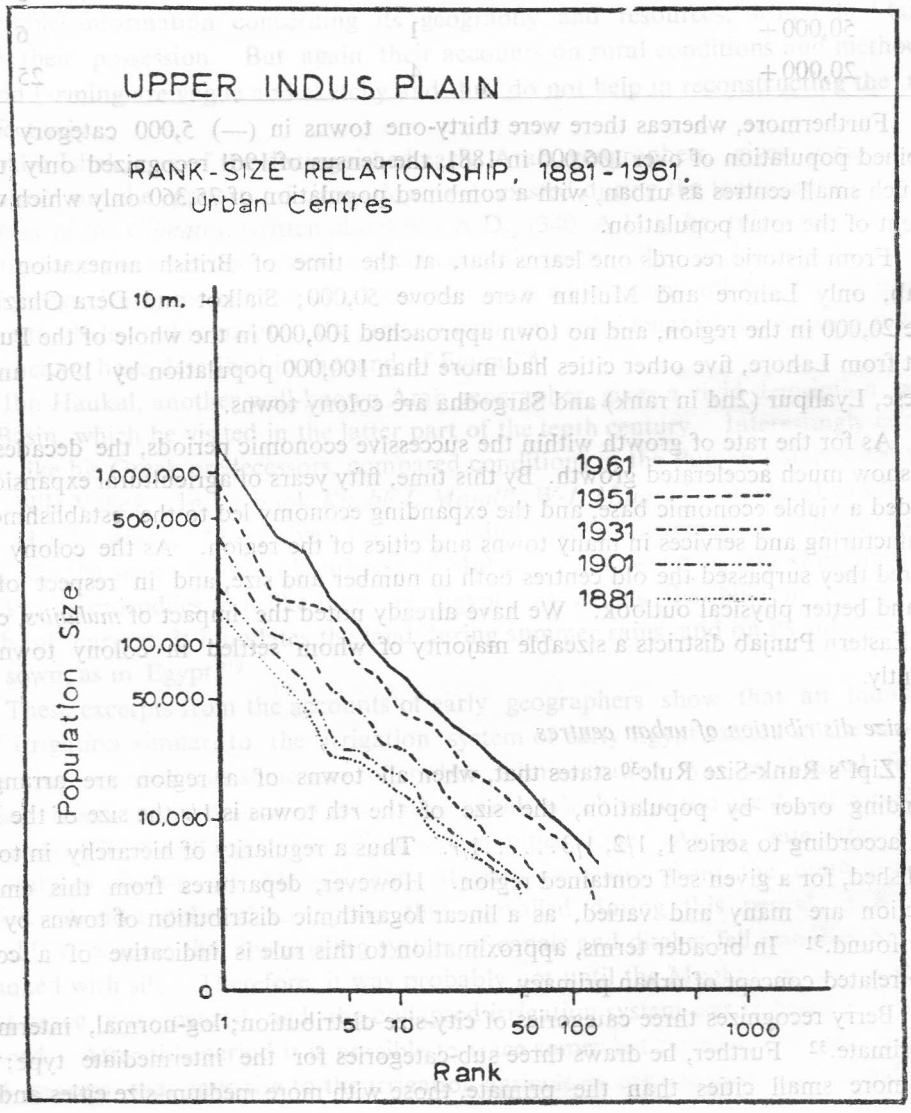

Fig. 5. Rank-size Relationships of the urban centres in the Upper Indus Plains.

followed by five medium sized cities, each one of which is maintaining steady growth, followed by twenty-five medium sized towns.

Approximation to Berry's model of city-size distributions in the Upper Indus Plains.

Berry from his study of 'City-size Distribution and Economic Development' concludes 'primacy' as the simplest city-size distribution, affected by fewer forces, whereas on the other hand 'rank-size' distributions are found, when many forces (economic and political as also historical) affect the system of cities for a long time. In the case of the Upper Indus Plains, the distribution of urban centres, approximating to near normalcy, has already been noted above. This is now tested on Berry's Model of City-size Distribution. Table 5 shows the cumulative frequencies of the percentage of each size class to 100 per cent of the population at the largest city, for different size classes: namely, 5,000-10,000, 10,000-20,000, 20,000-50,000, 50,000-100,000, 100,000-250,000, 250,000-500,000 and 500,000 to 1,000,000. In Fig. 6 these frequencies have been plotted on a log-normal probability paper, so that if a city size distribution is log normal it would assume the form of a straight line.[33]

TABLE 5. CITY-SIZES IN THE UPPER INDUS PLAINS, 1961 FREQUENCY NUMBER AND CUMULATIVE POPULATION

Class	Frequency Number	Cumulative Number	Cumulative Population	Cumulative Percentage
5,000	21	21	75,360	1.5
5,000—10,000	64	85	560,273	11.47
10,000—20,000	37	122	1,073,728	21.98
20,000—50,000	25	147	1,858,890	38.0
50,000—100,000	6	153	2,315,871	47.4
100,000—250,000	3	156	2,805,662	57.43
250,000—500,000	2	158	3,589,111	73.46
500,000—1,000,000	—	158	3,589,111	73.46
1,000,000+	1	159	4,885,588	100.00

The resultant graph for the cumulative percentages assumes a shape which closely resembles Intermediate-II group of Berry's Model. Considering the pattern of urbanization for the whole period of growth the different curves illustrate clearly the sharp reduction of percentages in the lowest size-class from 1881 to 1961 and inclusion in the high-class over the same period. Thus while smoothening of the curve is indicative of tendency towards log-normalcy, its spread denotes greater urbanization.

Though no definite correlation between log-normalcy of the city-size distribution and

either degree of economic development or degree of urbanisation is suggested by Berry, the phenomenon is regarded as depicting a distinct pattern. Vapnarsky has shown that a "well defined pattern" of rank-size distribution of cities is conditioned by a relatively high degree of closure of the area under analysis.[34] He further postulates that rank-size rule is related to the degree of interdependence, that is, a high level of interaction among the different units in the system is a requisite for differentiation of the system in a complete hierarchy for city sizes. Trends towards long-narmalcy in the Upper Indus Plains are thus indicative of greater interaction among the constituting urban units.

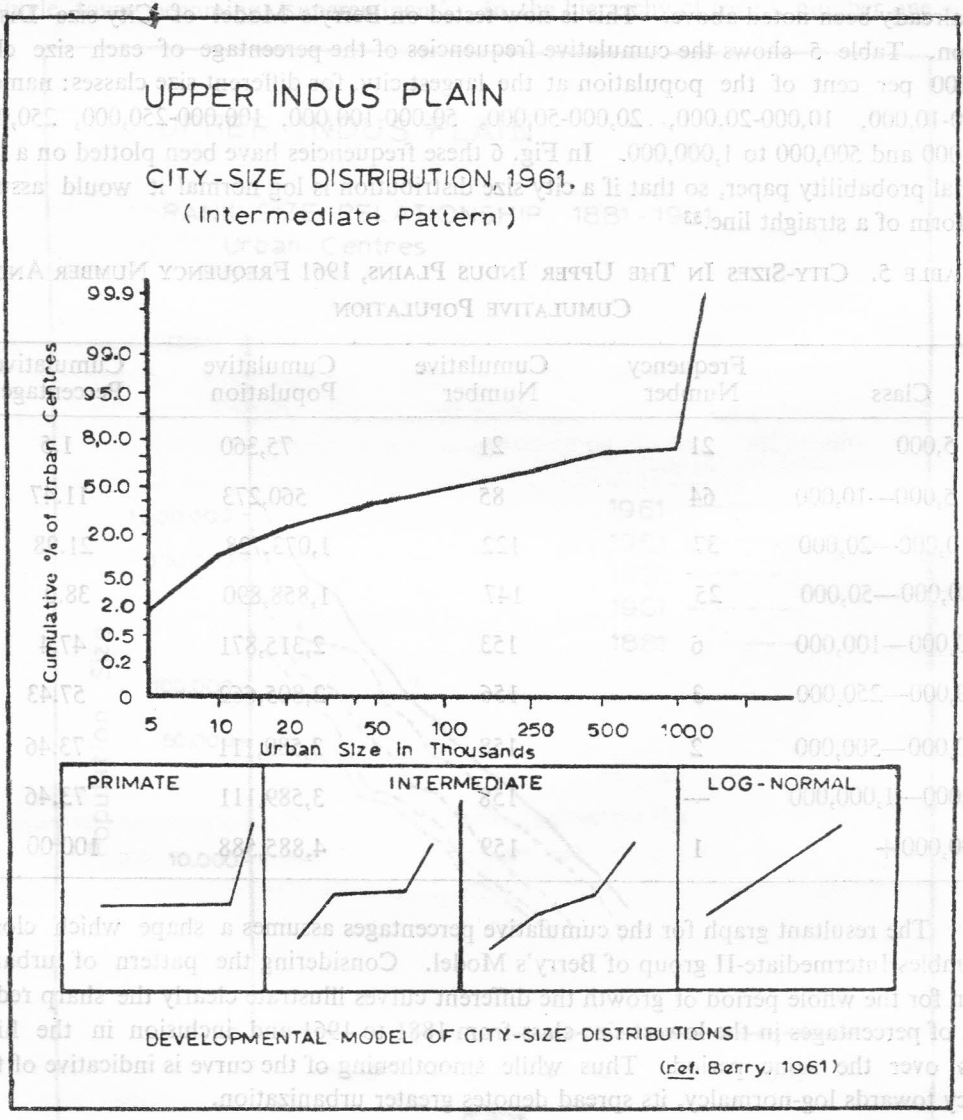

Fig. 6. City-size Distribution (1961) in the Upper Indus Plains together with Development Model of City-size Distribntions.

References

1. Hausar, P. M., "Urbanization: An Overview", *The Study of Urbanization*, (1965), edited by P. M. Hauser and L. F. Schuore, p. 6, and Clarke, J. I., *Population Geography*, Pergamon (1972), 2nd Ed., p. 46 ff.
2. See Hauser, *op. cit.*, p. vi.
3. Mayor, H. M., "Cities and Urban Geography", *Journal of Geography*, (January 1969), pp. 6-19.
4. Holzner, L., "World Reglons in Urban Geography", *Annals of Association of American Geographers*, Vol. 57/4 (December 1967), pp. 704-712.
5. Davies, W. K. D., "Approaches to Urban Geography", *Urban Essays* : Studies in Geography of Wales, Longman, (London 1970), edited by W. D. D. Davies and H. Carter, pp. 1-21.
6. See Clarke, *op. cit.*
7. United Nations, *Demographic Year Book* 1967 (New York, 1968), p. 2.
8. *Census of Pakistan*, 1961, Vol. I, pp. II/15, 16.
9. Ahmad, K. S., "Urban Population in Pakistan", *Pakistan Geographical Review*, Vol. 10/1 (1955), p. 2.
10. Keyfitz, N , "Political-Economic Aspects of Urbanization in South and Southeast Asia", *The Study of Urbanization* (1965), *op. cit.*, p. 278.
11. David, K., "The Origin and Growth of Urbanization in the World", *American Journal of Sociology*, Vol. 60/5 (1955), p. 429.
12. Grigg, D., *The Harsh Lands*, Macmillan (1970), p. 23.
13. *Royal Indian Irrigation Commission Report* (1903), Part I, p. 2.
14. Bennerjee, D. N. "Punjab Canal Colonies", *International Review, Agricultural Economics* Vol 3 (1925), p. 219.
15. Darling, M., *The Punjab Peasant in Prosperity and Debt* (Lahore 1947), 4th Ed., p. 149.
16. See Bennerjee, *op. cit.*, p. 225.
17. Calvert, H. B., *The Wealth and Welfare of the Punjab* (Lahore 1936), 2nd Ed., p. 143.
18. Papenek, G. F., *Pakistan's Development*, Harvard University Press (1967).
19. *Pakistan Census of Agriculture*, 1961, Vol. II, pp. 103-153.
20. Harris, C. D., "The Pressure of Residential Industrial Land Use", *Man's Role in Changing the Face of the Earth*, (Chicago, 1966), 6th Ed., edited by W. L. Thomas Jr., pp. 881-8 5.
21. *Urbanization in Newly Developing Couutries* (Princeton, 1966), pp. 3 and 39ff.
22. Beyer, G. H., *The Urban Explosion in Latin America* (Ithaca, 1967), p. 141.
23. Clarke, J. I., *Population Geography and the Developing Countries*, Pergamon Press Ltd., (Oxford, 1971), p. 121.
24. Fryer, D. W., "The 'Million City' in Southeast Asia", *Geographical Review*, Vol. 43/3 (Oct. 1953), pp. 474-494.
25. Ginsburg, N. S., "The Great City in Southeast Asia", *American Journal of Sociology*, Vol. 60 (1955), pp. 455-462.
26. Sjoberg, D., Cities in Developing and Industrial Societies, *The Study of Urbanization* (1965), *op. cit.*, pp. 213-263.
27. Sjoberg, D., *The Pre-Industrial City—Past and Present* (Glencoe, Illinois, 1960).
28. Berry, B. J. L., "City Size Distributions and Economic Development", *Economic Development and Cultural Change*, Vol. 9/4.
29. India Government, *1st Census of the Punjab*, 1968, *Lahore* (1870).
30. Zipf, G. K., *Human Behaviour and the Principle of Least Effort*, (Cambridge, Massachusetts (1949).
31. See Berry, *op. cit.*
32. *Ibid.*
33. *Ibid.*
34. Vapnarsky C. A., "*On Rank-Size Distribution of Cities:* An Ecological Approach", *Economic Development and Cultural Change*, Vol. 17/4 (July 1969), pp. 584-595.

