Pakistan Geographical Review

Volume 16 JULY, 1961 Number 2

GROWTH OF SETTLEMENTS IN WEST PAKISTAN*

KAZI S. AHMAD AND K. U. KUREISHY

University of the Panjab, Lahore

THE settlements of West Pakistan may be conveniently grouped into the following broad chronological divisions :

1. Prehistoric.
   - (*a*) Early Prehistoric or Pre-Harappa (probably beginning towards the end of the fourth millenium B. C. or early third millenium B.C.)[1].
   - (*b*) Middle Prehistoric or Harappa period or the Indus Age (probably 2,500 —1,500 B.C.)[2].
   - (*c*) Late Prehistoric or Post-Harappa period or the Dark Age (probably beginning after 1,500 B. C.)[3].
2. Proto Historical (522 B. C.—A. D. 470 approximately).
3. Histotical (470 A. D.—1843 A. D.).
4. Settlements of the British period (1843-1947) and post Partition settlements (1947 upto date).

Prehistoric Settlements

The information about the layout of settlements in the Early Prehistoric period is extremely meagre and restricted to parts of a few sites. At Kohtras Buthi (Dadu, Sind) there is evidence of blocks of buildings about 40 ft. square. At Siah-Damb (Nundra) (Jhalawan, Baluchistan) a common orientation of the blocks can be presumed, at least in the south-eastern part of the site.

The generally small size of the '*tells*' affirms that the settlements were small. The size and other evidence, particularly of the individuality of craftsmanship of different areas of settlement, chiefly found in the unearthed pieces of domestic and funerary pottery, point to the settlements being parochial villages. The diversity of physical conditions in Baluchistan (where most of the Early Prehistoric sites are located), with small basins and narrow valleys, reflected itself in the formation of localized peasant communities.

The conditions of agricultural prosperity obtaining at that time in the now barren areas of Baluchistan, appear to be related to higher annual rainfall in those days. The numerous relics of the elaborately built dams[4] for the holding up and storage of flood

*A Paper Contributed to the International Geographical Congress held at Stockholm, July—Augst, 1960.

water from the streams, suggest a heavier rainfall. The dams, locally known as *gabar-bands*, were a common feature of settlements in southern Baluchistan. The *gabar-bands* made of stone were about 300 yards long, up to 8 feet wide and upto about 12 feet high. Their stone facing was sometimes backed by earthen ramps[5]. In the opinion of Stein these *gabar-bands* reflect climatic conditions with a greater rainfall and a large population to provide the necessary labour for their construction[6]. Marshall suggests that the annual rainfall might have been between 15 to 20 inches[7].

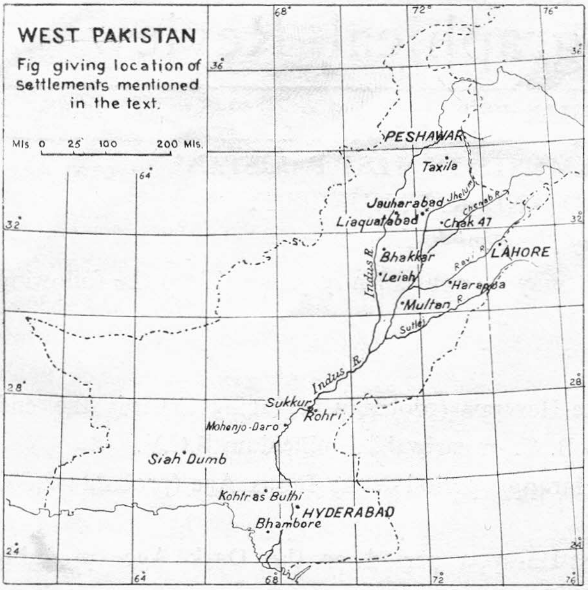


Fig. 1

Unlike the essentially small agrarian settlements of the Early Prehistoric period, the Indus Age settlements present a well-developed hierarchy, ranging from small villages to large cities. However, our detailed study of the settlements of the later period derives mainly from the better-excavated type sites of Harappa (Montgomery, Punjab) and Mohenjo Daro (Larkana, Sind) each of which is interpreted as a city, enjoining a high administrative status. Each of the two sites covers an extent of over three miles in circuit. At each of the two sites a number of structural phases, or starta of occupation, have been discovered, which signify the long occupation of the sites. At each site, the mounds fall in two groups, western and eastern. The western and higher one is interpreted to be the citadel or acropolis, and the eastern and larger one as the main town. The evidence gathered from the two sites suggests that the main towns were devoid of defenses. The towns had a well-planned system of rectangular blocks of buildings, separated by north-south and east-west streets. The *insulae* or blocks were approximately rectangular and roughly of equal size. The exacvated main streets at Mohenjo-Daro were about 30 ft. wide, and lanes subdividing the *insulae* were 5—10 feet. wide. These were unpaved but were supplied with a system of brick-drains, having at intervals brick-built manholes. It is assumed, mainly on the basis of evidence from Harappa, that the citadel at both places was surrounded by defensive walls with a number of bastions. Parts of the sites, including those interpreted as living quarters, working floors and granaries, furnish examples of impressive planning. The nearness of the granaries to the river, and evidence of their riverward entrance, suggest the use of water transport for the collection and distribution of grain. There is also evidence, at both sites, to suggest that the people must have lived in ever-present dread of floods from the river, for example, in the form of high plinth levels and protective constructions.

While the Middle Prehistoric settlements were well-planned, these did not show any signs of evolution in them. On the contrary, basing the argument on the available evidence from Mohenjo-Daro, signs of deterioration in building and planning were visible in the later structural phases of the settlements, in the form of sub-division of houses and lesser attention to the requirements of sanitation.

The Middle Prehistoric period was followed by a long span of about one thousand years, when the process of growth of settlements of our region of study suffered a serious setback. The late Prehistoric period is considered to have commenced with the Aryan incursions. The inclination of the Aryans was to destroy than to found settlements. The recorded settlements of the period were of a humble nature, with no signs of planning, and with shoddily built dwellings, no better than hovels.

Proto Historical Settlements

Our knowledge of the settlements of the Proto Historical period is based on the evidence gathered from Taxila, for which there is detailed information on size, layout of streets and types of buildings. In written history there are references to a town with the name of Taxila. But the detailed information became available as a result of archaeological work.

It is now clear that the settlement occupied four different sites at different periods. The sites and the approximate periods for which these remained in occupation are given below[8] :

Site		*Approximate period of occupation*
Bhir Mound	..	522 B.C.—100B.C.
Kachcha Kot	..	100 B.C.—50 B.C.
Sirkap	..	50 B.C.—A.D. 80.
Sirsukh	..	80 A.D.—470 A.D.

The site of Sirkap covered part of the Kachcha Kot site. There is no indication in the archaeological evidence that the periods of occupation of the four sites overlapped.

Of the four sites, more detailed information is available about Sirkap. It was founded by the Scythians from Turkestan. The stratigraphy of the mound reveals seven successive periods of rebuilding. A stone wall, 6,000 yards long, surrounded the settlement. The thickness of the defensive wall was 15-21½ feet and the height, in all probability, was between 20 and 30 feet. It had in it rectangular and polygonal bastions with solid lower storey and hollow and loopholed upper storeys, presumably rising above the wall level. On its northern side it also had a ledge with a stone facing. A supplementary stone wall marked off the lower northern town from the southern.

The settlement of Sirkap was a planned one. The main street, starting from the north gate, and having a width of 25-30 feet, ran axially for a length of about 2,000 feet, receiving east-west running streets at right angles. The streets enclosed *insulae* with a frontage of 110-120 feet.

The excavated buildings on the sides of the main street are interpreted as shops. Behind these the close-set houses opened into side streets. The shops often had a shallow verandah or open platform in front. Exceptional structures were of stupas in rectangular courts, and of a spacious building (400 by 350 feet) in the middle of the town, on the eastern side of the main street. This central building is suggested by Marshall to have been a palace[9].

Between the palace and the north gate was the quarter of settlement with spacious houses. In this quarter a house averaged about 15,000 sq. ft. in area and had a score or more rooms on each floor. The rooms were grouped about several open courts, and had windows in the outer walls. In Sirkap the structures were massive, and foundations deep and secure. In some edifices the foundation was carried down as much as 20 ft. The height of buildings was reduced by making the lower of the two storeys into something like a basement, buried underground to more than half its height.

Historical Settlements

The historical settlements ranged from the small villages ; through the market town (*sangrahana*), serving the uses of ten villages ; the country town (*kharvataka* and *dronamukha*) for 200 or 400 villages; the provincial capital (*thaniya* or *thana*); the great city (*nagara, pura*); or port (*pattana*); to the royal capital (*rajadhani*); all provided with defences of varying solidity[1] . As a legacy of the past, we have, in our region of study, a well marked hierarchy of settlements and a wide variety of their form and size, including a small number of non-permanent settlements. The rural settlements, outside the canal colony areas, are of amorphous growth, with a generally high rate of development of their land, and of varying form and size in accordance with the terrain of their site and their situation. The density of distribution of these settlements is highly variable from region to region, according to the agricultural and other economic resources of each region.

The non-permanent settlements are highly restricted to some areas of alternate availability and absence of means of subsistence. These are found, for example, in some riverain tracts, in parts of Baluchistan and in Cholistan in Bahawalpur. Taking the example of Cholistan, a village located in sand-dune-girt flat lands near a *toba* (a ditch into which rain water collects) consists of half a dozen mud huts with roof made of dried bushes. These are semi-permanent dwellings occupied by graziers when water is available. When the time arrives for going out in search of water, the village packs up whatever it can, but leaves the rest in the hut, without any anxiety for its loss. Generally, the huts are without doors.

Permanent settlements ranking high in the above noted hierarchy are generally located at the following points which had a commercial as well as a strategic value ;

1. Nearer ends of the passes opening into the plains, e.g., Peshawar.

2. Bridge-heads at the crossing of the historical routes, e.g., Lahore.

3. River nodes, e.g., Multan.

4. Physically fixed points on the rivers, which are subject to frequent change in their courses in the plain and delta stages, e.g., Hyderabad and towns of the Sukkur area, including Alor, Bhakkar, Rohri and Sukkur.

From the historical study of West Pakistan with reference to Peshawar, Lahore, Multan, Hyderabad and the Sukkur area, the following characteristics of our old settlements can be made out. Some of these characteristics are still retained in the older parts of our larger settlements :

1. The site generally chosen, particularly for an important settlement, consisted of an eminence in the lowlying fertile land near the river. The eminance furnished a dry point during the monsoon floods in the rivers[11]. Subsequent greater height of the sites of settlements was of their own raising. Historico-archaeological evidence generally points to a number of structural phases of settlements. These structural phases are largely associated with the destruction and rebuilding of settlements, mostly as a consequence of the historical developments of the region. Important settlements of a high strategic, commercial and administrative status seem to have had more numerous structural phases than other settlements.

2. The settlements were generally of large size, and were circumscribed by defenses. The large size of settlements is partly explainable on the basis of security measures against invaders and marauders[12]. The settlements were generally "enclosed by a wall or stockade with gates"[13]. Defenses were constructed not only as a measure of security against invasions. Sometimes a settlement "surrounded by a wall and entered by gates, with perticullis, could give sufficient trouble to a Mogul, Afghan or Sikh revenue collector to render him reasonable"[14]. Large settlements are recorded to have had strong defenses. In some of these large settlements the citadel occupied a distinct position, generally on the commanding eminence of the site. The plains of Punjab were more open to invaders than other parts of West Pakistan. Therefore, the village settlement in the Punjab plains attained a larger size.

3. The land in a settlement was intensively used, giving rise to a high density of buildings, overcrowding of houses, and a dark and dismal look of the settlement. The degree of intensive use of land seems to have varied directly with the size of the settlement. The intensive use of land in larger settlements

seems to have resulted partly from the well-known gregarious habits of the oriental people, and partly owing to the limitations put by the defenses on the expansion of the urban land. There is evidence of the outgrowth of only a few important urban centres outside the town walls at times of greater political security, for example, in Lahore during the Mogul rule. Zoning of density is at present in greater evidence in larger urban centres, while it is ill-defined in smaller settlements. A large number of the more important present urban agglomerations are old settlements. Higher density of population and over-crowing of residential buildings in the hard core of the larger towns of old origin is mostly a legacy of the past.

4. The old settlements underwent an amorphous growth. The Hellenistic influences, manifest in the well-planned layout of Sirkap, Taxila, do not appear to have gained much ground in West Pakistan. There is hardly any evidence of planning of settlements in the Historical period. The road system was an irregular one. The streets were generally narrow, of uncertain width and direction, and ill-paved[15]. The width of the streets and residential lanes was inadequate with reference to the height of buildings abutting on them. The streets were, thus, generally dark and dismal, and the back-to-back houses, with small courtyard, insanitary. Narrow streets were perhaps also in consonance with the needs of defence and utilization of urban space to the maximum.

5. There was a sharp contrast between the structures of the residential buildings of the ruling classes and of the common people in the big cities. "In these cities the splendour was confined to the dwellings of the ruling class........the common people lived in huts and hovels"[16]. The monumental buildings, for example tombs, and the public buildings, like mosques and *serais* also stood in contrast to the predominant poor buildings of the urban centres. Excluding the citadel, there is little evidence of the concentration of the better buildings in a particular district of the city, which could be called the Civil Lines or the fashionable quarter of the urban centre. On the contrary, the monumental and public buildings are recorded to have been generally scattered over several districts of a city and over the suburbs.

6. Unlike the modern Western towns, there is no recorded evidence of a decrease in the height of buildings from the centre to the periphery in the old towns of West Pakistan. However, the buildings abutting on the main bazaars generally stood higher than the rest of the town. Even today the topography of our urban centres has no well-marked gradient from the centre to the periphery. The interior of the settlement was singularly free from parks. Town parks were built during the Mogul period in some of the

important administrative centres. But these were located in the suburban areas, *e.g.*, Shalamar Garden in Lahore.

7. From the sporadic information available regarding the drainage of the old settlements, it can be concluded that the same was poor[17]. The settlements generally had open surface drains.

8. The several functional areas of settlements were not well-defined. The present inappropriate mixture of uses in the urban complex seems to be partly related to the unwillingness of the people to change their traditional ways of living.

Historical accouts do not point to any distinctive traits of urbanization of our region of study during the Muslim rule in India. Evidence that can now be gathered from those towns of the region, which enjoyed greater attention during the Muslim rule, also does not point to these settlements having acquired any special traits, different from the general characteristics discussed under 1—8, above. However, the recent archaeological excavations at the ruined settlement of Bhambore (about 40 miles east of Karachi on the road to Hyderabad), have revealed valuable, and hitherto unknown, information regarding the morphology of the Muslim levels of occupation of that settlement. This information is set out in the following paragraphs. But it must be pointed out that in the absence of historical and other evidence establishing any distinctive traits of the other settlements of the region during the Muslim period, the characteristics of the Muslim settlement of Bhambore, noted below, cannot be generalised.

The Archaelogical site at Bhambore falls into two distinct parts—the high citadel mound measuring approximately 2000 feet × 1200 feet, and the lower unwalled city spreading far outside. Archaeological diggings are confined more or less to the citadel mound only, and at present it is difficult to ascertain the limits of the lower city. The Islamic settlements containing about a dozen successive occupation levels, occupy the upper half of the entire accumulation of the mound. Only the upper levels—datable to 11th—13th Centuries A.D.—have been investigated to any considerable extent, where it is possible to study the archaeological details and city plans. The informations refer to these levels only.

The city, so far uncovered, was well planned with broad and straight roads, some of them as wide as 24 feet, dividing the city into large sectors, sub-divided into smaller units, usually of 200 ft. × 200 ft. squares, by streets and lanes cutting one another at right angles. Stone or mud-brick houses with stone foundations are arranged more or less formally round a central courtyard in these units, rooms of individual houses also being arranged round an inner court-yard in the same fashion.

As most of the houses have mud-brick super-structures on 2½ feet thick walls, they do not seem to have any double storeys. Their probable height, therefore, would be 12 ft. to 14 ft. The width of the development lanes varies from 9 ft. to 12 ft., with back lanes of 3 ft. width.

The entire citadel area appears to have been thickly populated with a concentration in the southern sector around the main gate of the port, facing the sea and the anchorage, as well as in the eastern and northern sectors overlooking the lower city.

Density of buildings within an area of 100 ft. × 100 ft. in the

(*i*) eastern sector—is 5 houses with 30 rooms;

(*ii*) northern sector—is 5 houses with 40 rooms.

Other areas are not yet adequately uncovered.

The commercial centre of the city and the main bazar with shops and ware houses lies on both sides of the main road, connecting the port gate with the central area of the settlement. The industrial areas are located in the northern lower city at the foot of the citadel. The administrative centre with the city mosque appears to be at the central part of the mound, which has been only partially uncovered.

The entire citadel area was strongly fortified by a massive defence wall of stone with rectangular and semicircular bastions, which are still in good state of preservation.

Settlements of the British period and Post-Partition Settlements

The British period added much to the urbanism of our region of study by way of introducing a planned layout of the streets and residential lanes, modern and semi-modern commercial areas, better residential districts (for example, Civil Lines) and open recreational land within the urban area (Fig. 2 & 3). The British contribution to the urbanism of West

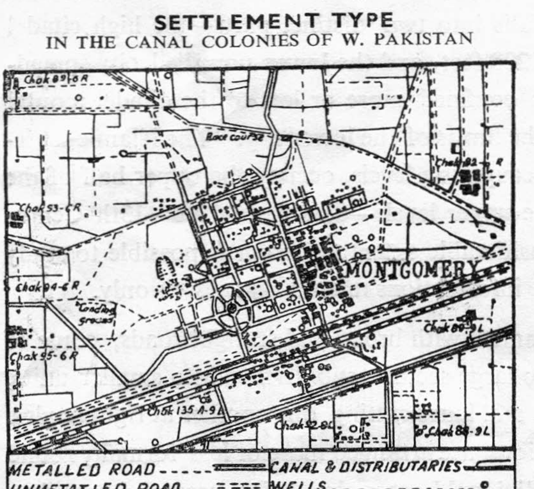


Fig. 2

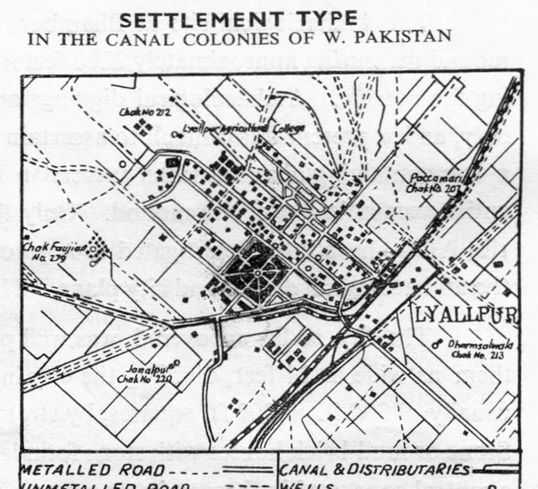


Fig. 3

Pakistan is best manifest in the resort centres, cantonments, canal colony towns and railway colonies. These urban centres are not peculiar to West Pakistan but are striking features of the urbanism of our region of study.

We have in West Pakistan, as a result of the developments in the Historical and British periods, two main strains of urbanism : (*i*) the compact old bazar towns representing the Eastern element of urbanism and having an analogy with the general form of urban centres in South-East Asia, and (*ii*) the open "mechanically laid out" town representing the Western element. The old urban centres of West Pakistan, which retained their high administrative status during the British period, are specimens of towns in which an admixture of the Western and Eastern elements has taken place. It may be mentioned that the two elements have not been properly integrated or harmonized. The indigenous parts of these urban centres stand in apathetic contrast to the anglicized parts. The former parts of amorphous growth were not subjected to any large-scale redevelopment during the British period.

The rural settlements of the British origin in the canal-colony areas of our region also present a planned rectangular layout of streets and building blocks (Figs. 4 & 5). The centre

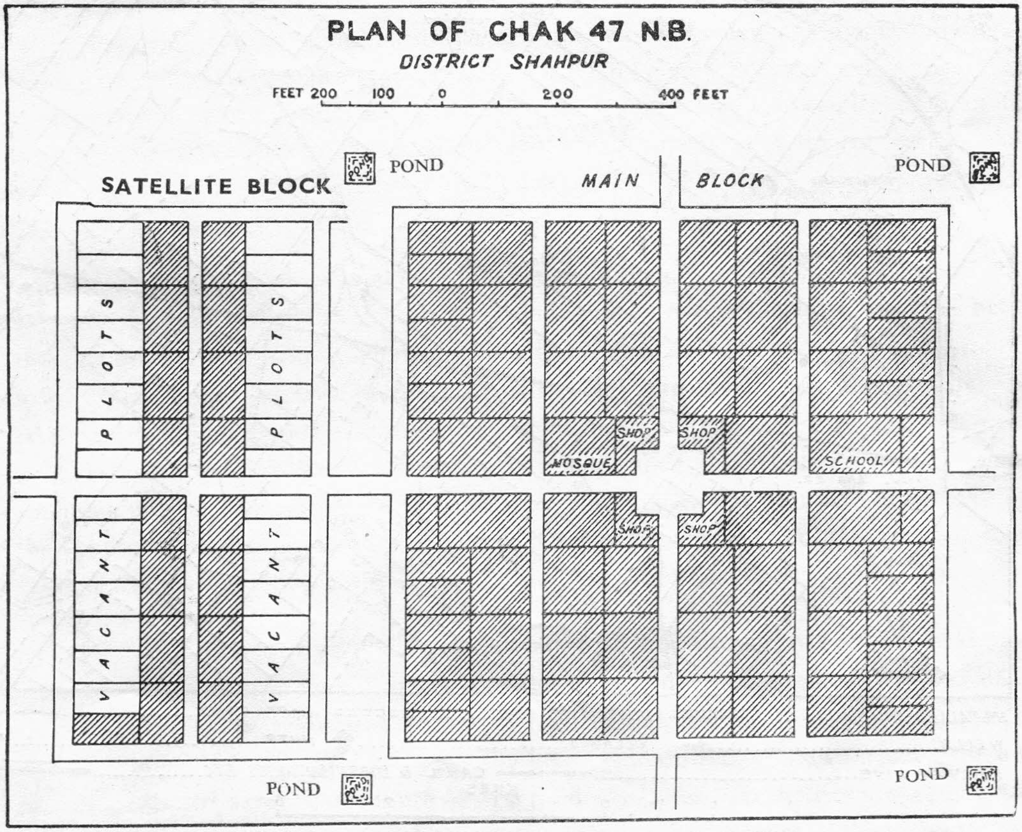


Fig. 4 Plan of 47 N. B. : a rural settlement of the British origin in the Canal Colony with a planned rectangular layout of streets and building blocks. It serves as a type plan.

of these settlements has a *Chawk* (square) around which is the market area. In some cases, the commercial function of the settlement extends to other parts of the main streets. The comunity buildings, for example mosques and schools, are suitably located so as to be easily accessible to all parts of the settlement. The building sites in the settlements were so allotted to the agricultural land holders of the village, to *lambardars* (petty village officers) and to tenents and *kamins* (agricultural labourers) that zoning of density of buildings was not allowed to be maximised[18]. Generally one—kanal (1 kanal = 600 sq. yards) and two—kanal houses predominated, with the result that even now, after the subdivision of building sites over a period of about 60 years, since colonization began, the residential areas manifest no marked congestion. There was generally, provision for the later extension of the settlement (see satellite block of the above plan), because of the availability of the Crown Land in the neighbourhood. Cattle ponds on the periphery of the built-over area is another general characteristic of these settlements.