ANTECEDENTS OF IRRIGATION DEVELOPMENT AND SETTLEMENT PATTERN IN THE PUNJAB*

RASHID A. MALIK†

THE history of agricultural land use and urban occupance in the Punjab, where rainfall is both insufficient and irregular, is closely associated with the developmental process of irrigation technology. In the exotic fluvial environment of the region, the irrigation technology is so intimately fused into the total economic and cultural complex that it becomes difficult to determine whether irrigation is the cause or effect of the regional occupance. Irrigation development, in fact, may be considered as an areal process which has set into motion the interaction between man and his milieu. In the course of time, man has developed various techniques of irrigation to insure better and more efficient means of water supply, thereby humanizing the cultural landscape. The purpose of this paper is to historically trace the fundamental technological and organizational changes in the irrigation development process and as they have been instrumental in shaping the nature and form of land occupance in the Punjab. An examination of the indigenous irrigation systems provides the necessary understanding of the pioneer settlement pattern as it existed before the development of modern irrigation technology.

Beginning of Irrigation

The practice of irrigation in the Punjab is older than the recorded history of the subcontinent. As indicated by recent archaeological findings and Aryan literature, it appears that irrigation was an important means of production in agriculture as early as three millennia B. C. The remains of the Indus civilization, which evolved at Harappa and Mohenjodaro and stretched from the Mekran Coast to the Jumna River, show that it was a well-organized and prosperous society which owed much for its existence to the development of irrigation.[1]

However old hydraulic civilization may be in the Punjab, it is evident that it did not evolve from within the indigenous societies of India. Instead, its cultural origin and development lay in the neighbouring countries to the west, *i.e.*, the Middle East. In the long history of the basin, various culture groups have entered India and have contributed significantly to the socio-cultural pattern of the region. Undoubtedly, the Aryans had inherited the science of irrigation farming, which they introduced into India, from their long experience in the Tigris-Euphrates Valley.[2] Later on, the Persians, Arabs and Moghals who successively invaded the basin from the west made a strong impress on the mode and efficiency of irrigation agriculture in the area.

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*This article is based on the research work done by the author in regard to his doctoral dissertation submitted to the Indiana University, Bloomington, Indiana in 1963.

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These recurrent cultural invasions were facilitated by the geographic setting of the Punjab. Lying in the path of any invader of the Indian subcontinent through the passes on the northwestern frontier, the Punjab province experienced frequent invasions up until the nineteenth century.[3] It was the gateway through which poured hordes of Aryans, Persians, Greeks, Arabs and Moghals to rule the subcontinent. Even for the British, who unlike preceding invaders chose the eastern seaboard to conquer India, the effective development and control of this strategic region was necessary to insure peace and security. Thus, the Punjab has been the scene of intense cultural interaction in which elements of many creeds and cultures have been intermingled, enmeshed and assimilated. This cultural fusion is manifested in the existing systems of irrigation and land occupance, which are the complex product of several technological and organizational forms introduced by different cultures in different places at different times.

Our earliest knowledge of the irrigation systems in the Punjab begins in a fragmentary way and gives only a hazy picture at best. The available literature compiled by early historians and travellers who visited various parts of the region give varying accounts of their contacts and experiences in the imperial courts and cities. They give the world little or no information on the methods of irrigation and farming as practised in their times.

The Greeks, perhaps, are the earliest sources of information on condition existing in the pre-Christian era. Greek explorers first entered the Punjab in 327 B.C. when Alexander the Great invaded it as part of the Persian Empire. From their accounts, it appears that irrigation agriculture had attained considerable efficiency at that time and sustained a large population.

Aristoboulos, who accompanied Alexander on his campaign, gives interesting accounts of the urban as well as the rural life of early India. In one of his reports on the Punjab he tells that "rain and snow fall only on the [Himalayan] mountains and the country immediately below them" and "the plains experience neither one nor the other, but are overflowed only by the rise of the water of the rivers. The rivers filled by melting of the snow and by rain, irrigate the plains."[4] On another occasion he noted a large deserted area in the basin, which in his words "contained more than a thousand cities with their dependant villages." On closer examination, he found that "the Indus, having abandoned its course, had diverted itself into another much deeper channel on the left hand, and precipitated into it like a cataract.... The country on the right hand, from which it receded, was no longer watered by the inundations, since it was elevated above the level, not only of the new channel of the river, but above that of inundation."[5] It is difficult to determine what general area Aristoboulos was referring to in this case ; nevertheless, it does point out that the inundation type of irrigation existed at that time. This account also bears out the fact that the Harappa culture, which flourished on the banks of the Ravi four thousand years ago, may have been destroyed due to the adverse effects of changes in the course of its river rather than to a deterioration in climate, as is generally speculated.

The very fact that the Greeks have always likened the Indus Valley to the Nile Valley indicates that they found comparable natural and cultural conditions in both.

The similarity was found to be so striking that Alexander for some time erroneously believed that the Indus Valley was part of the Nile Valley and that he could return to Egypt by way of the Indus River.[6] The great Greek geographer Strabo, who did a monumental work on the geography and history of India, admitted along with other Greek historians that "India resembles with Egypt and Ethiopia, since the plains which are not overflowed do not produce anything for want of water."[7]

Following the Greek invasion, the historical records are silent for over a thousand years, and one does not hear about conditions prevalent in the country until the conquest of the Punjab by the Arabs in the tenth century. During the tenth through the fourteenth centuries, the province was visited by the Arab geographers and travellers who gave considerable information concerning its geography and resources, which had largely become their possession. But again, their accounts on rural conditions and methods of irrigation farming are vague and sketchy and thus do not help in reconstructing the rural past effectively.

Abu Ishak, one of the distinguished early Arab geographers, gives some specific information on the pattern of irrigation that existed during the tenth century. In his work *Book of the Climates*, written about 951 A.D. (340 A.H.), he refers to the rivers in the area and the irrigation system associated with them. Put in his words, "it [the Indus] springs from the summit of a mountain from which many other affluents rise. It rises like the Nile, and inundates the land, which on subsidence of the water is sown in the manner we have described in the land of Egypt."[8]

Ibn Haukal, another well-known Arab geographer, gives a vivid description of the Indus Basin, which he visited in the latter part of the tenth century. Interestingly enough, he also, like his Greek predecessors, compared conditions in the Punjab plains with those in the Nile Valley. In his book *Kitabh-L Masalik W-L Mamalik* completed in 976 A.D. (366 A. H.), he wrote, "Many rivers [of the Indus system] increase its volume, and it appears like the sea in the neighbourhood of Multan.... Its water is very sweet and there are said to be crocodiles in it like those of Egypt. It equals the Nile in volume and strength of current. It inundates the land during summer rains, and on its subsidence the seed is sown, as in Egypt."[9]

These excerpts from the accounts of early geographers show that an inundation type of irrigation similar to the irrigation system of early Egypt existed in the area. It may also be supposed that some sort of public administration was established for the construction and maintenance of inundation canals which were too great and complex to be undertaken by the efforts of the village communities alone. At any rate, this system was paralysed during the Mongol and Moslem invasions from the ninth to twelfth centuries. Amidst political instability that prevailed during this period, it is quite reasonable to assume that the existing system of canals and ditches fell into disrepair and was choked with silt. Therefore, it was probably not until the Moghal period that permanent peace was insured and the collapsed irrigation system was restored and further developed. After this period it is possible to trace somewhat systematically the developmental process that gave rise to the irrigation agriculture organization that existed at the time of the British occupation.

Irrigatin System under the Moghals

The Moghals, with their irrigation experience in the Middle East and Central Asia, were quick to realize the potential significance of irrigation in the arid parts of the Punjab. However, they were also aware that an efficient irrigation system required a complex machinery of irrigation works. The building of dams, the digging of ditches and trenches and their supervision required so much labour that they were profitable only if kept in repair. Interruption in the regulation of the stream and its distributaries might well result in the total ruin of a rural population dependent on irrigation. They also realized that a prerequisite to an uninterrupted and efficient irrigation system was internal peace provided by a strong and stable government, a situation quite wanting at the time. Thus, the Moghals saw to it that security and peace were insured in the area so that proper efficiency in irrigation and agriculture might be attained.

The Moghals, who followed in the footsteps of earlier Moslem invaders, brought over three centuries of peace and order to the Punjab. To them the area was like a fortress, proper control and development of which was insurance of peace and security to the rest of India. Thus, the defences of the northwest frontier were strengthened and invasions from outside were stopped. The Punjab was turned into a strong military base with Lahore as its major bastion. The region, formerly a highway for invaders, became a bulwark between Central Asia and India.

Peace and order in the Punjab were accompanied by development of the irrigation system and rehabilitation of the agricultural communities. The complex and efficient agricultural organization that evolved in the Moghal period insured efficiency in irrigation-water supply and proper management of irrigation works. Under the new administration, the old ditches and canals were renovated and new inundation canals were constructed in hitherto unirrigated areas. The existing well irrigation system was also revitalized and enlarged by the introduction of the Persian wheel. All the social and economic development that occurred during the Moghal period was based on the practice of irrigation and its expansion.

Seasonal Inundation Complex

It seems reasonable to infer that the regularity with which the summer floods arrived in the Punjab plains first gave the riverine population the idea of "catching the flood water" for irrigation purposes. In the early stages of development, nature itself would have acted as a motivating force, since in times of abnormal flood more land would naturally be watered and fertilized than during a low one. Later on, the idea of digging trenches or shallow ditches along the river bank probably followed through imitation of nature's method of inundating the fields during the flood period.[10] In its pristine conditions, this method of annual inundation of the farmland may be compared to the irrigation systems of the Nile and the Tigris-Euphrates valleys.

It will be noticed that the topography of the Punjab and the conditions of water availability make it physically feasible to erect a longitudinal network of inundation canals. Owing to the nature and pattern of the fluvial environment, generally similar

features have developed in the *doab* areas. In each the general elevation gradually rises from the rivers towards the center of the *doab* and then falls again until the level of the next river is reached. Along the river bed, the inundation zone is locally called *sailaba*. In this zone of the *doab* during the flood period, the greater part of the heavier particles of alluvium are dropped immediately next to the river while the finer material is deposited farther away. Thus, as the rivers bring down silt, the river bed is continuously built up to a level slightly higher than that of the valley. Consequently, when the river is flooded, the bed overflows the natural levees and the water must flow down the slope away from the river bed over the country for two or three miles, depending on the height of water in the river and the volume of water it carries.[11] During the dry season, the *sailaba* is partly occupied by sand and alluvial mud with channels, some dry and some with water in them, wandering aimlessly.

It was in this flood zone that inundation canals were constructed in the earlier times and still sustain a large population in the riverine areas [12](Fig. 1). These canals branched off from the river at a height of about five meters above the river bed and the cultivated area in the flood plain. When the flood arrived in July and reached its peak in September, the canals were opened to water the cultivated land. Inundation canals, therefore, were built at an angle to the river and merely collected the surplus water of the flood.[13] This method of irrigation was more appropriate to the lower and flatter parts of the Upper Indus Basin, where the old alluvium was gradually replaced by newer alluvium. Thus, great inundation canal works were built in the southwestern reaches, of the rivers, where they converged to form one single stream called the *Panjnad*.

Considering the time they were constructed, the inundation canals were a great engineering work. Since the canals were gravity fed, they were carefully dug to maintain a gradual gradient suitable for proper water flow. The canals received water directly from the river generally through temporary dams which were removed at flood time. The method of irrigation employed when once the canals had been filled with water was by channels and ditches, as was the common practice in other irrigated lands. Banks of earth divided the land into compartments, and water was allowed to run into them by the process of breaking the earthen banks and making a temporary diversion dam with the material removed. This process of irrigation was surface flooding and was of a non-perennial nature.

Canal irrigation, however, was greatly improved and developed under the Moghal administration. It was first under the Moghals that the method of directing water from debouchures and distributing it through canals on the highest part of the *doabs* was introduced. The first canal of any size to reach an upland was constructed from the Jumna in 1351 A.D. by the pre-Moghal king Feroz Shah Tughlaq.[14] Later on, during the reign of Akbar the Great, this canal was renovated and remodelled to irrigate more efficiently the arid district of Hissar in the former Punjab province, which was a scene of frequent famines in Moghal times.[15] Still later, Ali Mardan Khan, a Moghal engineer, constructed a new branch from this canal to provide the water supply to the fountains of the Imperial palace and to irrigate the gardens in the vicinity of the rising city which Shah Jehan was developing at Delhi[16].

Perennial Irrigation Complex

Perennial Canals. The Moghals not only introduced the idea of irrigating the upland areas of the *doabs*, they also introduced a perennial canal irrigation system for the first time in the history of the Punjab. The one perennial canal which was operating even at the time of the British invasion of the province was the Huslee Canal, which had been built by Nawab Ali Khan on the order of the Emperor Shah Jehan in 1633.[17] This canal received irrigation water from the Ravi River at Madhopur and apparently was controlled by a fairly efficient weir or a barrage which insured a year-round water supply to the palaces and gardens at Lahore (Fig. 1). Later, under Sikh control, the canal was extended from Lahore to Amritsar to supply water for the tanks surrounding the Golden Temple, a holy shrine for the Sikhs.[18] The modern Upper Bari Doab Canal, which also takes off at Madhopur and was constructed in 1859 by the British, was extended on a Moghal alignment of the Huslee Canal.

The primary use of the perennial canals, such as the Western Jumna and the Huslee canals, was to convey an adequate amount of water for the urban needs of the big cities such as Delhi and Lahore. The water received by such canals was used mainly to irrigate the Imperial gardens and public parks and to run the fountains in the royal gardens and other public buildings such as mosques and courts. Economic advantages that could accrue from such perennial systems were at that time of a secondary consideration.[19] As mentioned, the purpose of the Huslee Canal was to supply water for garden irrigation and urban use in Lahore and Amritsar. Any irrigation water that the canal supplied en route to the general public for the purposes of cultivation was purely incidental and may be called a secondary use.[20] However, the economic success of such a development can be estimated by the fact that although these canals were not primarily intended for irrigating private lands, they accrued considerable revenue to the Moghal Government in the form of a water tax. For example, the Huslee Canal, at the time of British annexation of the Upper Indus Basin, was giving a net income of Rs. 76,000 collected as water rate on lands irrigated by this canal[21].

Dhenkli and Charsa. Where water was easily accessible from surface or underground sources, cultivation could be year-round, allowing the growth of nonwinter crops. From the ponds or lakelets remaining after the floods receded or from the river itself, water was first lifted in buckets by hand and carried to nearby fields. Later, lift irrigation was further improved when devices were developed to draw water from underground wells. Thus, with the introduction of various mechanical devices employing human or animate power to lift water, intensive perennial cultivation was developed in many favourable areas.

Irrigation from underground wells has proceeded from times immemorial, but methods and techniques of lifting water from them have changed from time to time depending on the level of technology developed in the area. Perhaps one of the oldest contrivances used for lifting water is the *dhenkli*, commonly known as *shaduf*. The *dhenkli* has been a poor man's water lift and is still in use in the riverine areas where the water table is five or six feet below the surface and the size of the land holdings are too small

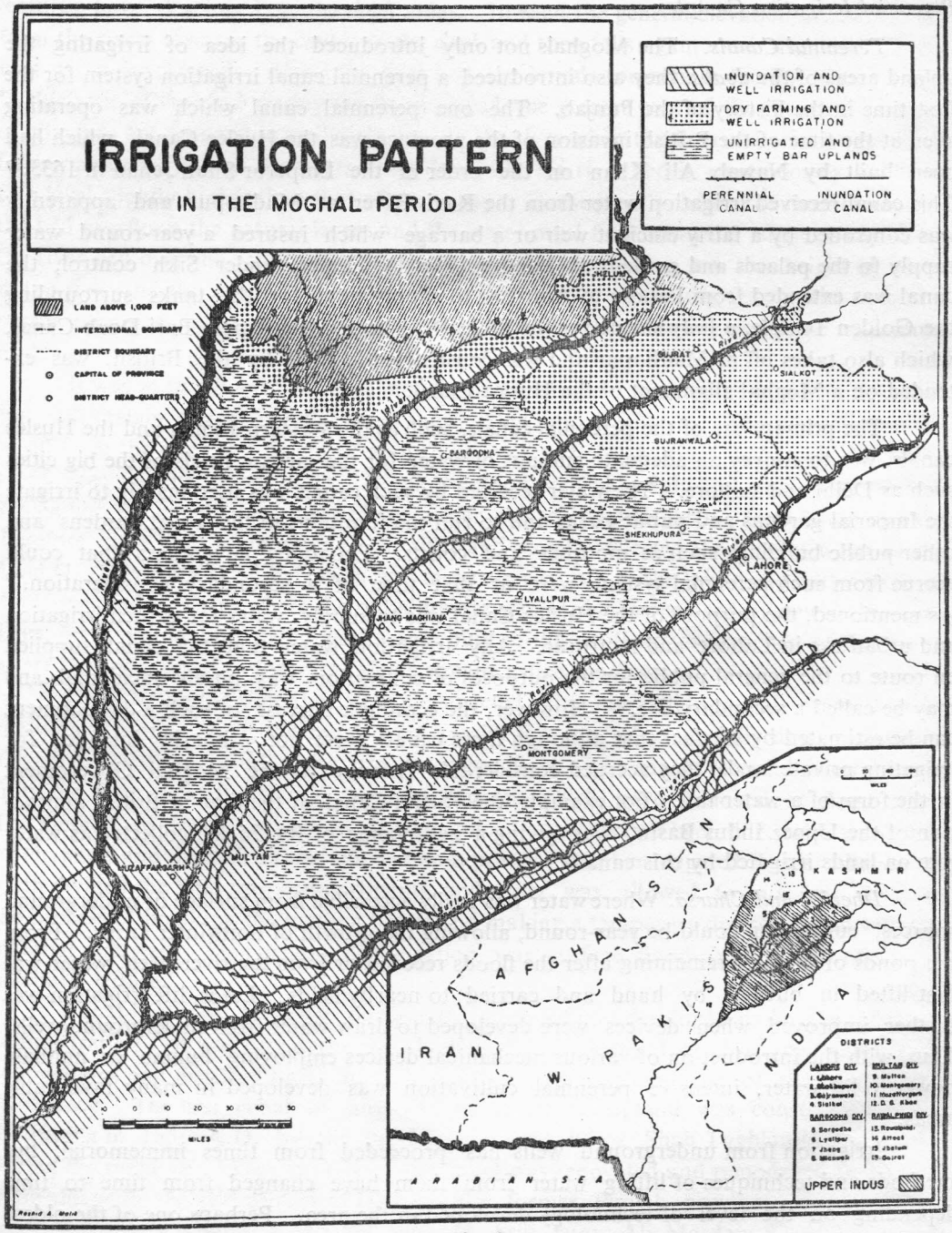

IRRIGATION PATTERN
IN THE MOGHAL PERIOD
INUNDATION AND WELL IRRIGATION
DRY FARMING AND WELL IRRIGATION
UNIRRIGATED AND EMPTY BAR UPLANDS
PERENNIAL CANAL
INUNDATION CANAL
LAND ABOVE 1,000 FEET
INTERNATIONAL BOUNDARY
DISTRICT BOUNDARY
CAPITAL OF PROVINCE
DISTRICT HEAD-QUARTERS
JHELUM
GUJRAT
SIALKOT
GUJRANWALA
SHEKHUPURA
LAHORE
LYALLPUR
JHANG-MAGHIANA
MONTGOMERY
MULTAN
MUZAFFARGARH
DERA GHAZI KHAN
BAHAWALPUR
SARGODHA
MILES
AFGHANISTAN
IRAN
W. PAKISTAN
INDIA
KASHMIR
ARABIAN SEA
DISTRICTS
LAHORE DIV.
1. Lahore
2. Sheikhupura
3. Gujranwala
4. Sialkot
SARGODHA DIV.
5. Sargodha
6. Lyallpur
7. Jhang
8. Mianwali
MULTAN DIV.
9. Multan
10. Montgomery
11. Muzaffargarh
12. D. G. Khan
RAWALPINDI DIV.
13. Rawalpindi
14. Attock
15. Jhelum
16. Gujrat
UPPER INDUS

Fig. 1

for economical use of improved techniques of lift irrigation. This device consists of a leather or metal bucket, suspended by a rope from a pole. The other end of the pole carries a counterweight which, when worked manually, helps balance in such a manner that no great physical effort is needed in either lifting the bucket when it is full or lowering it when empty. In the early stages of irrigation development the *dhenkli* was a welcome addition to complement the flood supply and, where the water level was within reach, made perennial cultivation possible and profitable for the farmer. Thus, it may be stated that in the Punjab the *dhenkli* system was the connecting link between non-perennial inundation and perennial irrigation.