COLONY VILLAGES
(LYALLPUR DISTRICT)

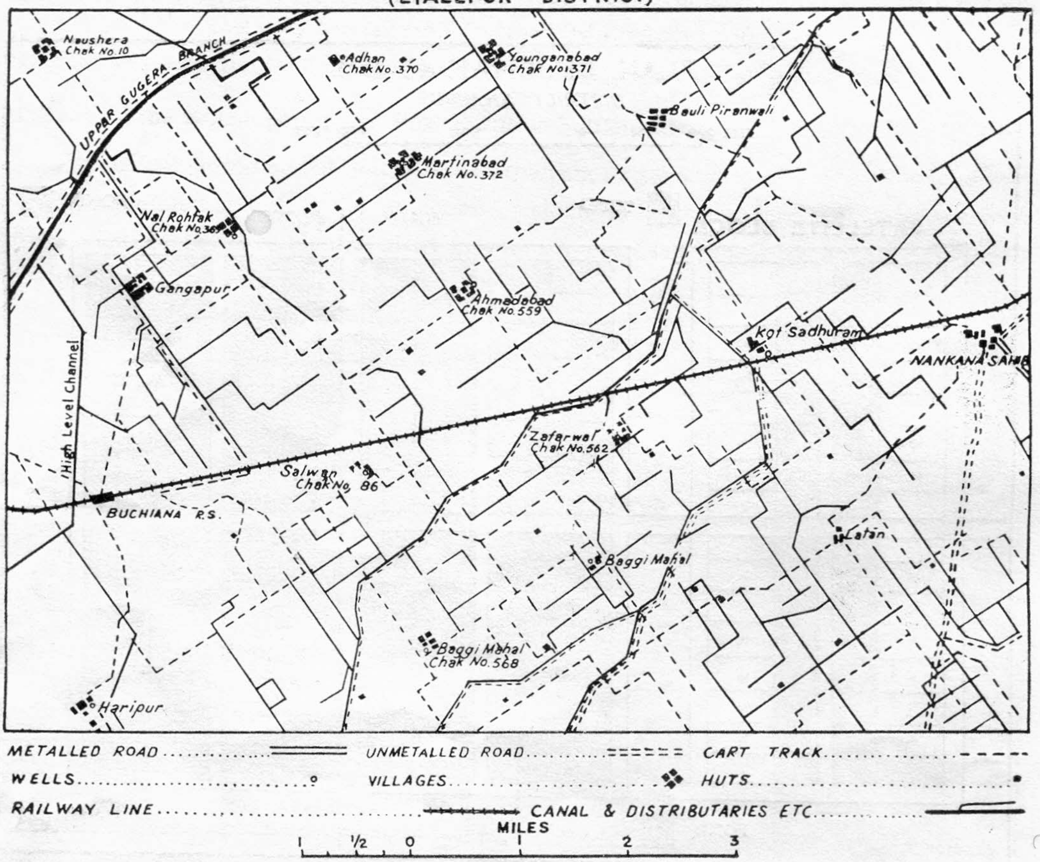


Fig. 5

The post-partition development of settlements has taken two main forms: (*i*) sizable extension of the brick-and-mortar area of larger urban centres, in the form of planned residential colonies, and (*ii*) growth of new towns and villages in the recently colonized areas.

The post-partition planned residential colonies generally are not conveniently related in position to the rest of the town, its commercial centre and its main areas of employment. It aggravates the problems of transport of the workers from residence to the areas of employment and back. However, these residential colonies generally contain within them some necessary land uses, for example local shopping area, schools, dispensaries, open spaces and other places that the residents have frequent need to visit.

The post-partition colonized area of the Thal has 6 new towns and 640 villages. The towns answer most of the essential requirements of Howard's 'Garden City'. The Thal towns are a new experiment in urban planning in West Pakistan. The planning in evidence in the Thal town is a 'physical planning'. It covers the several essential aspects of modern town planning : the choice of site, layout of roads and building blocks, determination of population size, provision within the town of means of livelihood for a high proportion of dwellers, and the distribution of functional areas in the urban complex (Fig. 6).

The urban centres are primarily *mandi* or market towns, with the planned population varying from 8,000 people in Liaquatabad to 50,000 in Leiah. Spacious grain storage bins, grain markets and fair grounds are the special features of the Thal towns. But each of these towns is also served with an "essential industry on which a large section of its population will depend"[19]. The road pattern of the towns in the Thal is predominantly rectangular. The main streets are 80—100 ft. wide.

Distribution of the several functional areas in the urban complex is planned. Segregation of functions, wherever necessary, is made perfect by interposing green belts between two functions. The main shopping area is suitably located in the approximate centre of the town. The residential area of the town is divided into several neighbourhoods. Each neighbourhood is provided with the necessary amenities ; it has a primary school, a mosque, a central open space used as children's playground, and, in some cases, its own ancillary shopping areas. The acreage of the open recreational area per thousand of population of the Thal town is over 13.0 acres, which is much higher than that of our other towns and cities. It compares favourable with the European and American standards.

The Thal villages are equally well laid out, with broad streets of constant bearing, and with a consequent open look. Since the villages, like towns, were planned, developed and raised by the Thal Development Authority, their layout, rate of development of their land and the design of buildings, have generally been standardized. The village usually has an area of about 100 acres, divided into 40—50 residential sites. The houses are either arranged in semi-circle or on three sides of the rectangle. Along the diameter of the semi-circle or on the remaining side of the rectangle community or public buildings, like hospitals, mosques, are built. The middle of the village, thus, has adequately large compound, generally used as a playground. In a number of villages wells are also sunk in this compound for the supply

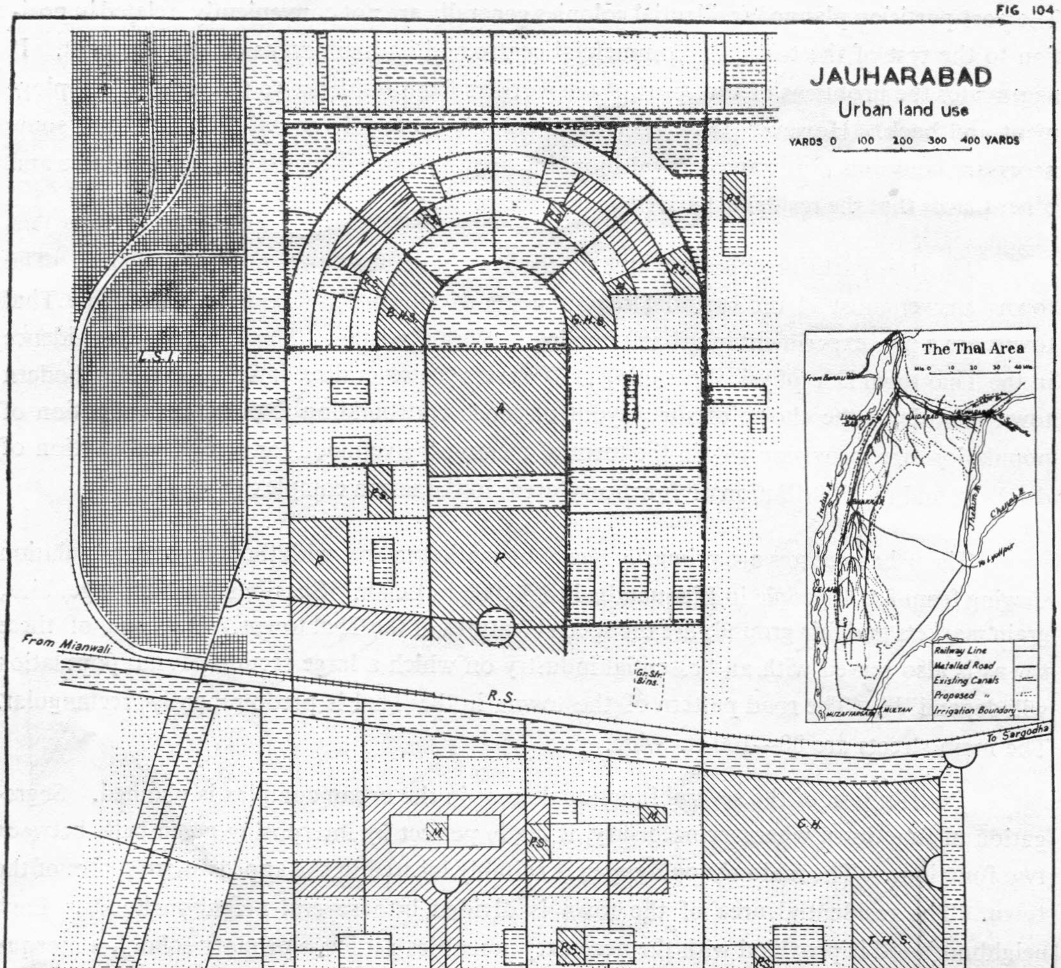


FIG. 104
JAUHARABAD
Urban land use
YARDS 0 100 200 300 400 YARDS
The Thal Area
L.S.I.
P.S.
B.H.S.
G.H.S.
A
P
From Mianwali
R.S.
Gr. Str. Bins.
To Sargodha
C.H.
M.
T.H.S.
J.M.
I.B.
FAIR GROUND
G.H.S.
S.S.I.
Ch.
V.H.
Railway Line
Metalled Road
Existing Canals
Proposed "
Irrigation Boundary
Industrial area
Commercial area
Residential area
Administrative buildings, educational institutions, libraries, hospitals, and other public buildings.
Open recreational area and green belt.
Approximate boundary of Civil Lines.
T.H.S. Technical High School
G.H.S. Girls' High School
B.H.S. Boys' High School
P.S. Primary School
M. Mosque; J.M. Jameh Mosque
I.B. Imām Bārā
Ch. Church
P. Other Public buildings
A. Administrative buildings.
C.H. Civil Hospital; V.H. Veterinary Hospital
R.S. Railway Station
L.S.I. Large Scale Industry
S.S.I. Small " "
Land use recorded by Dr. K.U. Kureishy, M.A., Ph.D. (Panjab), Ph.D. (London), Dept. of Geography, University of the Panjab, Lahore

Fig. 6

of drinking water for animals and for washing and bathing purposes. The village is surrounded by a green belt, 100—120 feet wide, which also serves as a common *charagah* (grazing ground) of the village. On one side of the village site there is a forest stand of 50 acres, which supplies the village with fuel wood, and allows grazing during open season.

The houses generally are of 2 kanals in area, having two rooms, and, in some cases, verandah in front. The rooms are usually 10 feet by 9 feet and 16 feet by 10 feet, and their walls have kiln-baked bricks on the outer side and sun-baked bricks on the inner side. This type of construction is suitable for the hot climate of the Thal area without being costly.

REFERENCES

1. *Archaeology in India*, Government of India, Ministry of Education, Department of Archaeology. Publication No. 66, Delhi, 1950, p. 31 ; S. Piggott. *Prehistoric India*, Hammondsworth, Middlesex, 1950, p. 67.
2. R.E.M. Wheeler, *The Indus Civilization*, Camb. University Press, 1953, pp. 64, 84—9.
3. *Ibid*, pp. 43, 45, 55, 86.
4. The dams are considered to be of Prehistoric age (*J. Marshall, Mohenjo-Daro and Indus Civilization*, Vol. 1, London, 1931, p. 21).
5. A Stein, *An Archaeological Tour in Gedrosia*, Calcutta, 1931, pp. 7—24.
6. Quoted in S. Piggott, Prehistoric India, *op. cit.*, p. 69.
7. J. Marshall, *op. cit.*, p. 3.
7. J. Marshall, *op. cit.*, p. 3.
8. R.E.M. Wheeler, *Five Thousand Years of Pakistan*, London, 1950, p. 41.
9. J. Marshall, *Taxila*, Camb. University Press, 1951, p. 140.
10. E. W. Hopkins, 'The social and military position of ruling castes in ancient India, *Journal of the American Oriental Society*, Vol. XIII, p. 76.
11. H. K. Trevaskis, *The Land of Five Rivers*, O.U.P., 1938, p. 19.
12. H. K. Trevaskis, *ibid*, p. 19.
13. H. K. Trevaskis, *Ibid*, p. 19.
14. H. K. Trevaskis, *Ibid*, p. 174.
15. H. K. Trevaskis, *Ibid*, p. 133.
16. H. K. Trevaskis, *Ibid*, p. 133.
17. Alexander Burns, who visited Lahore in 1837, writes about the city. " The houses are very lofty, and the streets which are narrow, offensively filthy, from a gutter that passes through the centre " (Quoted in M. Baqir, *Lahore : Past and Present*, Lahore, 1952, p. 326). For the difficulties experienced by the British to improve the drainage of Lahore *see Record of the Government of India* (Foreign Department) for the years 1851-52 and 1952-53, quoted in S. M. Latif, *Lahore : Its History, Architectural Remains and Antiquities*, Lahore, 1892, p. 25.
18. " Land holders are allowed one site for every square which they hold. *Lamburdars* may be given an extra half site in virtue of the office. Large land holders are allowed one site for every square held by them in chak upto a maximum of 6 sites. *Kamins* and tenants are ordinarily allowed half site " (see Colony Manual).
19. *Handbook of Thal Development Authority*, Jauharabad, 1954, p. 131.

CHROMITE AND ITS MINING IN WEST PAKISTAN

ASRAR ULLAH

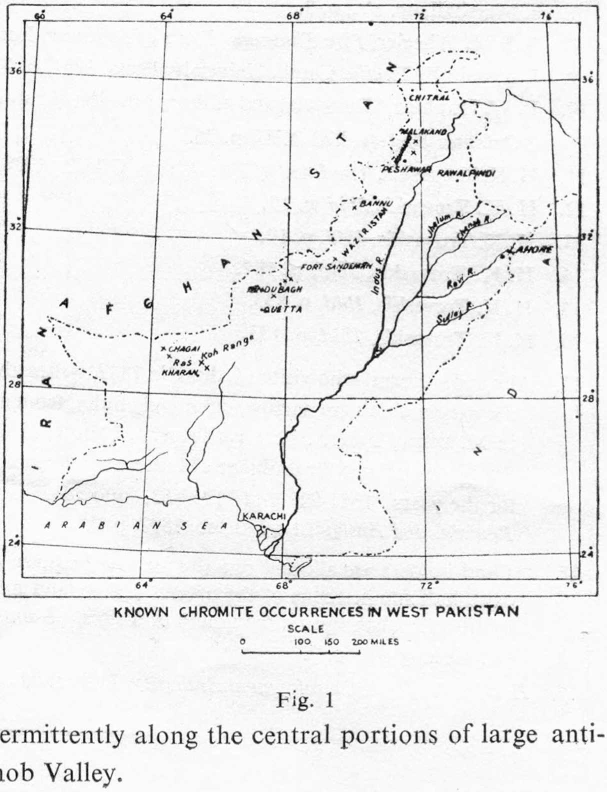
Geological Survey of Pakistan, Quetta

CHROMITE was first discovered in Zhob Valley in 1901 by E. Vredenberg (Coulson, 1941). Production was started in 1903 and has continued without interruption to the present time. Exploration and development for the discovery of other than the known chromite deposits in adjacent and adjoining areas could not be carried out owing to uncertain conditions of the areas until the time of Independence in 1947. It is an unfortunate coincidence that most of the known chromite deposits are in comparatively inaccessable areas of tribal territories in the western border areas of West Pakistan.

Chromite occurrences and the associated ultrabasic rocks are known in the Malakand, Mohmand and Waziristan agencies and in the areas around Fort Sandeman, Hindubagh, Khanozai, Chagai and Kharan. (Fig. 1). Little information is available about deposits from tribal territories of Malakand, Mohmand and Waziristan agencies except that there are sizeable exposures of ultrabasic rocks.

The best known and the only chromite deposists which have been extensively exploited are those in the Hindubagh area in the Zhob Valley. Next in importance are the deposits of Kharan and Chagai. Chromite deposits are known in the Fort Sandeman area but little is known about these deposits at the present time.

The areal distribution of ultrabasic outcrops from the Malakand agency to Chagai in the Ras Koh range apparently follows the regional tectonic trends. This regional trend is best seen in the distribution of the ultrabasic exposures between Fort Sandeman, Hindubagh and Khanozai. (Fig. 2). The ultrabasic rocks appear to have been intruded intermittently along the central portions of large anticlines or an anticlinorium along the Zhob Valley.



KNOWN CHROMITE OCCURRENCES IN WEST PAKISTAN

Fig. 1

In the following pages the more important and better-known chromite producing areas will be briefly described.

The principal chromite mining district in West Pakistan is near Hindubagh, a town 75 miles northeast of Quetta in the Zhob Valley in the Quetta Division. Extensive exposures of ultrabasic rocks in this area are within the Zhob Valley and have been given the collective name of the Zhob Valley Igneous Complex. This igneous complex is well exposed over a large area of approximately 1000 square miles, but at the present time the exact aerial extent is not known. The westernmost ultrabasic exposures are at Khanozai and crop out almost continuously north-eastward to 30 miles east of the town of Hindubagh, a total distance of about 55 miles (Fig. 2).

GEOLOGICAL MAP OF CHROMITE BEARING ULTRABASIC ROCK QUETTA DIVISION, WEST PAKISTAN

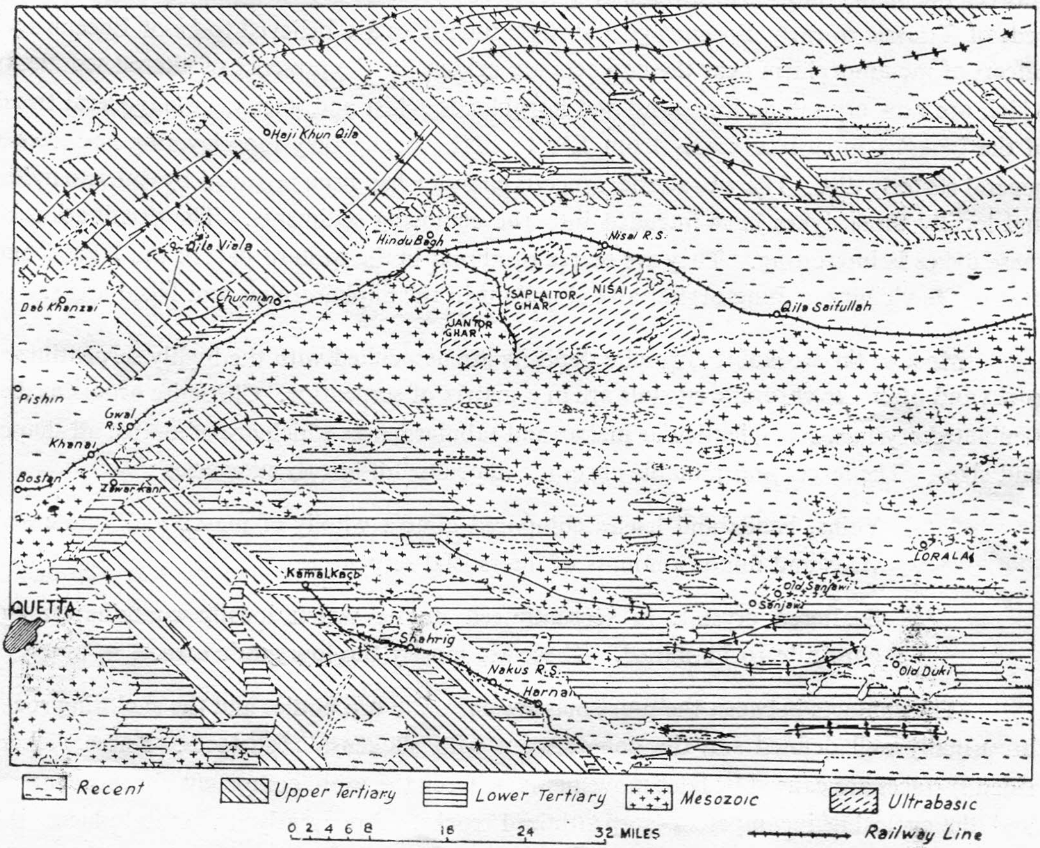


Fig. 2

Previous work and Geology

The igneous complex has been geologically mapped on a small scale, however, little is known about the detailed geology, mineralogy and petrology of the chromite-bearing ultrabasic rocks. S. A. Bilgrami of Pakistan Chrome Mines Ltd., Hindubagh has written a paper on the petrology of the ultrabasic rocks of a part of the Hindubagh area and another paper on chemical composition of the chromites. Richard G. Bogue, of U. S. Geological Survey has written a paper on the mineralogy and chemical composition of the chromite from Hindubagh and Fort Sandeman. These studies are preliminary in nature and based on a small number of samples (and so furnished insufficient data). The intent of these papers has been to bring out the problems and serve as guides for future investigations. Considerable information and material from these papers has been used in the preparation of this paper.

In the Hindubagh area the ultrabasic igneous complex consists of unaltered and serpentinized or partly serpentinized dunite, harzburgite, and periodite which locally contain chromite ore bodies. Transitional rock types are common and often there are gradations between the main types. The ultrabasic igneous complex has been intruded into sedimentary beds of Triassic to early Eocene age and these intrusives are believed to be of Eocene age. Effects of metamorphism near the contacts are evident by the presence of altered sediments which are now crystalline limestone and hornblende schist and gneiss. The general trend of the igneous intrusives varies from EW to ENE, locally they show layering and have a general easterly dip. The ultrabasic igneous complex has been intruded by dolerite dykes and locally these dykes have intruded into the enclosing sediments. The distribution of these dykes is interesting. They are scarce or absent in the western part of the Hindubagh area in the vicinity of Jungtorghar and abundant in the Saplaitorghar and Nisai areas.

Most of the workable chromite deposits are associated with the highly serpentinized rocks and often the chromite crystals are in a matrix of serpentine. Chromite occurs as disseminated crystals, veins, lenticular masses and tabular lenses which are of almost all shapes and sizes, The larger and minable chromite deposits fall in two categories :

(*a*) Veins, bands and lenses composed almost wholly of massive chromite with veins and minor amounts of interstitial serpentine.

(*b*) Scattered crystals in serpentinized dunite which locally contains enough chromite to be mined. These are mostly the low grade ores.

The contacts between the more massive chromite ore bodies and the enclosing rocks are usually well defined and the contacts are with slickensided surfaces. These slickensided surfaces are caused by later movements between the more competent chromite masses and the enclosing incompetent serpentinized rocks. Apparently in most places this later movement has taken place along pre-existing zones of weakness. The vein-type deposits, and in some places the massive chromite has been injected along and in these fracture zones on which later movement has taken place.

There is no apparent directional relation between the veins, bands and lenses of chromite ore bodies and the boundaries of the intrusives but at places there is a parallelism between adjacent ore bodies. The bands, veins and lenses are found over wide areas and range in thickness from a fraction of an inch to several feet. In the banded ore the serpentine between the bands of chromite is pale yellowish-green in colour and may or may not contain disseminated grains of chromite. In some places there is uniform banding of the chromite and serpentine, but generally the thickness of the individual bands is variable. The vein type deposits of chromite follow cracks, joints and fracture zones in the serpentinized igneous rocks and are often associated with magnesite and zeolites.

Chromite also forms as scattered or disseminated globules and irregular granules in a matrix of pale green serpentine. This type of ore has a mottled appearance and is locally called "Leopard skin" or "grape-shot" ore. The individual grannules and globules range in diameter from a fraction of a millimeter to two to three centimeters. A reverse relationship may also exist when "eyes" of serpentine are enclosed in massive chromite.