The *dhenkli* system involved a great deal of time and labour and still irrigated only about one fourth of an acre daily. Also, the fact that this system could only lift water from shallow wells or surface water set severe limits on its extensive application. Thus, a change from the physical transportation of water from high water table areas to a waterlifting machine capable of getting water from greater depth was found necessary. The *charsa*, which seems to have been introduced before the Moslems entered the basin, appears to be the next most logical development after the *dhenkli*. This system is still in use in areas where the water table is rather low and rainfall on the whole quite adequate ; consequently, there is a short period when irrigation from wells is necessary to mature crops.[22] The *charsa* contains a leather bucket capable of holding 24-42 gallons of water, which is tied with a rope and suspended from a pulley on the top of the well. The bucket, when full of water, is pulled by a pair of oxen who walk down an inclined plane. After emptying the bucket in a surface ditch, the bulls are made to turn around and walk up the slope for the next load. Although one pair of bullocks may be adequate for satisfactory results, generally two pairs are employed for economy of time and greater efficiency. While one pair goes down the slope, the other pair comes up, thereby speeding and regularizing the process of irrigation. It is estimated that the average discharge from a *charsa* worked by two pairs of animals is about one-sixth c. f. s.[23]

It is evident that the *charsa* system of lift irrigation was economically impractical for a common peasant who did not have means to either build the structure or to maintain a pair of bullocks to run it. This system is only feasible in areas where rainfall generally is almost adequate and supplemental irrigation water is needed only for a short period of time. Thus, its extensive application in the arid parts of the Punjab was not economically practical.

Persian Wheel. A great technological advance in lift irrigation was made when the Persian wheel was first introduced. This technique was applied extensively in early history[24] to the lifting of water from surface streams, and its adoption to raising water from underground wells must have been only a question of time. However, as is suggested by the name, the Persian wheel was probably introduced into the basin when the Moslems invaded the subcontinent in the tenth century.[25] The Persian wheel consists of a large drum (*bair*), over which is placed a rope or iron ladder (*mahl*) with buckets attached to it at intervals of one or two feet.[26] The ladder on the other end dips into the water surface in the well. The drum then is revolved by means of a simple roundabout gear worked by a pair of bullocks. In general, the bullock track is on one side of the well, but in some cases it is

around the well. The indigenous wheel was made of wood, and the iron Persian wheel was a development made by the British.

The Persian wheel rapidly replaced the *dhenkli* and *charsa* systems so that today irrigation from wells is primarily carried out by this means. This rapid replacement may be attributed to the fact that the Persian wheel is very flexible and therefore, can be easily adapted for wells of varying depths. Futhermore, the ease with which the increase or decrease in water discharge from wells can be obtained by adjusting the number of buckets on the wheel or altering the relative gears of a cogwheel gives the Persian wheel system supremacy over the other methods of lift irrigation. On an average, the draft of an iron Persian wheel is about $1\frac{1}{4}$ cwts. and with bullocks a discharge of about 1/7 c. f. s. from a depth of 25 feet is obtained.[27]

Well Irrigation in the Bet. In discussing the inundation system of irrigation, it was pointed out that irrigation from inundation canals has been confined since early times to the flood zones of the *doabs*. Here flood irrigation during summer facilitated the growing of *rabi* crops. However, away from this narrow flood zone on either side of the river valley there is slightly elevated land, which is still of relatively low level and has a high water table due to seepage and percolation from the adjacent river valley. In this belt, shallow wells could easily be dug and water found at a depth of seven to twenty feet below the surface.[28] Thus, from early times this tract on either side of the *doab* has formed an attractive place for practising settled farming. With his primitive technology, which made water lifting from underground sources of over twenty feet an arduous and uneconomic task, early man selected this low land for settlement and permanent cultivation. At the time of British occupation of the basin, this land was one of the more densely populated parts of the basin, and main source of water for irrigation and domestic use was the many scattered wells (Fig. 1).

These well irrigated areas have been popularly called the *bet* but other names such as *dhaya* or *khadir* are sometimes used. Although the *bet* was easily cultivated by the early farmer, the land did not give the best results. Beyond the *bet* the land is relatively higher, but has better drained soil and is more healthy country. As the water table is generally deeper than in the *bet* area, it demanded deeper, brick-lined wells. It seems appropriate to conjecture that digging of wells and settlement in this higher part came at a later date when the Persian wheel was introduced. The Persian wheel facilitated the lifting of water from depths greater than twenty feet, and thus masonry wells were dug more freely. Wells away from the *bet* vary in depth from twenty-five feet to seventy feet, depending on the distance from the river banks[29]. The land which had a water table deeper than seventy feet was not settled, since cattle could not economically and efficiently pull the long bucket ladder from a well that deep with only the technological means which pre-industrial man had at his disposal.[30] Irrigation by means of the Persian wheel has been in use everywhere in this area since Moghal times and has been called *bhangar* or *manjha*.

Beyond the *bhangar* region, the land is higher still and the water table still deeper. At the time of annexation this was a sparsely cultivated area consisting of wide tracts of

grass prairie and stunted trees. Locally called the *bar*, this tract was largely unirrigated and was a scene of nomadism and pastoralism. The only exception to this general pattern in the *bar* region was the Sind Sagar Doab, where the *bar* is so extensive that it turns into a sandy desert[31] devoid of any vegetation.

Another part of the Punjab where, well irrigation has been an ancient practice, is the sub-humid belt lying at the foot of the Himalayas where the five rivers enter the plains from the mountains. Thus, this region is a combined series of alluvial fans built up by the rivers. The water table here is high, since percolation and seepage from the hill torrents continuously recharge the underground water.[32] Rainfall in this belt ranges from 20 to 35 inches and there is an appreciable amout of rainfall during the winter also, but the nature of the rainfall is so unreliable and seasonal that dry farming has been a highly speculative undertaking. There has always been a need for an insured water supply during the times of water scarcity when monsoon rains came late or ended prematurely. As the water table was high and the land holdings were small, the Persian wheel was found to be very suitable. Thus since early times well irrigation in the submontane district has been able to provide supplemental irrigation water during the times of scarcity (Fig. 1). However, the general rainfall conditions greatly influenced the importance and intensity of well irrigation. Since the regional aridity increased from northeast to southwest, the frequency and number of wells also increased in the same order.[33] It may be noted that the higher water table in the northeast of the basin has permitted the practice of well irrigation even in the *bar* areas of the *doabs*. It was only in this sub-humid belt that permanent cultivation was practised and fairly dense sedentary populations occupied the *bars* before the British occupation.

Agricultural Land Use

Perhaps it was in the submontane region of the Punjab that early man first settled and cultivated the land on a dry farming basis. According to Carl Sauer and Vavilov,[34] bread wheat was first grown near the Himalayas in Afghanistan and later migrated to the submontane areas.[35] The reason for selecting this part of the Punjab was the relatively humid climatic conditions under which dry farming could be practised. With a well-distributed rainfall of 25 to 35 inches a year, this area could grow crops all the year round. However, in the arid zone of the Punjab where rainfall nowhere is more than 20 inches, the early sedentary agriculturists settled in the riverine areas during Chalcolithic times and irrigated their lands by inundating the fields. The continuous level surface with a rich alluvial soil, enriched by flood every year, provided a very favourable environment whereon to develop extensive agriculture. On the more difficult and arid environment of the *bars*, no comparable agricultural land use system was developed. Until recently, the *bar* areas away from the *bet* were virtually a waste and were used as grazing lands by the sparse nomadic population.

In the Punjab Plains, where both non-perennial and perennial cultivation have been practised since early times, it would seem that the elements of the crop complex in early times were fundamentally the same as those existing today. From historical records, it appears that crops such as wheat, barley, cotton, sugarcane and oil-seeds were grown

at the time of the invasion by Alexander the Great in 327 B.C.[36] It would seem, however, that under the technology existing at that time, the agricultural economy could not be anything better than a subsistence type. The production of food for the family was the first care of the individual, and even if there were a surplus it could not be disposed of with the existing communication system. There was, therefore, nothing on the order of the large commercial crops such as wheat and cotton grown over large tracts in the canal colonies today.

Inundation Crop Complex

Limited to the riverine areas, the inundation crop complex was in the first place an annual and in the second place a winter system. Cropping was seasonal because the water from the rivers was utilized only during the flood period. Thus, seasonal cultivation with basically an extensive type of land use became associated with areas irrigated by inundation canals. The crops occupied the flood plains during the cold season and were essentially winter (*rabi*) crops. Therefore, supremacy of cereals, whose climatic requirements were particularly adapted to the cycle of the growing season, was natural. At the time of sowing the weather was humid, while the crop matured it remained cool and later the warm season followed at harvest time in late spring. Apart, therefore, from the exceptional cases of perennial islands in the riverine areas and the sub-humid northeast, to be discussed separately, winter cropping was basically on subsistence level.

Barley was the major crop in the earlier times down to the classical period. According to Carl Sauer,[37] barley is certainly an ancient cultivation and constituted a major element of the crop complex at the time. The cultivation of wheat which gained ascendancy later, had, according to Peake,[38] its origin in Palestine and was introduced into the Punjab during the Aryan migrations into the subcontinent. In the excavation of Mohenjo-Daro and Harappa, carbonized wheat and some quantities of barley have been found, which indicate their cultivation during the Chalcolithic period.[39]

Until well irrigation by the Persian wheel was extensively employed in the river valleys, areas having less than 15 inches of rainfall could not possibly grow *kharif* (summer) crops, which were then limited to the sub-humid submontane districts. Thus, in the arid riverine areas under the inundation system of irrigation, only winter crops such as wheat or barley could be securely grown. Wheat, however, was by this time the staple crop and was raised all over the inundated areas in the basin. In drier areas, which did not have easy access to water, it was superseded by the hardier barley. It may be said, therefore, that the annual system of growing winter crops was an important element of the inundation crop complex.

Perennial Crop Complex

Where perennial irrigation from natural or artificial means was possible, the range of crops naturally was greater due to the addition of *kharif* (summer) crops. The economic advantages associated with the cultivation of summer crops were soon realized ; and irrigation, mainly by Persian wheel, was increasingly applied in the Moslem period. Since

the food crops grown in winter satisfied the day-to-day food requirements, the early peasant saw to it that the summer crops satisfied his other needs. Thus, a rudimentary cash crop economy evolved with the introduction of cash crops grown under irrigation in summer. Foremost among the cash crops were sugarcane, rice, indigo, cotton, saffron and oilseeds. This cash crop economy eventually led to handicraft and manufacturing industries in the towns and cities. The preparation of fine muslins, sugar and flour became quite common and thus a rudimentary basis for an industrial structure were founded.

In the perennial cultivation system, two harvests took place each year. The *rabi* crop was usually sown in October and reaped in April or May. The *kharif* crop was sown between June and August and reaped from early September to the end of December. The rhythm of cultivation was directly related to the seasonal distribution of rainfall. *Kharif* crops were raised just after the monsoon rains set in. Accordingly, harvest took place generally after the rainy season. *Rabi* crops, on the other hand, were planted just after the monsoon so that the seed could be sown in damp soil and plants would be a few inches high at the time of the winter rains.[40]

Submontane Crop Pattern. With an annual rainfall of 25 to 35 inches, the submontane region of the Punjab is largly a dry farming country and has supported relatively dense populations from early times. In this region, even today, canal or well irrigation by comparison is unimportant, and the cultivator mainly depends on precipitation for his subsistence. The water table is high, and wells could be sunk at a small expense. The increases in irrigation with the introduction of Persian wheels has been mainly responsible for the extensive growth of commercial crops such as sugarcane and cotton and has insured against recurrent drought in the area. Before the British occupation, wells protected more than one-third of the total cultivated land, where heavily manured maize was followed by a crop of wheat, and sugarcane was commonly grown.[41] In parts of Sialkot and Gujrat, well irrigation was intended, however, largely to protect the *rabi* crop under wheat.