Properties of Chromite ore

In thin section, and often in hand specimens, two distinct types of chromite may be recognized :

(*a*) In one type the chromite crystals have an anhedral form, dark brown colour, translucent and traversed by irregular veins of serpentine. Most of the crystals contain colourless intrusions of serpentine or chlorite, some of which are pseudomorphous after olivine.

(*b*) The other type is generally more massive and the chromite is a dark opaque variety which may also contain veins of serpentine. This type of chromite is generally found in the low grade ores. Bilgrami (1960) has referred to the suggestions of Kramm, Dresser and Phillips that this opaque variety of chromite has been formed by the alteration of pictotite. However, in his studies of the chromites of the Hindubagh area, he did not find any support ing evidence. The suggestion made by Dresser that the opaque chromite is highly ferruginous and that the translucent variety is richer in magnesium and lower in iron may be correct and the analysis given in Table 1 apparently confirm this suggestion.

Chemical analyses of three high grade samples and four low grade samples of chromite ore and cleaned chromite from the Hindubagh district are given in Table 1.

Fortunately the variation in chemical composition of the chromite ore in the Hindubagh district does not occur in a haphazard manner. In the Hindubagh area the grade of ore decreases from west to east. The Jungtorghar area in the west produces the highest grade ore (see Table 2). The Nisai area in the east produces lower grade ore with a lower chromium-iron ratio (see Table 4). The Saplaitorghar area in the central part produces ore of intermediate grade (see Table 3).

TABLE 1

Chemical Analyses of the Zhob Valley Chromite

	1	2	3		4		5		6		7	
			Partial a	Cleaned b	Partial a	Cleaned b	Partial a	Cleaned b	Partial a	Cleaned b	Partial a	Cleaned b
Cr_2O_3 ..	57.43	52.17	50.7	58.7	41.1	56.5	39.2	54.5	40.8	54.5	43.0	56.1
Al_2O_3 ..	9.37	5.28		11.7		11.1		13.9		13.4		12.7
TiO_2 ..	0.23	0.20		0.17		0.19		0.43		0.25		0.21
Fe_2O_3 ..	6.16	2.56		6.3		4.3		4.7		1.6		3.2
			12.9 (1)		14.0(1)		12.8(1)		13.6(1)		14.0(1)	
FeO ..	9.99	15.30		8.8		13.8		12.2		15.1		13.6
MnO ..	0.38	0.93		0.16		0.20		0.18		0.18		0.18
MgO ..	14.17	13.43		14.1		13.6		14.1		13.6		13.9
CaO ..	0.04	0.06		0.00		0.00		0.07		0.04		0.07
V_2O ..	0.04	0.11		0.50		0.05		0.06		0.07		0.06
NiO ..	p.n.d.	p.n.d.		0.20		0.12		0.16		—		0.16
SiO_2 ..	0.80	5.44	4.4	0.24	9.9	0.38	12.0	0.48	9.5	0.57	7.9	0.38
H_2O Total..	0.86	2.63		0.29		0.10		0.24		0.09		0.18
	99.42	98.16		100.7		100.4		101.0		100.0		100.8
Cr ..	39.29	35.69	34.7	40.2	28.1	38.6	26.8	37.3	27.9	37.3	29.2	38.4
Fe ..	12.09	13.78	10.0	11.2	10.9	13.7	9.9	12.8	10.6	12.9	10.9	12.8
Cr/Fe ..	3.24	2.83	3.47	3.56	2.58	2.81	2.69	2.92	2.64	2.89	2.69	2.99

(1) Total Fe reported in partial analyses as Fe0.

1. Uncleaned chromite (B-327), Mine 132, Jungtorghar, Hindubagh, Analyst, Ingamells Bilgrami (1960).
2. Uncleaned chromite (B-353), Mine 136, Saplaitorghar, Hindubagh, Analyst, C.O. Ingamells Bilgrami (1960).
3. a. Buk sample (RGB-5H-59) Grab composits ore from 10 miles in 135 group of mines Jungtorghar, Hindubagh Bogue (1960)
   b. Cleaned chromite
4. a. Bulk sample (RGB-1H-59) Mine 40-DMC/4 Nisai group, Hindubagh, Bogue (1960).
   b. Cleaned sample
5. a. Bulk sample (RGB-2H-59) Grab composite ore from 13 mines, Nisagruop Hindubagh, Boque (1960)
   b. Cleaned sample
6. a. Bulk sample (RGB-3H-59) Grab sample ore dump Mine 5 CPL/1. Nisai group, Hindubagh, Boque (1960).
   b. Cleaned sample
7. a. Bulk sample (RGB4-H-59) Grab sample ore dump Mine 7 ML/1, Nisai group, Hindubagh, Bogue (1960).
   b. Cleaned sample

Bogue (1960) in a mineralogical study of the problem, analysed five samples from Nisai and Jungtorghar groups. He states: "The mineralogic data and chemical analyses of these five samples indicate that the principle difference between the low-grade and high-grade chromite is in the Cr_2O_3 and FeO contents. The contents of the five principal constituents are given below with the differences. Also total iron is given as FeO.

TABLE 2

COMPARISON OF CLEANED CHROMITE IN LOW-GRADE AND HIGH-GRADE SAMPLES, HINDUBAGH

	Average of 4 low-grade (Nisai group)	One high-grade (Jung-torghar)	Difference
Cr_2O_3	55.4	58.8	+3.03
FeO	13.7	8.8	—4.9
Fe_2O_3	4.5	6.3	+1.8
Al_2O_3	12.8	11.7	—1.10
MgO	13.8	14.1	+0.3
Total Fe as FeO	17.8	14.5	—3.3

It may be noted above that the Al_2O_3 and MgO are nearly the same in the low-grade and high-grade samples. The increase of 3.3 percent in the Cr_2O_3 and the decreases in total Fe when calculated as FeO is also 3.3 percent. The difference of 4.9 per cent in FeO indicates that in the low-grade there has been substitution of Cr by Fe".

The same trend is indicated by the study of end members of low-grade and high-grade samples from Hindubagh district. Table 3 below gives the percentage of end member of low and high grade chromite from Hindubagh district as calculated by Boque (1960).

TABLE 3

END MEMBERS OF LOW-GRADE AND HIGH-GRADE SAMPLES HINDUBAGH AREA

Calculated end members	Average of 4 4 low grade from Nisai	Difference	One high grade from Jungtoraghar	Difference	Difference LG.-H.G.
MgO. Cr_2O_3	32.3	..	39.8	..	+7.5
	..	—5.1	..	+5.5	..
FeO. Cr_2O_3	37.4	..	34.3	..	—3.1
Mg. O. Al_2O_3 ..	24.0	..	22.5	..	—1.5
FeO. Fe_2O_3	6.3	..	3.4	..	—2.9

In the low-grade there is 32.3 percent MgO. Cr_2O_3 (Magnesochromite) and 37.4 percent FeO. Cr_2O_3 (chromite). There is a difference of 5.1 percent, with FeO. Cr_2O_3 being the highest.

In the high grade there is a reversal. The MgO. Cr_2O_3 is 39.8 percent and the FeO. Cr_2O_3 is 34.3 percent a difference of 5.5 with the FeO. Cr_2O_3 being the lowest.

The MgO. Al_2O_3 (Spinel) member is about the same in both with a difference of only 1.5 per cent.

The FeO. Fe_2O_3 (magnetite) is 2.9 percent higher in the lowgrade and indicates some substitution of Cr by Fe".

Chromite Producing Mine Groups

As a result of differences in the grades of ore produced and also upon the differences in geographical distribution, the chromite occurrences and mines of the Hindubagh area have been divided into four groups :

(1) Jungtorghar group ;
(2) Saplaitorghar group ;
(3) Nisai group ;
(4) Khanozai group.

In the Hindubagh district the terms high-grade and low-grade ores are used. Ore containing 48 percent Cr_2O_3 or more and with a chromium-ratio of 3 :1 or better is termed high-grade. Ores with less than 48 percent Cr_2O_3 and with a chromium-iron ratio of less than 3 :1 are termed low-grade. This terminology is used in this paper.

(3) Jungtorghar Group

The Jungtorghar group is in and around the highest hill in the area that is composed of ultrabasic rocks. It has an elevation of 9600 feet above sea level and the area is over 20 square miles. Harzburgite is the dominant rock and the chromite occurs as bands, veins and lenses irregularly distributed in the partially serpentinized harzburgite. No definite pattern of distribution of ore bodies has been established though there is a general north-south trend. At present thirty mines are being worked in the group. No estimates of the total reserves have been made. Some of the mines have produced over 18,000 tons of high-grade ore.

Chemically the chromite ores of Jungtorghar are generally high grade and have a high chromium-iron ratio but locally there are low grade ores with a Cr_2O_3 content of less than 48 percent. The partial analyses given in table 4 shows that all the samples have a chromium-iron ratio greater than 3 :1.

TABLE 4

PARTIAL CHEMICAL ANALYSES OF JUNGTORGHAR GROUP CHROMITE ORES

Serial No.	Mine No.	%Cr_2O_3	%FeO	Cr	Fe	Cr/Fe
1	166 B	45.7	11.3	31.2	8.8	3.5 :
2	166 C	52.4	12.7	35.8	9.9	3.6 : 1
3	162 A2 ..	55.3	14.2	37.8	11.1	3.4 : 1
4	140 E	49.4	12.4	33.8	9.8	3.4 : 1
5	134	50.8	13.2	34.7	10.3	3.4 : 1
6	135	41.7	11.3	28S4	8.8	3.2 : 1
7	203	55.3	13.1	37.8	10.2	3.7 : 1

(2) Saplaitorghar group

Saplaitorghar is one of the largest hills of the district and occupies an area of over 90 square miles. More than 40 mines are being worked in the group. Here, too, the deposits do not show any definite shape, size or form. Some of the deposits are low-grade at the surface but improve in depth. Although the Cr_2O_3 content increases in depth but no

Analyst : Shabbir Khan, Pakistan Chrome Mines Ltd., Hindubagh. (Table No. 4 of Belgrami, 1961).

substantial change takes place in the chromium-iron ratio. Chromite ores from this group show considerable variation in Cr_2O_3 content, but the chromium-iron ratio generally remains near 3 : 1 (see Table 5)

TABLE 5

PARTIAL CHEMICAL ANALYSES OF SAPLAITORGHAR CHROMITE ORES

Serial No.	Mine No.		$\%Cr_2O_3$	FeO	Cr	Fe	Cr/Fe
1	7 ML*a*	..	44.6	13.4	30.5	10.4	2.9 : 1
2	7 ML*b*	..	45.3	14.0	30.9	10.9	2.9 : 1
3	7 ML*c*	..	48.6	15.3	33.2	11.8	2.9 : 1
4	136 ..	..	43.9	12.7	30.0	9.9	3.0 : 1
5	3 AML/6	..	44.0	12.9	30.1	10.1	3.0 : 1
6	23 A	..	47.1	13.9	32.2	10.8	2.9 : 1
7	34 ..	..	42.6	11.9	29.1	9.4	3.0 : 1
8	186 ..	..	52.5	15.9	39.9	12.4	2.9 : 1

3. Nisai Group

Nisai group of mines are about 20 miles east of the town of Hindubagh. Serpentinized dunite is the dominant rock type of the area. The shapes of ore bodies, though irregular, are generally tabular lenses. The ore bodies dip at steep angles and have a general north-south trend. The deposits are larger in size as compared with the deposits of other groups. About 80 mines are being worked in the group and one mine has produced 35,000 tons of chromite ore. Partial Chemical analyses of samples from this group are given in Table 6, and high-grade ores have a chromium-iron ratio of less than 3 :1.

TABLE 6

PARTIAL CHEMICAL ANALYSES OF NISI GROUP CHROMITE ORES

Serial No.	Mine No.		%of Cr_2O_3	%of of FeO	Cr	Fe	Cr/Fe
1	153*a* ..	..	46.3	14.9	31.6	11.6	2.7 : 1
2	153*b* ..	..	53.8	17.6	26.2	13.7	2.7 : 1
3	2 CPL..	..	44.1	14.8	30.1	11.5	2.6 : 1
4	1 CPL..	..	39.5	12.4	27.0	9.8	2.7 : 1
5	3 CPL..	..	41.1	12.2	28.1	10.3	2.7 : 1
6	34 ML	..	36.5	11.3	24.3	9.8	2.8 - 1
7	2 CPL/1	..	39.6	13.8	27.1	10.8	2.5 : 1

There is estimated to be, 50,000 tons of low-grade ore with a chromium-iron ratio of less than 3 : 1 in the Nisai group. The benefication of these low-grade ores is under consideration.

(4) Khanozai Group

Apart from the above mentioned three chromite producing groups of Hindubagh, the chromite-bearing ultrabasic rock exposures of the Khanozai area are also included in the Hindubagh area because of geographical contiguity. Khanozai is 29 miles west-southwest

(1) Analyst : Shabbir Khan.
a, b samples from 31 and 72 feet below the surface respecting Table 6, Bilgram (1960).

(2) Analyst : Shabbir Khan.
a, b and c Samples from 7 ML mine, from surface, 25 and 40 feet below the surface respectively. (From Table No. 5, Bilgrami, 1960).

of Hindubagh town. The Khanozai ultrabasic rocks are connected with the main outcrops of Hindubagh by intermittent exposures. In Khanozai ultrabsic rocks are exposed as continuous belt on the southeast side of the valley for a distance of about 12 miles. The exposure is about one mile wide.

Serpentine is the predominant rock type in the area. Harzburgite and other basic rocks are also exposed.

Minable chromite deposits have been found in the Khanozai area. Ore of mixed quality is produced from these mines. Partial chemical analyses of 10 chromite samples from the Khanozai ore are given in Table 7. Production from the Khanozai group of mines is about 500 tons per year. Reserves of high-grade cheomite ore have been estimated to be over 10,000 tons while low grade ores are estimated to be about 5000 tons.

TABLE 7

PARTIAL CHEMICAL ANALYSIS OF KHANOZAI GROUP CHROMITE ORES*

Mine No.	Cr_2O_3	Fe	Ratio
8 DMC	49.6	10.3	3.2 : 1
1	52.8	9.9	3.6 : 1
199	55	11.7	3.2 : 1
E E Gwal	46.9	10.6	3.0 : 1
1 A	50.9	10.7	23.3 :
199	52.9	12.5	2.9 : 1
1 E Gwal	51.4	9.98	3.5 : 1
1 E Gwal	32.9	8.57	2.6 : 1
1 E Gwal	39.0	11.8	2.3 : 1
1 E Gwal	36.1	9.41	22.6 : 1
1 E Gwal	45.8	10.5	3.0 : 1
1 E Gwal	49.3	10.05	3.4 : 1

Deposits of Chagai and Kharan

The chromite deposits of Chagai and Kharan districts are found as scattered pockets in the ultrabasic rocks exposed on the flanks of the Ras Koh Range (Fig. 1). The ultrabasic rocks are mostly pyroxenite and peridotite altered or partially altered to serpentine. Pyroxenite is almost a monomineralic rock consisting essentially of enstatite. The ultrabasic intrusions are generally in the form of sills from 1000 to 4000 feet thick and are aligned parallel to the regional east-west trend of the structure. Isolated outcrops of ultrabasic rocks are found throughout the Ras Koh Range for more than 150 miles, but most of the exposures of these rocks are in the eastern half of the range in the Nag-Bunap area ; and at one place are exposed over an area of about 1½ square miles. The age of the ultrabasic Intrusions in the area is Eocene, they have been intruded into the Bunap shales which are early to middle Eocene in age. The Kullan shale of proved middle Eocene age has not been intruded and the ultrabasic intrusions are older than Kullan shales. Scattered outcrops of ultrabasic rocks apparently have also been intruded along a large fault zone which trends NE. Chromite deposits have been discovered in a number of places in these areas and some are large enough to be mined.

*Analyses supplied by Pakistan Chrome Mines Ltd., Hindubagh.

West of Nag the ultrabasic outcrops bifurcate and follow west-northwest and west-southwest directions. The exposures with the west-southwest trend extend into the Rayo area of the northern Ras Koh Range in Chagai district.

The origin of chromite in this area is considered by Waheed-ud-Din to be magmatic segregation.

Estimates made from the surface in the Rayo area indicate the presence of at least 10,000 tons of chromite and reconnaissance samples show that the chromite contains from 47 to 54 percent Cr_2O_3 with FeO as much as 17.5 percent. In the Nag-Bunap area the estimates of 10 scattered deposits of chromite total about 10,500 tons of chromite. Reconnaissance samples indicate that the amount of Cr_2O_3 ranges from 35 to 50 percent., with iron and alumina as high as 31.8 and 16.0 percent respectively.

Reserves

Since the discovery in 1901 and exploitation of chromite in the Zhob valley in 1903, no systematic effort has been made to determine the reserves of chromite ore. The proved ore reserves have never exceeded 50 to 60 thousand tons at any one time. Since 1903, to the present, more than 800,000 tons of chromite have been exported from these mines. The present estimated known reserves of high grade ore today are of the order of 40,000 tons (Figure verbally communicated by A. H. Khan, Chief Geologist, Pakistan Chrome Mines Ltd., Hindubagh.) The proved reserves of low-grade ore are estimated to be about 60,000 tons. The estimated reserves of low grade are 240,000 tons.

In Kharan and Chagai it has been estimated that there are reserves of 20,000 tons of mixed quality of ore.

In the other areas only reconnaissance investigation have been made and it is not possible to make any firm estimates of the reserves.

Production

Chromite mining started in 1903 in the Hindubagh-Khanozai area of the former Baluchistan province by local interests and very small quantity of chromite was produced by them in the beginning. Regular mining of chromite, however, did not start till 1914 when the world war became imminent, the Baluchistan Chrome Company was formed with British Capital and management to accelerate the development of chromite mining in the area. The company acquired nearly all the leases in the Zhob Valley and organised mining commenced during the first world war. The production of chromite by M/s Baluchistan Chrome Company Ltd., who were the only producers for 1914 to 1950 has varied from year to year. The output ranged from 2,578 tons in 1915 to 24,334 tons in 1918. When the need for improvement of means of transport was felt the Hindubagh Railway Section was laid at the request of the Company. The production then increased to 26,695 tons in 1921. Thereafter the average production remained at about 19,000 tons per annum upto 1931. The production then suddenly dropped due to the world wide industrial slump to an insignificent figure of 354 tons during 1932. The position gradually recovered and by 1936 pre-slump level of production was again achieved. The production touched the peak figure of 39,344 tons during the Second World War in 1942. After the war, the prod ıction declined again. During the year of Independence, 1947 the production was 20,365 tons. Since Independence, the average level of production has remained at 18,000 tons per annum upto 1952 and nearly, 24,000 tons upto 1958. The output again dropped to 16,023 tons in 1959 and is likely to retain this level in 1960.

The annual production figures since independence are given below :—

Years.		Tons.
1947	..	20,365
1948	..	17,873
1949	..	16,922
1950	..	18,125
1951	..	17,498
1952	..	17,426
1953	..	23,442
1954	..	21,663
1955	..	28,401
1956	..	22,746
1957	..	16,173
1958	..	24,049
1959	..	16,023

Baluchistan Chrome Company had the monopoly of operation till 1950 when they incorporated their interests in Pakistan as Pakistan Chrome Mines Ltd. In 1950 Pakistan Industries Ltd., a Pakistan-mining company entered the field and in 1957 both the comppanies amalgamated their interest into one big concern. At present there are about half a dozen other minor mining interests in the area, but their performance is very insignificant.

Marketing and Export

Almost all the chromite produced in the country is exported abroad. It is mainly sent to U. S. A. and U. K. Some ore has also been exported to other European countries and Japan. The demand is mainly for high grade ore with at least 40% Cr_2O_3 and a chromium-iron ratio of 3 : 1 or better. The FOB Karachi value of the high grade ore is £ 11-17-0 per ton. The cost of production and transportation from the mining area to the port at Karachi is estimated to be about Rs. 111/9 per ton.

About 28,75,000 tons of chromite are annually produced by different countries of the world; and the Pakistan annual output of about 20,000 tons is very insignificant indeed. The annual production of major chromite producing countries of the free world is given below :

	Chemical	Refractory	Metallurgical	Maximum Potentiality of product with existing facilities
New Caledonia	..	..	60,000	60,000
Cuba	..	60,000	..	60,000
Greece	..	40,000	..	40,000
India	..	..	40,000	60,000
Iran	..	20,000	30,000	150,000
Turkey	..	50,000	400,000	700,000
Sierra Leone	..	..	16,000	15,000
South Africa	320,000	..	380,000	1,000,000
Rhodesia	..	..	650,000	1,000,000
Philippines	..	550,000	150,000	700,000
Pakistan	..	..	20,000	40,000

Mining and its problems

Due to the pockety and scattered nature of the deposits, their comparative inaccessibility and peculiar local labour problems the mining of chromite is mostly done by hand. Very little mechanisation has been effected with the exception of uses of a few compressors, jack hammers, pumps etc.

For removing the ore from the mines no mechanical hoists or winches are used. Haulage along the inclines is done by donkeys. The ore is collected at a central mine or depot, wherefrom it is transported by trucks or donkys to the rail head.

Mining is usually done by tribal labour employed through local Maliks who work as raising contracters and virtually own the mines situated in their territory. The mine owners are obliged to enter into wholesale raising contracts with them. These contractors employ labour independently and work the mines to suit their convenience. The mine owners have generally no direct control over the labour and method of working. As a result of this the productivity in Hindubagh-Khanozai area is lowest in the world. One person produces 3 to 3½ tons of ore per month. The average earnings are Rs. 3/- per day.

Recruitment of labour and the tribal system of working is the major problem of the chromite mining in Pakistan. It is the greatest hindrance in the scientific development of the industry and causes greatest set-back in the efforts to raise production to sufficiently high level. 2nd Five-year Plan target is 50,000 tons.

Another major problem of chromite mining at Hindubagh is the utilization of large reserves of low grade chromite ores. At present these ores are not marketable because of the low grade and low chromium-iron ratio. Beneficiation of these ores has been considered for a number of years. However, the feasibility of beneficiation is uncertain because there is no sufficient data on the characteristics of the ores and not enough tests have been made to determine if these low gade ores can be utilized. One milling test on these ores was made by Denver Equipment Company in 1952. The test indicated that the concentrates made from these low grade ores had a satisfactory Cr_2O_3 content but the chromium-ironratio was too low. Further milling tests are being considered to explore the possibility of benefication. If the beneficiation of low grade ore proves feasible, this will greatly help the industry in its programme of expansion of production by opening up new areas.

REFERENCE

Asrarullah (1960)—Geology of Chromite in West Pakistan CENTO Symposium on Chromite. Ankara, Turkey, September, 1960.

Bilgrami S. A. (1960)—Mineralogy and Petrology of the Hindubagh igneous complex. West Pakistan ; Rec. Geol. Survey of Pakistan (In press).

Bilgrami S. A. (1960)—Chemical composition of Zhob Valley Chromites, West Pakistan : The American Mineralogist, 45, 576—590

Bogue, R. G. (1960)—Introductory Mineralogic studies of Chromite ; Hindubagh and Fort Sandeman District, West Pakistan ; Unpublished (available in USGS/ICA files).

Coulson, A. L. (1914)—Chromite Rec. Geol. Surve. India, 76, 9—11.

Heron, A. M. and Crookshank, H. Directory of Economic Mineral of Pakistan. Rec. Geol. Surv. Pakistan, 7 pt. 2, 25-26.

Khan, A. M. (1960)—Benefication of Chromite in West Pakistan. CENTO Symposium on Chromite, Ankara, Turkey, September, 1960.

Qureishy, N. H. (1960)—Chromite Mining in West Pakistan. CENTO Symposium on Chromite, Ankara, Turkey, September, 1960.

Siddiqui, M. (1960)—Economics of chromite mining in Pakistan. CENTO Symposium on Chromite, Ankara, Turkey, September, 1960.

Wahid-ud-Din Ahmed—Geological Report of Kambran-Rayo and Nag-Parshad-Charkohan Kulian (Western and Eastern Ras Koh, unpublished (Geological Survey of Pakistan files).

DRAINAGE BY TUBEWELLS IN RECHNA DOAB, WEST PAKISTAN

MUHAMMAD BADARUDDIN*

RECHNA Doab lying between the Rivers Ravi and Chenab is a vast agricultural area in West Pakistan which is dependent upon irrigation for its economic stability. Prior to the advent of irrigation, some seventy years ago ,the whole area except for narrow strips of lands along the rivers was a desert waste. With the development of irrigation over 5.4 million acres of virgin land comprising 77% of the gross area of the Rechna Doab has been brought under the plough. From the Chenab River 11,500 cusecs of water was first diverted into the Doab which was later supplemented through other canals by another 40,000 cusecs. This major change in the disposition of the waters of the region coupled with the interference of the surface drainage by man-made structures such as canals, roads and railways disturbed the hydrologic equilibrium, the most significant effect of which was a steady rise in the water table. Waterlogging and attendent salinity soon started to undermine agricultural productivity and the urgent need for initiating corrective measures came to be realised. Various approaches were tried from time to time but the problem was so little understood that no tangible results were achieved. In 1958, 35.5% of the Rechna Doab was surveyed as predominently poorly drained or waterlogged, 15% as severely salinized and another 30.5% as affected to a varying degree of salinization. Realizing the necessity for basic data concerning the geologic, hydrologic and other conditions which contribute or are related to the problems of waterlogging and salinization, a programme of investigations was initiated, rather belatedly in 1954. Based on the results of these investigations a project was taken up in a major portion of the irrigated areas of the Rechna Doab. This project represents the first major step in Pakistan for controlling waterlogging and salinity by means of tubewells to achieve sub-surface drainage and to realize additional water for irrigation.

This paper describes the conditions prevailing in the Rechna Doab, the need for adequate sub-surface drainage and the feasibility of using tubewells for this purpose as examplified by a major project undertaken in the area.

Location

Rechna Doab is a part of the Indus valley bounded by two of its tributaries the Rivers Ravi and Chenab from which it derives its name. ('Doab' meaning land between two rivers). The Rivers Ravi and Chenab originate in the Himalayan mountains in the Indian territory and flow into West Pakistan from north east to south west. Only that portion of the Doab which lies within West Pakistan has been considered here. It is bounded by the Pakistan-Kashmir boundary on the north east and by the Rivers Chenab

*Director Drainage Projects, Water and Power Development Authority, Lahore.

and Ravi, flowing roughly from north east to south west, down to their confluence. The width between the rivers is 50 to 60 miles and the length of the Doab from the foot of the mountains to the confluence is about 220 miles, the gross area being 11000 square miles. The location of the Rechna Doab is shown in Fig. I.

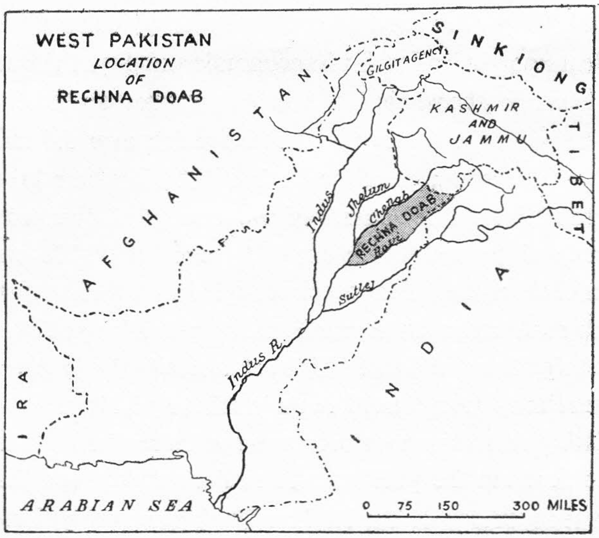


Fig. 1

Climate

Climatically Rechna Doab is arid to semi-arid. The average rainfall progressively decreases from 20—35 inches in the north east to 7—8 inches in the south west. The annual precipitation is generally concentrated in the four months from June to September, July and August are the months of heaviest rainfall, while October and November are the driest. There is a secondary rainfall period from December to February. May and June are the hottest months. The average maximum temperature for these months is about 105° F. The daily maximum temperature during these months may reach 115° F. or more for several days. In the rainy season July to September, the average maximum temperature is 100° F. From December to February the day temperatures are in the 60's or 70's while the night temperatures are in the high 30's or low 40's. Freezing temperatures are recorded only occasionally.

Physiography

Rechna Doab has a relatively flat and even surface constituting a vast plain. In the north-eastern sub-mountain region, the height averages 850 ft. above sea level. In the south-west near the confluence of the Ravi and Chenab rivers it averages about 450 ft. above sea level with a more or less uniform gradient of 2 to 3 ft. per mile. Across the Doab the land surface rises 25 to 30 ft. above the level of the Rivers. The most conspicuous relief features in the Doab are three isolated hills which occur at Shahkot, Sangla and Chinot, having elevations of 140, 160 and 360 ft. above the surrounding land surface.

Sub-regions : The sub-regions of Rechna Doab according to different land forms are shown in Fig. 2. and their principal features are given below :

Shakargarh Piedmont : This is a part of the Himalayan piedmont plain. It has a slope of 100 ft. in the first six miles and another 100 ft. in the next 12 to 15 miles. The plain is deeply cut by several streams. The northern edge has been intricately dissected by a network of eroding streams, but on the lower slopes the land between gullies is wider and more level. The southern edge of the piedmont is marked by a badly dissected bluff which is 30 ft. high at places.

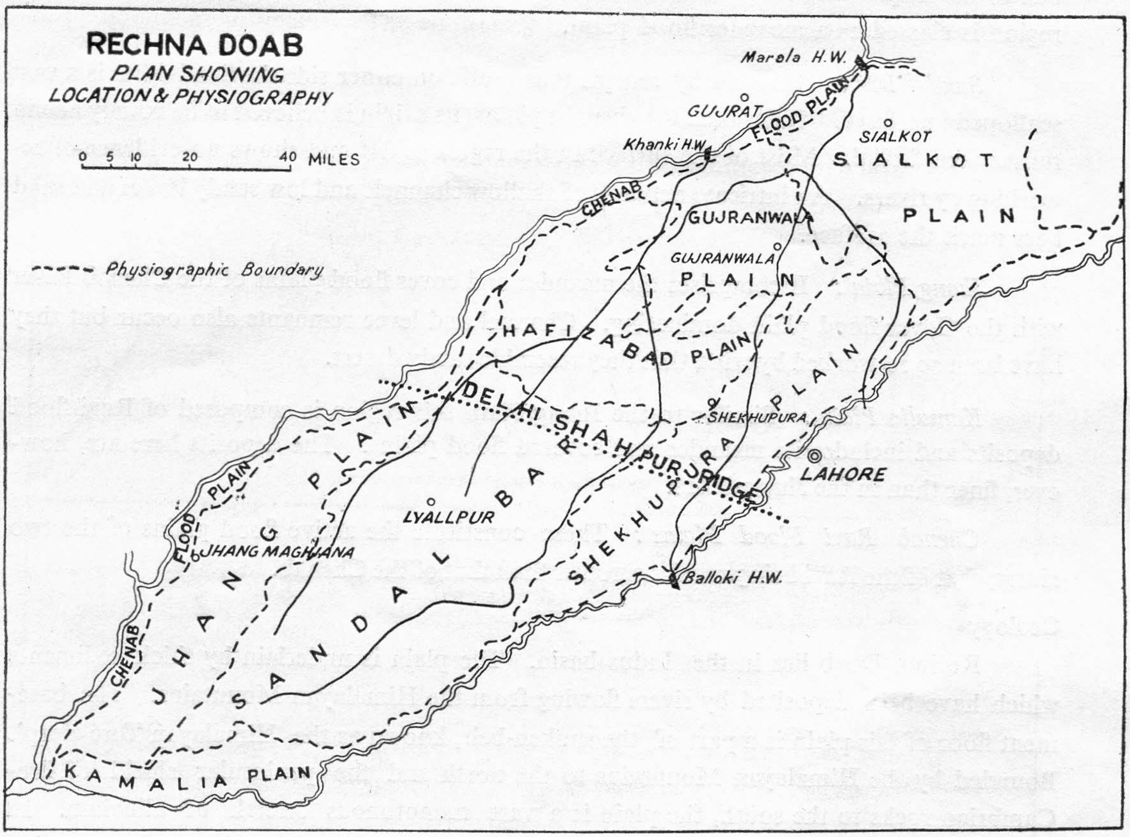


Fig. 2

Sialkot Gujranwala Plain : A major portion of this sub-region is a covered flood plain, most of the sediments having been brought down by the flood waters of the Chenab and Ravi and the streams flowing from the piedmont plain. The surface of the plain is much more level than in the meander flood plains farther west, but there are many broad ill-drained depressions. The surface configuration in the eastern part of this sub-region indicates that the alluvial deposits were laid down by the Chenab as the highest parts are only a few feet above the level of the Chenab. To the south eastern edge lies a prominent bluff which confines the Ravi floods to the south.

Hafizabad Plain: This is a meander plain of the river Chenab. Its south-east boundary runs along the top of a bluff overlooking the Sheikhupura plain. The surface configuration here is very complex including such features as channel remnants, meander scrolls, river bars, levees and slack water deposits.

Sheikhupura Plain : It consists of the alluvial deposits of the Ravi River and the Deg Nullah which originates in the Himalayan piedmont. The surface of the region is level and channel scars, levees, sand bars and slack water deposits form a complex pattern. The bed of the Deg and other nullahs are sunk as low as 20 ft. below the ground surface. The region is classed as a meander flood plain.

Sandal Bar : Bounded by conspicuous bluffs on either side the Sandal Bar is a vast scalloped interfluve. Older than the riverain plains, its origin is believed to be mainly aeolin rather than fluvial. Most of the surface in the region is flat and shows no evidence of re-working by rivers. An intricate network of shallow channels and low sandy levees and sand bars mark the surface.

Jhang Plain : It comprises the meander and cover flood plains of the Chenab River with the Cover flood plain dominating. Channel and levee remnants also occur but they have been so re-worked by wind that they resemble sandy desert.

Kamalia Plain : Similar to the Jhang Plain this region is composed of Ravi flood deposits and includes its meander and covered flood plains. The deposits here are, however, finer than in the Jhang Plain.

Chenab Ravi Flood Plains : These constitute the active flood plains of the two rivers, that of the Ravi being much narrower than that of the Chenab.

Geology

Rechna Doab lies in the Indus basin. The plain is underlain by thick sediments which have been deposited by rivers flowing from the Himalayan Mountains. The basement floor of this plain is a part of the sunken-belt, known as the Himalayan 'fore deep'. Bounded by the Himalayan Mountains to the north and the peninsular shield of Pre-Cambrian rocks to the south, the plain is a vast monotonous stretch of alluvium. In the Rechna Doab this plain is marked by a few outcrops of Pre-Cambrian rocks occurring at Shahkot, Sangla and Chiniot forming the hills mentioned above, which are believed to be the eroded remnants of a subterranean ridge, called the Delhi-Shahpur Ridge, (Fig. 2). A geologic section through the outrops along the general trend of the burried ridge based on a series of borings 600 ft. deep is shown in Fig. 3. from which it will be seen that except in the close vicinity of the outcrops the ridge is deeply burried. On either side of this ridge the alluvium which is of Quarternary age assumes great thickness and is believed to be from 1000 ft. to 3000 ft. A test well near Sheikhupura (See Fig. 2) was drilled to 1500 ft. without striking bedrock.

The nature of the alluvium in Rechna Doab which is the most important element in the control of ground water, has been determined by an extensive programme of investigations under which 276 exploratory holes, 600 ft. deep were drilled and 44 test wells were installed. These investigations have revealed that the alluvium consists of a large variety of sediments ranging in size from sands to silt and clays. As is usually true of fluviatile sediments, the deposits change markedly in texture and character both horizontally and vertically, thus rendering geological correlations difficult. A few geological sections across the Doab are shown in Fig. 3 from which it will be seen that except for the upper portion of the Doab along the Ravi River and the vicinity of the Delhi Shahpur ridge clays are not the predominent sediments. The continuity of the silts and sands down the Doab is also manifest.

Irrigation and Drainage

History of Irrigation : In the Rechna Doab, irrigation was initiated on a large scale in 1892

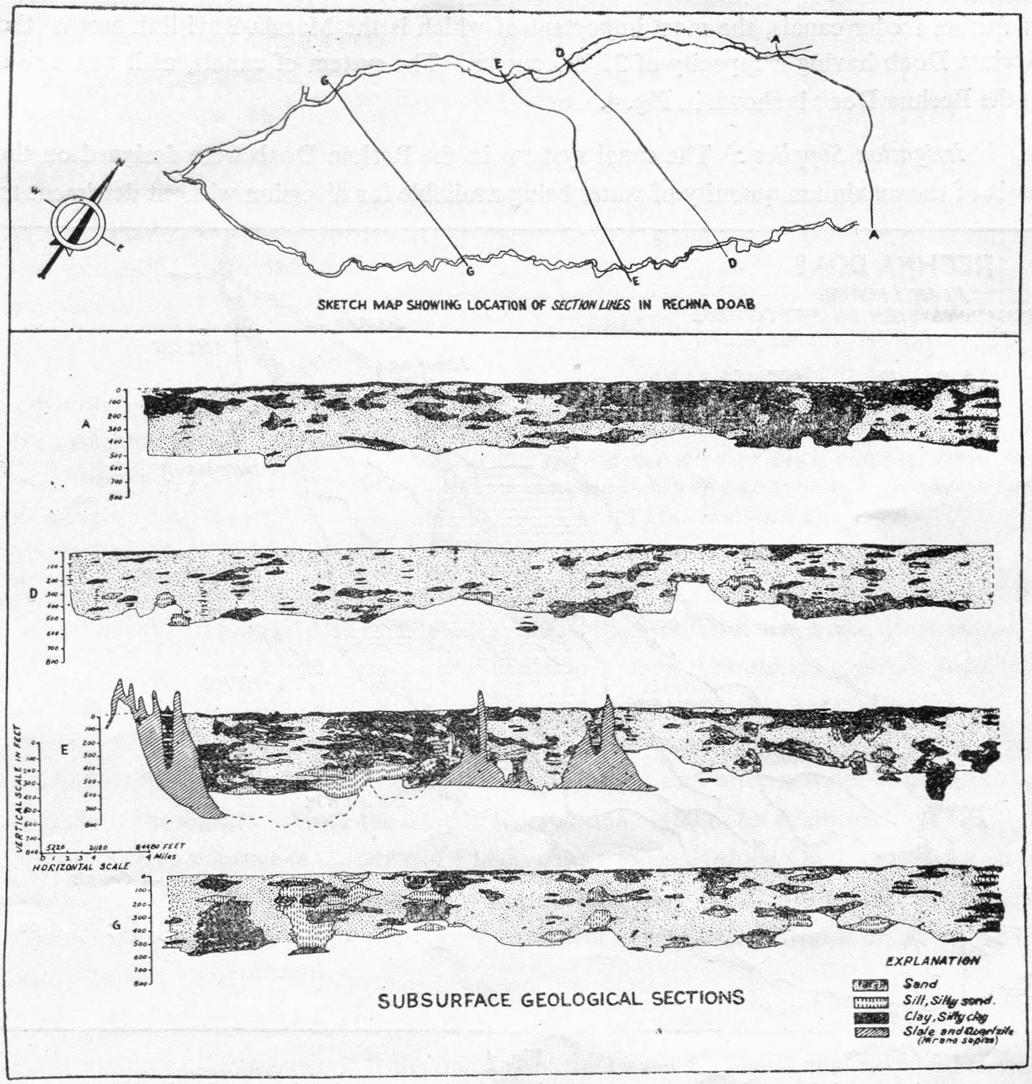


Fig. 3

with the construction of a diversion weir on the Chenab River at Khanki and the Lower Chenab Canal System. In this canal system 11,500 cusecs are diverted from the Chenab perennially to irrigate an area of 2.9 million acres. To irrigate the areas south of the River Ravi a project was completed in 1915 under which a canal was constructed across the Rechna Doab to transfer the surplus water of the Chenab River to the Ravi. This canal called, the Upper Chenab Canal takes off from a barrage or diversion weir at Marala and carries a discharge of 13,000 cusecs. It also irrigates a small area on the way. The south-west tip of the Doab is irrigated from the Haveli Canal opened in 1939, as a feeder link, to carry 5,000 cusecs of surplus water from the Chenab at Trimmu to the Ravi above Sidhnai headworks. With the partition of the Indian Sub-Continent in 1947 canals taking off from the Ravi and the Sutlej were threatened with shortage of supplies. This led to the construction of further feeder canals, the most important of which is the Marala-Ravi link across the Rechna Doab having a capacity of 22,000 cusecs. The system of canals, as it now exists in the Rechna Doab is shown in Fig. 4.

Irrigation Supplies : The canal systems in the Rechna Doab were designed on the basis of the maximum quantity of water being available for diversion without detriment to

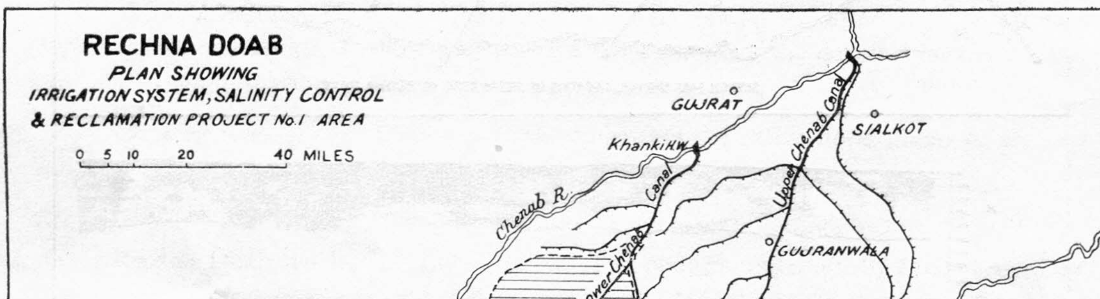


Fig. 4

the water rights of down-stream users. This quantity termed "the Authorised full-supply" has never been achieved in practice and diversions over a long period have averaged 66% during the *Rabi* (growing season October-March) and 70% during *Kharif* (growing season

April-September). On the other hand there has been no control over the intensity of irrigation. The canals were designed to supply 1 cusec for 350 acres, with an annual intensity of 75%—One cusec for 88 acres during Kharif (intensity 25%) and one cusec for 176 acres during Rabi (intensity 5%). Against these designed intensities the actual intensities have varied from 85 to 90%, resulting in the irrigation waters being applied too thinly. Studies made by Messrs. Blaney and Criddle indicate the inadequacy of water applications on the Lower Chenab canal system. The requirements in cusecs according to the Blaney Cirddle method are compared with the actual supplies in Fig. 5.

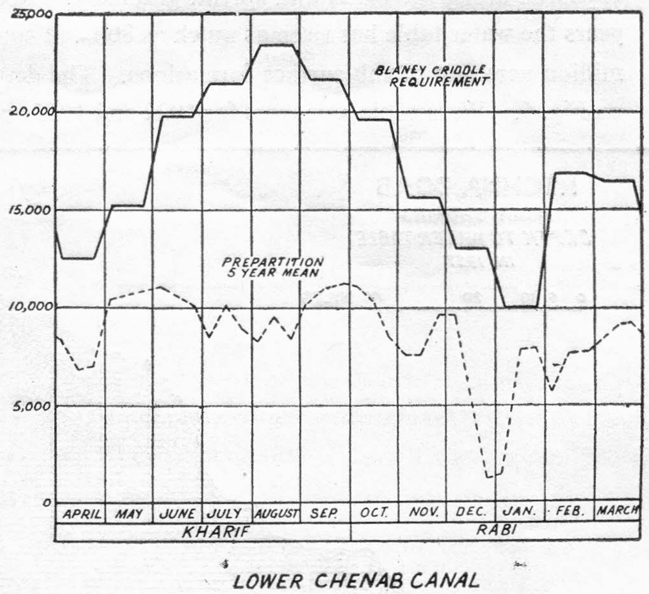


FIGURE SHOWIG THE AVERAGE CANAL SUPPLIES FROM THE LOWER CHENAB CANAL AND THE ESTIMATED CROP REQUIREMENTS BY THE BLANCY-CRIDDLE METHOD

Fig. 5

Drainage : Due to the flat topography, surface drainage in the Rechna Doab has always presented a problem. Natural drainage is not very well defined. The principal Nullahs are the Deg and Aik which transverse only the upper portions of the Doab and fall into the Ravi and Chenab respectively. After heavy rains, particularly when the river stages are high and the outlets are blocked these Nullahs and their tributaries overflow their banks and inundate vast areas. The drainage problem has been further aggravated by the construction of canals, roads and railways which form obstructions against the natural slope and contribute to local flooding as the capacities of syphons and bridges is not sufficient to cope with flood discharges. Since the advent of irrigation, 1400 miles of drains have been constructed having a designed capacity of 13,800 cusecs in the Rechna Doab mostly for surface drainage and partly to drain sub-soil water. That these drains are grossly inadequate is testified by recurring floods in the area. The affect of the seepage drains on the water table has also been insignificant.