The frequency of well distribution corresponds directly to the relative ardity in the areas. The number and importance of wells increases with distance from the Himalayan foothills. Aside from mainly protecting the *rabi* crops and helping raise *kharif* crops, well irrigation has also encouraged intensive market gardening to meet the needs of a large urban population settled in this area since early times. Since the relative crop pattern in this region has undergone little change since British occupation, it may be safely estimated from the available data that of the total cropped area in the submontane region about 70 to 80 per cent were under food grains at that time. Of this, wheat accounted for two-thirds of the total acreage under food grains. *Bajra*, maize, sugarcane and cotton followed wheat in relative acreages.[42] Because of better rainfall conditions, efficient well irrigation and fertile soils, the crop yields in this region were relatively higher than in other areas of Punjab.

Riverine Crop Pattern. From the technological standpoint, other areas where perennial cultivation was potentially possible were the riverine lands away from the flood zone. Locally called the *bet*, this narrow zone, extending about two miles on both sides

of the river has a relatively high water table, and well irrigation could easily be introduced. Thus, the *bet* areas above the flood zone and below the *bar* (upland) area, having a water table lower than 70 feet, become studded with innumerable wells. The Persian wheel was everywhere in use for lifting water from the wells. The winter crops in the *bet* areas were generally irrigated by inundation canals, whereas summur crops were irrigated from wells. Among the winter crops, wheat was by far the most important, followed by barley. Cotton, sugarcane and rice, the major cash crops, were summer crops and were the prize of the perennial cultivation.

Settlement Pattern

The pattern and character of human settlement in the Punjab have been influenced strongly by conditions of water availability. Other factors such as soil, terrain, location and social structure have had an important bearing on the mode and pattern of settlements, but these were again dependent partly or wholly on the hydrographic conditions in the area. No doubt, water resources continue at present to be a major limiting factor in regional development, but their availability and adequacy was of critical consideration to the early farming societies. Man's tools and skills, less developed in the past, made him more dependant on the natural conditions of his environment. Thus, the parts of the Punjab which were either naturally humid or were near to water sources became the early settled areas. The submontane region and the river valleys constituted the agricultural frontier within which the pioneer settlements took their roots. In the *bar* areas away from these settlements, either the land was too high for inundation cultivation or the water table was too low for well irrigation. In either case the land, although productive if water were available, was as yet uncultivated waste and awaited future settlement.

In the Punjab, the most important source of irrigation water has been the rivers that traverse it. Therefore, the settled agricultural population has been mainly confined to those areas through which the rivers flowed and where water from them could be used for irrigation purposes. In the dry plains, therefore, early settlements were limited to the immediate vicinity of the rivers where the soil was fertile and annual floods would naturally irrigate the fields.[43] These were the settlements, in the words of Karl Wittfogel,[44] "basically hydraulic in nature in which the management and use of water played an important role in the subsistence agriculture." On the other hand, settlements have long been in existence in the submontane region, where a relatively more humid environment permitted the practice of dry farming. In due course, these settlements became increasingly dependent on irrigation when wells and canals were introduced into the area. These hydro-agricultural communities may be distinguished from the hydraulic communities, in that the former resorted to irrigation only on a small scale, whereas the latter developed large productive and protective water works that were managed collectively by the government or village bodies.[45]

Agglomerated Rural Settlements

Although great hydraulic urban communities existed as early as the Indus civilization, the areal basis of social organization in the Punjab has always been essentially non-

urban. The area was a country of villages, which accommodated over 90 per cent of the total population. The village community tended to be self-sufficient ; requirements were simple and there was little association or contact with cities or towns. The great majority of the rural population lived in agglomerated settlements. There was mainly concentrated in the northeastern districts of Lahore, Sialkot, Jhelum and Gujrat and the river valleys in the *bet* land outside the flood plains.

The major reason for the agglomeration was inherent in the nature of irrigation agriculture. It is quite evident that hydraulic agriculture prerequired division of labour and communal cooperation. It necessitated comprehensive preparatory activities to make cultivation possible in arid areas and safe rewarding in semi-arid areas.[46] An efficient irrigation system demanded the building of canals, dams and ditches from which the cultivating group could jointly irrigate. Because of this cooperative and communal need, farmers tended to cluster in rural communities so that together they could effectively execute the complex and painstaking hydraulic task. Consequently, a village-level or state-level hydraulic organization evolved, through which proper distribution of water to each farmer was allocated and the water works were efficiently controlled and maintained. Oriented basically to hydraulic considerations, therefore, large agglomerations of both rural and urban communities with their complex organizational and governmental systems developed.

The lack of security that prevailed in the past has also contributed to the nucleation of settlements. The whole region, and particularly the submontane belt, has been associated with the movement of armies, recurrent battles and incursions of marauders. The battles and troop movements meant a danger to crops, property and life. In such unsettled conditions, cultivation was hardly possible except within reach of some chief's fortress or other place of refuge. In the Punjab where the level land and hydraulic agriculture encouraged village settlements, the consideration and defence against the enemy further intensified the process of nucleation. As each group had to be prepared to defend itself against sudden attack, they came together in compact habitations, often surrounded by mud walls, around the fortress or mansion of a local chief or landlord.[47]

Settlement Structure. Although a settlement in the pre-British Punjab was generally a group of farm houses or dwellings clustered to form compact unit, each differed greatly from others in shape, size and kind. The number of dwellings in such clusters could vary from two to three house groups to a village of 1,000 houses or even more. In dry parts of the basin, where cultivation was not possible unless a well or canal was constructed to irrigate the farmland, the relative size of a settlement depended on the amount of water available from such a source. In this connection, it is not surprising to note that the largest agglomerations of population were located either on the river banks above the flood plains or in the relatively more humid areas in the submontane regions.

In these agglomerated settlements, a village was compact agricultural community usually from 50 to 200 acres in area and with defined boundaries. It was a closely built residential area with a heterogeneous pattern of narrow alleys and access lines running

into the individual dwellings. In addition to the farm dwellings ; service centers, cottage industries, stables, cattle enclosures and the house of the moneylender formed important elements of the village structure. An early village commonly was surrounded by a mud wall or had a walled enclosure within it, which along with the high degree of nucleation of settlement structures were the product of the hydraulic agriculture and the historic need of defence against the oft-repeated invasions and internal disorder. Walled village sites in strategic locations on a river fork, a bridge-head or a central position reflect considerations for water and defence.

Transportation and Trade

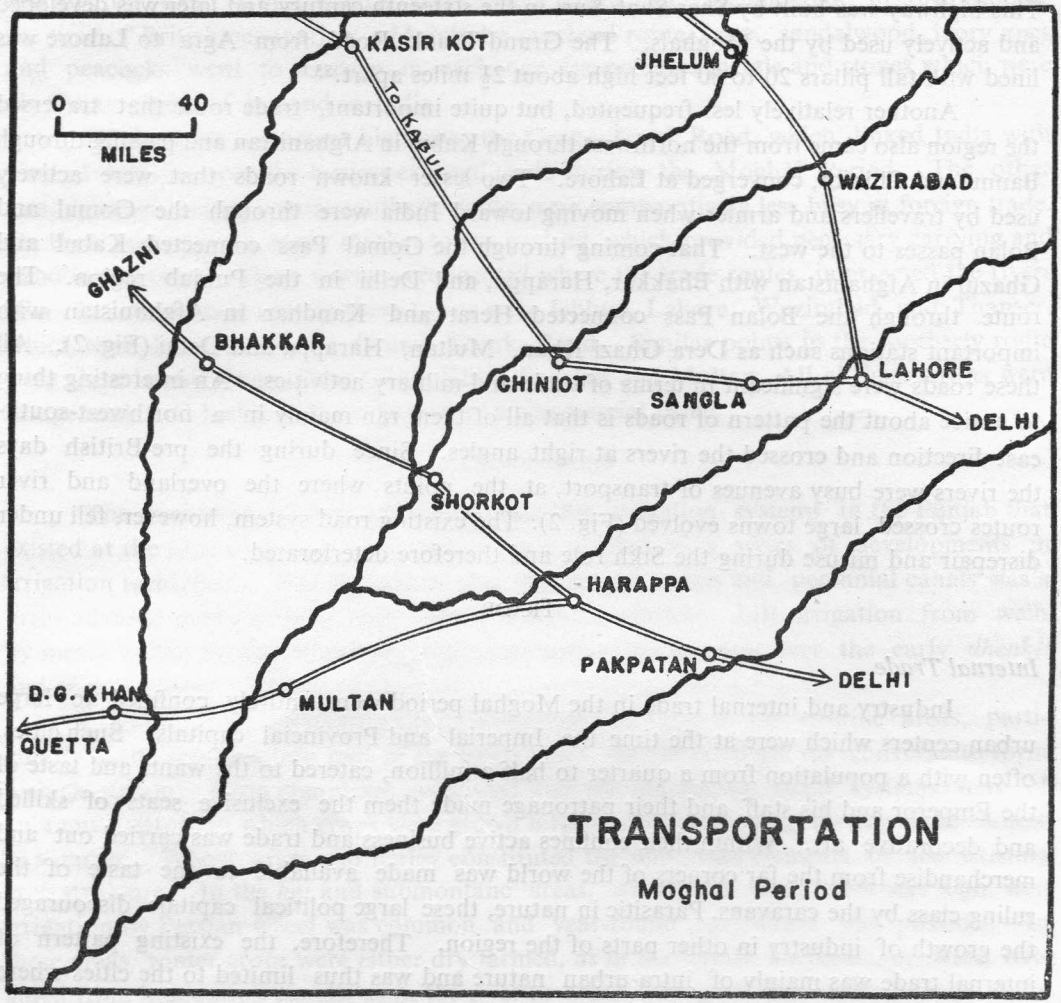
Although a great hydraulic organization had been established in the Punjab at the time of British occupation, it is clear that the inadequacy of the system of transportation was a major factor adversely affecting its efficiency. In an area where floods and droughts were a common occurrence, a largely non-perennial inundation system could easily collapse and lead to an agricultural crisis. It has been seen that in the basin, despite all the development in irrigation at that time, crop failures were common and if they occurred in quick succession certainly meant a famine.[48] As against this, the means of transportation in the area were inadequate and rendered the cost of transporting grain long distances by land prohibitive.[49] Therefore, famine conditions prevailing in one region could not be alleviated by the surplus of another. Clearly, there was great need for more efficient and cheaper means of transportation.

Transportation by River

The cheapest and busiest commercial avenues of trade were the rivers, which connected the Punjab with the great through trade routes via the Indus River. Until about 1880, the rivers in the region enjoyed a busy trade and were an important means of transport. The existence of boatbuilding and repair yards in Pind Dadan Khan and Wazirabad bear witness to such a statement. On these rivers, which then carried much larger volumes of water, plied large flat-bottomed rowing boats. At Lahore, the boats were 60 tons and upward, which suggests a considerable volume of traffic by water. During the monsoon period, such traffic was particularly facilitated when the heavily laden boats sailed up the river with the southwest monsoon directly behind them.[50] It may, however, be pointed out that at the time when India was actively engaged in overland trade and commerce with Central Asia and southern Europe, it would have been more profitable for the basin if the rivers had flowed in an east-west direction, as is the case with the rivers in the Ganges Valley. In the situation as it existed, the main trade route from Central Asia, when it entered the basin, had to bridge five large rivers before reaching Delhi, causing considerable difficulty in transportation.

Transportation by Roads

Whatever roads existed in the early times were developed and maintained by the Moghals who had established a strong central government in India. Though the roads were unmetalled, they were clearly defined by avenues of trees and caravanserais.[51] Such



Source : H. R. Trevaskis, *The Land of the Five Rivers*
Fig. 2

improved roads stimulated wheeled traffic, especially needed for precious goods such as treasures or indigo, which could easily have been pilfered during the repeated loading and unloading if carried on pack animals. Though the roads were unsurfaced and unbridged, the hard clay soil served as a good surface material for most of the year, and the rivers were crossed by bridges of boats. During the monsoon season, however, the roads became boggy and bridges of boats unserviceable.[52]

At the time of British annexation, there was only one road that was known to be adequately serviceable and safe for traffic. At present called the Grand Trunk Road, it had been the great highway for armies, traders and travellers from Central Asia, Western Asia and Europe. Lying at the northern part of the Punjab this road was marked with a string of towns commanding river crossings or central positions on the *doabs* (Fig. 2).

This highway was built by Sher Shah Suri in the sixteenth century and later was developed and actively used by the Moghals. The Grand Trunk Road from Agra to Lahore was lined with tall pillars 20 to 30 feet high about 2½ miles apart.[53]

Another relatively less frequented, but quite important, trade route that traversed the region also came from the northwest through Kabul in Afghanistan and passing through Bannu and Chiniot, converged at Lahore. Two lesser known roads that were actively used by travellers and armies when moving toward India were through the Gomal and Bolan passes to the west. That coming through the Gomal Pass connected Kabul and Ghazni in Afghanistan with Bhakkar, Harappa, and Delhi in the Punjab region. The route through the Bolan Pass connected Herat and Kandhar in Afghanistan with important stations such as Dera Ghazi Khan, Multan, Harappa and Delhi (Fig. 2). All these roads were significant in terms of trade and military activities. An interesting thing to notice about the pattern of roads is that all of them ran mainly in a northwest-south-east direction and crossed the rivers at right angles. Since during the pre-British days the rivers were busy avenues of transport, at the points where the overland and river routes crossed, large towns evolved (Fig. 2). The existing road system, however, fell under disrepair and misuse during the Sikh rule and therefore deteriorated.

TRADE

Internal Trade

Industry and internal trade in the Moghal period were entirely confined to large urban centers which were at the time the Imperial and Provincial capitals. Such cities, often with a population from a quarter to half a million, catered to the wants and taste of the Emperor and his staff, and their patronage made them the exclusive seats of skilled and decorative art. Within their confines active business and trade was carried out and merchandise from the far corners of the world was made available to the taste of the ruling class by the caravans. Parasitic in nature, these large political capitals discouraged the growth of industry in other parts of the region. Therefore, the existing pattern of internal trade was mainly of intra-urban nature and was thus limited to the cities where demand for finished articles existed.

As against this, there was little inter-village or intra-village trade in the region. A few village weavers, who provided necessary cloth in exchange for a share of the grain of harvest, would satisfy the needs of the farmer. Villages were mainly self-supporting and met their ordinary requirements locally. If there were some surplus products, the inadequate means of transport made their exchange difficult. Consequently, there was little buying or selling and not much barter in the villages.

Foreign Trade

The Punjab has been famous for its textile and handicraft industries since early times. Herodotus described the Indian troops of Xerexes as clad in cotton, and Nearchos admired this vegetable wool, from which stuffs af dazzling white were woven[54]. Other well khown industries such as carpets, brocade and embroideries were also associated with agriculture. Clay, metal and woodwork were in great demand in Medieval Europe

and Central Asia. Consequently, there was a flourishing foreign trade in operation at the time of British occupation. Mainly by overland routes, rice, sandalwood, ivory apes and peacocks went to Europe in exchange for precious metals and stones which were always an object of demand in India.

Of the three important highways, the Grand Trunk Road, which linked India with Central Asia, enjoyed the busiest external trade during the Moghal Period. The other two highways, taking a more southerly route, were comparatively less busy in foreign trade. On these trade routes, many market towns evolved, which provided necessary carrying and handling services. These towns were located where the trade routes intersected the rivers (Fig. 2). Important among these towns were Jehlum, Lahore, Wazirabad and Thanser, which were located on the Grand Trunk Road. Similar points in the southerly route were Dera Ismail Khan, Dera Ghazi Khan, Shorkot and Multan. All of these towns were bridgeheads and had a military as well as a commercial value.

Conclusions

The preceding discussion shows that the irrigation systems in the Punjab that existed at the time of British occupation were a product of a series of developments in irrigation techniques. The introduction of inundation canals and perennial canals was a great advance over the indigenous system of flood irrigation. Lift irrigation from wells by means of the Persian wheel was a great technical improvement over the early *dhenkli* and *charsa* system.

Irrigation from inundation canals was largely confined to the riverine areas, particularly in the southwestern part of the basin where the rivers begin to converge to form a single stream. Crop complexes associated with the inundation canal systems were of an annual nature in which crops were grown largely during winter, leaving land fallow in summer. Wheat, gram and barley constituted the important elements of the existing crop structure. In the *bet* and submontane areas, where the water table was high, well irrigation by Persian wheel was common and year-round agriculture was possible. In these areas, winter crops were either dry farmed, as in the humid northeast, or were irrigated from inundation canals, as in the riverine areas. To grow the summer crops, wells were used for supplemental irrigation. Of the two, winter crops were by far the most important and occupied as much as four-fifths of the total cultivated area.

The pattern of settlement naturally conformed to the conditions of water availability. The submontane and riverine land, where conditions for both well and canal irrigation were favourable, became the early settled areas. Being of hydraulic origin, the indigenous settlements were mainly of an agglomerated type and occupied strategic positions on river crossings or bridgeheads. The village settlements were primarily of a subsistence type with simple requirements and little contact with towns or cities. The inadequate system of transport prevented an easy exchange of agricultural goods, often leading to local food shortages. Although river transport was locally important, overland routes to Central Asia and Europe constituted the significant avenues of trade and commerce. The articles of trade, involving products of great value and specialized skills, catered to the needs of the urban areas rather than the village communities.

References

1. Stuart Piggott, *Prehistoric India* (Middlesex : Penguin Books, 1950), p. 70.
2. E. B. Havell, *History of Aryan Rule in India* (London : George G. Harrap & Co., Ltd., 1928), p, 73,
3. The Indo-Pakistan subcontinent is well protected by the Himalayas to the north and by the Indian Ocean to the south. The only access to it is through a series of passes in the northwest, of which the Khyber and Bolan are the best known. These passes have acted as a cultural funnel for the inhabitants of Central Asia and the Middle East.
4. A. V. Williams Jackson (ed.), *History of India*, IX (London : The Grolier Society, Publishers, 1907), p. 5.
5. *Ibid.*, p. 9.
6. *Ibid.*, p. 14.
7. *Ibid.*, p. 13.
8. H. M. Elliott, *The History of India—The Muhammadan Period*, ed. by John Dowson from osthumous papers, I (London : Trubner & Co., 1867), p. 26.
9. *Ibid.*, p. 40.
10. E. H. Carrier, *The Thirsty Earth* (London : Christophers, 1928), p. 30.
11. B. H. Baden-Powell, *The Land-System of British India*, II (Oxford : Clarendon Press, 1890), p. 535.
12. O. P. Bhardwaj, "The Arid Zone of India and Pakistan," *A History of Land Use in Arid Regions*, ed. L. Dudley Stamp, XVII of *Arid Zone Research* (Paris : UNESCO, 1961), p. 159.
13. Carrier, *op. cit.*, p. 36.
14. H. K. Trevaskis, *The Land of the Five Rivers* (Oxford : Oxford University Press, 1928), p. 131.
15. Now called the Western Jumna Canal, it was again renovated and improved by the British.
16. Trevaskis, *op. cit.*, p. 131.
17. P. W. Paustian, *Canal Irrigation in the Punjab* (New York : Columbia University Press, 1930), p. 26.
18. *Ibid.*
19. Trevaskis, *op. cit.*, p. 120.
20. Paustian, *op. cit.*, p. 26.
21. Punjab Government, *General Administration Report*, 1849-1850 (Calcutta : 1850), p. 9.
22. Roberts and Singh, *op. cit.*, p. 144.
23. *Ibid.*
24. Monuments built by the Assyrians indicate the practice of irrigation by the Persian Wheel.
25. Trevaskis, *op. cit.*, p. 75.
26. The buckets are either earthen pots holding from three to four pounds of water or are made of iron holding six to twelve pounds of water.
27. Roberts and Singh, *op. cit.*, p. 144.
28. Baden-Powell, *op. cit.*, p. 536.
29. *Ibid.*, p. 536.
30. *Ibid.*
31. Locally called "Thal" meaning empty land.
32. Spate, *op. cit.*, p. 461.
33. *Ibid.*, p. 47.
34. Bhardwaj, *op. cit.*, p. 161.
35. *Ibid.*
36. Trevaskis, *op. cit.*, p. 127.
37. Carl O. Saure, *Agricultural Origins and Dispersals* (New York : American Geographical Society, 1952), p. 79,

38. H. J. E. Peak, "The First Cultivation of Wheat", *Man*, 36, Vol. 39, 1939.

39. Bhardwaj, *op. cit.*, p. 162.

40. Mohammad Akbar, *The Panjab under the Moghals* (Lahore : Ripon Printing Press, 1948), p. 236.

41. James Douie. *The Punjab, North-West Frontier Province and Kashmir* (Cambridge : Cambridge University Press, 1916), p. 148.

42. Spate, *op. cit.*, p. 470.

43. B. H. Baden-Powell, *The Indian Village Community* (New York : Longman's, Green and Co., 1896), p. 51.

44. Karl A. Wittfogel, "The Hydraulic Civilizations", *Man's Role in Changing the Face of the Earth*, ed. W. L. Thomas, Jr. (Chicago : University of Chicago Press, 1956), p. 153.

45. *Ibid.*

46. Wittfogel, *op. cit.*, p. 155.

47. Baden-Powell, *The Indian Village Community*, p. 67.

48. In the pre-British times famines were frequent, and at times food was so scarce that men and women were driven by hunger to eat human flesh. These famines were particularly severe in the Upper Indus, where rainfall was precarious and years of plentiful harvests were succeeded by periods of continued droughts.

49. Before British occupation, produce was carried to the market in bullock or camel carts ; on pack animals such as camels, ponies, buffaloes and donkeys ; or in head loads.

50. Trevaskis, *op. cit.*, p. 82.

51. The important roads, particularly the Grand Trunk Road, were provided with walled enclosures of brick or stone, in which travellers and merchants could rest for the night in comparative security. Such caravanserais contained a well with a bath and a tank with fresh water and attendants to look after the building and to wait on travellers.

52. Trevaskis, *op. cit.*, p. 83.

53. *Ibid.*, p. 133.

54. Paul Masson-Oursel et al., *Ancient India* (London : Trubner and Co., Ltd., 1951), p. 108.

SPATIAL PATTERN OF POPULATION IN HYDERABAD (SIND) 1948 - 1968

ZAFAR HASSAN*

The post-Partition period witnessed an abrupt increase in the population of Hyderabad and a simultaneous growth in its areal extent (Figs. 1 & 2). The population of the city[1] (excluding the Cantonment) according to the latest estimate is 539,542[2] while in 1941 it was 127,521, thus registering an increase of about 323 per cent. In terms of area (excluding the Cantonment area) the city has registered an increase of ninety-eight per cent from about four square miles in 1941 to eight square miles in 1968.[3] In view of this phenomenal increase in its population in less than three decades and also considerable increase in its area, though not to the same extent as in population, it would be interesting to analyse the spatial pattern of its population between 1948 and 1968, the period for which the wardwise population figures are available.[4]

This study is concerned with two aspects of population variation in Hyderabad. First, the density gradients from the highest levels in or near the centre of the city; second, intraurban density changes that accompany growth of area and increase of population in the city as a whole.

A study of this nature must take account of existing models of urban structure. Usually a downward gradient is to be expected from the greatest concentrations per unit area in or near the centre out towards the periphery, in conformance with the negative exponential rule proposed by Bleicher,[5] and verified by Clark,[6] and later by Berry,[7] *et al*, who found the rule to be a satisfactory description of the density gradients observed in a large number of cities in various parts of the world, including areas outside the western world.