Waterlogging and Salinity : Based on the experience on some of the earlier canal systems it was apprehended that the opening of the Lower Chenab Canal may lead to waterlogging. In order to keep the trend of the water table under review a series of observation wells were established as early as 1902 and regular observations were made in June and October each year, prior to and after the rainy season. These observations soon confirmed that the water-table had been rising, and it was not long before waterlogging developed. Similarly, within four years of the opening of the Upper Chenab Canal in 1915, waterlogging appeared along the canal and spread gradually. Records indicate that during the last 50 years the water table has risen as much as 80 ft. at some places in the Doab, saturating 180 million acre feet of sub-surface formations. The depth of watertable in 1957 is indicated on Fig. 6. Watertable contours for 1920 and 1955 are shown in Fig. 7. & 8, which indicate

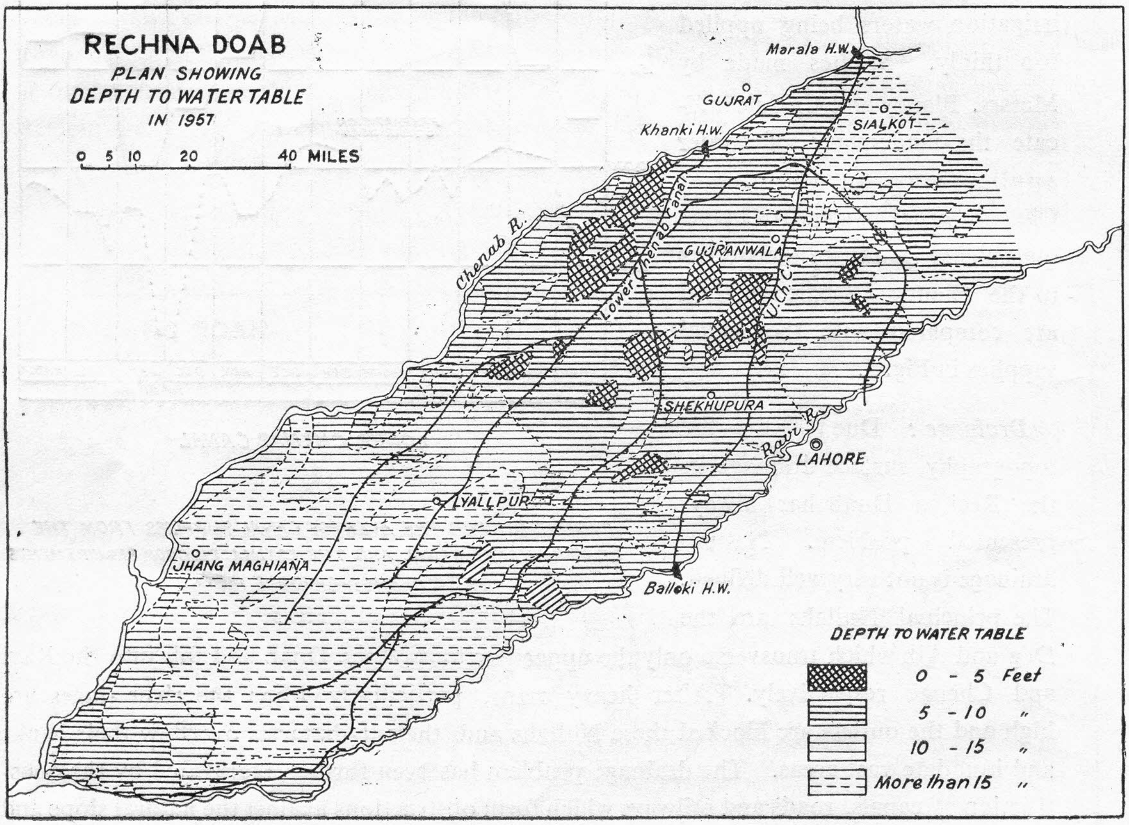


Fig. 6

the general trend of ground water movement down the doab and the building up a groundwater ridge in the centre where originally there was a trough. A generalised section through the Doab is shown on Fig. 9. which depicts the pre-irrigation and the present configuration of the watertable indicating that conditions have changed from influent to effluent seepage from the Rivers Chenab and Ravi.

Concurrently with waterlogging, salinization of the soils has taken place. In 1.7 million acres of the central portion of the Doab which can be taken as representative, 16.5% of the soils are strongly to highly saline (salts more than 0.5%) and 18.3% are moderately saline (salts 0.20 to 0.5%), as determined by a recent survey in 1956-57. Non-saline Alkali, or saline Alkali soils, however, are not present to an appreciable extent.

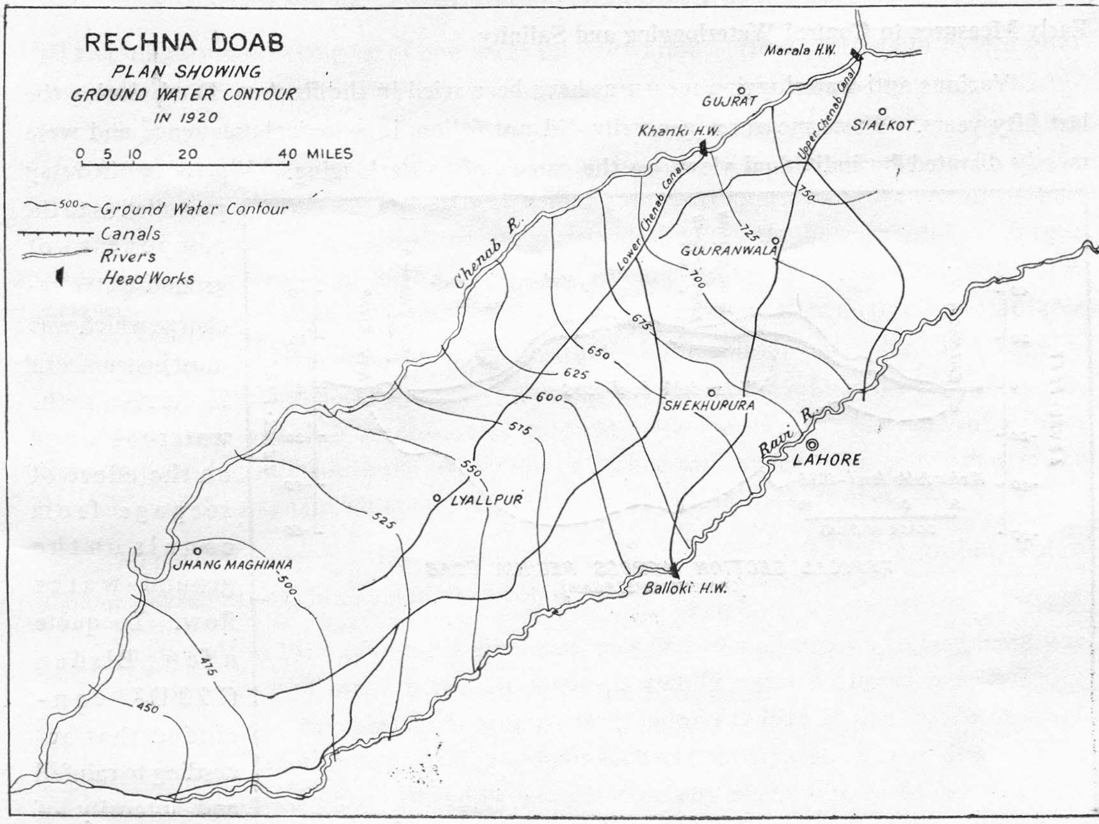
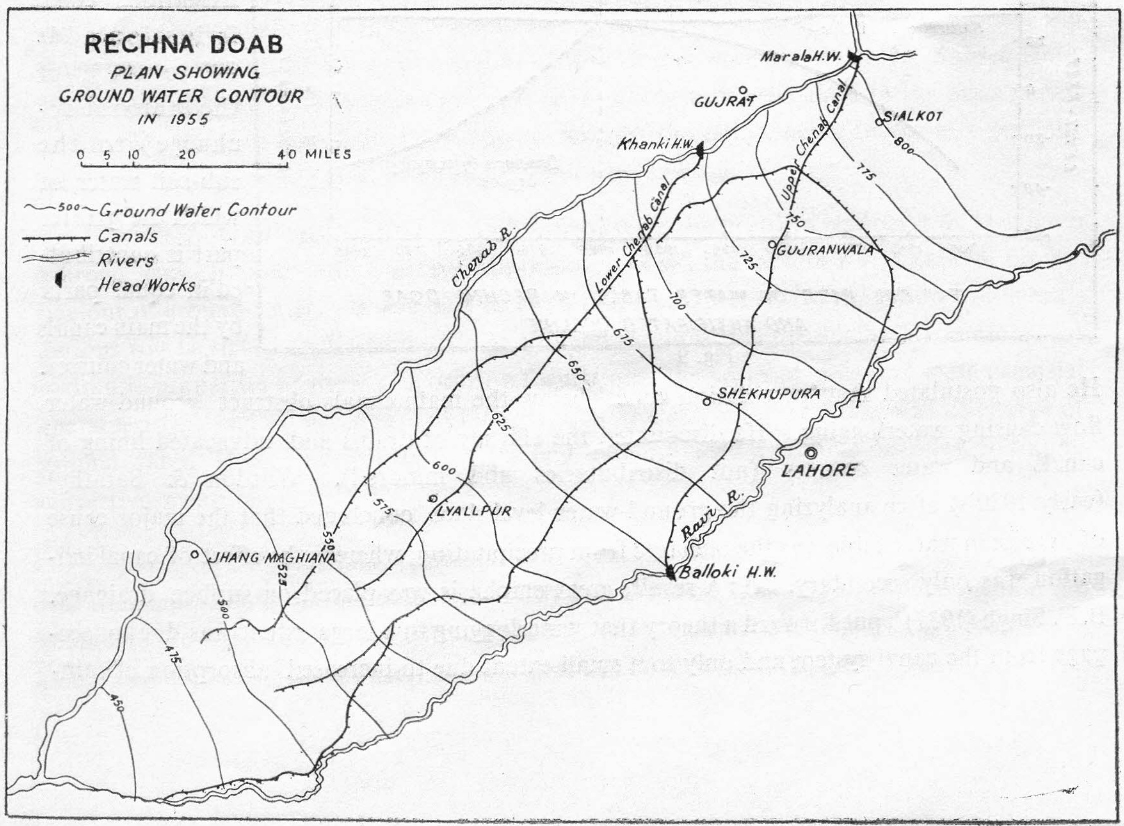

RECHNA DOAB
PLAN SHOWING
GROUND WATER CONTOUR
IN 1920
0 5 10 20 40 MILES
500 Ground Water Contour
Canals
Rivers
Head Works
Marala H.W.
GUJRAT
SIALKOT
Khanki H.W.
Upper Chenab Canal
Lower Chenab Canal
Chenab R.
GUJRANWALA
SHEKHUPURA
Ravi R.
LAHORE
LYALLPUR
JHANG MAGHIANA
Balloki H.W.
750
725
700
675
650
625
600
575
550
525
500
475
450

Fig. 7


RECHNA DOAB
PLAN SHOWING
GROUND WATER CONTOUR
IN 1955
0 5 10 20 40 MILES
500 Ground Water Contour
Canals
Rivers
Head Works
Marala H.W.
GUJRAT
SIALKOT
Khanki H.W.
Upper Chenab Canal
Lower Chenab Canal
Chenab R.
GUJRANWALA
SHEKHUPURA
Ravi R.
LAHORE
LYALLPUR
JHANG MAGHIANA
Balloki H.W.
800
775
750
725
700
675
650
625
600
575
550
525
500
475
450

Early Measures to Control Waterlogging and Salinity

Various anti-waterlogging measures have been tried in the Rechna Doab during the last fifty years. These measures generally did not follow in a logical sequence and were mostly dictated by individual views on the causes of waterlogging. A great controversy prevailed as to the component of ground-water recharge which was most instrumental in the rise of the water-table and on the effect of seepage from canals on the ground-water flow. To quote a few; Elsden (1921)[2] concluded that according to rainfall and intensity of irrigation, canal irrigation adds 200 to 600% (of the natural recharge) to the sub-soil water, of which the greater part is contributed in equal parts by the main canals and water courses.

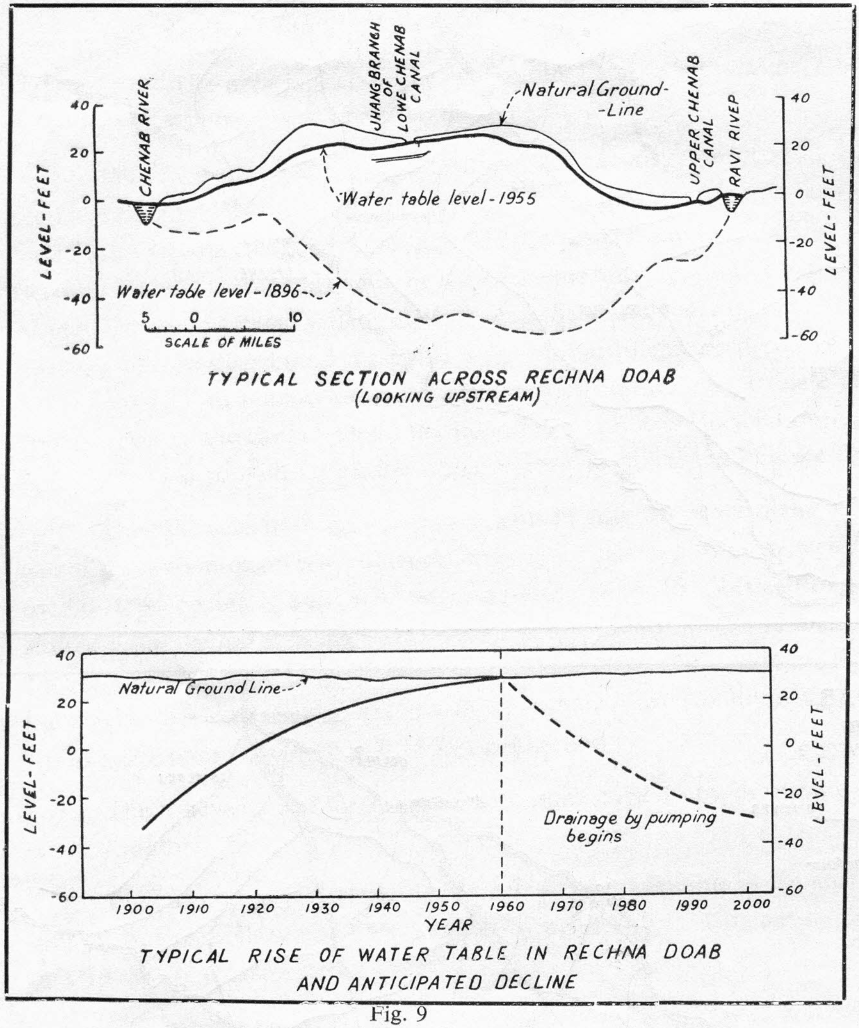


Fig. 9

He also postulated that 'percolation cones' below the main canals obstruct ground-water flow causing waterlogging. He discounted the efficacy of drains and advocated lining of canals and water courses (not distributaries and minors !). Wilsdon & Sarathy[5] (early 1920's) after analyzing the ground-water level data concluded that the major cause of the rise in water-table was the recharge from precipitation, whereas the effect of canal irrigation was only secondary. As a result, great emphasis was placed on surface drainage. B.N. Singh (1937)[7] put forward a theory that waterlogging to a large extent was due to seepage from the canal system and only to a small extent due to increased absorption of rainfall resulting from breaking up of new areas for cultivation. He suggested drains as a solution and considered pumping by tubewells as having a local and temporary effect. Khangar[8] (1947) estimated that in Lower Chenab Canal System, the contribution to the water-table from irrigation channels and rainfall was in the ratio of 2 : 1.5 whereas for the Upper Chenab Canal it was 1 : 2. He advocated lining of distributaries and water-courses and adoption of tubewells as a method for sub-surface drainage. He, however, did not favour seepage drains on account of their purely local effect and the use of surface drains on a very limited scale was suggested. Nazir Ahmad and others (1959)[10] after analyzing water table data formulated the view that clay lenses obstruct the sub-soil flow of water which is insignificant and completely blocked at places and this has caused the infiltered water to rise upward rather than establish a sub-surface gradient. He ascribed the lack of sub-surface drainage as an impediment to the reclamation of saline soils by leaching, and suggested the circulation of the stagnant water and redistribution of salts in thicker zones.

Methods of Control : The various methods which were adopted for controlling water-logging and salinity are briefly described below :

From 1908 to 1918 there was a great emphasis on surface drains and a beginning was made with the lining of main irrigation channels and 12 miles, scattered over different channels, were lined. No substantial progress was made from 1918-26 due to World War I but in the period 1926-33 a number of measures such as provision of seepage drains along the Main Canals, lowering of full supply levels in canals by eliminating canal falls, and restricting of canal supplies were tried. A few tubewells were also installed. However all these measures resulted in doubtful benefits. From 1933 to 1941, surface drainage was given great emphasis and a large number of new drains were constructed. Subsequently a new approach was tried which consisted of installing tubewells close to the main canals and putting the pumped water back into the canals, the object being to create a partially saturated zone below the canals so as to cut down the seepage.

It is significant to note that during all these years the problem was never tackled from a broad concept and with a proper appreciation of all the factors which control the behaviour of ground water. It was only in 1954, that a comprehensive programme of investigations was launched to determine the nature and extent of the sub-surface formations, the hydraulic properties of the water bearing formations, the types of soils and their chemical characteristics, and all other related factors, such as elements of recharge and discharge of ground water. These investigations for the first time provided a rational basis for initiating corrective measures.

Need for Drainage and Additional Water : Waterlogging in the Rechna Doab and the attendant salinity as indicated previously has assumed such large proportions that the economic life dependent on agricultural productivity is threatened. The average crop yields in the area are among the lowest in the world as will be seen from the table 1 below :

TABLE I

Country	Average yields in Maunds per acre				
	Rice	Wheat	Sugar	Maize	Cotton
Rechna Doab (West Pakistan)	15	12	30	8	6
Egypt	40.3	19.9	76.2	29.6	10.9
U.S.S.R.	23.3	10.2	..	11.6	..
U. S. A.	28	14.5	25.5	7.7	..

(One Maund =81.27 Lbs.)

The cause of this low level of productivity is not entirely the waterlogging and salinity of the soils. As brought out previously the irrigation applications are far below the optimum crop requirements. The situation is further aggravated by improper irrigation and agricultural practices, lack of adequate pest control and declining fertility of soil for want of fertilizers. The agricultural production is also limited by the recurring floods which damage standing crops and render the sowing of winter crops impossible in the affected areas.

As a fundamental requirement to the remedy of the above problems of agricultural productivity is the urgent need for controlling the waterlogging and removing the salts from the soils. Unless this is done, efforts in all other directions cannot be expected to achieve any lasting benefits.

In order to control waterlogging it is necessary to depress the water-table, and the salts can be removed by excess applications of water for leaching. These objectives can only be achieved by drainage and supplementary supplies of water over and above the optimum crop requirements.

Ground-Water Conditions in Rechna Doab : Extensive exploratory drilling coupled with electrical resistivity surveys and laboratory testing of formation samples have yielded sufficient data about the nature and extent of water-bearing formations in the Rechna Doab. The storage and transmissibility characteristics have been determined by a series of pumping tests and for the water-table conditions, records are available from the time irrigation was introduced in the region. All this data has helped in an understanding of the ground-water conditions. The sub-surface formations in the Rechna Doab to depths of exploration down to 600 ft. consist of a wide variety of sediments ranging from coarse sands to clays. The clays and silts usually occur in the form of lenses, and there is no evidence to indicate that the less impermeable formations form any barriers to restrict or confine ground-water flow through the sands. The thickness of the aquifers in the 400 feet depth zone was found to vary from 350 ft. in the lower portions of the Doab to less than 100 ft. in the area along the Ravi in the upper reaches. The thickness of the aquifers was also noted to decrease in the vicinity of the Pre-Cambrian outcrops near Chiniot and Sangla where the finer sediments predominate. The transmissibility of the aquifers was found to vary from 0.5 to 1.0 cusecs per foot corresponding to the thickness of the aquifers in the different portions of the Doab, Thus the entire Rechna Doab is underlain by a vast contiguous body of ground-water. Prior to the development of irrigation enterprises there is reason to believe that this body of ground-water was in a state of equilibrium and the water-table as depicted by the earliest observations lay at depths of 40 ft to 50 ft. in the upper reaches, 80 ft. to 100 ft. in the central portion and at shallow depths near the confluence of the Ravi and Chenab. The rivers Ravi and Chenab at that time were influent and the general movement of ground-water was towards the centre of the Doab and down to the confluence where it was discharged, there being a ground-water through between the two rivers as shown in Fig. 9. The conditions gradually changed with the introduction of irrigation systems and a comparison of ground-water contours in 1920 and 1955 (Fig. 7 & 8) would indicate how the upper reaches of the rivers changed from influent to effluent. The present section across the Doab indicates that there is now a ground-water ridge in place of a trough (Fig. 9). The water-table in the upper reaches has more or less reached a position of equilibrium while in the central portions where the water-table is still 15 to 20 feet below the ground surface, it is still rising. The effect of the Delhi-Shahpur Ridge on the movement of ground-water has always been a subject of controversy but the recent investigations have indicated that it does not restrict the ground-water flow materially.

Feasibility of Drainage by Tubewells : To control waterlogging by eliminating the sources of ground-water recharge in Rechna Doab would involve lining of thousands of miles of Canals, Branches, Distributaries and Minors and effective means to dispose off the surface run off before it can contribute materially to the ground-water. These measures to be effective will have to be undertaken throughout the Doab before any marked changes can come about in the ground-water regime. Moreover, even if infilteration were eliminated it will take a considerable time before the high water-table is lowered by the discharge of ground-water to the rivers and to areas down gradient. The cost of such a venture would be so colossal that it is unthinkable at this stage. The obvious alternatives are a system of drains or tubewells which would achieve positive drainage and bring about the desired results in a short period.

Apart from lowering the water-table in Rechna Doab there is a need for additional water supplies to meet the optimum crop requirements and for leaching the salts. The surface sources of supply are presently dependent on river flows which are fully committed. The only way surface sources can be supplemented is by the construction of storage reservoirs which can conserve the flood discharges from going to the sea. Such surface storages will be necessary in Pakistan to bring more land under cultivation and to meet the needs of a growing population, but areas which are already developed cannot depend on these sources for more water. The only other way, resources of supply can be supplemented, is by developing ground-water, and it is in this context that the use of tubewells achieves a dual purpose—providing sub-surface drainage and making usable water supplies available for irrigation.

A system of drains can help in lowering the water-table and provide a means for removing the salts but in areas like the Rechna Doab it has only a limited usefulness. Tube-wells offer the best solution, but their feasibility is dependent on practical and economic considerations. To be successful, the tubewells should be able to achieve the desired lowering of the water-table with a reasonable number and to pay off for their cost, at least partly, the pumped water should be in sufficient quantity for irrigation applications. These factors as applicable to the Rechna Doab are discussed below :

As far as the quantity of available ground-water is concerned the recent studies have indicated that an operational yield of 1.25 ft. depth of water over the gross area can be achieved resulting in the gradual decline of water-table as portrayed in Fig. 9. This yield along with the existing canal supplies is sufficient to meet the crop and leaching requirements for an intensity of irrigation of 100% in the canal irrigated areas (The tube-well supply representing 45% of the total supplies).

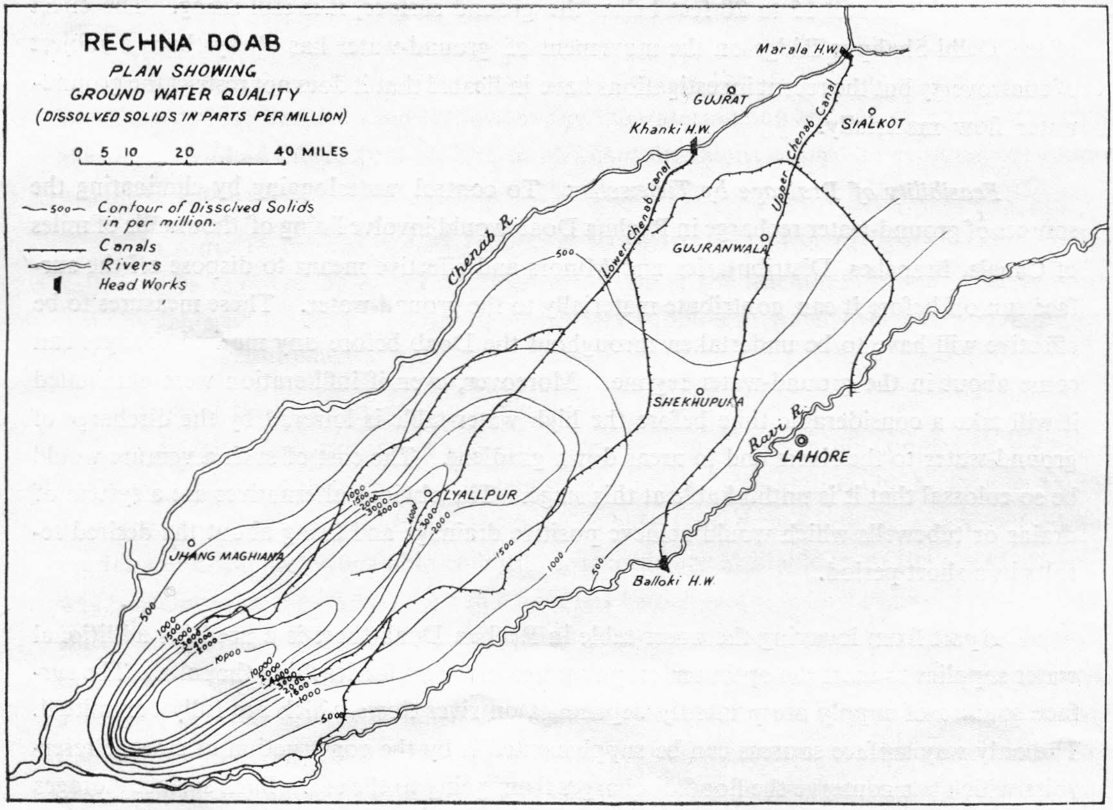


Fig. 10

The chemical quality of shallow as well as deep ground-water has been thoroughly investigated. These investigations reveal that there are no gradational changes which could be expressed by Isochlors as far as shallow waters are concerned. Generally, however, the quality of shallow water is such that it can be used for irrigation. The quality of the ground-water from deep holes is portrayed in Fig. 10 which shows lines of equal dissolved solids in parts per million. From this Map it will be readily apparent that in a major portion of the Doab the ground-water is of excellent quality and when it is considered that this water is to be utilized after mixing with canal waters, its usefulness can be extended to waters of moderate to high salinity. It is only in the lower portion of the Doab that the ground-water becomes highly brackish, but here the water-table is at sufficient depth so that the dangers of salinisation of the soil are not imminent. Ground-waters in a major portion of the Doab can, therefore, be utilised.