The second aspect of urban population variation in a city is differential change in intraurban distribution through time. Newling[8] has offered evidence of an inverse relationship between population density and growth rates. In other words, general population growth in an urban area is accompanied by decrease at the centre and diminution of the density gradient. Clark also presented evidence of deconcentration of urban population in Western cities, which he interpreted as the result of economic factors, especially transportation improvement. In later study Clark discussed the worldwide phenomenon of outward movement of population from cities to suburbs..... However, faced with contrary evidence in Asian cities, Berry has theorized that non-Western, and particularly Indo-Pakistani cities have a pattern of growth characterized by rising residential concentration in the city centre concurrently with outward expansion and peripheral population increase.

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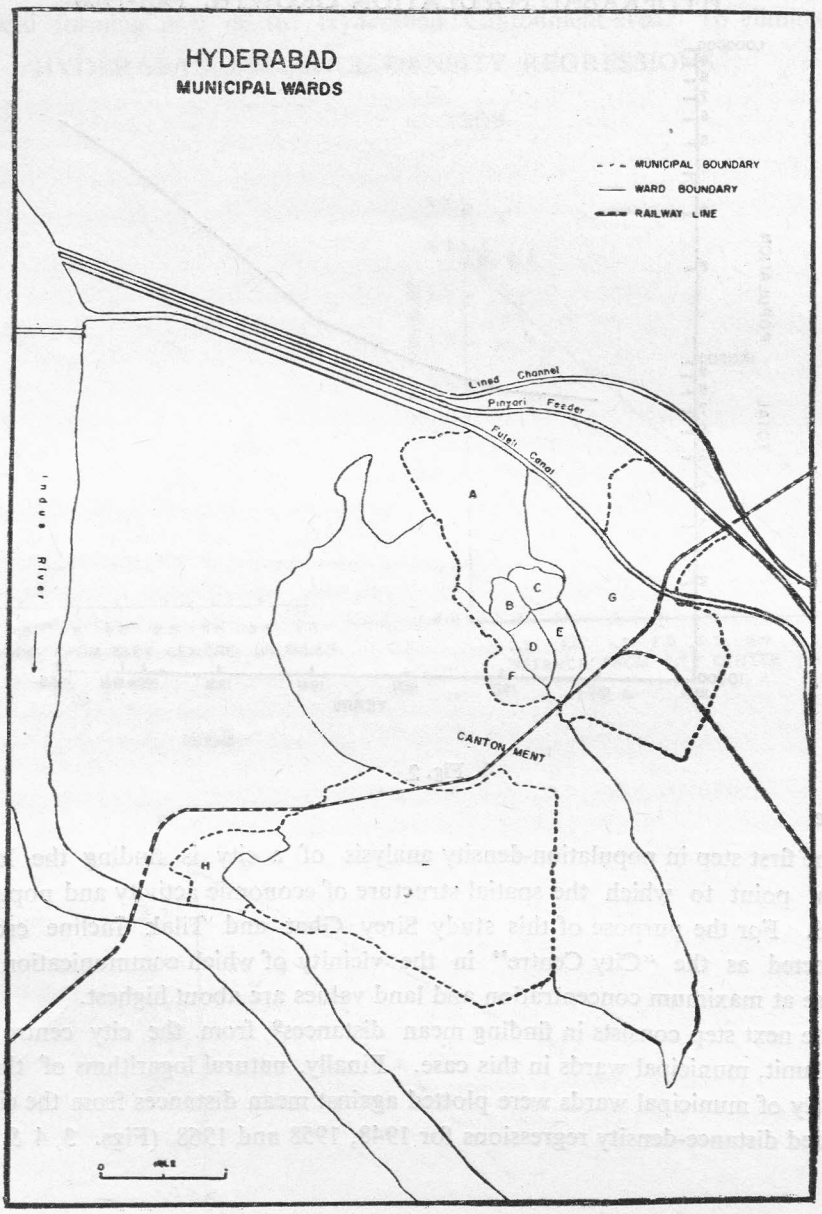

HYDERABAD
MUNICIPAL WARDS
MUNICIPAL BOUNDARY
WARD BOUNDARY
RAILWAY LINE
Lined Channel
Pinyari Feeder
Fulali Canal
Indus River
A
B
C
D
E
F
G
H
CANTONMENT

Fig. 1

HYDERABAD POPULATION GROWTH, 1901-1968

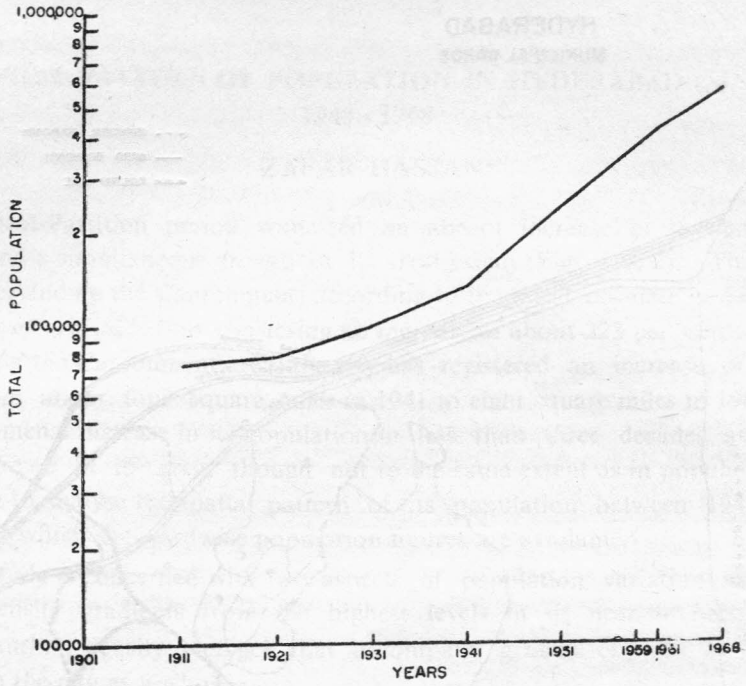


Fig. 2

Procedure

The first step in population-density analysis of a city is finding the location of the nodal point to which the spatial structure of economic activity and population can be related. For the purpose of this study Sirey Ghat and Tilak Incline crossing has been selected as the "City Centre" in the vicinity of which communication and interchange are at maximum concentration and land values are about highest.

The next step consists in finding mean distances[9] from the city centre for each statistical unit, municipal wards in this case. Finally, natural logarithms of the population density of municipal wards were plotted against mean distances from the city centre. This yielded distance-density regressions for 1948, 1958 and 1968 (Figs. 3, 4 & 5).

Results

Figure 3 represents distance-density relationship for the year 1948, based on the then existing seven municipal wards. Later on, in the fifties, two wards were created through annexation of adjoining land. The distance-density regressions for 1958 and 1968, therefore are based on nine city wards. Comparison of the three regression lines on each graph (Figs. 3, 4 & 5) gives the impression that during the past two decades there has been well-marked decline in the density gradients, so much so that the regression lines for 1958 and 1968 seem to create a somewhat distorted picture of the population density gradient. This is mainly due to the fact that the newly annexed wards of Latif-

abad and Gidu Bander (H ward) are separated from city proper by the intervening stretch of vacant land forming part of the Hyderabad Cantonment area. To eliminate this

HYDERABAD DISTANCE DENSITY REGRESSIONS

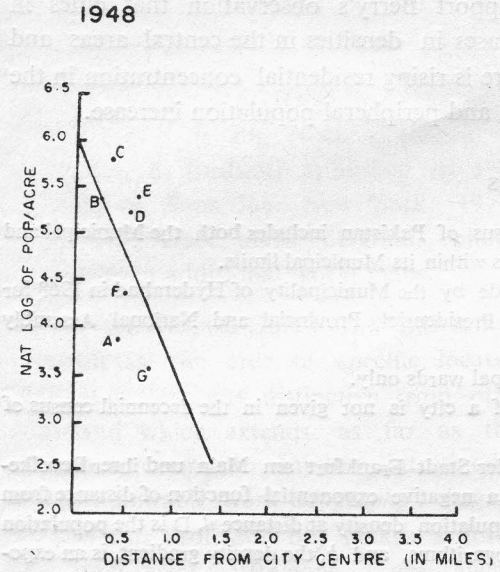
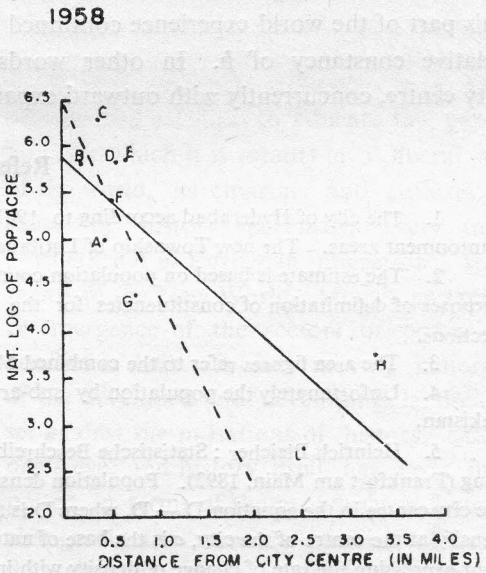


Fig. 3



Flg. 4

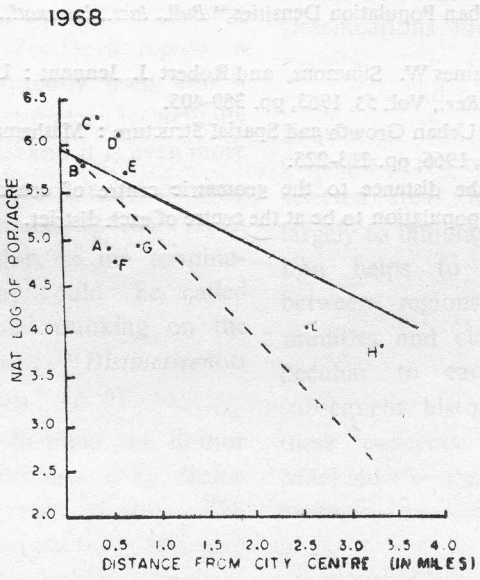


Fig. 5

abnormality, another set of regression lines were drawn (Broken lines in Figs. 4 & 5), based on seven original wards. The distance-density relationship as expressed by these lines seems to have greater correspondence with reality. The three regression lines for 1948, 1958 and 1968 conform to the Bleicher-Clark model based on negative decline of

density with incease of distance from the city centre. The highest density of population is found in a compact central area (B, C, D, and E wards) situated around Shahi Bazaar. Within about a mile from the city centre the gradient slopes downward to the periphery.

The three regression lines also tend to support Berry's observation that cities in this part of the world experience continued increases in densities in the central areas and relative constancy of *b*. In other words, there is rising residential concentration in the city centre, concurrently with outward expansion and peripheral population increase.

References

1. The city of Hyderabad according to 1961 census of Pakistan includes both the Municipal and Cantonment areas. The new Township of Latifabad falls within its Municipal limits.

2. The estimate is based on population count made by the Municipality of Hyderabad in 1968 for purposes of delimitation of constituencies for the 1969 Presidential, Provincial and National Assembly elections.

3. The area figures refer to the combined Municipal wards only.

4. Unfortunately the population by sub-areas of a city is not given in the decennial census of Pakistan.

5. Heinrich Bleicher : Statistische Beschreibung der Stadt Frankfurt am Main und ihrer Bevolkerung (Frankfurt am Main, 1892). Population density is a negative exponential function of distance from the city centre in the equation $D - D$, where D is the population density at distance *d*, D is the population density at the centre of the city, *e* is the base of natural logarithms, and *b*, the density gradient, is an exponent expressing the rate of change of density with increasing distance from the centre of the city.

6. Colin Clark : Urban Population Densities, *Journ. Royl Statist. Soc.*, Ser. A, Vol. 114, 1951, pp. 490-496. See also his "Urban Population Densities," *Bull.. Inst.. Internatl.. de Statisque*, Vol. 36 Part 4, 1958, pp. 60-68.

7. Brian J. L. Berry, James W. Simmons, and Robert J. Jennant : Urban Population Densities : Structure and Change, *Geogr. Rev.*, Vol. 53, 1963, pp. 389-405.

8. Bruce E. Newling : Urban Growth and Spatial Structure : Mathematical Models and Empirical Evidence, *Geogr. Rev.*, Vol. 56, 1966, pp. 213-225.

9. Mean distance is the distance to the geometric centre of census districts. Probably little accuracy was lost by assuming population to be at the centre of each district.

BOOK REVIEW

GEOGRAPHY : REGIONS & CONCEPTS by Harm J. de Blij (with a chapter by Stephen S. Birdsall) published by John Wiley & Sons Inc. New York, 1971 : pp. 642 preface, maps, diagrams, photos and seven additional world maps.

Professor Richard Hartshorne* has defined a region as "an area of specific location which is in some way distinctive from other areas and which extends as far as that distinction extends." In the introduction to his admirable work *Geography : Regions and Concepts* Professor Blij makes a forthright confession: "Regions....are always artificial constructs, intellectual devices if you like, designed to function as organising concepts in Geography (p. 5)..a region, a term so easily and frequently used and a concept so deceptively simple, is actually very difficult to define....and it is even more difficult to put the concept to really productive use." (p. 2) Commenting on Hartshorne's concept, he points to the terminological cause of what could be called involved and controversial thinking on the classification of regions : "*Distinctiveness* can mean almost anything." (p. 5)

With these limitations in mind the author broaches this very sensitive and risky theme with masterly candour and lucidity. The work reflects his insight into a fairly extensive and in no small measure intricate problem. He has a flair for turning the abstract conceptual stuff into interesting material. The book synthesises three approaches : —physical, regional, cultural— in a broad premise and attempts to educate the generation (for which it is meant) in a liberal view of the world, its environs and cultures. A sense of history permeates every theme —whether it is European migrations, settlements in the New World, Africa's awakening or emergence of the sectors of power and conflict in Asia. A fast moving panorama of the developed and developing landscapes, set against the pulsations of history, catches one's eye; and history itself has been interpreted in terms of the geographical factor of changes in the resource pattern. Titles of the chapters show a certain degree of departure from the tradition in which classifications hinged solely on climate or politics. The sub-titles, particularly, are suggestive and evoke interest. A distinctive feature of this work is that over a hundred concepts have been discussed and applied to selected areas and situations. Restricted largely to familiar areas though, the application helps to emphasise differentiation between regions, countries, towns, communities and clans and the characteristics peculiar to each. Besides, seen against subsequent history, the relative weight of these concepts is brought into relief. Mackinder's theory of *Heartland*, for example, is considered by many geographers to have lost its substance ; in point of "hydrographic and impregnability considerations", as the author puts it, it has ceased to be valid. The remotest corners of the globe have become vulnerable as a result of

*Hartshorne, Richard : *Perspectives on the Nature of Geography.*

the tremendous development of air-power; no part of the earth is safe from the 'eye' of an intercontinental ballistic missile. In another respect, however, the theory is as sound today as it was when first propounded three quarters of a century ago. The economic aspect—expansion of resource-base—of the Heartland region offers the Soviet Union vast possibilities particularly in the Asian part of her realm. Key to world influence, therefor, stays in her hands. As the author observes: "Whether Mackinder had the benefit of historical accident or special insight, the fact is that the Heartland today sustains one of the two most powerful states in the world." (p. 157) A number of theories relating to agricultural regions, urban growth and core areas have been examined. The author puts each to the test of history and convincingly brings out the 'chance-factor' in many a case.

The book has its weak portions where the author does not seem to steer clear of the projections that have damaged the scientific merit of many a work on regions. The "Realms of the World" map (p. 16) includes Pakistan in the "India & Indian Perimeter" instead of "North Africa & South West Asia" although she so obviously fits into the pattern of variables he has enunciated for the latter. Culturally, Pakistan has her face to the Afro-Asian region; with it she shares a common (dominant) faith, a common pattern of languages and common historical ties. The ethnic complex of her population has its origin in western Asia; and semi-aridity is the chief feature of her climate. In short, the countries of the belt stretching from Morocco to Pakistan have similar "prevailing ways of life, ideas and values" and a "common heritage." Her exclusion from the realm could only be explained in terms of factors other than geographical.

In his account of southern Asia, the author appears to have been carried away by politically charged currents so characteristic of the contemporary world. It is not strange that he has taken an oblique look at a particular area but that he has not done so in regard to identical areas elsewhere. Treating of South Asian sub-continent, he feels obliged to see, and magnify, only in the border between Pakistan and Afghanistan something that is so common a feature of almost every country. He does not indicate if there is a *de jure* position of the so-called problem since the boundary under reference stands settled in international law. If Afghanistan's pinpricks (surely, not by choice) with Pakistan merit graphical representation of a bogy (p. 455), the more than half a century old Irish problem and equally old and volatile linguistic nationalism in Basque (both Christian community areas) are no less deserving of such illustrations. And there are quite a few explosive areas around the world that have, fortunately, escaped his notice. Should (inspired) ethnic troubles become yardsticks worthy of a geographer, the Americas, Europe and the Soviet Union will be found to contain a host of "potential" dreamlands. A geographer's strength lies in the breadth and detachment of outlook. From this and other publications it would appear that Pakistan and Kashmir are the points on which many American geographers are at their weakest.

Cartographic representations are attractive as well as instructive. But for the quality of paper, these would have been brighter. The historical maps and those related to the theories are particularly valuable.* The

* Pages 154, 156, 319, 321, 336, 337, 380.

World Map plates 2, 3, 4, (modified and simplified) are important guides. The book carries very useful and detailed author and subject indices at the end.

The conceptual and historical aspects, exposed in letter and colour, distinguish it from P. E. James' "Geography of Man" and Wheeler & Kostbade's "Regional Geography of the World" to which genere this book, in general, belongs. It is splendidly readable and should have its impact beyond the limits (college course) the author has set for it. Readers with a taste for good books on world geography cannot resist the temptation of having it.

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ENVIRONMENTAL PROTECTION RESEARCH CATALOG : Prepared by the Smithsonian Science Information Exchange, Inc. U.S.A. for U.S. Environmental Protection Agency. Office of Research & Monitoring, Research Information Division, Washington, D. C. January 1972. Reported in Two Parts (incl. one Addendum to Part I). Total 2399 pages.

For maximizing benefits from the gross number of on-going studies about environmental protection, an effective information transfer among individual scientists, engineers, administrators, policy officials, and the concerned agencies and institutions becomes the key element. It is necessary because of the very number and diversity of phenomena and organizational activities, and to avoid serious hazard of writing duplication or gaps in research efforts.

The U. S. Environmental Protection Agency deserves scientists' sincere appreciation for releasing the *Environmental Protection Research Catalog*. Compiled by the Smithsonian Science Information Exchange, from its files of on-going research notices as of October 1971, this compilation provides an overview of the scope, balance, and texture of 5488 on-going environmentally-related research studies. The publication, reported in two parts and spread over 2399 pages, contains description of research tasks in terms of Air Quality, Water Quality, Solid Waste Management, Pesticides, Radiation, and Noise; a Subject Index, an Investigator Index, a Performing Organization Index, and a Supporting Agency Index with a brief chapter on Definitions of Environmental Research Categories, as used in the Catalog, at the end. Although the publication covers the project descriptions mainly from the United States, an appreciable number of selections from rest of the world also appear.

Descriptions of 917 projects on Air Quality cover wide range of information about sources of air pollution including types, materials and processes ; instrumentation, identification of pollution sources, and pollution monitoring ; basic chemical and physical properties of various pollutants ; theoretical, field and laboratory studies concerned with air pollutant formation, identity, and effects ; pollution control equipment, abatement and operation relating to air quality control ; medical and epidemiological studies ; laboratory animals studies and other biological effects on man; economic losses from air pollution damage and costs of control programmes ; social attitudes and their significances ; and air quality research concerned with standards, management,

legislation and other related subject areas.

1941 project descriptions on Water Quality provide extensive coverage of studies on sources of water pollution including, *e.g.*, eutrophication, environmental cycling, run-off-erosion-sedimentation, oil spills, precipitation-atmospheric washout, trace element pollution, radioactive fallout, dredging, and residuals disposal ; pollution identification; water management and pollution dispersal; water treatment; pollution effects ; social implications, legislation, management and other related aspects of water pollution control operations.

Projects on Solid Waste Management cover 410 descriptions of studies about sources (agricultural, industrial, municipal and domestic) ; collection, transportation, processing and disposal methods ; recycling and utilization of solid wastes.

1135 project descriptions on Pesticides provide informatian about pesticidal pollution with reference to air, water, and soil environments ; their adverse effects on plants, animals, man, and general environment ; and analysis, monitoring and instrumentation techniques.

Chapter on Radiation lists 966 project descriptions covering nondesired radiation sources, its effects and measurement. Studies report sources of radiation detrimental to human health, animal and plant communities, materials, or the general environment ; ultraviolet, electromagnetic, radioactive isotopes, and other radiation sources ; physical, chemical, and biological injury (excluding medical studies utilizing radiation) caused by the nondesired radiation ; instrumentation, dosimetry, and studies on other radiation control equipments including bioindicators.

The newly introduced field in the environmental research—Noise—is covered by 119 project descriptions. It contains studies on noise sources; effects on behaviour, physiology (deafness), and ecology ; measurement ; intrumentation techniques ; monitoring, management and control of urban noise ; sonic boom effects and sound attenuation acoustics.

The valuable project descriptions in this Catalog, encompassing so broad spectrum of disciplines, will certainly assist the environmental scientists to select new areas for research, while avoiding wasteful duplication, and, at the same time, facilitating communication of ideas, opinions, and data in the same or closely aligned fields.

The publication reflects the onerous efforts of the scientists and technologists from physical, chemical, physiological, and engineering sciences towards the protection of their deteriorating environment—a victim of man's scientific and technological advancement and sophistication. However, the 'piecemeal' contribution by the earth and social scientists deserves need to stress them for an immediate action to meet the challenge accordingly. At the same time, such skilled and prompt performances by other agencies and institutions, like the United Nations Environment Programme, are recommended to further co-operation and co-ordination of environmental protection efforts between the nations of the world.

ASHHAD AHMAD

Lahore:
Dated: 25 August 1974.

PAKISTAN GEOGRAPHICAL REVIEW was instituted in 1949, replacing Punjab Geographical Review, which was started in 1942. The object of this publication is the dissemination and exchange of scholarly knowledge. Its volumes contain research articles on various topical and regional themes of Geography with particular reference to Pakistan. The Review is published half-yearly in January and July.

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SUBSCRIPTION

Foreign	Inland
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Volumes 1, 3 and 18 No. 1 not available.

Volume 11, Number 2, 1956 contains index from volumes 1 to 10.
Volume 17, Number 2, 1962 contains index from volumes 11 to 17.
Volume 22, Number 2, 1967 contains index from volumes 18 to 22.

Printed at the Ripon Printing Press Ltd., Bull Road, Lahore
by Mirza Mohammad Sadiq.
Published by K. U. Kureshy, Editor, Pakistan Geographical Review