The quality of surface waters from the Chenab which irrigates the area is on the other hand highly desirable. Although the salt content varies during the year the dissolved solids average about 250 ppm.

Pumping by tubewells does not result in the removal of the salts from an area as they are circulated and the continual additions of salts even in small quantities from outside sources such as from the irrigation waters can increase the overall salt content of the ground-waters. This aspect in tubewell drainage projects is of vital importance. In the Rechna Doab, however, there is no need to worry on this account. Assuming that the ground-water has an average of 750 ppm, of dissolved salts or 1 ton of slats per acre foot, then in a 200 depth layer of water there would be an estimated 470 million acre feet of water in the Rechna Doab with a gross area of 7.04 million acres, and a corresponding amount of 470 million tons of salts. To render this water unfit for irrigation the salt content will have to be increased four-fold to 3000 ppm or 4 tons per acre foot of water. Therefore, 1410 million tons of salts will have to be added which can only come from the irrigation water in 700 years at 1¼ ton per acre foot. Even if no salts are removed from the area, the possibility of ground-water becoming unfit for irrigation is, therefore, quite remote.

From the above considerations alone a plan of drainage by tubewells is eminently suitable for the Rechna Doab.

First Tubewell Drainage Project in Rechna Doab : Based on the extensive investigations in the Rechna Doab, and subsequent studies carried out, a major tubewell drainage-cum-irrigation project has been taken up since 1958, by the West Pakistan Water and Power Development Authority which is a semi autonomous body. This project called the Salinity Control and Reclamation Project No. 1, covers a gross area of 1.2 million acres served by the Lower Chenab Canal System. The location of the area is shown in Fig. 4. The prime considerations which led to the choice of this area were :

(1) Prior to deterioration, the land in the area had a very high-level of productivity.

(2) The area is among the worst affected by waterlogging and salinity.

(3) From the point of view of geological condition and soil types the area is best suited for drainage by tubewells.

(4) Soil types respond readily to reclamation by leaching operations.

(5) Quality of ground-water is good to excellent.

(6) Area is well developed. Communications, marketing and electric power facilities are available.

(7) The area is a compact contiguous block where the pumping operations can achieve their objective most prominently.

Main features : The project involves the construction of 1800 tubewells having an installed pumping capacity of 5500 cusecs. The pumping capacities of the individual tubewell ranges from 2 cusecs to 5 cusecs. The Capacities and locations of the tubewells have been determined keeping in views the requirements for irrigation. The tubewells are generally located close to the canal water outlets so that the combined canal and tubewell waters after mixing could be distributed most efficiently without the necessity of constructing long link water courses. In places, however, where it was desirable to irrigate areas which are uncommanded by the canal waters, the tubewells have been located on high spots and short links have been provided with the water courses to utilize the balance supplies.

The tubewells have been designed with 18 and 22 inches diameter depending on the use of percussion or reverse rotary drilling rigs. The depths have been specified as 250 ft. to 300 ft. according to the thickness of aquifers met with. Instead of screen 10 inch dia, slotted pipes having 1/16 inch wide openings to provide 30 sqaure inches of entry area per foot of pipe have been adopted., with gravel shrouding. Normally the length of slotted casing would vary from 100 to 150 ft. resulting in theoretical maximum water velocities through the slot openings from 0.10 to 0.15 feet per second.

The tubewells will be equipped with multistage deepwell turbine pumps operated by electric motors.

Electric energy for operating the tubewells is available in the area and the electrification of the tubewells would only involve laying of 11 kw. distribution lines and installation of step down transformers.

The project is under execution at the moment and is scheduled for full operation by the end of 1961.

In order to achieve the maximum benefits from the project it has been proposed to set up a Reclamation Management Organisation, which would ensure that the operation of the tubewells is properly co-ordinated with canal supplies for efficient distribution and water-table control, and that proper reclamation practices are adopted by the cultivators. This Organisation will also keep under constant review the changes generated by the ground-water withdrawal, particularly in respect of the water-table decline, changes in chemical quality and re-evaluation of the assumptions about the operational yield. Keeping in mind that the completion of drainage projects does not mean the solution of all problems, but only marks the beginning for the efficient pursuit of land and water management, the proposed Organisation should be able to achieve the objectives of bringing the lands back to full life and maintaining their productivity.

Financial and Economic aspects : No engineering enterprise can be justified on its merits alone unless the benefits derived therefrom are economically and financially acceptable. The salinity Control and Reclamation Project in this respect has a high order of justification.

If drainage is not provided, at the present rate of deterioration virtually all lands would ultimately become unproductive. In such a case the only alternative would be abandonment of extensive irrigation works and other improvements, relocation of the population now resident in the area to a new area not affected by waterlogging and salinization, and construction of new works to serve an area capable of producing the corresponding amount of food and fibre this area has produced in the past. Obviously the cost of this alternative would be many times the cost of drainage works.

The initial cost of tubewells under the project works out of Rs. 88 per irrigated acre, and the annual operational expenses as Rs. 15.5 per acre. If the tubewell water were charged at the existing rates for canal water then annual cost of tubewells debitable to drainage would work out to Rs. 10/- per acre. If adequate water supplies were available, as an alternative to tubewells, a system of tile and/or open drains would be a fundamental requirement. It is estimated that such a system would cost about Rs. 225 per irrigated acre in initial cost and the annual cost would be of the order of Rs. 10 to 12 per acre. It would therefore be evident that as a means for drainage alone the tubewells are financially more justifiable than a system of drains.

Aside from their justification for drainage the tubewells are an economically attractive source of supplementary water for irrigation. In the project area the present canal supplies delivered are 1.15 million acre feet annually. The tubewells will supplement this supply by 1.46 million acre feet and provide optimum crop requirements to an area of 1.08 million acres, 17.5% greater than the present cultural area commanded by canals. If the entire annual cost of operating the tubewells is realized by the sale of the water produced, the rate per acre foot will amount to Rs. 11.4 against the canal water rate of Rs. 4 per acre foot. That this water rate for the tubewell water is not excessive has been brought out by the studies carried out to determine the increase in productivity. It is estimated that with adequate drainage and reclamation the gross annual value of crop production would increase from the present level of Rs. 120 to Rs. 210 per acre. The increase in cost of production exclusive of water charges is estimated at Rs. 40 per acre (from Rs. 80 to Rs. 120). There would thus be an increase in farm incomes of Rs. 50 per acre before payment of water charges. The present canal water charges are Rs. 5 per acre whereas the tubewell-cum-canal supplies would amount to Rs. 19.5 per acre so that even after payment of all water charges there would be a net increase in farm incomes of Rs. 35.5 per acre annually.

With substantial rise in yields the gross value of crop production is estimated to increase from Rs. 111 million to Rs. 226 million annually. This increase amounting to Rs. 115 million is more than the capital cost of the project of Rs. 95.3 million.

The above financial estimate is based on the average annual operating expenses which includes fixed charges for the repayment of capital in 20 years at 3.5% interest and a sinking fund reserve to replace the pumps and motors in a 20 year period at 2% interest. The useful life of the tubewells is conservatively estimated to be 40 years so that the benefits over the life of the project are likely to be even more favourable.

Ancilliary benefits of the tubewells project : With the operation of the tubewells it would be possible to draw the water-table down to depths much greater than what is practical with a system of drains. This will have a direct benefit in reducing evaporation losses and conserving about 1 foot depth of water per year which would otherwise have been lost with an open drainage system. By lowering the water-table, the tubewell system would tend to minimize the threat of floods, as the absorptive characteristics are improved, and a greater component of recharge from rainfall and overland flows would be available for re-use. Also a much larger storage space would be created for possible recharge by overland flows during occasional peak flood periods.

The elimination of waterlogging would help in improving the sanitary conditions and controlling malaria which is widespread in the area. This will lead to better standard of health.

The network of distribution lines to energize the tubewells would make electric power available to remote villages where it will foster small scale industry and remove to some extent the pressure on the land.

Conclusion : The above presentation brings out the urgent need for sub-surface drainage in the Rechna Doab and the conditions prevailing there, which have b en determined to a large exten by an appropriate programme of investigations clearly demonstrate the feasibility if drainage by tubewells. The Salinity Control and Reclamation Project No. 1 which has been undertaken in this area gives concrete evidence that tubewells are both economically and financially superior to any other method of drainage. To correct the situation now prevailing in the rest of the Doab and in other areas of West Pakistan, more and more drainage projects by use of tubewells, therefore, need to be examined and initiated as early as possible. The responsibility for this task must rest with large Government Organisations as the extent and magnitude of the drainage problem is beyond the means of the cultivators and requires co-ordinated efforts by many men in different fields at all stages from the investigations to the planning, design, execution and finally operational management of schemes.

REFERENCES

1. Hussain, Iqbal—Waterlogging. Paper No. 52 Vol. VII proc. Pb. Engg. Cong. 1919.

2. Elsden, F. V.—Waterlogging from irrigation canals in Alluvial Soil. Paper No. 68, Vol. IX Proc. Pb. Engineering Cong. 1921.

3. Middleton, H. H. T.—Sub-soil Water in the Punjab Plain. Paper No. 72, Vol. X. Proc. Pb. Engg. Cong. 1922.

4. Wilsdon, B. H.—Percolation and Absorption of Water in the Soil Paper No. 78, Vol. XI Proc. Pb. Engg. Cong. 1923.

5. Wilsdone Sarathy.—A Statistical Examination of the Sensitivity of Water Table to rainfall and Irrigation—Memoir, Vol. 1, Pb. Irr. Res. Lab. 1927.

6. Wilsdon, B. H. and Bose, N. K.—A gravitational survey of the Sub-Alluvium of the Jhelum—Chenab—Ravi Doabs and its application to Waterlogging. No. 1, Vol. VII, Pb. Irr. Res. Inst. 1934.

7. Natha Singh Bawa Rai Bahadur.—Waterlogging on the Upper Chenab Canal, its causes and cure. Paper No. 197, Vol. XXV. Proc. Pb. Engg. Cong. 1937.

8. Khanger, S. D., Rai Bahadur.—Waterlogging in Western Punjab. Paper No. 284 Vol. XXV. Proc. Pb. Engg. Cong. 1947.

9. Maierhofer, C. R.—Reconnaissance Report on the Drainage, Waterlogging and Salinity Problems of West Pakistan. U. S. Department of Interior, U.S.B.R., 1952.

10. Nazir Ahmad.—Soil Salinity in West Pakistan and means to deal with it. Symposium on Salinity Problems in Arid Zone, UNESCO Iran, 1959.

11. Blaney, H. F. and Criddle W. D.—Report on Irrigation Water Requirements for West Pakistan. Tipton and Kalmbach, Inc. 1957.

12. Fraser, I. S.—Report on a Reconnaissance Survey of the Land forms Soils and present land use in the Indus Plains, West Pakistan. Colombo Plan Project, Government of Canada, 1958.

13. Salinity Control and Reclamation Project-West Pakistan Water and Power Dev. Authority, 1959.

14. Kazmi, A. H.—Report on the Geology and Ground Water Investigations in Rechna Doab (West Pakistan). Adm. Report No. 25 Geol. Sur. Pak. 1959.

15. Nazir Ahmad, Dewan Ali and Afaz Ahmad.—A new concept on the waterlogging and the Salinity problem of Rechna Doab, Symposium, on Waterlogging and Salinity in West Pakistan, W. Pak. Engg. Cong. 1959.

16. Sarathy Partha R.—A Statistical Examination of the Sensitivity of a Water Table to Rainfall and Irrigation. Memoirs of the Punjab Irr. Research Lab. No. 2, Vol. 1, November, 1928.

17. Sarathy Partha R.—A Statistical Examination of the Sensitivity of a Water Table to Rainfall and Irrigation. Memoirs of the Pb. Irr. Research Lab. No. 1, Vol. 1, June 1927.

MANCHHAR LAKE

M. M. MEMON

Sind University, Hyderabad.

THE big fresh-water Manchhar Lake in the Lower Indus Basin, at the foot of the Kirthar Range, with its highly pulsating expanse from 14 to 200 square miles forms an attractive surface feature. The Sindhi word Manchhar is a compound of 'man' (a jewel or crystal) and 'char' (expanse of water after rains). Thus Manchhar means a crystal or jewel-like expanse of water after rains. According to Captain T. Postans, the name Manchhar may be supposed to have been derived from the ancient Muslim town of Mansura[1] which according to the reports of Al-Idrisi and Abul-Fazl should have been somewhere in the region of this lake. However, this conjecture does not seem to be correct, as the ruins of the settlement unmistakebly identified with Mansura have been recorded by H. Cousins on the eastern side of the Indus in the former Sind Province[2].

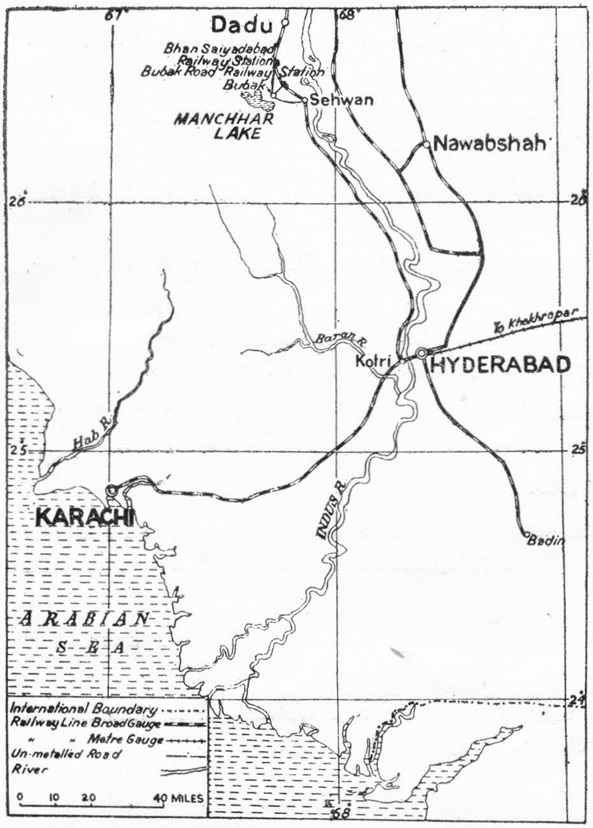


Fig. 1 Location map, Showing Position of Manchhar-lake in the lower Indus Plain.

Manchhar Lake is an alluvial depression and is situated in the middle of the Western valley section of the Lower Indus Plain between longitude 67°-34′ and 67°-43′ E and latitude 26°-23′ and 26°-28′ N. (Fig. 1) It occupies the extreme southern portion of the depressed area formed by the dipping of Kirthar rocks near the flanks of the mountains and the high bed of the Indus. On its north-west and southeast are the Piedmont Plains of the Kirthar Range, while on the northeast is the Old Flood Plain of the river Indus. To the west and southwest are the exposed Bed rocks which also encircle the Alluvial Fan deposits south of the Piedmont Plain. Towards the east of the exposed bed rocks and the old Flood Plain is the Active Flood Plain of the river Indus. (Fig. 2).

Lake Manchhar is fed by the Western Nara and the Aral which take their waters from the Indus, and also by numerous hill torrents which flow down the mountains on the west and south during the rainy season. Some of the important hill torrents are Gaj Nai, Mazarani Nai, Khenji Nai, Dilan Nai, Nari Nai, Sita Nai and the Salari Nai. The Western Nara, Manchhar and Aral together appear to form a "loop" of the Indus. The loop was for-

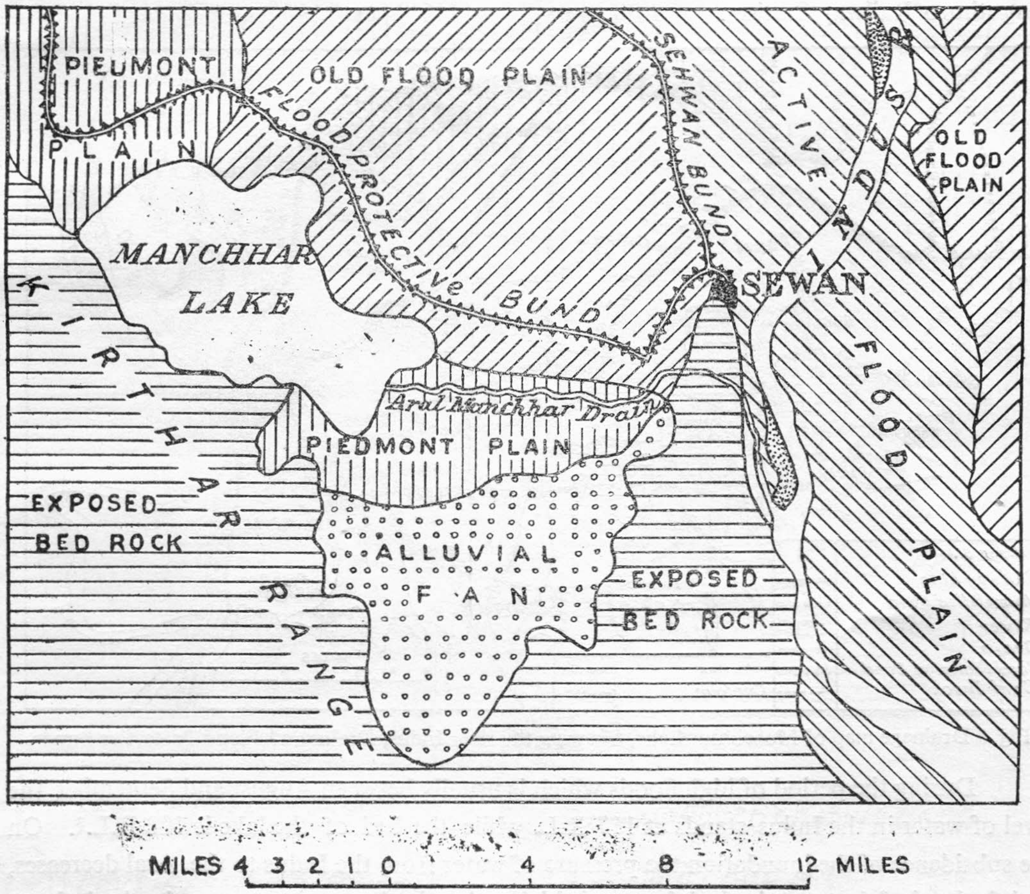


Fig 2 Morphological map of the area around Manchhar lake, Showing Landforms (Based on maps and report on a Reconnaissance Survey of the landforms, Soils and Land use of the Indus plains).

merly called by the two different names of Kumbargundee and Larkhanu river and was once used as a waterway, particulary for boats going up the river during the Summer (April to September) in order to avoid the fury of the current of the mighty Indus. The Western Nara (Nara or 'Naga' in Sindhi means snake so called on account of its serpentine course) which discharges into the lake in the north may reasonably be accepted as an old branch of the Indus on account of its level banks and numerous meanders. It was converted into a canal and is now used as a drain called the Main Nara Valley Drain. The existence of

Lake Manchhar itself may be regarded as the local expansion of the Western Nara channel on account of the rush of flood waters of the Indus during the Monsoons, and further aided by the erosive action of the numerous hill torrents at this point. The Aral stream serves the dual purpose of feeding as well as draining the lake. It leaves the lake at its southeastern extrimity, runs eastward and then takes a turn towards the north, till it reaches the town of Sehwan. From Sehwan it flows southwards for about 7 miles to join the Indus south of Bhagothoro Railway Station.

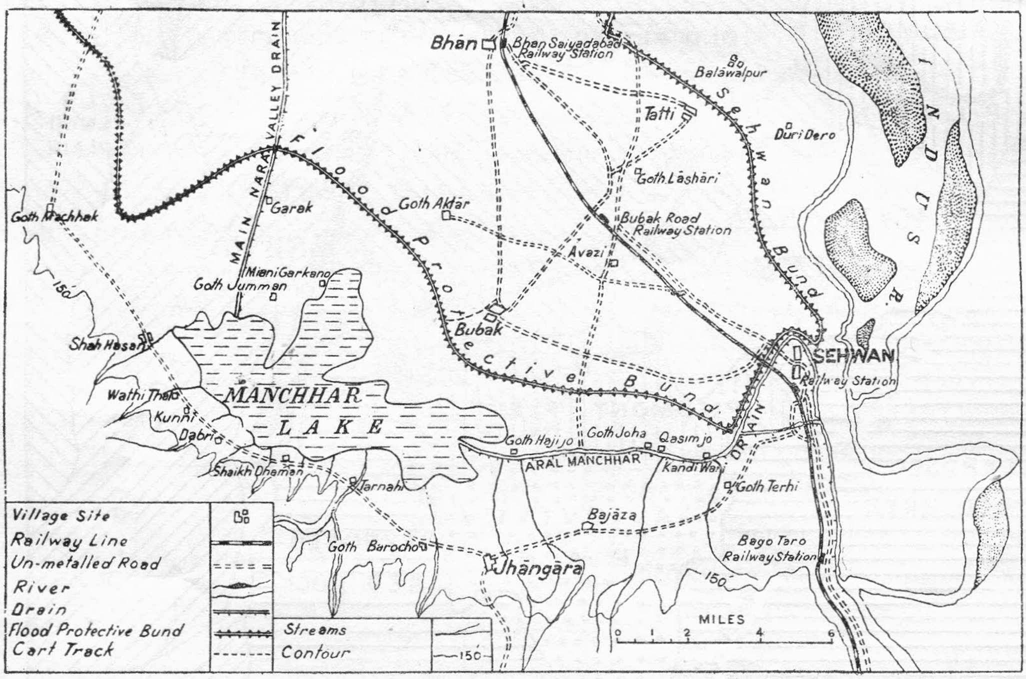


Fig. 3 Drainage map of Manchhrar Lake, Showing the river Indus, Drains and Flood Protective Bunds.

During the period of high floods which is usually between August and September the level of water in the Indus stands at 117 R.L. while the bed of the lake is 100 R.L.[3]. On the subsidence of the inundation the pressure of water from the Indus to the Aral decreases, and the level of the water in the lake stands higher than in the parent stream; the Aral, therefore, now serves as a channel of discharge for the waters back into the Indus. A new channel was excavated about a mile south of the Sehwan Railway Station known as "New Cut" which serves to straighten the course of the Aral in this reach. The portion of the Aral between the "New Cut" and the Manchhar is known as the Aral Manchhar Drain while that between the "New Cut" and its junction with the Indus is known as the Aral Laki. There are two regulators to control the inflow and outflow of water, known as the Aral Head Regulator and the Aral Tail Regulator respectively. The former is located on the Aral loop, west of Sehwan town, while the latter on the "New Cut" to the south-east of the Sehwan Railway Station. The incoming water has to pass through the Head Regulator, while the outgoing passes through the Tail Regulator (Fig. 3).

The lake extends from north-west to south-east for about 10 miles with an average breadth of about 3 miles. Its depth is from 8 to 10 feet only. During the period of inundation it increases in size to about 20 miles in length, 10 miles in breadth, and near about

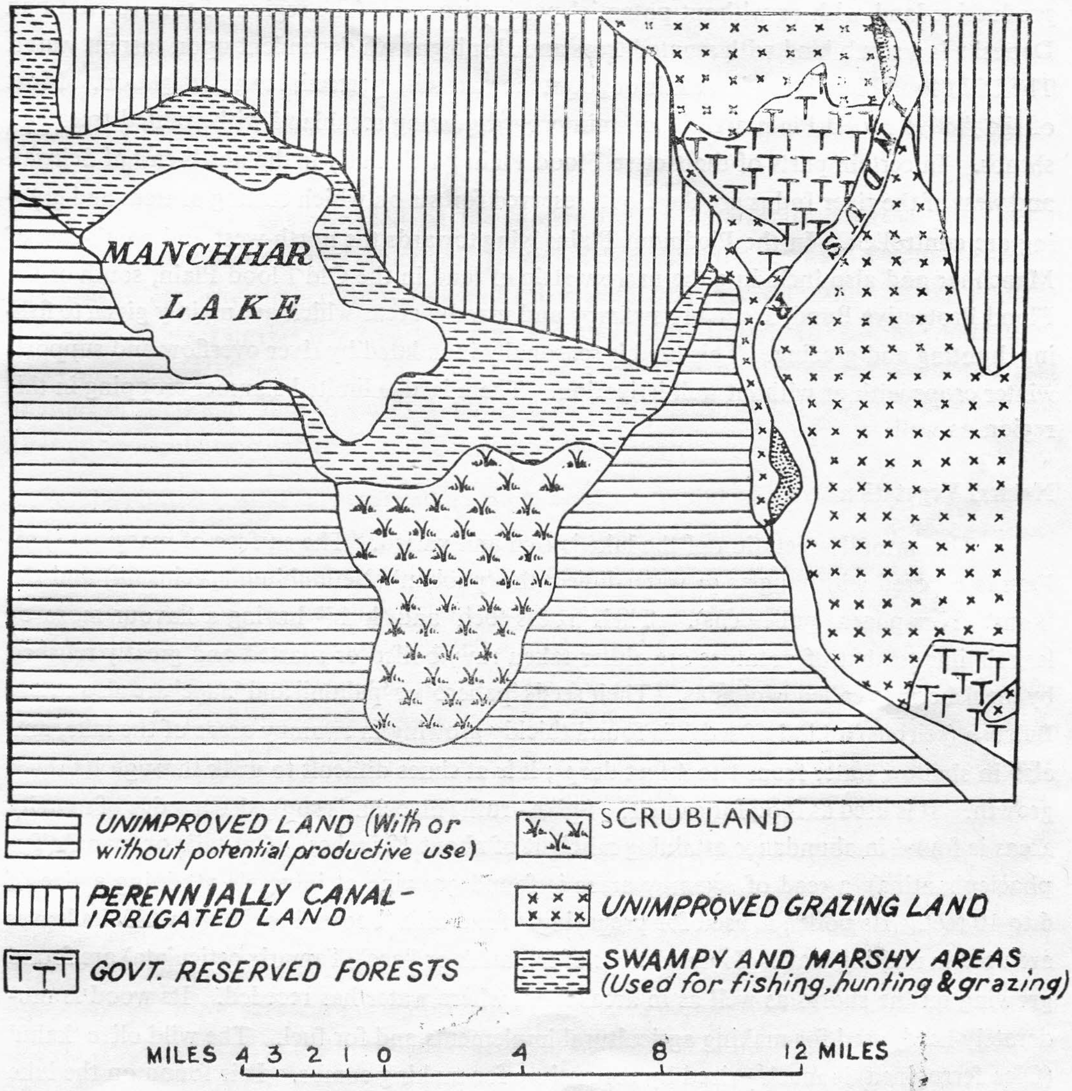


Fig. 4 Land use map of the area around Manchhar Lake, Showing predominant Land use (based on maps and report on Reconnaissances Survey of the Land forms Soils and Land use of the Indus plains).

200 square miles in area[4]. During the off season *i.e.*, dry season, it shrinks to 14 square miles only. The land thus secured by the receding of the water which is about 186 square miles is devoted to the raising of Rabi crops like wheat, gram, barley, peas and mustard etc., and yields good crops. Incidentally it is these cultivations, which serve as pasture to the countless wild birds of this beautiful lake.

Land Use

The Land Use of the area around manchhar Lake is given in Fig. 4 A comparative study of Fig. 2 and Fig. 4 reveals that the Exposed Bed Rock area is presently unproductive land with or without potential productive use. The region of the Alluvial Fan Deposits is a scrub land with stunted trees and shrub growth dependent upon torrent water. The Old Flood Plain is cultivated throughout the year with perennial canal irrigation. Most of the Active Flood Plain area is an unimproved grazing scrubland with stunted trees and shrubs. In certain parts of the Active Flood Plain particularly in the north-east of Sehwan and west of the river Indus are the Govt. reserved forests on which cutting of trees and grazing are controlled. In the Piedmont Plains lying towards the north-west and south-east of Manchhar and also including the narrow strip of land in the Old Flood Plain, south of the Flood Protective Bund, are many swampy and marshy areas which are mainly given to fishing, hunting and grazing. This land is seasonally inundated by river overflow and supports winter crops with or without well irrigation. There is also limited summer cropping in this region as well.

Natural Vegetation*

The natural vegetation of the lake is rich and varied. The surface of marginal shallows is covered with tangles of water-lillies, the 'pabban' (Nelumbium speciosum) and the 'koni' (Nymphaea pubescens). Their roots 'beh' and 'lorh'[5] having a flavour more or less similar to that of potatoes are either taken raw, boiled or roasted and greatly relished by the fishermen called Mohanas. Their seeds 'pabero' or 'pabuni' and 'nape' are also eaten. Bulrush (scirpus) a kind of sedge is found thickly growing in swampy areas of the lake, and also in shallow water from 1 to 4 feet deep ; it is at times difficult to walk through its thick growth. It is used as food for camels. Spike - rush (Eleocharis spp), also a sedge of marshy areas is found in abundance attaining a height of about 18 inches. Cat-tails or 'pann' (Typhaelephantina), a reed of swampy areas is found growing at intervals attaining a size of 6 to 10 feet. Its pollen is used for preparing a food dish 'boorani' or 'buri' while its leaves are used in making mats. Isolated trees of tamarisk or 'laee' (Tamarix articulata) are found growing on the shores as well as in areas from where water has receded. Its wood is moderately hard, used for making agricultural implements and for fuel. The wild olive 'kahu' (Olea ferruginea) is much prized by the natives for making combs. It is found on the lake banks as also the dwarf-palm or 'pish' (Chamacrops ritchiana) used for making ropes, mats and baskets.

The lake's shores were once forested, difficult to penetrate, and served as the abode of panthers. Other animals found in the neighbourhood were hyaenas, wild hogs, wolves

*This account is primarily based on field-study undertaken in the winter of 1958, along with Mr. Moinuddin Ahmad of Botany Department, Government College, Hyderabad, who helped in identifying the plants and to whom the writer is greatly indebted.

foxes, jackals, the 'pharo' or hog-deer and the Schinkara' or ravine antelope[6]. Much of the animal life has disappeared on account of whole-sale destruction at the hands of man within the last hundred years. All the resources of the lake including its fisheries, birds and vegetable products are state owned, and leased out for a sum of 25 to 30 thousand rupees for a period of one year.

Fishing and Fowling

Manchhar abounds in fish fauna and exhibits a great variety. Practically all the fishes found in this lake belong to ten families, Cpyrinidae, Siluridae, Percidae, Notopteridae, Clupeidae, Belonidae, Anabantidae, Gobiidae, Mastacembelidae and Ophicephalidae, but

Fig. 5 Tall grass grows thickly in the Swampy areas of the lake. Its pollen is used as pood, and leaves are used in mats making.

the lake best represents the first two families[7]. The 'dambhro' or Labeo rohitta (family Cyprinidae) is of far greater importance to the fishermen than any other variety from the point of view of sale and is thus, one of the most highly prized fish of the lake. The 'paila or Hilsa Ilisha (family Clupeidae) which ascends the Indus for spawing reaches the lake through the Aral and is caught-during the months of June and July.

The average annual fish catch was estimated at 75,000 maunds for the year 1954-55 of the total value of Rs. 5,25,000 at the rate of Rs. 7/- per maund at the auctioning centre.[8] Rohu or 'dambhro' accounts for the highest percentage of the total fish catch (35%). Other fish caught are — mirgala or 'morakhi', catla or 'theli', murrel or 'shakur', cat-fish or 'khaggo', hilsa or 'palla', prawn or 'jhinga', 'dohi', 'jerkhi', 'gundan', 'popri' etc.

Fishing is carried on every day except Fridays and a few of the rainy and stormy days. Over 500 boats of all sizes are employed in fishing operations. They are flat bottomed, made of plank and driven by bamboos. They consist of a hold in the middle, elevated platform in the aft, and a small flat deck behind. The hold is invariably covered with a mat roof for protection against the sun, rain and cold.

Various types of nets are employed in fishing *viz* : Gill net or 'nara', drag net or 'paree' conical net or 'kurri' and fixed net or 'bhan'. The gill net or 'nara' is used to catch big fish and has a mesh of about 4 inches. Fishing in the lake is not easy because a thick growth of weeds and water lilies obstructs the spread of nets Fig. 6.

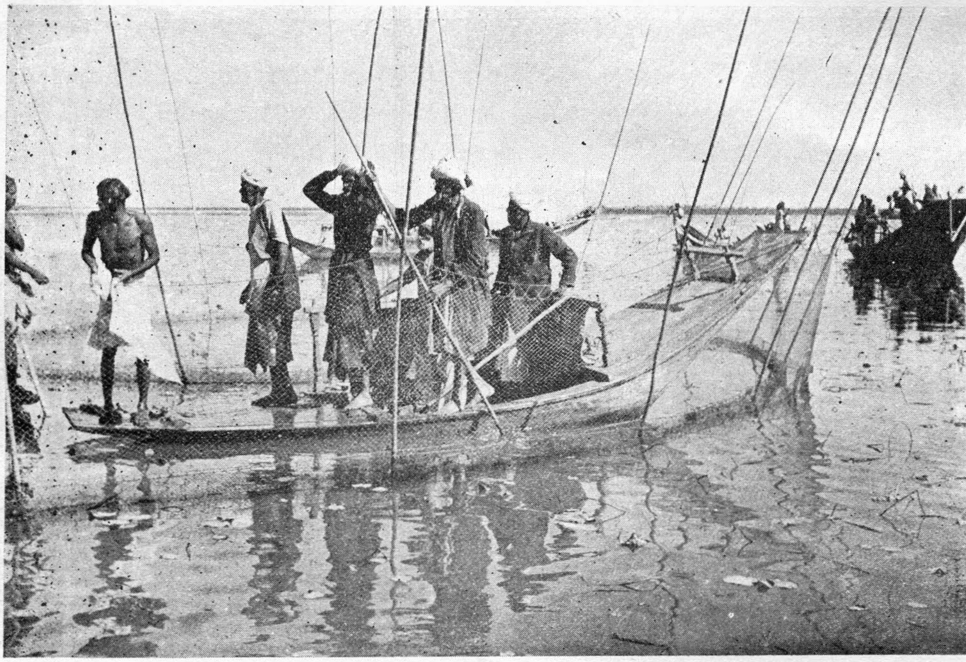


Fig. 6 Mohanas (Fishermen) of Manchhar Lake on a routine Sail for fishing. Note the weeds and water lillies in the foreground which Obstruct the Spread of nets.

When the catch is small and is not worth being taken to the auctioning centre for sale, the Mohana (fisherman) keeps the fish alive by resorting to a cruel method. He drives a needle with twine through the gill and similarly treating others he fastens the bunch to his boat, so that they keep floating in water till they are carried to market for sale the next day. Fishing starts early in the morning and is over by about mid-day. The catch is then sold to a few commission agents. The stock is later auctioned and by evening packed and carried to Bhan Saidabad and Bubak Road Railway Stations for despatch to different destinations. Of the total fish catch 5% is processed by crude un-hygenic methods of salting and drying. 10% finds its way to the neighbouring villages, 20% is consumed by the fishermen and the remaining 65% is despatched to big towns *viz* Karachi, Quetta, Multan and Lahore.

TABLE 1

SHOWING EXPORT OF FISH FROM THE MANCHHAR LAKE DURING THE YEARS 1944 AND 1954, IN TERMS OF BAGS (EACH BAG WEIGHS ROUGHLY 3 MAUNDS).

Months.		1954			1944
		From Bubak station.	From Bhan Saidabad	Total of both stations.	Total of both the stations in 1944.
January	..	1,091	255	1,346	2,600
February	..	409	360	769	2,200
March	..	230	500	730	2,150
April	..	93	100	193	1,500
May	..	48	750	798	1,400
June	..	19	1,050	1,069	2,300
July	..	55	550	605	3,000
August	..	380	450	830	1,050
September	..	283	900	1,183	1,000
October	..	101	1,460	1,561	3,200
November	..	327	465	792	4,400
December	..	235	850	1,085	4,000
Total	..	3,271	7,690	10,961	28,800

SOURCE :—"Report on the Manchhar Lake Fisheries by Moinuddin Ahmad" unpublished (1955).

The tables I and II show the export of fish from the Manchhar Lake during the year 1944 and 1954, as well as 1957-58. According to these tables export of fish was the highest in 1944 (28,800 bags or 86,400 maunds) from both the stations Bubak and Bhan Saidabad. Within a decade *i.e.*, in 1954 it was reduced to less than half of this figure (10,961 bags or 32,883 maunds). During the year 1957-58 it was slightly higher than in 1954 (11,789 bags or 35,367 maunds). From these export figures it may be safely assumed that the production too, has declined by about 50% of what it was in 1944, and this may be attributed to unabated silting and depositing of vegetable matter from weeds and water hyacinth.

TABLE 2

SHOWING EXPORT OF FISH FROM THE MANCHHAR LAKE FROM SEPTEMBER 1957 TO AUGUST 1958, IN TERMS OF BAGS (EACH BAG WEIGHS ROUGHLY 3 MAUNDS).

Months		From Bubak station	From Bhan Saidabad station.	Total
September, 1957	..	910	12	922
October, ,,	..	820	44	864
November, ,,	..	297	234	531
December, ,,	..	1,219	474	1,693
January, 1958	..	1,248	450	1,698
February, ,,	..	1,054	179	1,233
March, ,,	..	1,127	267	1,394
April ,,	..	1,148	212	1,360
May, ,,	..	1,515	325	1,840
June, ,,	..	..	133	133
July, ,,	..	..	77	77
August ,,	..	..	44	44
Total	..	9,338	2,451	11,789

SOURCE :—"Report on the Biological and Chemical conditions of Manchhar Lake" by Dr. A.J. Faruqi & Mohammad Yunus Khan, etc., unpublished, 1959.

The fish is packed by the dealers in mat-cum-gunny bags with ice flakes. It is unfortunate that about 25% of the total fish catch forms the share of the lake contractors, another 25% of the local commission agents, while the remaining 50% goes to the fishermen. It is, infact, the dealers which make the maximum profit (200 to 300%) by selling fish on attractive rates in large towns while the poor fishermen get the lowest.

Means of communication and transport of fish are poor. The catch is carried by head loads, horse loads and by cart loads to Bubak Road and Bhan Saidabad Railway stations for onward despatch to distant stations. Proper facilities for ice making, blast freezing, cold storage, processing of dry-salted and hot smoked fish and transportation, if provided, would go a long way in the development of this industry on sound lines.

One of the most fascinating features of Manchhar is, the variety of its bird-life, Wild fowls in countless numbers migrate southward to escape the icy cold winters of their northern homes and take refuge on the peaceful waters of this beautiful lake. The winter grain crops on the drained off portions of the lake considerably add to their attraction by providing rich pasture grounds. At times, their number in certain portions of the lake is so great that the eye can see nothing but floating water fowls spattering and quacking. Coots are found in their tens of thousand and outnumber all the other water fowls. Their stupidity makes them fall an easy victim to the ingenious devices of both the fowler and the marksman. Despite wholesale destruction their numbers does not appear to dwindle and they return each year equally strong during the winter season. Other birds found on the lake are Starlings, Wagtails, Eagles, Cranes, Starks, Ibises, Herons, Geese and numerous varieties of ducks; there is also the Pied Kingfisher, the Indian Purple Moorhen, the White-tailed Lapwing, the Black-Tailed Godwit, the Caspian Tern, the Little Grebe, the Spoonbill, the Pale Harrier, and the Desert Buzzard[9]. It has been estimated that the lake harbours more than a thousand varieties of birds.

There are various methods of entrapping ducks. At times as many as thousand birds are collected in a single operation and then despatched for sale to many places, particulary, Karachi. Coots in which this lake abounds are also killed by bows and arrows.

Manchhar is a source of sustenance to about 5,000 people. Fishing, fowling, boat plying, farming, gathering of lotus seeds and roots are the chief occupations of the people. As many as 2,000 persons are actively engaged in fishing and nearly a quarter of this figure in fowling and other allied occupations. Young boys take active part in fishing to help their parents and women assist in plying boats, knitting and repairing of nets and gathering of lotus seeds and roots. The per capita monthly income is as low as Rs. 40/- and within this amount a Mohana has to provide food, clothing and shelter to a family of about half a dozen members.

People

Practically all the people inhabiting the Manchhar and its shores are Mohanas or Mirbahars (meaning sea-lords or admirals). They either live in their floating habitations with all their worldly belongings, or, in the small settlements very near the banks of this lake. The Jhinwar and Machhi who follow their avocations on land and the Mallah and Mohana on water, all belong to the same caste. The Mohanas are in fact the original inhabitants in the former Sind and have directly decended from the aboriginal Hindus who later embraced Islam[1]. There are also many castes amongst this tribe. The Mohanas are of darkish complexion and look different from other Sindhis. They are tall, stalwart, athletic, laborious, pleasure-loving and merry-hearted and, at the same time, orthodox, uneducated and poor. They are addicted to 'bhang', opium and many other kinds of intoxicants and this bad habit may perhaps, be attributed to their hard and precarious life, most of which is spent either in or on the water. They are, by no means, irreligious; keep fast during the holy month of Ramzan and offer prayers more or less reqularly. Their women are considered beautiful at least by the people of the former Sind Province. Jam Tamachi, one of the rulers of the former Sind had married "Nuren" the beautiful daughter of a Mohana fisherman. The event is celeberated in the legends and Hazrat Shah Abdul Latif Bhitai, the saint poet, has given them immortality in one of his Sufi effusions.

The dress of a Mohana male consists of a vest or shirt and a cloth wrapped about the loins instead of pyjamas ; turban is the usual head wear. Women folk put on shirt and 'shalwar' and use a sheet as a head covering (dopatta). The Mohanas speak Sindhi language although, a few of them have picked up Urdu after the inception of Pakistan.

It is, indeed, painful to find that they have still kept up many of their old un-Islamic practices - always offering salam, as if begging permission to enter the water, lest it might be their grave, making of rice offerings in earthen pots with a cover of red cloth and addressing hymns to the "river - god". Whenever there are caste disputes they are settled by the head men, who are called 'changa mursa', and invested with full powers to administer justice to those who consult them.

Conclusion

If it is intended that this most productive of all the lakes in the country should continue to serve and beautify the natural landscape of Dadu District in particular, and West Pakistan, in general, then necessary measures shall have to be taken, in order to save it from its impending doom of being turned into a marshy area, not in a very distant future. The lake is getting shallower every year due to unabated silting, further aided by the depositing of layer after layer of decomposed vegetable matter derived from weeds and water hyacinth. If the present situation is allowed to deteriorate any further, it might result in depriving the province of West Pakistan of a rare reservoir of fresh water fauna and a beauty spot. Ours is chiefly a meat consuming country and an ever increasing shortage of animal proteins is now being experienced. It is, therefore, an urgent necessity to preserve and utilize the immense natural wealth which this lake so bountifully offers.

It is in the interest of Manchhar lake fisheries that a public fish marketing company on the lines of "The Uganda Fish Marketing Corporation Limited" (Tufmac) should be floated which would purchase all its supplies of fish from individual licensed fishermen operating on the lake. It should collect the catches daily from the fishermen, after paying an assured price of every pound of fish caught. It should be the business of the company like the Tufmac for supplying fishing requirements and food at below the normal retail prices ; to provide financial assistance to the fishermen in the purchase of their boats and fishing gear ; and in general an effort to provide a useful service as well as a useful livilihood to the fishing community.

This vast expanse of safe and limpid water is an ideal place for those fond of angling, shooting, swimming, boating and picknicking. Hilly ranges close to the lake abound in red deer and thus afford excellent opportunities for the hunters. It is in the interest of the country that a suitable area of land all around the lake immediately be declared as a "National Park" by the provincial government as has been done in the U. S. A., Canada and other progressive countries of the world. The development of orchards, parks and forests along the shores of this lake would, no doubt, considerably add to its charm and attraction. The creation of a National Park can be achieved by honouring existing rights and without disturbing the people from the fishing settlements. Occupation of these settlements can, of course, be subject to control and fishing, in general, be closely supervised and managed by the Game and Fisheries Department.

REFERENCES

1. Postans, Capt. T. and Knight, R.C. .. Reports on the Manchhar Lake, Aral and Nara Rivers, journ. Roy. Asia. Soc. Great Britain and Ireland, lst Series Vol. VIII 1846. P. 381.
2. Cousins, H. .. .. .. The Antiqutties of Sind, Calcutta, 1929. pp. 48 and 66.
3. Information obtained by the writer from the Executive Engineer, Southern Dadu Division, Irrigation Branch, P. W. D.
4. Pithawala, Maneck, B. .. .. A Geographical analysis of the lower Indus Basin (Sind) Part I, Karachi, 1936. P. 303.
   Basin (Sind), Part I, Karachi, 1936. P. 303.
5. Hughes, A. W., Gazetteer of the Province of Sind, London, 1876, P. 696.
6. Ross, David .. .. .. The land of the five rivers and Sindh, London, 1883. P. 49.
7. Prashad, B. .. .. .. On the Fishes of the Manchhar Lake (Sind) Journ. Bom. Nat. Hist. Soc. Vol. XXXIV No. 1 1930, P. 165.
8. Ahmad, Moinuddin .. .. Report on the Manchhar Lake Fisheries, (unpublished), 1955. P. 5.
9. Salim, A. Ali .. .. .. A Sind Lake, Journ, Bomb. Nat. Hist. Soc. Vol: XXXII, No : 3, 1928 P. 471,
10. Burton, Richard, F. .. .. Sindh Revisited, Vol. 11, London, 1877. P. 197.
11. Ibid. P. 197.

NEWS AND NOTES

REPORT OF THE VISIT OF THE PANJAB UNIVERSITY STUDENT-TEACHER DELEGATION TO EAST PAKISTAN 10TH JANUARY—25TH JANUARY, 1961

Under the auspices of the Department of Geography and with the co-operation of the Bureau of National Reconstruction, Government of West Pakistan and the Asia Foundation, Lahore, a delegation of the students and teachers of the University visited East Pakistan on the occasion of the Pakistan Science Conference.

The visit had for its purpose :

(*i*) attending the Pakistan Science Conference at Dacca,

(*ii*) field-study of East Pakistan and

(*iii*) promotion of good-will between the two wings of the country.

The delegation consisted of 25 students of the Department of Geography, Panjab University, Lahore, including 9 girls, and 6 teachers of the University, including 1 lady teacher.

The delegation left Lahore for Dacca on the 10th/11th January and came back on the 25th.

The tour proved both interesting and instructive and also helped in re-inforcing the good-will that exists between the two parts of the country.

The tour was instructive from the very beginning. The panoramic view of the changing physiography of the Indo-Gangtic plain from west to east could best be had through an air journey. The sight of the Himalayas in the north in a long reach of the flight and the scenery of the Rajmahal Hills in the other section were interesting. The distribution of water-bodies, numerous Bhils and winding rivers over west Bengal and East Pakistan was almost fascinating. Similarly, much useful information was gathered about the rural and urban land-use over the plain, as also about water-logging in the western parts of the Indian plain.

The rail journey from Dacca to Chittagong, the bus journey to Kaptai and rail-bus journey to Cox's Bazar enabled the delegation to cover large representative areas of East Pakistan, with dominant amphibious character and its impact on the agricultural scheme of that part of the country and on the overall human activity. The potentialities were appreciated of the Kaptai Project as a multipurpose scheme and of Cox's Bazar as an attractive tourist centre of East Pakistan.

The rail journey from Cox's Bazar to Sylhet and therefrom to Dacca was equally useful. The visit to the tea gardens in Sylhet revealed many aspects of the industry which could only be vaguely understood by the study of books.

The programme of the delegation in East Pakistan was chalked out by the Bureau of National Reconstruction at Dacca in co-operation with the Dacca University Geography Department. It was so well organized and so well conducted that it proved an unqualified success. The delegation is extremely thankful to all who contributed to the success of the delegation. The list includes a number of officials, the Chief Secretary of East Pakistan, the Director of the Bureau of National Reconstruction and his deputies, Dacca, the Deputy Commissioner of Chittagong and Sylhet, and the S. D. O. of Cox's Bazar and particularly our thanks are due to Dr. Nafis Ahmad, his Collegues and the team of his students who made our stay in Dacca so happy and interesting.

KAZI S. AHMAD

THE THIRTEENTH ALL PAKISTAN SCIENCE CONFERENCE

The 13th Annual session of the Pakistan Science Conference was held at the Dacca University from January 11, to 16th, 1961. The opening was inaugurated by Gen. Azam Khan, Governor of East Pakistan.

The General President of the Conference was Professor Dr. Abdul Salam.

The sectional meetings of the Geography, Geology and Anthropology were held in the Department of Geography, University of Dacca. Due to illness of Dr. N. M. Khan, Deputy Director-General, Geological Survey of Pakistan, Prof. Dr. Kazi S. Ahmad presided over the meetings. Dr. Fazal-i-Karim from the Dacca University worked as the Secretary.

The meetings of the section were attended by a large number of delegates from Panjab, Sind and Rajshahi Universities, and by the Officers of the Geological Survey of Pakistan. After the sectional meetings, the delegates left for a river-trip to Narayangunj and visited the Adamji Jute Mills. Few other local trips were also arranged.

The following papers were contributed :—

A. H. Kidwai .. Application of Aerial Photographs to Geologic Mapping in Pakistan.

2. William R. Hemphill. Application of Photogrammetry to isopach mapping, structure contouring and other similar Geologic problems.

3.	K. U. Kureishy and Miss M. K. Elahi.	Agrieulture Land Use of Chak No. 47 N. B. (Sargodha).
4.	Md. Shafiqullah	The Structure of the Karnaphuli Valley between Rangamati and Barkal.
5.	Miss Meher Akhtar.	Cox's Bazar : A Tourist Resort.
6.	A. H. Kazmi	The Stratigraphy of Zardalu-Ziarat Area.
7.	M. W. A. Iqbal	Geology of Islamabad Area.
8.	M. I. Chowdhury.	Morphometry of Tributary Streams.
9.	Kazi S. Ahmad and Anis A. Abbasi.	Water Resources of the Indus Plain.
10.	A. H. Kazmi and Mohd. Rafiqul Islam.	Application of Laboratory Tests of Soil Samples to Hydrological Studies of Soils.
11.	M. Rahman ..	Nar-well Irrigation in the Lower Indus Valley.
12.	Farhat Husain	An Abstract on Structure and Coal Reserves for Sor Range.
13.	M. M. Memon	Manchhar Lake.
14.	W. Ahmad ..	Geology of the Eastern Part of Ras Koh Range, Kalat Division.
15.	A. F. M. Haque.	Smaller Forminifera from the Cardita Beaumonti Bed of Laki Range.
16.	S. deR Diettrich.	Mindanao : A Frentier of Cultural conflict.
17.	Asrarullah ..	Chromite and its Mining in West Pakistan.
18.	A. A. Kazmi & M. Husain.	Water Resources of the Quetta Basin.
19.	Rafiquddin Ahmad.	Alinagar : A study in Land Use.
20.	Kazi S. Ahmad and K. U. Kureishy.	Urban Study of D. G. Khan.
21.	Habibur Rahman.	Stratigraphic code of Pakistan.

UNESCO-PAKISTAN REGIONAL TRAINING COURSE IN SOIL SCIENCES

Within the last few decades, the agricultural production in Pakistan has not been increasing with the increase in population. Amongst many causes which are responsible for the stagnation in agriculture production, the waterlogging and salinisation of land are the worst. WAPDA on the basis of recent estimates has given alarming figures. More than 50 per cent. (1) of West Pakistan's irrigated or potentially irrigable land are affected by salinity and waterlogging.

Salinity has, therefore, become one of the major problems in irrigation agriculture and an important factor in the economic development of Pakistan.

The Pakistan Government which is actively engaged to eradicate this evil from the soils of Pakistan, with the help of WAPDA, offered to act as a host for the South Asian Region. The Government, WAPDA and the Irrigation Department displayed considerable interest in the Course on soil salinity which was jointly sponsored by the Agricultural Council of Pakistan and the UNESCO South Asia Science Co-operation Office.

It was inaugurated by Mr. Ghulam Farooq, Chairman, WAPDA, Dr. R. H. Fritsch represented UNESCO and Dr. A. G. Asghar, Director, Land Reclamation, Government of Pakistan was the Chief Organizer and Director. The course was conducted by Dr. R. L. Branson of California University and Professor J. Boulaine of University of Algier.

Approximately 20 participants from Afghanistan, Burma, Ceylon, India and Pakistan attended the course.

Special lectures were delivered by Dr.A. G. Asghar, Director, Land Reclamation.

PAKISTAN SOVIET OIL AGREEMENT

The agreement between Pakistan and the Soviet Union for the exploration of oil was signed in Karachi on the 4th March, 1961.

West Pakistan lies within the oil belt of Middle East. Since independence, all efforts have been made to search oil. During the Year 1959, eight oil companies namely : Attock Oil Company Ltd., Pakistan Oilfields Ltd., Pakistan Petrolium Ltd., Standard Vacuom Oil Company, Hunts, Pakistan Shell Oil Company Ltd., Pakistan Sun Oil Company Ltd., and Tide Water Oil Company were engaged in the search for oil. Oil prospecting has been carried out over 12000 sq. miles by Geological and Geophysical methods including drilling of 100 explorating and development wells with a total drilling depth of over 770,000 ft. The total investment in oil expiotation in the country amounted to Rs. 41 crores. The oil production has been increasing steadily since independence from 3·34 million barrels in 1957 to 20·41 million barrels in 1959. The results shown, however, have not been satisfactory. To stimulate further competition, an agreement on cooperation in search and prospecting of oil has been signed which provides for a loan of approximately 30 million dollar from the U. S. S. R. Government. The Government of Pakistan, repayable in Pakistan rupees over a period of 12 years, at an annual interest of $2\frac{1}{2}$ per cent. The repayment will be utilized by the U. S. S. R. Government in the purchase of Pakistani goods. The Government of Pakistan will utilize the loan in purchasing of U. S. S. R. equipment and material and for the salaries of the Soviet technicians.

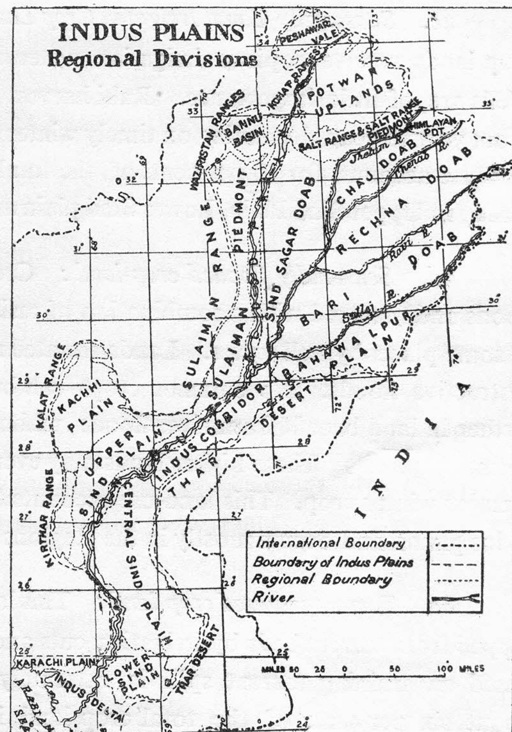
ANIS A. ABBASI

STATISTICAL SUPPLEMENT

LAND-USE OF INDUS PLAIN

In the early 1950 it was realized by the Governmet of Pakistan that the basic data showing the land-use, land-forms, soils and the area affected by waterlogging and salinity was very scanty and the information that existed was not sufficient for country wide planning.

The Government of Pakistan signed a contract with Photographic Survey Corporation limited Toronto, Canada under Colombo Plan, through the Colombo Plan Administration with the co-operation of Canadian Government. Under this contract the air photographs of the whole of West Pakistan on the scale of 1 : 40,000 (9x9) were taken during 1952—1954. The Survey was carried out in co-operation with the central soil conservations organizations, Ministry of Food and Agriculture Government of Pakistan. According to the schedule of the contract, two sets of reconnaissance maps (Landuse & Landforms) covering an area of 110,901 sq. miles were handed over to the Government of Pakistan some times in Feb., 1958. The Indus plain has been divided into 20 regions. The accompanying map shows the boundaries of these regions and the tables give data on the predominant land uses in these regions. The map, the tables and following notes have been extracted from the survey report.



1. *Settlements and Associated non-agricultural Lands*: This category includes urban areas and once-rural sites which have been set apart for Industrial development or housing. This accounts for 2,22,500 acres.

3. *Tree and other Perennial crops :* This category includes main concentrations of orchards of deciduous and citrus fruits and groves of date palms and mango trees. This covers 19,000 acres of which 10,000 are in the Central Sind Plain.

4. *Crop Land :* This category includes continual and rotation cropping and land rotation. This accounts for a little over half of the Survey Area.

4a. Perennially Canal Irrigated Crop Land : This is cultivated land which is watered throughout the year by flow from canal systems originating in the great rivers of the Indus Plains. This category covers 16.8 million acres—the single biggest land-use and accounts for 43 per cent. of total crop land of Indus plain. This land-use occurs mostly in Rechna Doab, Bari Doab and Central Sind Plain.

4b. *Perennially Canal Irrigated Crop Land:* (Considerable well irrigation). In summer these lands are irrigated by seasonal canals, Rabı crops are sown either with the aid of a canal watering, applied shortly before the canals close for the winter, or in the soil moisture left after summer crops have been harvested They are matured by means of wells or rainfall, or both. This category covers, 5.4 million acres or a little less than 14 per cent. of the total crop land. This land-use mostly occurs in Bari Doab and Indus Corridor.

4c. *Seasonally Canal Irrigated Crop Land:* (Inconsiderable well-Irrigation). These crop lands receive copious irrigation water from canals during the river-flood season. Wells are of little importance. Rabi harvest is insecure and liable to extreme fluctuations from year to year, depending on timely winter rains to bring sown crop to maturity. This land-use accounts for 10 per cent. of the total crop-land in the Indus Plains and occurs mostly in Upper Sind Plain, Lower Sind plain and Rechna Doab.

4d. *Seasonally flooded crop-land:* Crops are sown in the moisture supplied by floods and matured with a combination of residual soil moisture and rainfall, supplemented in some places by well water. Lands situated near the river channels are mostly subjected to destructive floods. No summer crops can be raised on such lands. Higher tracts, lying further in land benefit from river floods without suffering from their destructive force in normal summers These higher lands may even produce a small summer crop in addition to a major winter crop. This land-use accounts for six per cent. of the total crop land in the Indus plains and occurs mostly in the Regions of Indus Flood Plain and Bari Doab.

4e. *Torrent-watered crop land:* This land-use is dependant on spordic flood-waters tapped from torrent beds by irrigation cuts and trained anti-embanked fields. Cultivation based on training torrent spill is extremely precarious. This land-use accounts for about six per cent. of the total crop land in the Indus Plains and occurs mostly in Sulaiman Piedmont and Kachhi Plain Regions.

4f. *Dry-cropped land:* Land of this category produces crops watered by rainfall only, unaided by canals, well-water or river spill. Dry-crops are at the mercy of a deficient and capricious rainfall and, consequently they are the most precarious of all crops on the Indus Plains. This category accounts for about one-fifth of the total crop land in Indus Plains and occurs mostly in the Regions of Potwar Uplands, Sind Sagar Doabs, Rechna Doab and Salt Range and Salt Range Piedmont.

4g. *Well-Irrigated crop land:* The land of this category is irrigated with ground-water raised and distributed from wells. Cultivation is extremely painstaking, for it involves great deal of labour on the part of men and draught animals. This category accounts for about two and a half percent of the total crop land in Indus Plains and occurs mostly in Rechna Doab.

6. *Unimproved Grazing Land :* This category includes all natural grazing grounds, *i.e.*, densely to sparsely vegetated tracts which are not seeded, fenced or maintained in any other way. This category covers a little less than one-fifth of the total land in the Indus plains.

6*a*. *Grass Land :* The grazing of natural grass land is either the sole or predominant land-use over 4,35,500 acres occuring mostly in Rechna Doab and Peshawar Vale.

6*b*. *Scrub Land :* The grazing of scrub has been mapped as either the sole or predominant land-use where the crown cover more than fifty per cent. of an area. The area of this land is 6.4 million acres, half of which occurs in the Regions of Indus Flood plains and Upper Central and Lower Sind plain.

6. *Semi-Desert Scrub Land :* These lands are unreliable grazing grounds in Thar and Thall tract. This category accounts for 6.5 million acres and occurs mostly in Sind Sagar Doab, Bahawalpur Plains and Central Sind Plain.

7. *Wood Land :* West Pakistan is seriously deficient in forest resources. The true forest growth is confined to 719,500, acres, about one per cent. of the total surveyed area. The best forest growth is found in tracts which have been declared as 'reserved' or 'protected' forests. Over half of this wood land occurs in the Indus Flood plain Region.

8. *Swamp and March* : This category includes fresh or salt-water areas used for fishing, hunting or grazing, covering 3,65,000 acres in the Indus Plains—about seventy per cent. being in the Sind Plains and Indus Delta.

9. *Un-used Land* : This category comprises of all land which is at present unproductive, *i.e.*, land which is not cropped, grazed or devoted to wood land or urban settle ment, only those lands are left un-used which are beyond the present scope of peasant techniques because of physical defects or water shortage. Unused or predominantly unused land covers an area of about 15 million acres a little over one-fifth of the total surveyed area.

Besides these 'Land-uses,' 'water' covers an area of 2 million acres *i.e.*, about three per cent. of the total surveyed area.

Source :—1. Report on a Reconnaissance survey of the landforms, soils, and present land-use of the Indus Plains, West Pakistan.

2. Statistics of West Pakistan Agricultural Data by Division of District 1947-48 through 1958-1959.

INDUS PLAINS

Predominant Land-use According to Regional Divisions

(in thousands acres)

Region	1	3	4*a*	4*b*	4*c*	4*d*	4*e*	4*f*	4*g*
Peshawar Vale	12.5	..	619.5	..	2.5	25.0	13.5	347.5	41.5
Bannue Basin	2.0	..	107.0	..	38.5	..	92.5	479.0	..
Suleman Piedmont ..	7.5	..	68.5	383.5	161.0	35.0	1,061.0	420.0	21.5
Kachhi Plain	3.0	..	317.0	..	175.0	..	711.5	..	..
Kirthar Piedmont ..	.5	..	90.5	10.5	13.0	4.5	137.0	..	..
Karachi Plain	43.0	..	..	..	12.5	1.5	17.0	..	25.5
Potwar Uplands ..	21.5	..	..	..	26.0	19.5	12.5	2,703.5	83.5
Salt Range and Salt Range Piedmont.	4.5	..	134.5	1.5	32.0	57.5	223.5	754.5	19.0
Himalayan Piedmont ..	1.5	..	2.5	..	..	37.0	..	487.5	22.5
Sind Sagar Doab	10.0	..	130.0	614.0	.5	144.5	..	980.5	76.5
Chaj Doab	5.0	..	1,448.5	239.5	135.0	178.5	..	278.0	44.0
Rechna Doab	22.0	..	3,554.5	441.6	466.5	276.0	..	909.0	487.0
Bari Doab	44.5	2.5	3,734.0	2,120.5	52.0	367.5	..	34.5	69.0
Bahawalpur Plain ..	6.0	1.0	1,075.0	442.0	266.0	84.0	..	167.0	1.5
Indus Flood Plain ..	2.0	2.0	5.0	37.0	31.5	1,140.0	4.0	13.0	8.5
Indus Corridor	4.0	..	417.5	1,065.5	70.0	56.0	..	4.0	.5
Upper Sind Plain ..	11.0	3.5	613.5	6.0	1,287.5	16.0	..	..	..
Central Sind Plain ..	18.5	10.0	4,528.0	4.5	209.5	1.0	..	..	..
Lower Sind Plain ..	1.5	..	4.0	1.0	852.5	..	..	..	..
Indus Delta	2.0	..	..	..	140.0	26.5	..	..	..
Indus Plains	222.5	19.0	16,849.5	5,367.0	3,971.5	2,470.0	2,272.5	7,578.0	900.5
Per cent. of Indus Plains ..	.5	T	24.0	7.5	5.5	3.5	3.0	10.5	1.5

INDUS PLAINS

Predominant Land-use According to Regional Divisions

(in thousands acres)

Region	6*a*	6*b*	6*c*	7*a*	7*b*	8	9	Water	All uses
Peshawar Vale	79.5	3.0	..	..	..	..	206.0	48.5	1,399.0
Bannu Basin	6.5	4.5	20.5	..	..	..	380.0	44.0	1,174.5
Suleman Piedmont	4.5	597.5	194.5	..	2.5	1.5	1,957.5	..	4,916.0
Kachhi Plain	..	168.5	120.5	..	6.0	..	2,488.0	..	3,989.5
Kirthar Piedmont	..	167.0	..	..	..	8.5	342.0	..	773.5
Karachi Plain	..	196.5	..	..	..	2.5	229.5	21.0	549.0
Potwar Uplands	1.0	14.5	..	1.0	..	..	1,424.5	68.5	4,376.0
Salt Gange and Salt Range Piedmont.	4.5	12.5	..	1.0	..	..	1,215.5	56.0	2,516.5
Himalayan Piedmont	3.5	5.0	..	..	..	..	80.0	35.0	674.5
Sind Sagar Doab	8.0	181.5	3,296.5	8.0	..	2.5	832.0	96.0	6,380.5
Chaj Doab	45.0	100.5	..	12.5	.5	16.0	223.0	97.5	2,823.5
Rechna Doab	204.5	114.0	..	6.5	1.0	39.5	895.5	163.0	7,580.5
Bari Doab	56.0	474.5	..	63.5	..	7.0	596.5	177.5	7,799.5
Bahawalpur Plain	..	157.0	1,106.5	8.0	2.0	21.0	381.5	65.5	3,785.0
Indus Flood	1.5	1,206.0	2.0	381.0	42.5	4.0	64.5	993.0	3,937.5
Indus Corridor	21.0	509.5	421.5	92.5	2.5	8.0	352.5	12.0	3,037.0
Upper Sind Plain	..	753.5	..	71.0	..	105.5	445.5	25.5	3,338.5
Central Sind Plain	..	888.5	1,289.5	17.0	1.5	29.0	473.0	..	7,470.0
Lower Sind Plain	..	370.5	16.5	1.5	..	63.0	665.5	..	1,976.0
Indus Delta	..	436.0	.5	56.0	..	57.0	1,680.0	123.0	2,521.0
Indus Plains	435.5	6,360.5	6,468.5	719.5	58.5	365.0	14,932.5	2,027.0	71,017.5
Per cent. of Indus Plains	.5	9.0	9.0	1.0	T	.5	21.0	3.0	100.0

BOOK REVIEWS

Africa : Its people and their cultural history by George Peter Murdock xiii and 456 p. p ; maps, ills. bibliogrs. (of tribal names). McGraw Hill Book Company, Inc. New York, Toronto and London 1959. $8.75 $9\frac{1}{4}$ x6 inches.

This is a scholarly, well written and illustrated account of the cultural history of the African people. It is a useful addition to the text books on African anthropology.

As the author puts it. "This book does not present a distillations of long and intimated familiarity with the African continent. The author has had field experience only about indigenous peoples in N. America and oceanica, and his first-hand knowledge of Africa has been limited to three brief visits—a week in Egypt in 1945, and a fortnight in Kenya and Tanganykia in 1957."

It was due to author's interest in the African ethnology for the past 8 years and probably his study of the literature that stimulated him to write an appraisal of the African culture from the period around 5000 B.C. to the beginning of the twentieth century. In course of his research the author seems to have revalued or even discarded some of the existing data. After critical examination, he has sifted and organized the work from the mass of descriptive material.

The author has limited himself in the subject matter to the social and political organizations, marriage and family life, housing and settlements, the division of labour by sex, food-producing activities and "a few miscellanea such as cannibalism and genital mutilation.

The book is divided into eleven parts, part one comprising seven chapters covers 40 pages and gives a very brief account of Geography, Race, Language, Economy, Society, Government and History. Selective bibliographies at the end of each chapter provide a useful guide for supplementary study. This part is well illustrated. Out of a total of 17 maps (including the pocket map inside the cover) as many as 9 maps are included in this section.

After the general introduction in part one, the author in the remaining ten parts deals with the subject in a historical way, in which he evaluates the surviving hunting group and the effect of migration on the cultural history of the people. African societies acquired and maintained distinct culture in their own geographical environment. Murdock has very skillfully traced their main cultural developments and movements during the past 7000 years.

The author has shown how the north-eastern african learned the art of agriculture and animal husbandary from the Middle-East countries, which in period became the basis o fpharanic Egypt. The art of agriculture and animal husbandary was developed independently by the Negros of the West Africa, and is a great contribution to the entire human history. He has very aptly brought out how the subsistance techniques, acquisition of suitable plants and the development of agriculture have played important role in the migration of the people.

On the whole it is a good text book.

ANIS A. ABBASI